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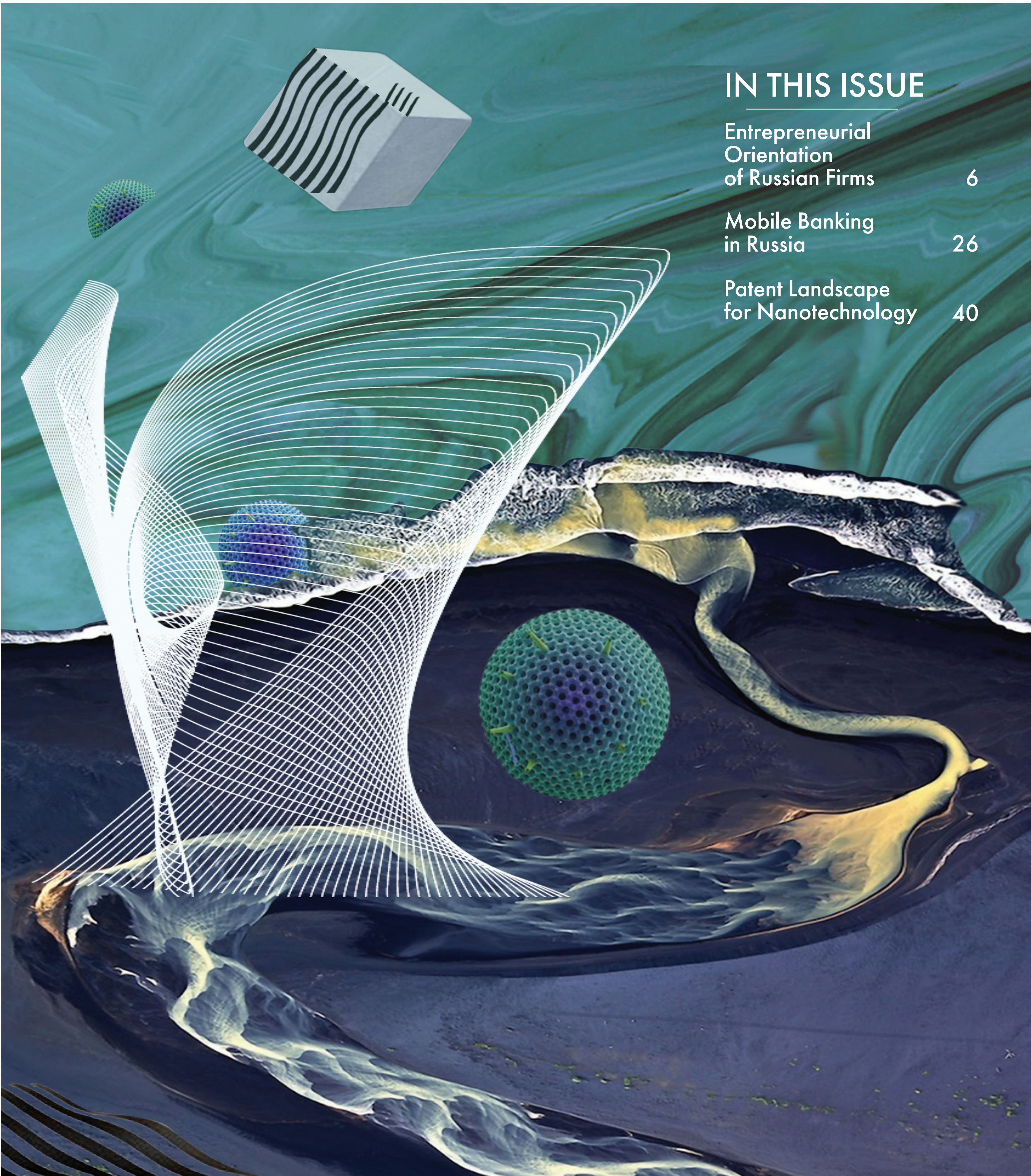

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Foresight and STI Governance

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About the journal

Foresight and STI Governance (formerly Foresight-Russia) — a research journal established by the National Research University — Higher School of Economics (HSE) and administered by the HSE Institute for Statistical Studies and Economics of Knowledge (ISSEK), located in Moscow, Russia. The mission of the journal is to support the creation of Foresight culture through dissemination of the best national and international practices of future-oriented innovation development. It also provides a framework for discussing S&T trends and policies.

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References

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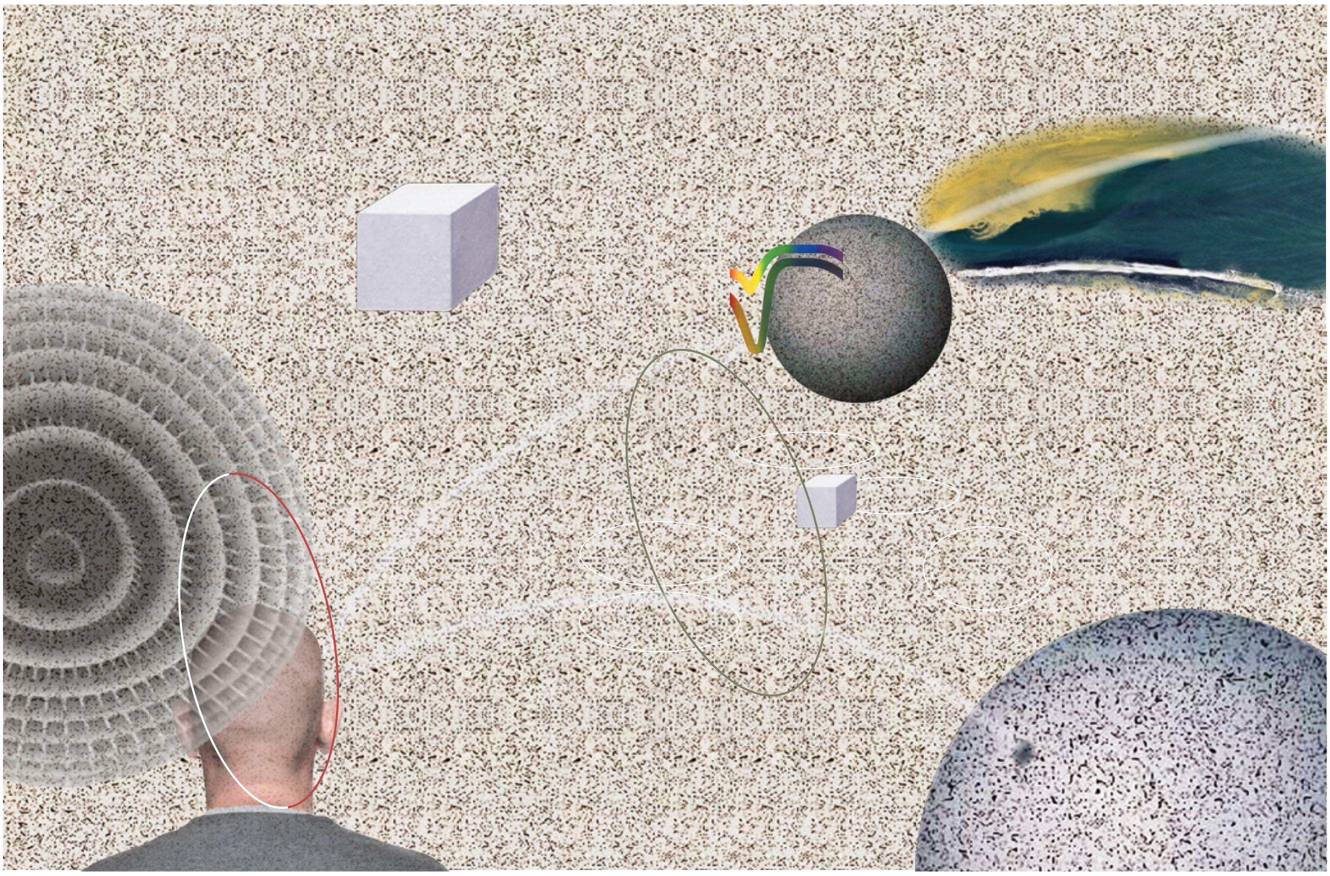
Entrepreneurial Orientation of Russian Firms:
The Role of External Environment

Galina Shirokova[I], Karina Bogatyreva[II], Tatiana Beliaeva[III]



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Abstract

The paper investigates a relationship between the entrepreneurial orientation (EO) dimensions — innovativeness, proactiveness, and readiness to risk — and firm performance of Russian SMEs. We assess EO effects on firm performance in the context of an emerging market taking into account environmental contingencies.

Our findings are underpinned by the results of the survey which covered managers of 104 Russian small and medium firms. The data were processed by the structural equation modeling. The analysis has revealed that EO structure in the context of Russian market differs from the traditional three-dimensional conceptualization of entrepreneurial orientation, typical to western countries. Emerging markets i.a. Russian are characterized by the two-dimensional EO structure: innovativeness and proactiveness are perceived as a single dimension, while the and readiness to risk is a separate component.

Moreover, a positive relationship between the united dimension of entrepreneurial orientation – innovativeness and proactiveness – and firm performance is manifested only in dynamic or hostile external environment. The features of Russian institutional and cultural environment may serve as a base to explain the research findings.

Keywords: entrepreneurial orientation; firm performance; external business environment; emerging markets; structural equation modeling

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In an ever-changing business environment, companies continually seek new opportunities to guarantee growth and an augmenting market share. Firms strive to be more innovative and implement entrepreneurial initiatives in order to preserve their competitive advantage and maintain a sustainable market position [*Rothaermel,* 2008].

The concept of entrepreneurial orientation (EO) was first formulated more than 30 years ago and is now one of the most popular areas of research in strategic management [*Shirokova*, 2012; *Wales et al.*, 2013]. Entrepreneurial orientation represents the active strategic position of a company, which is linked to ongoing developments in innovation, proactiveness and willingness to invest in high-risk projects where results are not necessarily clear, and the likelihood of success is unknown [*Covin, Slevin*, 1989; *Stam, Elfring*, 2008].

Over the last three decades, while studies in developing countries have progressed at a far more sedentary pace, entrepreneurial orientation and its role in business has received widespread coverage in developed countries [*Lan, Wu*, 2010; *Wales et al.,* 2013; 2015]. Therefore, the instrument developed to operationalize entrepreneurial orientation as a theoretical construct[1], comprising three components (innovativeness, proactiveness and risk-taking) [*Covin, Slevin*, 1989], was tested in developed market conditions. Such an approach in a context different to the original setting could lead to certain problems in terms of its adequacy in measuring the corresponding components while carrying out an empirical analysis of the structure[2] of entrepreneurial orientation [*Hansen et al.*, 2011]. Discussions regarding the reliability of the entrepreneurial orientation measurement scale raised questions concerning the contextual invariance of the construct of entrepreneurial orientation. A number of studies have been carried out which have shown that the entrepreneurial orientation structure does not always consist of three components. Consequently, applying the classical approach to its conceptualization and operationalization in the context of emerging markets requires a detailed analysis of the construct's structure with regard to the reliability of the measurements.

In academic literature, there have been numerous attempts to study the relationship between a firm's entrepreneurial orientation and its performance. Different factors have been analysed on various occasions that could have an impact on the strength or direction of this relationship in different external environments [*Rauch et al.*, 2009]. Despite the fact that a number of studies have shown a positive link between a firm's entrepreneurial orientation and its performance [*Boso et al.,* 2013; *Lumpkin, Dess*, 2001; *Rauch et al.*, 2009; *Shirokova, Bogatyreva*, 2014; *Wiklund, Shepherd*, 2005], in some cases a negative relationship [*Arbaugh et al.*, 2009; *Hart,* 1992; *Kulikov, Shirokova*, 2010;] or indeed a non-linear dependence was identified [*Dai et al.*, 2014; *Su et al.*, 2011; *Tang et al.*, 2008; *Wales et al.*, 2013]. These contradictions in findings could be attributed to the fact that the strength and direction of the relationship between entrepreneurial orientation and a firm's performance are in many ways shaped by the characteristics of external environment [*Lumpkin, Dess,* 1996; *Wiklund, Shepherd*, 2005]. Business conditions in certain countries can shape entrepreneurial behaviour [*Chepurenko, Yakovlev*, 2013; *Lee, Peterson,* 2000; *Marino et al.*, 2002; *Shirokova, Sokolova*, 2013] and predetermine the nature of its impact

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[1] Theoretical construct refers to mean unobserved characteristics, which may be defined by a designated set of corresponding observed variables and the relationships between them.

[2] Structure of a theoretical construct refers to associated set of components, which can be measured through numerous observed variables.

on a firm's performance. Thus, studying the relationship between a firm's performance and entrepreneurial orientation in the context of an emerging market will help to better understand the essence of this dependence in this environment and evaluate the significance of each of the aforementioned components for a firm.

The aim of this paper is to identify features reflecting entrepreneurial orientation in Russian SMEs and to study their relationship with performance, taking into account the external environment peculiarities. We use a multidimensional approach to conceptualize entrepreneurial orientation [*Lumpkin, Dess*, 1996], which assumes that components present in a firm may vary largely and change independently of one another; this allows us to evaluate the relationship between them and the firm's performance.

Ultimately, we are trying to answer the following questions in this study:
- What is the structure (set of components) of firms' entrepreneurial orientation in the Russian context?
- How is entrepreneurial orientation linked to Russian SMEs' performance?
- Does the nature of the relationship between entrepreneurial orientation and a firm's performance change in a dynamic, hostile, and heterogeneous external environment?

The theoretical framework of this research is based on the resource-based view [*Barney*, 1991], which holds firm's entrepreneurial orientation to be a rare, valuable, non-substitutable, and inimitable resource that allows for an increase in certain aspects of performance. The resource-based view is combined with the contingency approach [*Lawrence, Lorsch*, 1967], which opines that organizations demonstrating greater harmony between the parameters of their own internal environment and the features of the external surroundings [*Smith, Lewis*, 2011] are likely to be more successful. A data sample of 104 Russian SMEs, taking into account specific contextual features of an emerging market[3] forms the basis of our analysis. Finally, the study uses the structural equation modelling (SEM) method, which makes it possible to recognize the specific structure of theoretical constructs operationalized through multiple observed variables, one of which is entrepreneurial orientation. One must take into account the fact that the various concepts developed for a developed market often require adaptation when applied to emerging markets [*Bruton et al.*, 2013]. It is already established that in the Russian context it is perceived as a bivariate construct, in which innovativeness and proactiveness are combined into one component, while risk-taking constitutes a separate component. Considering the specific conditions in which a firm operates, we stress the importance of the external environmental characteristics in the formation of relationships between entrepreneurial orientation and a firm's performance.

This paper continues as follows. The first section sets out the theoretical framework of the research and the hypotheses. The second section is devoted to the empirical study method used. The third section presents the main results of the analysis; and the fourth discusses the results. The conclusion outlines the findings and examines the limitations and possible areas for future research in this field.

[3] A detailed review of approaches to defining and classifying emerging markets is given in the paper [*Alkanova, Smirnova*, 2014]. Russia falls under this category according to all the main classifications (UN, IMF, BRICS, Next Eleven, EMGP, Morgan Stanley Capital International, FTSE, Standard&Poor's, BBVA). These classifications are based on macroeconomic indicators which characterize the quality of the market environment, infrastructure development, etc.

Theoretical framework and research hypotheses

The relationship between entrepreneurial orientation and a firm's performance

As noted above, a firm's entrepreneurial orientation is a strategic process characterized by innovation development, its active position in the market, and willingness to make decisions in times of uncertainty. This gives rise to a theoretical construct, which accordingly covers three dimensions: innovativeness (inclination to develop new ideas), proactiveness (searching for new market opportunities) and risk-taking (willingness to take part in projects renowned for their uncertainty) [*Covin, Slevin*, 1989; *Stam, Elfring*, 2008]. There are two approaches to the conceptualization of entrepreneurial orientation: unidimensional [*Covin, Slevin*, 1989] and multidimensional [*Lumpkin, Dess*, 1996]. Under the unidimensional approach, only firms with high levels of development in the above components maybe considered entrepreneurial, while the multidimensional approach views them as independent of one another, where firms can be entrepreneurial without adopting all of these components.

At present, there have been a large number of empirical studies devoted to studying the relationship between entrepreneurial orientation and a firm's performance. Most of these studies have shown that this relationship is positive in nature [*Martins, Rialp*, 2013; *Rauch et al.*, 2009; *Van Doorn et al.*, 2013; *Wiklund, Shepherd*, 2003, 2005; *Zahra*, 1991].

Entrepreneurial orientation allows a firm to develop ideas and realize them in the form of new products and services, participate in risky projects, predict future requirements, and find new market opportunities [*Covin, Slevin*, 1989]. These characteristics in a firm can be positive when they face various challenges from the external environment. Thus, firms can derive benefit from their entrepreneurial strategic status [*Rauch et al.*, 2009].

Entrepreneurial orientation can serve as an instrument for a firm to adapt to external environments [*Covin, Slevin*, 1989; *Hameed*, 2011; *Khandwalla*, 1976]. Further, developing entrepreneurial behaviour can help to precisely position a company in the market, taking into account internal and external factors. Entrepreneurial orientation maybe viewed as a special resource — organizational ability, which allows companies to develop competitive advantages and improve performance [*Aloulou, Fayolle*, 2005; *Grande et al.*, 2011; *Madsen*, 2007; *Wiklund, Shepherd*, 2011]. Developing entrepreneurial orientation involves adapting a firm's alternative strategic orientations and skill sets, which can in turn have a positive impact on business performance; in particular, it can serve as a prerequisite for strengthening market orientation [*Blesa, Ripolles*, 2003; *Matsuno et al.*, 2002], learning orientation [*Alegre, Chiva*, 2013], experimental learning [*Zhao et al.*, 2011] and accelerate the process of launching new products, services, and technologies on the market [*Clausen, Korneliussen*, 2012]. In addition to the unidimensional approach for conceptualizing entrepreneurial orientation, some authors consider entrepreneurial orientation from the perspective of a multidimensional approach. They do so by studying the impact of its individual components (innovativeness, proactiveness and risk-taking) on a firm's performance [*Dai et al.*, 2014; *Kreiser, Davis*, 2010; *Shirokova, Bogatyreva*, 2014] which have yielded positive results [*Richard et al.*, 2004; *Simon et al.*, 2011; *Van Doom et al.*, 2013]. Innovative and proactive thinking form another basis to increase market share and further differentiate their products. A high level of proactiveness often allows companies to use the first-mover advantage and simultaneously enhance their ability to predict forthcoming changes in the external environment, which can in turn enable them to make well-timed decisions [*Lumpkin, Dess,* 1996]. Firms renowned for their strong entrepreneurial orientation often find themselves permanently monitoring such changes, always searching for new opportunities to strengthen their competitive position, resulting in a positive impact on their performance [*Keh et al.*, 2007]. Involvement in risky projects in times of uncertainty can bring the opportunity for high profits [*Martins, Rialp*, 2013]. The specific character inherent in entrepreneurially oriented firms is critically important in emerging markets as the latter are generally characterized by heightened instability vis-à-vis the external environment [*Ahlstrom, Bruton*, 2002], which encourages firms to have an active strategic position. We can therefore deduce the following:

Hypothesis 1. Each component of entrepreneurial orientation (innovativeness, proactiveness, risk-taking) is positively related to the performance of firms operating in an emerging market context.

The impact of situational variables on the relationship between entrepreneurial orientation and a firm's performance

Entrepreneurial orientation may be viewed as a mechanism by which firms adapt to the external environment. A contingency approach in studies of the process of strategy development and implementation involves taking into account the different external environmental parameters of an organization when establishing its strategic course [*Cyert, March*, 1963; *Saeed et al.*, 2014; *Simon*, 1957]. Accordingly, a business' strategic orientations evolve under the influence of external environmental conditions [*Rosenbusch et al.*, 2013], the characteristics of which can have an impact on the strength and direction of the relationship between entrepreneurial orientation and a firm's performance [*Kreiser, Davis,* 2010].

One of these external environmental characteristics is *dynamism*, which reflects the degree of uncertainty and speed of change in an industry [*Miller, Friesen*, 1983]. Changes in the market can stem from technological innovations, transformations in consumer demand and preferences, and the unpredictability of competitor behaviour [*Caruana et al.*, 2002; *Miller, Friesen,* 1982]. These all cause complications for firms operating in times of uncertainty and unpredictability; however, a dynamic external environment still opens up new opportunities to expand business and establish and develop competitive advantages [*Ruiz-Ortega et al.*, 2013].

Various studies [*Covin, Slevin*, 1989; *Miller*, 1983; *Miller, Friesen*, 1983; *Rauch et al.*, 2009; *Wiklund, Shepherd*, 2004] show that an entrepreneurial strategic position is more preferable for firms operating in a highly dynamic external environment. Firms of this orientation, in particular those that are in high-tech industries, are found often in conditions unique for their high dynamism and short product life cycles [*Moriarty, Kosnik*, 1989]. Under these circumstances, the relationship between entrepreneurial orientation and performance is stronger [*Lisboa et al.*, 2011]; as such, firms use opportunities arising in the market in a more productive way [*Moreno, Casillas*, 2008; *Rauch et al.*, 2009; *Wales et al.*, 2013]. They adapt to the dynamic external environment by developing innovative solutions, conquering new markets, and participating in high-risk projects [*Alexandrova*, 2004; *Frank et al.*, 2010]. Reinforcing an entrepreneurial orientation in such conditions helps firms to monitor emerging trends in the marketplace, factor such variables when developing new products, and expand their product portfolio, thereby minimizing the threat of existing products becoming obsolete.

Emerging markets are often characterized by a high degree of uncertainty compared with developed markets [*Ahlstrom, Bruton,* 2002; *Tang, Tang*, 2012] and in this context an entrepreneurial orientation can contribute to achieving better performance [*Tang, Tang*, 2012; *Zhou, Li*, 2007]. In view of the foregoing, the following hypothesis may be posited:

Hypothesis 2a. The dynamism of the external environment intensifies the positive relationship between each component of entrepreneurial orientation (innovativeness, proactiveness, risk-taking) and the performance of firms operating in emerging market context.

Another parameter of the external environment is *hostility*, which is linked to various threats to a firm's existence [*Miller, Friesen*, 1982]. These include the narrowing of products and services markets, limited access to the necessary labour, material and other resources or shortages, state interference, unfavourable demographic trends, and so on [*Alexandrova*, 2004; *Caruana et al.*, 2002; *McGee et al.*, 2012; *Miller, Friesen*, 1983].

There are several studies devoted to the role of external environmental hostility in the development of the relationship between entrepreneurial orientation and a firm's performance [*Covin, Slevin*, 1989; *Kreiser, Davis*, 2010; *McGee et al.*, 2012; *Miller*, 1983; *Miller, Friesen*, 1982, 1983; *Rosenbusch et al.*, 2013]. It has been shown that in a hostile environment, entrepreneurial firms report better results compared with conservative firms as entrepreneurial behaviour helps them to cope more effectively with external threats.

External environmental hostility not only requires innovative and proactive behaviour from firms, but also their willingness to take risks, which can in turn lead to better performance [*Miller, Friesen*, 1982; *Shirokova, Sokolova*, 2011]. Innovativeness allows businesses to modify their products and services to satisfy customers' needs and preferences [*Kreiser, Davis*, 2010; *Vij, Bedi*, 2012]. Risky and proactive market activity makes it possible for firms to outstrip their competitors, while at the same time seeking out access to the necessary resources [*De Clercq et al.*, 2010; *Miller*, 1983]. To compete successfully in a hostile environment, managers are 'inclined to take risks [and] to favor change and innovation' [*Covin, Slevin*, 1989, p. 218]. Risk-taking and proactive and innovative behaviour in place of passive reaction are a guarantee of a successful strategy to maintain competitive advantages in a hostile environment.

In contrast to the hostile environment, a benign environment is characterized primarily by broad access to resources [*Covin, Slevin,* 1989]. In these conditions, there is no pressing need to develop an entrepreneurial orientation to achieve better performance, and firms confining themselves to conservative strategies are perfectly capable of achieving success [*Martins, Rialp*, 2013]. As a result, those with a strong entrepreneurial orientation maybe found rarely in a benign environment, compared with a hostile one [*Miller, Friesen*, 1982].

In emerging markets, the level of hostility is higher than in developed markets [*Ahlstrom, Bruton*, 2002]. This is attributable to the imperfection of institutions in emerging markets, which poses certain threats to business operations. In the context of emerging markets, the regulatory environment, including the process of registering a company, the time and financial costs as per administrative regulations, or tax regulation, all serve as a hindrance to business development, which calls for an active entrepreneurial strategic position from firms [*Li, Zhang*, 2007]. In light of these points, the following research hypothesis may be put forward:

Hypothesis 2b. The hostility of the external environment intensifies the positive relationship between each component of entrepreneurial orientation (innovativeness, proactiveness, risk-taking) and the performance of firms operating in emerging market context.

An important characteristic of the external environment, which can have an impact on the relationship between entrepreneurial orientation and a firm's results, is *heterogeneity*. This type of external environment is often the backdrop for diversified firms operating in different, but not always closely related sectors [*Miller, Friesen*, 1982] and firms operating in countries with high regional differentiation in terms of economic and cultural development. A heterogeneous external environment is remarkable for the significant differences in consumer preferences, competitor behaviour, and business models [*Caruana et al.*, 2002; *Fayolle et al.*, 2010]. These differences cause complications for business operations and require extremely diverse approaches to business [*Rosenbusch et al.*, 2013].

A heterogeneous environment assumes the existence of market segmentation, and this is a question of developing a broad and diversified product portfolio. A willingness to participate in risky and innovative projects combined with proactive behaviour helps entrepreneurial firms to develop such a portfolio [*Miller, Friesen*, 1982; 1983]. A heterogeneous external environment also implies diversity in approaches to business operations in different market segments, administrative practices, and production technologies. Entrepreneurial orientation is linked to the development of learning orientation [*Wang*, 2008] and the flexibility and adaptability of a strategy to a heterogeneous environment [*Caruana et al.*, 2002; *Miller*, 1983; *Rosenbusch et al.*, 2013]. This helps in better satisfying customers' needs and, therefore, increases a firm's performance. In addition, proactive behaviour enables firms to be the first to occupy corresponding market niches, thereby deriving a first-mover advantage [*Fayolle et al.*, 2010].

Thus, it can be argued that in an external environment characterized by a high degree of heterogeneity, entrepreneurial orientation has a positive relationship with a firm's performance.

Hypothesis 2c. The heterogeneity of the external environment intensifies the positive relationship between each component of entrepreneurial orientation (innovativeness, proactiveness, risk-taking) and the performance of firms operating in an emerging market context.

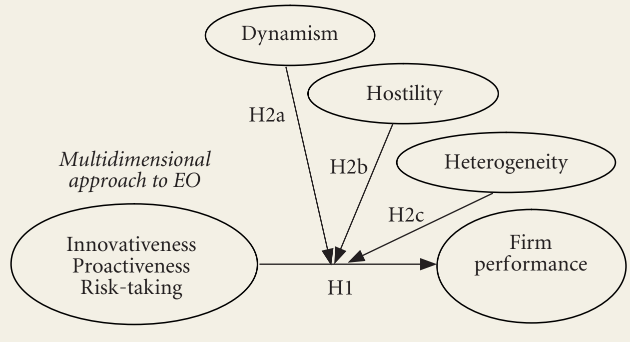
The theoretical model is outlined in Figure 1.

Research methodology

Sample description

This study is based on survey data from Russian firms carried out from September 2013 to March 2014. For the study, we selected private SMEs in different industries. The standardized survey developed in this paper,

Fig. 1. **Theoretical model**



Source: compiled by the authors.

based on the confirmed and approved measurement scales of the corresponding theoretical constructs, was distributed among representatives of firms with access to corresponding information. The survey asked questions relating to various aspects of the firm's activities and the characteristics of the main industry in which it operates. It was conducted in Russia, using the 'back translation' method [*Brislin*, 1970] to reduce the possibility of differing perceptions of notions by respondents. In the preliminary stage, a pilot test survey was carried out on a small sample, which made it possible to make certain necessary adjustments to the survey. During the data collection process, respondents were guaranteed full anonymity and non-disclosure of personal information.

The sample covered 8,000 companies selected at random from the 'SPARK-Interfax' and 'Amadeus' databases. The standardized survey was distributed automatically among respondents using the Webropol 2.0 survey software. However, the survey suffered from extremely low response rates. In particular, the number of respondents, which received and opened the survey, was 233, of which 14 responded, resulting in an effective response rate of 6%. This outcome can be explained by the fact that SMEs are generally unwilling to disclose information about their performance. Therefore, the decision was made to use the 'convenience sampling' method[4], which allows for an increase in the number of respondents. The main sources of contact with companies were the St. Petersburg Graduate School of Management (GSOM) Alumni Association, which is a community of graduates spanning the last 20 years, and students on the St. Petersburg GSOM MBA programme for managers. In the end, 121 completed surveys were collected, which were then checked for missing values.

In order to meet the company size criterion, large firms were excluded from the subsequent analysis. According to the classification set out in Federal Law No. 209-FZ dated 24 July 2007 'On the Development of Small and Medium Enterprises in the Russian Federation,' companies with staff of less than 250 employees and total sales revenue of less than 1 billion roubles are classified as small and medium businesses in Russia. The revenue criterion is widely used in statistical databases to group companies according to their size (SPARK-Interfax). Since this paper examines the relationship between entrepreneurial orientation and a firm's performance, measured using growth in sales, this criterion seems most suitable in achieving the research objectives. Using only the employee numbers criterion to group companies imposes significant restrictions as actual sales at many Russian SMEs — according to the employee numbers parameter — do not meet the criteria used for SMEs in international studies [*Shirokova et al.*, 2013]. The upper limit of the size of companies under consideration was, therefore, increased to 500 employees.

The structure of the sample broken down by criteria such as company size, age, and industry is shown in Table 1. The age of the companies in the sample varies between 2 and 26 years. The majority of them (51.5%) have been operating in the market for less than 10 years, 38.8% of companies between 10 and 20 years, and 9.7% 21 years or more. Two thirds of companies in the sample (63.7%) are small firms with less than 50 employees and the remainder is medium firms (up to 500 employees). More than half of the companies in this study operate in the services sector (54.8%), 15.4% in production, and 29.8% in intellectual and information sectors.

[4] Convenience sampling is a judgment sample. When forming the sample, only those elements of the population were selected which would make it easier to obtain responses [*Saunders et al.*, 2003].

Table 1. **Sample structure**

Criteria	Categories	Company distribution (%)
Firm age, years	≤ 10	51.5
	11–20	38.8
	≥ 21	9.7
Firm size, number of employees	≤ 10	24.5
	11–50	39.2
	51–100	10.8
	≥ 101	25.5
Industry	Production	15.4
	Services	54.8
	Intellectual and information sector	29.8

Source: calculated by the authors.

Variable measurements

Independent variables. For the latent variables, the study used approved and confirmed scales. To measure entrepreneurial orientation, it applied the classic ordinal scale developed by Jeffrey Covin and Denis Slevin [*Covin, Slevin*, 1989]. The scale involves 9 questions, three for each of the components: innovativeness, proactiveness, and risk-taking. Respondents evaluate the level of a firm's entrepreneurial orientation on a scale from 1 to 7. The Cronbach's alpha value for this scale was 0.837, which confirms the internal consistency of the scale and the reliability of the measurement. The study considered dynamism, hostility, and heterogeneity of the external environment to be moderators of the relationship between entrepreneurial orientation and a firm's performance, i.e. variables capable of affecting the strength and direction of the relationship. To measure the dynamism and heterogeneity of the external environment, the ordinal scales presented in the paper [*Miller, Friesen,* 1982], containing five and four questions respectively, were used. The Cronbach's alpha values for the dynamism and heterogeneity scales were 0.729 and 0.733.

The overall level of hostility of the external environment was measured through respondents' evaluation of statements using a 7-point scale, where 1 matched the statement 'External environmental conditions pose the greatest threat to the firm's existence' and 7 meant 'The threat to the firm's existence is small'. This question was proposed in the work of Danny Miller and Peter Friesen [*Miller, Friesen*, 1982] and upon analysis was recoded using an inverted scale so that the value would increase as the level of hostility in the external environment grew.

Dependent variables. To measure a firm's performance, financial and non-financial indicators may be used [*Delmar et al.*, 2003; *Rauch et al.*, 2009]. Empirical studies make widespread use of financial indicators reflecting a firm's growth and profitability [*Soininen et al.*, 2012]. Examples of non-financial indicators of a company's performance include achievement of set goals, customer satisfaction, company success ratings, and so on [*Rauch et al.*, 2009]. Subjective indicators reflecting managers' views on company performance can also be singled out, together with objective indicators found in statistical databases, documents, or archives [*Rauch et al.*, 2009]. The first of these make it possible to use several measurements of a business' performance, including comparisons with competitors or with figures for previous periods [*Stam, Elfring*, 2008; *Wiklund, Shepherd*, 2005], but due to their subjectivity can be the cause of bias in evaluations.

In order to operationalize a business' performance, as in many other similar studies [*Delmar et al.*, 2003; *Boso et al.* 2013; *Frank et al*, 2010; *Lumpkin, Dess,* 2001; *Simon et al.* 2011; *Soininen et al.*, 2012; *Stam, Elfring,* 2008], we used the 'growth in sales' financial indicator, calculated as the percentage change in a firm's sales over the period 2010–2012. Corresponding questions were incorporated into the survey questionnaire. The information so received was verified and supplemented using the 'Amadeus' and 'SPARK-Interfax' databases.

Control variables. Given that a firm's performance and the level of entrepreneurial orientation can vary within firms of differing ages, sizes, and sectoral affiliation [*Lumpkin, Dess,* 1996; *Shirokova, Sokolova*, 2013; *Van Doom et al.*, 2013; *Wales et al.*, 2013], these variables were included in our study as control variables [*Pole, Bondy,* 2010].

The *firm age* is measured as the number of years since it was founded. The assumption and expectation is that firms that have been in the market for a long time will be more conservative and less entrepreneurial and could be slower to react to changes in the external environment [*Song et al.*, 2008].

The *firm size* is evaluated based on the number of employees at the time of completing the survey. Previous studies have pointed to a connection between the size of a company and the level of entrepreneurial orientation [*Durand, Courderoy*, 2001] and performance [*Ahuja, Lampert,* 2001]. Analysis of the distribution graphs showing the variables 'firm age' and 'firm size' demonstrates that the logarithm of their distribution is close to normal. In this regard, these variables were included in the model as a natural logarithm of their initial values.

The study found that the relationship between entrepreneurial orientation and a business' performance varies according to *industry* [*Zahra*, 2008]. To check the industry affiliation of a firm, binary variables were introduced to reflect the company's activity in one of three economic sectors (production, services, and the information sector).

Data analysis results

Reliability and validity of the entrepreneurial orientation construct

To test the relationship between the studied variables, the study used the *structural equation modelling* method. This is often encountered in studies of latent variables that can be indirectly measured by a number of observed variables. Structural equation modelling allows us to analyse the structure of these variables, evaluate the fit between the tested model and the empirical data, and test complex models involving several relationships between variables at the same time [*Anderson, Gerbing,* 1992].

Our data analysis was a two-stage process. The first stage involved analysing the dimensionality, reliability, and validity of the entrepreneurial orientation construct and the second comprised hypothesis testing.

A confirmatory factor analysis using the structural equation modelling package in AMOS 22.0 was used to define the structure of the entrepreneurial orientation construct. We used the maximum likelihood estimation method to define the model parameters [*Eliason*, 1993]. In order to evaluate the quality of the models, various goodness of fit indices were used: χ^2/df — a model fit indicator (threshold value < 2), GFI (goodness of fit) (threshold value > 0.9), CFI (comparative fit index) (threshold value > 0.9), TLI (Tucker-Lewis Index) (threshold value > 0.9) and RMSEA (root mean square error of approximation) (threshold value < 0.06 (< 0.08)), allow for making it possible to establish the level of fit between the model and the empirical data [*Anderson, Gerbing*, 1992; *Byrne,* 2009].

Using a confirmatory factor analysis, the applicability of the classic entrepreneurial orientation construct was verified [*Covin, Slevin*, 1989] together with the three aforementioned components (innovativeness, proactiveness, and risk-taking) for the sample of Russian SMEs. It was revealed that the model with the two-dimensional entrepreneurial orientation structure, where innovativeness and proactiveness were combined into one indivisible component and risk-taking constituted a separate component, was the best fit for the Russian data and satisfied the threshold values of the goodness of fit indices: χ^2/df = 1.37; GFI = 0.94; CFI = 0.97; TLI = 0.95; RMSEA = 0.06 (p = 0.339).

The Cronbach's alpha value for the 'innovativeness and proactiveness' component was 0.81 and for the 'risk-taking' component 0.7. All of the observed variables in the two-component entrepreneurial orientation model show significant loadings on the corresponding items, which confirm the convergent validity.

The descriptive statistics and correlation matrix for the variables used in the study are provided in Tables 2 and 3.

Testing of the research hypotheses

The second stage involved the testing research hypotheses (Fig. 2).

The study assessed the entrepreneurial orientation components for discriminant validity.[5] The quadratic correlation between each pair of entrepreneurial orientation components was less than the explained average variance, which is in line with the criterion presented by Claes Fornell and David Larcker [*Fornell, Larcker*, 1981]. However, the composite reliability (CR) indicator[6] exceeded the threshold value of 0.7 only for the combined innovativeness/proactiveness component (0.79). As for the risk-taking dimension, this figure was 0.69, which is slightly below the required level. The average variance explained (AVE) indicator[7] was lower than the threshold value for both of the entrepreneurial orientation components under examination (0.40 for innovativeness/proactiveness and 0.42 for risk-taking). As a result, the study took into account the effect of each of the indicated components separately instead of analysing the second order model.

Table 2. **Variable descriptive statistics**

Variable	Value			Standard deviation
	Mean	Min	Max	
Innovativeness / Proactiveness	3.89	1	6.83	1.31
Risk-taking	3.88	1	7	1.38
Sales growth	34.3	–90	300	59.3
Dynamism	3.31	1	6	1.22
Hostility	4.02	1	7	1.78
Heterogeneity	3.63	1	7	1.31
Firm age natural logarithm	2.18	0.69	3.26	0.67
Firm size natural logarithm	3.55	0.00	6.21	1.54
Production	–	0	1	–
Services	–	0	1	–
Intellectual and information sector	–	0	1	–

Source: calculated by the authors.

[5] Discriminant validity is achieved when a latent variable can be explained more by the observed variables constituting it than other variables in the model. One of the ways to verify latent variables for discriminant validity is the Fornell and Larcker criteria [*Fornell, Larcker*, 1981], whereby the quadratic correlation between each pair of variables must be less than the average variance explained (AVE).

[6] Composite reliability assesses the internal coherence of observed variables constituting a latent variable and can be calculated using the formula: square of the sum of standardized coefficients / (square of the sum of standardized coefficients + square of the sum of measurement errors); threshold value > 0.7 [*Hair et al.*, 2010].

[7] Average variance explained shows the extent to which a latent variable can be demonstrated by the observed variables constituting it and can be calculated using the formula: sum of squares of standardized loadings / (sum of squares of standardized loadings + sum of measurement errors); threshold value > 0.5 [*Hair et al.*, 2010].

Table 3. **Correlation matrix**

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Innovativeness / Proactiveness	1										
2. Risk-taking	.545**	1									
3. Sales growth	-.047	.087	1								
4. Dynamism	.310**	.112	-.045	1							
5. Hostility	-.023	-.143	-.129	-.005	1						
6. Heterogeneity	.269**	.203*	-.098	.286**	.016	1					
7. Firm age natural logarithm	.045	.014	-.391**	-.074	-.005	.084	1				
8. Firm size natural logarithm	0.189†	.083	-.270*	-.116	.049	.109	.466**	1			
9. Production	.114	.215*	-.077	-.157	.025	-.045	.246*	.342**	1		
10. Services	-.075	-.150	.174	.127	.043	.032	-.062	-.192†	-.467**	1	
11. Intellectual and information sector	-.009	-.004	-.128	-.014	-.066	.001	-.128	-.062	-.277**	-.714**	1

Source: calculated by the authors.

†p < 0.1; *p < 0.05; **p < 0.01 (2-tailed)

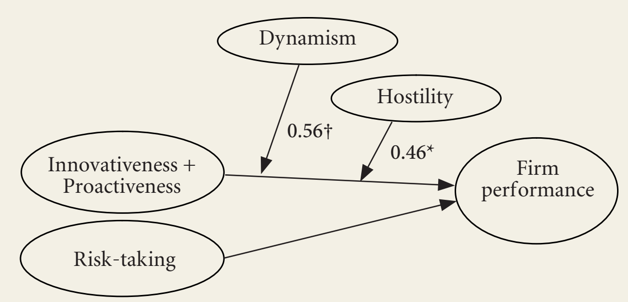
Note: when calculating the correlation between variables, one of which is binary, the spot biserial correlation coefficient is used, and in all other cases the Pearson correlation coefficient.

Both models reflecting a direct relationship between entrepreneurial orientation dimensions and growth in a firm's sales have acceptable goodness of fit indices: χ^2/df = 1.33/1.49; GFI = 0.91/0.95; CFI = 0.95/0.94; TLI = 0.93/0.90; RMSEA = 0.05 (p = 0.377)/0.07 (p = 0.263). The results of the analysis show that in the context of the Russian market, the direct relationship between the combined innovativeness/proactiveness component and the risk-taking component and a firm's performance is statistically insignificant. Therefore, the first hypothesis regarding the positive relationship between a firm's entrepreneurial orientation components and its performance has not been corroborated (Table 4).

The next stage of the analysis was to test the impact of external environmental characteristics (dynamism, hostility, and heterogeneity) on the relationship between entrepreneurial orientation components and a firm's performance by evaluating cross-sectional variables.

The calculations showed that the models in which dynamism and hostility of the external environment were considered as moderators between innovativeness/proactiveness and a firm's performance, showed good model

Fig. 2. **Results of structural equation modelling**



†p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001

Source: calculated by the authors.

Table 4. **Relationship between EO and performance at Russian firms**

Assumed effects	Coefficients	
	Model 1	Model 2
Innovativeness / proactiveness → Growth in sales	0.02	
Risk-taking → Growth in sales		0.11
Control variables		
Firm age natural logarithm → Growth in sales	–0.31**	–0.31**
Firm size natural logarithm → Growth in sales	–0.10	–0.10
Production → Growth in sales	0.12	0.10
Services → Growth in sales	0.18†	0.18†
Model fit indices		
χ^2 / df	1.33	1.49
RMSEA	0.05	0.07
GFI	0.91	0.95
CFI	0.95	0.94
TLI	0.93	0.90

†p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001

Source: calculated by the authors.

goodness of fit indices: χ^2/df = 1.54/1.74; GFI = 0.94/0.94; CFI = 0.98/0.96; TLI = 0.96/0.93; RMSEA = 0.07 (p = 0.272)/0.08 (p = 0.216). The two external environmental characteristics — dynamism and hostility — increase the positive relationship between the innovativeness/proactiveness component on the one hand, and growth in sales, on the other (dynamism: b = 0.56; $p < 0.1$; hostility: b = 0.46; $p < 0.05$). This means that in emerging market conditions, firms exhibiting a high degree of innovativeness and proactiveness in a dynamic or hostile external environment perform better than those whose innovativeness and proactiveness are less well developed. This therefore corroborates hypotheses 2a and 2b formulated above (Table 5).

Discussion of results

As we have seen, it was ultimately not possible to establish the direct effects of the entrepreneurial orientation components on Russian companies' performance. This result may be explained by the general conditions in which business is conducted in Russia. In particular, taking into account the state of institutions that are in some way related to the opportunities to implement entrepreneurial initiatives, the Russian business environment may not come across as sufficiently developed. The main indices characterizing the institutional features of the Russian economy are shown in Table 6.

According to the Global Competitiveness Report, Russia occupies 121st place, out of 148 countries, in terms of the level of institutional development [*Schwab, Sala-i-Martin*, 2013–2014]. With regard to parameters reflecting national culture, which traditionally go hand-in-hand with entrepreneurial spirit — avoiding uncertainty, individualism, power distance — there is low inclination for entrepreneurship in Russia [Hofstede Centre, 2012]. The perceived business opportunities index in Russia is also low, according to data from the Global Entrepreneurship Monitor [*Singer et al.*, 2014]. The state of affairs for parameters such as ease of doing business [World Bank Group, 2014], economic freedom [Heritage Foundation, 2015], corruption [Transparency International, 2014] and property rights protection [Property Rights Alliance, 2014] also point to certain institutional challenges. These challenges, which are related to legislative and judicial systems, patent and copyright protection, the tax system, the degree of market openness, and investment climate, are problems that with which Russian entrepreneurs and managers have to come to terms with. Such an

Table 5. **Impact of external environment on the relationship between EO and performance at Russian firms**

Assumed effects	Coefficients	
	Model 1	**Model 2**
Innovativeness / proactiveness → Growth in sales Dynamism → Growth in sales Innovativeness / proactiveness x Dynamism → Growth in sales Hostility → Growth in sales Innovativeness / proactiveness x Hostility → Growth in sales	–0.29 –0.45* 0.56†	-0.31† –0.45† 0.46*
Control variables		
Firm age natural logarithm → Growth in sales Firm size natural logarithm → Growth in sales Production → Growth in sales Services → Growth in sales	–0.29** –0.12 0.13 0.21*	–0.33*** –0.06 0.11 0.22**
Model fit indices χ^2/df RMSEA GFI CFI TLI	 1.54 0.07 0.94 0.98 0.96	 1.74 0.08 0.94 0.96 0.93

†p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001

Source: calculated by the authors.

institutional environment suppresses the development of an entrepreneurial orientation and profiting from such an orientation, a claim that is to a certain degree reflected in our findings.

The problems identified are related more to the regulatory and normative aspects of the institutional environment. However, we cannot disregard the cognitive aspect, reflecting the inward perception that individuals hold of external events and phenomena [*Scott*, 2001]. One of the main findings of our study is the specific structure of the entrepreneurial orientation construct in the Russian context, measured using Covin and Slevin's scale. For example, the measurement model with the two-dimensional entrepreneurial orientation structure, where innovativeness and proactiveness were combined into one component and risk-taking constituted a separate dimension, proved to be the best fit for this data. This scale has been used successfully and consistently in empirical studies [*Covin, Slevin*, 1989; *Covin, Wales*, 2011; *George, Marino*, 2011; *Kreiser et al.*, 2002; *Kreiser, Davis*, 2010; *Miller*, 1983], although exceptions were found to exist [*Anderson et al.*, 2014; *Runyan et al.*, 2012; *Soininen et al.*, 2012; *Tang et al.*, 2008].

Table 6. **Institutional and cultural features indices for Russia**

Institutional and cultural indices	Value
Overall institutional development (rank out of 148 countries)	121
Uncertainty avoidance (max 100)	95
Individualism (max 100)	39
Power distance (max 100)	93
Ease of doing business (rank out of 189 countries)	92
Economic freedom (max 100 points)	54.1
Level of corruption (rank out of 175 countries)	136
Property rights protection (rank out of 97 countries)	66
Perceived business opportunities	26.5

Source: compiled by the authors basing on [World Bank Group, 2014; *Schwab, Sala-i-Martín*, 2013–2014; *Singer et al.*, 2014; Heritage Foundation, 2015; Hofstede Centre, 2012; Property Rights Alliance, 2014; Transparency International, 2014].

The problems that we have identified with using Covin and Slevin's scale is attributable to the fact that, in practice, it is relatively difficult to clearly distinguish the notions of innovativeness and proactiveness (in particular, is it possible to implement innovative projects without being proactive?) We also noted the differing perceptions of the very notions of 'innovation' and 'innovativeness' amongst individuals working in different institutional contexts. It is noteworthy, however, that this scale was developed and tested in the context of a developed market. It has received criticism regarding the possibility of using several items comprising this scale to analyse the activities of firms operating in Asian countries [*Tan, Litschert*, 1994] and other emerging markets. According to *Hansen et al* [2011, p. 76], 'particular attention should be paid to the innovativeness and proactiveness dimensions, as these exhibited the lowest levels of cross-national invariance'. In a recent study [*Anderson et al.*, 2014], it was suggested that innovativeness and proactiveness should be viewed as a single dimension of entrepreneurial orientation, linked to entrepreneurial behaviour, while risk-taking was posited as a component that defined 'entrepreneurial attitude'. Our observations highlight the need to reconsider this widely used measurement scale for entrepreneurial orientation and its possible adaptation to the corresponding context. The call to consider not only the aggregate effects of entrepreneurial orientation, but also the role of its individual components in a firm based on a multidimensional approach is an important outcome of this study.

This research into the relationship between entrepreneurial orientation and a firm's performance in the Russian market has revealed that entrepreneurial orientation (including the innovativeness/proactiveness component) has a positive effect solely in a hostile or dynamic external environment. This suggests that in the short-term, in an emerging market context, this relationship would be largely dependent on the conditions in which a firm is competing. As a rule, less favourable business conditions characterize emerging markets compared to developed ones, and firms with a high level of entrepreneurial orientation are more capable of adapting to the conditions of a hostile external environment [*Covin, Slevin*, 1989; *Martins, Rialp*, 2013]. This requires a high degree of proactiveness and innovativeness, and these qualities enable organizations to identify and implement the limited set of profitable business opportunities that are available in such an environment [*Kreiser et al.*, 2002]. According to Shaker Zahra and Jeffrey Covin [*Zahra, Covin,* 1995, p. 15], 'hostile environments afford fewer opportunities for achieving growth and profitability, and that in these settings corporate entrepreneurship is a logical means for creating and exploiting new opportunities that result in competitive superiority'. In a dynamic environment renowned for constant changes and the unpredictability of market developments, innovative and proactive behaviour helps entrepreneurial firms to better adapt to the challenges posed by the external environment by changing existing and developing new products and services [*Ruiz-Ortega et al.,* 2013]. So the intensification of entrepreneurial orientation in the dynamic and hostile environment of an emerging market can be seen, in the short-term, as a response to unfavourable conditions.

Conclusion

This research has sought to study the specific structure and nature of the relationship between entrepreneurial orientation and a firm's performance, taking into account the different characteristics of the external environment in the context of the Russian market. The empirical analysis has shown that in the Russian context, the innovativeness and proactiveness components, viewed separately, do not exert the expected effects. This issue could be related to the specific perception of the terms 'innovation' and 'innovativeness' amongst individuals operating in certain institutional frameworks.

Of course, the results of our study should be considered alongside current limitations. The first limitation is the fact that the data on entrepreneurial orientation and a firm's performance come from the same point in time. While it would be extremely interesting to evaluate the impact of entrepreneurial orientation on a firm's performance over a longer interval, various special longitudinal studies are devoted to this topic (cf. for example, [*Grande et al.*, 2011; *Madsen*, 2007; *Wiklund*, 1999; *Yamada, Eshima*, 2009]). In particular, cross-country comparative longitudinal studies are promising.

The use of the 'convenience sampling' method for data collection is another limitation, as it does not allow for a random selection of companies for analysis. This approach is fairly often used not only in Russia, but also in other emerging markets due to objective difficulties in data collection. Thus, the findings should be viewed from the perspective of analytical generalization, which surmises general conclusions about theoretical concepts and models in similar situations and differs from statistical generalization, which extends the results to a general population. The results of this study may be tested in subsequent studies in the context of other countries, which will make for a fuller study of entrepreneurial orientation in developed and emerging markets. We consider dynamism, hostility, and heterogeneity in the external environment to moderate the relationship between entrepreneurial orientation and a firm's performance. In future, it will be worth studying the impact that certain contextual variables (external and/or internal) have on the relationship between entrepreneurial orientation and a firm's performance in the context of emerging markets as well as testing the proposed models in terms of their reliability when applied to different external environmental conditions. F

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Mobile Banking in Russia:
User Intention towards Adoption

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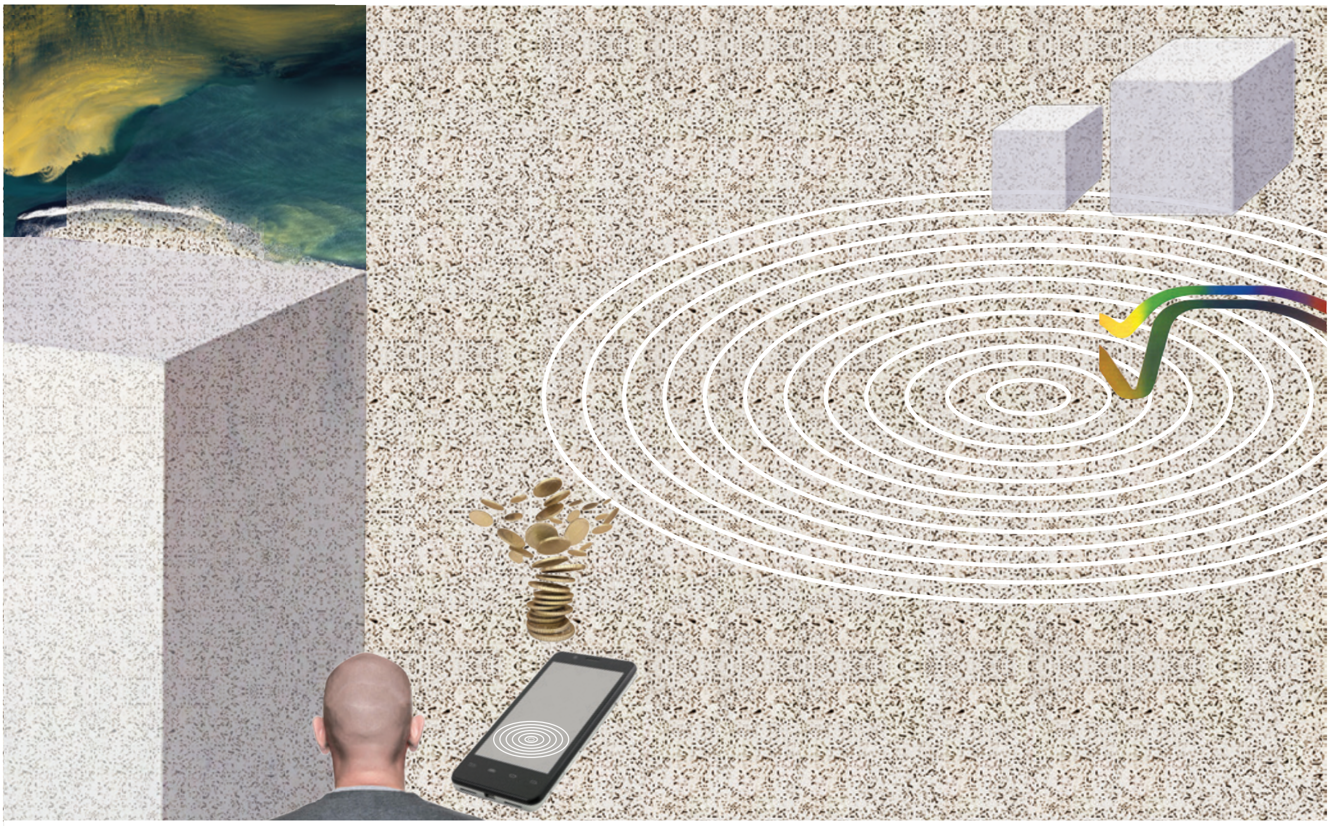

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Abstract

Mobile banking is one of the most dynamic developing types of distance banking services. For the recent years in Russia, the amount of individual bank accounts with the ability of the distance access through mobile devices increased more than by 20 times. Every year more and more banks start to offer mobile banking services. Despite this, the popularity of mobile banking applications is lower than the popularity of other banking services. Thus the problem of mobile banking adoption by customers is still an extremely important problem.

The authors analyzed foreign surveys devoted to the exploration of the incentives to mobile banking usage. The model developed by the authors is based on the well-known theoretical and empirical approaches and taken into account Russian peculiarity. As a theoretical basis, the most widespread theories describing technology acceptance and innovation diffusion were used. Using structural equation modeling (SEM) approach, the authors verified key incentives to use mobile banking by mobile Internet users i.a. perceived usefulness and perceived efforts.

These results are in accordance with most foreign surveys in this subject area. The findings also will be helpful for banks as they allow these financial institutions to highlight the cutting edge of mobile banking in Russia.

Keywords: mobile banking; structural equation modeling (SEM); acceptance of technology; perceived usefulness; effort expectancy; perceived risk

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The ever-quickening pace of modern life has significantly increased the value of free time and has given rise to growing demand for remote services. In response to the global financial crisis in 2008, increasing competition in the 'classic' financial services segment has led banks to focus their attention on optimizing operating costs structure, in part through out-of-office cross-selling of deposits, loans and payments using information technology. Remote banking services today are more widespread than ever: they can be accessed via telephone, SMS or the Internet. Perhaps the leading remote banking service available today is mobile banking, which allows customers to access their accounts remotely using a special application for Internet-enabled mobile devices [*Luo et al.*, 2010; *Shaikh, Karjaluoto*, 2015]. In fact, what we are seeing is the transfer of the now widespread Internet banking to mobile platforms.

Mobile banking retains all the same advantages of Internet banking, both for customers and banks. However, banks have even greater opportunities through mobile banking to attract new customers [*Aksenov et al.,* 2010]. According to the International Telecommunication Union, although 96% of the global population use mobile telephones of varying types, about half of them have only limited access to traditional financial services [*Shaikh, Karjaluoto*, 2015]. However, by using mobile devices, users can now access banking services with virtually no temporal or geographical restrictions [*Zhou et al.*, 2010].

The mechanism by which Russian users access mobile banking is not well covered in the literature. However, it should be examined in more details for several reasons. According to the National Payment System Development Strategy, the Bank of Russia is interested in increasing the geographical and financial accessibility of retail payment services and promoting widespread use of technology in financial transactions, especially mobile devices [*National Payment System Development Strategy*, 2013, p. 32]. The attention paid to these studies by the academic community and consultancy firms is contingent, among other things, on banks' preference for developing their own mobile applications as opposed to outsourcing. The emergence of new patterns of customer behaviour and factors that shape customer choices has helped banks to develop more economically profitable mobile services and effective strategies to promote mobile banking services for new and existing customers, especially among the younger generation.

The Russian mobile banking market is undergoing a period of extremely intensive development. This is complemented by the rapid progress in Wi-Fi and 3G networks, the penetration of smartphones and tablets into wide sections of the population, and the falling costs of devices and mobile data [Mail.ru Group, 2013]. According to data collected by analysts Markswebb Rank & Report, who carry out annual surveys among users of electronic financial and payment services in Russia, in 2014 17 million people in Russia actively used mobile banking. The top 30 Russian banks started to offer these types of services to private customers. In 2014, growth in this market reached 58%. This is slightly higher than the other dynamically evolving area of remote banking services — Internet banking (51%) [*Markswebb Rank & Report*, 2015].

The introduction of fundamentally new technological solutions is an equally important factor. Back in 2012, mobile banking was considered a lightweight version of the bank's website or a Java-based application. From 2013 onwards, banks showed a distinct preference for more modern, functional, and user-friendly technologies [Markswebb Rank & Report, 2013]. Mobile banking started to establish itself in its current form in Russia during this period and it still experiencing dynamic growth. According to an expert survey carried out by *R-Style Softlab*, in early 2014, roughly 50% of Russian banks considered mobile banking a priority area for improvement in their remote services [*Kostylev*, 2014]. According to the bank *VTB-24*, of late potential customers have tended to pay attention to whether or not a bank offers mobile banking when choosing a bank [*Shpyntova*, 2012].

The target group for our survey was mobile Internet users with smartphones and tablets. Current trends in the mobile device and banking markets determined our choice of target group: the gradual replacement of conventional mobile phones with smartphones, the popularity of tablets, and the rejection of older mobile services and versions of websites [Markswebb Rank & Report, 2014]. Research is yet to be carried out on these two types of mobile devices [*Shaikh, Karjaluoto*, 2015].

This paper first analyses the most well-known empirical studies on the incentives for users to choose services and sets out the analytical model and operational hypotheses. It then describes the survey methodology, sampling process and data analysis, empirical model validation and results of the hypothesis testing. The conclusion summarizes the data obtained and proposes areas for further research.

Empirical studies on user adaptation to mobile banking

Existing empirical studies make use of three theories of mobile banking user adoption depending on the level of their diffusion in the information technology sphere:

- the Technology Acceptance Model (TAM), developed in 1989 by Davis and Bagozzi [*Davis et al.*, 1989];
- the Innovation Diffusion Theory (IDT), proposed by Rogers in 1962 [*Rogers*, 2003];
- the Unified Theory of Acceptance and Use of Technology (UTAUT) [*Venkatesh et al.*, 2003].

The base version of the first model is an extension of Ajzen and Fishbein's Theory of Reasoned Action and is often formulated as an interlinked chain of cognitive elements: 'belief — attitude — intention — behaviour' [*Hanafizadeh et al.*, 2014]. In the model, 'belief' is understood to mean 'perceived usefulness' (the degree to which a person believes that using a particular system would bring him or her certain gains) and 'perceived ease-of-use' (the degree to which a technology will be free from or involve effort) [*Davis*, 1989].

IDT is based on the notion of diffusion and adoption of an innovation within a specific social system over time. Every innovative technology has a certain set of attributes, which influences a user's decision to use new technology. These attributes are broken down into five groups [*Rogers*, 2003]: relative advantage, compatibility, complexity, observability and trialability. The first two attributes are comparable with elements of the TAM model. Compatibility refers to the level of interoperability between the new technology and an individual's socio-cultural values, beliefs, and customs. Observability refers to other people's perception of the innovation's uses. The trialability of something new assumes that an individual has the means or opportunity to test the technology before choosing to use it.

The third approach (UTAUT) reviews and consolidates eight different theories and models [*Venkatesh et al.*, 2003] to identify four factors which affect a user's decision to use a particular technology: performance expectancy, effort expectancy, social influence and facilitating conditions (knowledge, customs, finances) [*Zhou et al.*, 2010].

Despite the recognized scientific importance of these models, each of them is limited in terms of its explanatory potential [*Pushel et al.*, 2010]. The TAM model is criticized often for its lack of attention to economic and demographic factors. It ignores factors such as trust, which is extremely important for remote banking services [*Shaikh, Karjaluoto*, 2015]. The IDT model does not explain how the relationship between users and technology develops and what role the innovations play in this process. The model also assumes that the innovation is fundamentally beneficial and should be adopted by all members of society, which is fairly far from being the case in all instances [*Laukkanen, Kiviniemi*, 2010]. On the other hand, the UTAUT model does not take into account cultural factors [*Shaikh, Karjaluoto*, 2015]. In view of these and other restrictions, the latest focus in studies of mobile banking is not just on empirical studies based on recognized theoretical models; instead, their attempt is to revise these models.

Among the other determinants integrated by the researchers into the basic model, one of the most important and widespread is the trust factor, which influences decision-making when it comes to adopting a new technology. Studying trust is particularly important in the case of mobile banking due to the lack of direct contact between a user and bank employees.

A Korean study on the subject serves as a good example of the TAM model in use [*Gu et al.*, 2009]. The model was expanded by redefining its key elements (for example, the relation between perceived usefulness and social influence was examined, etc.) and adding a new key factor: trust. In order to empirically evaluate the level of trust, the authors turned to one of Gefen's works [*Gefen et al.*, 2003], in which the trust factor covers four components: familiarity with mobile banking, situational normality, structural assurances and calculative based trust. Collectively, they form a holistic indicator of user trust making it possible to identify the two strongest channels that register intention to use mobile banking: 'self-efficacy — perceived ease-of-use — perceived usefulness — behavioural intention' and 'structural assurances — trust — behavioural intention.'

Another group of academics adopted a slightly different approach to study the same field: the Korean mobile banking market [*Kim et al.*, 2009]. Having analysed relevant studies in this field, they identified the following factors that affect trust: institutions (structural assurances), knowledge (relative benefits), inclination (personal propensity to trust), and a firm's characteristics (reputation). However, further analysis has shown that this last factor does not have a significant impact on user choice.

In the article [*Lin*, 2011], trust is viewed as a function of individual perception of the competence, benevolence, and integrity of mobile banking services. The combination of the trust factor interpreted in this way with the IDT model makes it possible to assert that aside from the attributes of an innovation, the perceived competence and integrity of a bank and its employees also affect significantly the behaviour of Taiwanese users towards mobile banking services.

The work [*Zhou*, 2012] uses the Elaboration Likelihood Model to study the trust factor. In this model, applied to mobile banking, a user changes his or her attitude towards a service through a central or peripheral route. The first route involves indicators reflecting the quality of information and a service offered to a user (reliability, personification, etc.). It also assumes certain intellectual and temporal costs in recognizing and analysing these indicators. The peripheral route is geared towards the quality of a system (speed, ease-of-use, etc.), the reputation of a bank, and structural assurances (user rights protection, etc.). It is less resource-intensive and less sustainable over time. However, empirical testing of the model has shown that both routes have a significant impact on trust in mobile banking.

Trust is such a popular factor when assessing the nature of mobile banking use because of both non-adoption of new technologies and the high-risk nature of this field. In this respect, sometimes studies analyse the trust factor, which reduces such risks [*Gu et al.*, 2009] as well as the risk factor itself. So, in [*Chen*, 2013], alongside the attributes of an innovation in the IDT model, the authors studied the influence of the risk factor in the context of banking services. He identified five forms of risk: financial, psychological, performance, time, and privacy risk, and empirically proved their relevance to the case of mobile banking. It confirmed the influence of an innovation's attributes on user behaviour.

Alongside trust and risk, a multitude of other factors are incorporated in the basic model. For example, it was discovered that alongside the standard factors set out in the TAM model, self-efficacy and perceived financial cost have a significant impact on behaviour [*Luarn, Lin*, 2005; *Wang et al.*, 2006]. A recent study on mobile banking in Iran revealed the likelihood of a change in user behaviour with regarding to its compatibility with the customs, lifestyle, and even registered a demand amongst users for real interaction and contact with bank employees [*Hanafizadeh et al.*, 2014]. In this case, the factor of compatibility to lifestyle was recognized as being the most significant.

The basic model frequently integrates not only individual factors, but also entire theories. In 2010, a study was published that supplemented the UTAUT model with the Task Technology Fit (TTF) model [*Zhou et al.*, 2010]. The idea was that a user decides to use a technology based on the relationship between the tasks the user needs to perform and the technology's capability to carry those tasks out effectively. In addition to proving the importance of this relationship, the greater explanatory potential of the 'synthetic' in comparison to the UTAUT and TTF models was also proved.

Model and operational hypotheses

The authors developed a model drawing on the extensive international experience outlined above, in which the main variable was intention to use mobile banking now or in the future. Of course, intention cannot fully reflect real use, but this type of 'substitution' is used in empirical studies in almost 90% of cases [*Shaikh, Karjaluoto*, 2015].

The model takes into account three fundamental user incentives: expected usefulness, effort, and perceived risk.

Expected usefulness

Expected usefulness is one of the key incentives taken into account by researchers [*Shaikh, Karjaluoto*, 2015]. In the TAM model and variations thereon it reflects the degree to which 'mobile banking will be useful and helpful for the efficiency of their work' [*Gu et al.*, 2009, p. 11609]. In the IDT models, usefulness is viewed as a relative advantage highlighting the value of mobile banking over other technologies that it replaces [*Riquelme, Rios*, 2010]. These advantages include 'increased efficiency, economic benefits, enhanced status' [*Lin*, 2011, p. 253]. Thus, despite the differing names, the essential usefulness of the innovation is a factor in both models [*Kim et al.*, 2009]. This incentive is interpreted in a similar way in models based on UTAUT [*Zhou et al.*, 2010].

The frequency with which the usefulness factor is used is contingent upon the economic gain for the user, as confirmed by multiple studies [*Luam, Lin*, 2005]. In particular, users point primarily to the lack of geographical restrictions, i.e. mobility, and the speed with which banking transactions can be carried out among the main economic advantages and gains of using mobile banking [*Lin,* 2011; *Kim et al.,* 2009; *Chen,* 2013]. Accordingly, the perceived usefulness determines the user's desire to use mobile banking. This gives rise to the following hypothesis:

H1: Expected usefulness has a positive impact on intention to use mobile banking.

Expected effort

Not all costs from the use of mobile banking can be attributed to direct financial expenses, such as fees or the cost of mobile Internet. The specific nature of using new technologies is also determined by the degree of user know-how, otherwise his or her interest in mobile banking may drop significantly despite obvious usefulness [*Gu et al.*, 2009]. In the TAM models there is an easy-of-use incentive, which reflects the effort required to use the technology [*Hanafizadeh et al*., 2014]. In IDT models this incentive takes into account the impact of difficulties faced when using remote banking services on users' choices. Both formulations of expected effort are extremely close to the characteristics of the corresponding incentive in the UTAUT model [*Zhou et al*., 2010].

When building the model, the study took the following circumstances into account. Expected effort reflects the portion of the cost associated with learning how to use mobile banking and the direct application of this learning. First, users take into account low time costs and the effort needed to learn a new application as an incentive. Second, working on the small screen of a mobile device can require high levels of concentration [*Riquelme, Rios*, 2010]. Third, the small screen size increases the importance of a user-friendly interface: if it is difficult to navigate the application, the incentive to use the application decreases [*Lin*, 2011]. The impact of the incentive thus described on both intention to use and on certain other factors has been confirmed empirically for Iran [*Hanafizadeh et al*., 2014], Singapore [*Riquelme, Rios*, 2010], Malaysia, Nigeria [*Shaikh, Karjaluoto*, 2015] and others. Based on this, three hypotheses can be formulated:

H2: Expected effort has a negative impact on intention to use mobile banking

H3: Expected effort has a negative impact on the expected usefulness of using mobile banking

H4: Expected effort has a positive impact on the perceived risk in relation to mobile banking

Perceived risk

Incentives which are somehow linked to trust are very popular in studies devoted to intention to use mobile banking [*Shaikh, Karjaluoto*, 2015]. It has been established that contactless services, which mobile banking also falls under, demand a higher degree of trust than those where the interactions between customer and bank take place face-to-face [*Lin*, 2011]. Two approaches can be used to study this phenomenon. The first makes direct use of the trust incentive, including the honesty and competence of the bank [*Lin*, 2011], its reputation and the extent to which it protects users' rights [*Kim et al.*, 2009]. The second allows an evaluation of this incentive from a different perspective: the expected level of risk [*Koenig-Lewis et al.*, 2010]. We prefer the second variant which factors in the risk incentive into possible economic costs of using mobile banking. The following additional circumstances were also taken into account:

- the likelihood of errors during data entry or technical errors in the application resulting in the customer failing to achieve the desired result from mobile banking [*Zhou*, 2011]
- personal data transfer over the Internet requires high levels of protection. In the event of personal data theft, criminals can gain access to the customer's banking transactions, which leads to financial losses [*Koenig-Lewis et al*, 2010; *Chen*, 2013];
- the loss of a mobile device could also allow third parties to gain access to the customer's banking transactions [*Riquelme & Rios*, 2010; *Hanafizadeh et al.*, 2014].

The more a customer views the likelihood of such circumstances and future costs occurring, the lower his or her incentive will be to use mobile banking. This results in the following hypothesis:

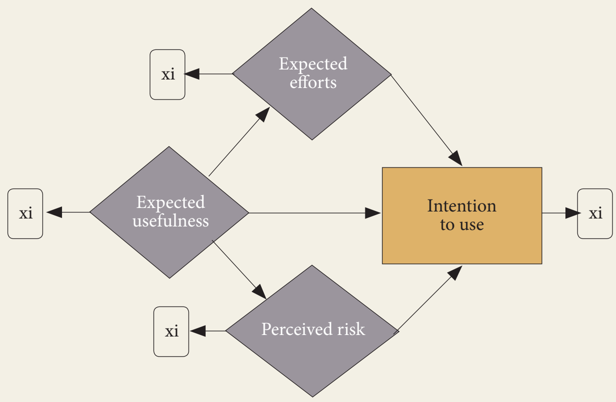
H5: The perceived risk has a negative impact on intention to use mobile banking

Thus, the developed model (Fig. 1) was used to empirically test the five hypotheses regarding the influence of the incentives described on the intention to use mobile banking and on one another.

Research methodology. Data collection and analysis

We tested the model using the survey method of data collection, which is commonplace in academic practice[1] [*Koenig-Lewis et al.*, 2010; *Luo et al.*, 2010; *Zhou*

Fig. 1. **Evaluation model**



Source: compiled by the authors.

[1] By way of example, in the Shaikh and Karjaluoto survey, they analysed 55 studies from different countries over the period 2005–2014. 45 of the works used the survey method, three used interviews, and five used both approaches simultaneously. Finally, two studies were entirely theoretical (conceptual in nature) [*Shaikh, Karjaluoto*, 2015, p. 133].

et al., 2010; *Luarn, Lin,* 2005; *Gu et al.*, 2009, *Wang et al.*, 2006; *Hanafizadeh et al.*, 2014].

To analyse each of the incentives to use mobile banking (factors), indicators adapted to the Russian-speaking audience were chosen. This ensured the relevance of the content reflected by the indicators [*Zhou et al.*, 2010]. In total, 12 indicators were taken into consideration to evaluate the four factors in the model (three incentives and actual intention to use) — three indicators for each factor. All of the indicators were measured on a 5-point Likert Scale with response variants ranging from 'completely disagree' to 'completely agree.' To verify the intelligibility and readability of the wordings, the chosen indicators were tested on a small sample of seven individuals. Based on the pilot test, some of the wording was adjusted. The final list of indicators and their sources is shown in Table 1.

The survey also included two additional groups of questions. The first group allowed us to establish whether the respondent was part of the target audience, whether he or she uses remote banking services, and the frequency of such use. The second group contained a number of questions on the demographic and other standard characteristics of the respondent, grouped according to sex, age, education, region of residence, size of settlement, income, and type and area of employment.

The survey was carried out in March 2015 using the online survey tools Webanketa and 'Anketolog'. The survey was distributed using several methods. First, based on British experience [*Koenig-Lewis et al.*, 2010], the 'snowball sampling method' was used, where the invitation to take part in the study and complete the survey was distributed over social networks. This method was chosen due to the high popularity of social networks among younger generations, who constitute the majority of mobile Internet users. Second, a link to the survey was included in an e-mail distributed to students at the NRU HSE campuses. In total, 206 surveys were collected. After removing incorrectly completed or incomplete questionnaires and those completed by respondents not in the target group, the final sample was

Table 1. **Indicators, factors and sources used in the model**

Indicator	Indicator code	Factor (number)	Factor code	Main sources
I consider mobile banking a useful service	Use-1	Expected usefulness (1)	Use	[*Chen,* 2013; *Gu et al.*, 2009; *Hanafizadeh et al.*, 2014; *Riquelme, Rios,* 2010; *Lin,* 2011; *Wang et al.*, 2006; *Zhou et al.*, 2010]
Mobile banking makes banking transactions faster	Use-2			
Mobile banking makes it easier to access banking transactions	Use-3			
The interface of mobile applications is difficult to understand and makes it difficult to navigate in the application	Eff-1	Expected effort (3)	Eff	[*Lin,* 2011; *Luarn, Lin,* 2005]
Using mobile banking requires a high level of concentration due to the small screen	Eff-2			
Using mobile banking is made harder by the insufficient technical and information support from the bank	Eff-3			
Data sent over the Internet can be accessed by criminals	Risk-1	Perceived risk (4)	Risk	[*Hanafizadeh et al.*, 2014; *Chen,* 2013; *Koenig-Lewis et al.*, 2010; *Luarn, Lin,* 2005; *Riquelme, Rios,* 2010]
Technical errors and bugs in the mobile application will lead to financial losses	Risk-2			
Using a mobile device to carry out banking transactions is unsafe due to the high risk of loss/theft	Risk-3			
I already actively use mobile banking	Int-1	Intention to use (8)	Int	[*Chen,* 2013; *Gu et al.*, 2009; *Lin,* 2011; *Wang et al.*, 2006]
I plan to use mobile banking in future	Int-2			
I plan not only to use mobile banking, but will also recommend it to friends/relatives/colleagues etc.	Int-3			

Source: survey results.

Table 2. **Demographic characteristics of the survey sample and comparison with the 'Mobile Russia' sample (%)**

Characteristic	Sample segments	This study	'Mobile Russia' (Summer 2014)
Sex	Male	49	50
	Female	51	50
Age	up to 24 years	47	34
	25–34	34	29
	35–44	14	19
	45–54	5	12
	55 or more	1	6
Education	Secondary general	6	35
	Secondary specialist	4	36
	Higher (including incomplete)	91	x
	Higher (including degree)	x	29
Region of residence (by federal district)	Central	37	29
	Southern and North Caucasian	9	15
	Northwestern	15	11
	Far Eastern	3	4
	Siberian	6	12
	Ural	5	10
	Volga	26	19
Settlement size	Moscow and St Petersburg	14	15
	> 1 million inhabitants	21	11
	500,000 – 1 million inhabitants	13	12
	100,000 – 500,000 inhabitants	28	21
	< 100,000 inhabitants	24	41
Income	< 10 000 roubles	22	x
	10,001 — 20,000 roubles	31	x
	20,001 — 30,000 roubles	22	x
	30,000 — 50,000 roubles	14	x
	50,000 — 75,000 roubles	8	x
	75,000 — 100,000 roubles	2	x
	> 100,000 roubles	1	x
Settlement size	Student, unemployed	26	x
	Unemployed	8	x
	Full-time employment	38	x
	Part-time employment	26	x
	Other	1	x
Income	Unemployed	34	x
	Wholesale and retail trade / services	13	x
	Financial activity	10	x
	Other	26	x
	Education / health care / state administration / military service	8	x
	Agriculture / fishery	4	x
	Mineral extraction / manufacturing / industry	4	x

Source: survey results.

160 respondents. The distribution of respondents by demographic parameters is shown in Table 2.[2]

The final sample only included those respondents who replied in the affirmative to questions about mobile Internet use on a tablet or smartphone. 58% of respondents use devices running the Android operating system, 42% iOS, and 21% other operating systems. These results are in line with the findings of the company Mail.ru [Mail.ru Group, 2013], NewMR and OMI regarding the dominance of these two operating systems in the mobile banking market.

[2] For comparison, the table also shows the distribution using comparable characteristics obtained during the regular quarterly survey of the Russian mobile Internet consumer market 'Mobile Russia' carried out by the companies NewMR and OMI (OnlineMarketing Intelligence) [NewMR, 2015]. The study sample was based on data from the 'Public Opinion' Foundation. The last available data are from summer 2014.

97.5% of those surveyed declared that they knew it was possible to carry out banking transactions on a mobile phone. 70% of those surveyed used Internet banking from a desktop computer or laptop, only 32% through a browser on a mobile device, 47% SMS banking, and only 42% respondents used special applications for mobile devices. It is worth mentioning that 12.5% of those surveyed do not use one of the aforementioned types of remote banking services at all. Similar results were collected in the e-Finance User Index 2015 study (Markswebb Rank & Report), according to which 66% of surveyed Internet users use Internet banking and 48% use mobile banking [*Markswebb Rank & Report*, 2015]. The frequency with which respondents use each type of remote banking services is shown in Table 3.

This frequency distribution reflects the key advantage of banking applications: their mobility. More than half of users use banking apps several times a week. If we consider only those who use the remote banking services several times a week, the proportion of application users still appears as the highest: 40%.

Answers were coded into digital format for analysis, where 1 is 'completely disagree', 2 is 'somewhat disagree', 3 is 'unsure', 4 is 'somewhat agree' and 5 is 'completely agree'. The analysis was carried out using the specialist software SmartPLS 2.0.M3.

Multivariate analysis

Following the recommendations of [*Hair et al.*, 2014], a PLS-SEM model analysis comprises three stages: PLS path model estimation, assessing the PLS-SEM results of the measurement model and assessing the PLS-SEM results of the structural model.

The research model can be expressed by structural equations 1–3:

$$Use = ß_{10} + ß_{11} * Eff + \varepsilon_1 \quad (1)$$

$$Risk = ß_{20} + ß_{21} * Eff + \varepsilon_2 \quad (2)$$

$$Int = ß_{30} + ß_{31} * Use + ß_{32} * Eff + ß_{33} * Risk + \varepsilon_3 \quad (3)$$

The measurement models can be expressed by equations in the form:

$$Ind_{ij} = \alpha_{ij0} + \alpha_{ij1} * Fac_i + \upsilon_{ij} \quad (4)$$

In equation (4) Fac_i — factor, Ind_{ij} — its indicators, i = 1…4 (1 — Use … 4 — Int, as per Table 1), j = 1,2,3. Within the PLS algorithm, the standard parameters recommended for such studies were chosen [*Hair et al.*, 2014; *Wong*, 2013].

The results of the algorithm are shown in Fig. 2, where latent (unobserved) variables are in dark and their indicators are in light; the arrows indicate the links between variables. Three groups of indicators can be identified. First, there is the value of the coefficient R^2. Accordingly, the factor Eff explains 12.2% of the dispersion of the factor Use and 24.6% of the dispersion of the factor Risk, and all three factors Use, Eff, Risk together explain 36.6% of the dispersion of the variable Int.

Second, path coefficients in the structural model have been calculated (in Fig. 2 above the arrows linking the latent variables). Thus, the model has identified two positive (in decreasing order of influence: Eff -> Risk = 0.496; Use -> Int = 0.441) and three negative relationships (in decreasing order of influence: Eff -> Use = -0.349; Eff -> Int = -0.215; Risk -> Int = -0.099).

Third, these are outer model loadings (in Fig. 2 above the arrows linking the latent variables with the indicators). Five iterations (instead of the set maximum value 300) were needed to generate the coefficients, which points to the high quality of the evaluation [*Wong*, 2013].

The significance of the structural model coefficients (hypothesis testing) was evaluated after testing based on individual indicator reliability[3] and internal consistency reliability.[4] The convergent[5] and discriminant validity[6] of the model were tested

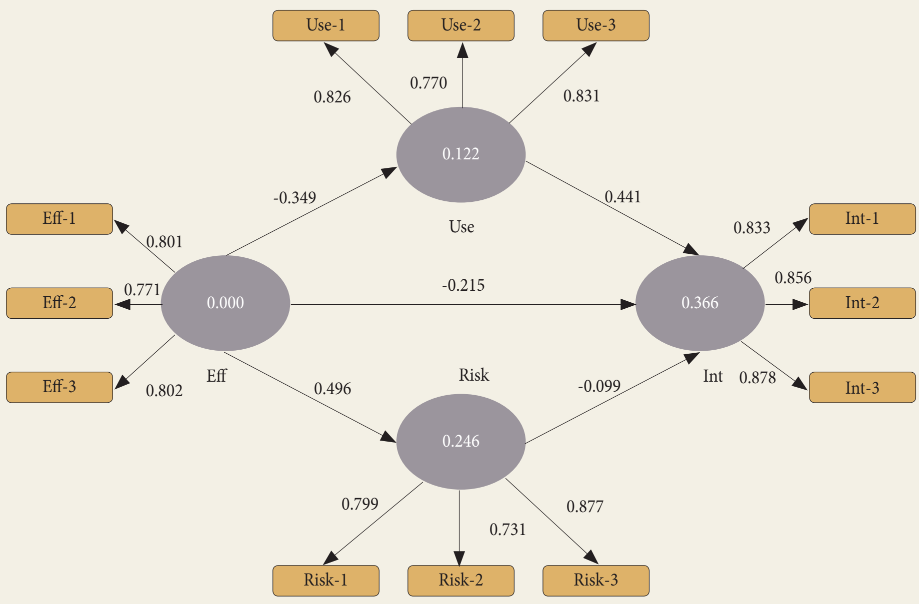
[3] The value of the outer model loadings exceeds the threshold value of 0.7.

[4] The 'composite reliability' coefficients satisfy the value range 0.7–0.9.

[5] All average variance extracted (AVE) values exceed the 0.5 threshold.

[6] This was checked using the Fornell-Larcker criteria [*Fornell, Larcker,* 1981].

Fig. 2. **Results of the model evaluation**



Source: authors' calculations.

and it showed no multicollinearity.[7] From Table 4, it is clear that the structural model obtained satisfies all the necessary requirements [*Hair et al.*, 2014].

To evaluate the significance of the structural model coefficients, we used a bootstrapping procedure. This verified the significance of the measurement model coefficients which were significant to a level of 1%. Regarding the significance of the structural coefficients and, accordingly, the hypothesis testing, hypothesis H5 was not corroborated, whereas hypotheses H1–H4 were accepted at 1% significance (Table 5).

As we have shown (cf. Fig. 2), expected usefulness has been identified (0.441) as a statistically significant effect prompting customers to use mobile banking to carry out everyday transactions. This means that simpler access to the full range of banking services at any time and in any place, as well as the increased speed with which they can be accessed, can be achieved through the special functionalities of mobile banking compared with Internet banking or debit and credit card payments. The development of mobile banking functionalities and its differences with Internet banking play a decisive role when banks attract new customers and try to retain

Table 3. **Frequency of use of remote banking services by respondents (proportion of respondents selecting the corresponding response, %)**

	Several times a week	Once a week	Once a month	Once every six months	Less than once every six months	Do not use
Internet banking on a desktop computer / laptop	12	27	26	8	3	24
Internet banking through the browser of a mobile device	8	6	15	5	3	63
SMS banking	19	14	13	3	4	47
Special mobile application on smartphone / tablet	26	12	5	2	0	55

Source: survey results.

[7] The VIF coefficients for the factor groups Use, Eff, Risk were significantly less than the recommended critical value of 5.

Table 4. **Indicators of the reliability and adequacy of the measurement model**

Variable	Outer loading coefficients			Composite Reliability	AVE*
Eff	0.801	0.771	0.802	0.8342	0.6265
Int	0.833	0.856	0.878	0.8913	0.7323
Risk	0.799	0.731	0.877	0.8458	0.6477
Use	0.826	0.770	0.831	0.8507	0.6554
Permitted values	0.7+			0.7–0.9	0.5+
	Eff	Int		Risk	Use
Eff	0.7915				
Int	– 0.4176	0.8557			
Risk	0.4958	– 0.3519		0.8047	
Use	– 0.3493	0.5488		– 0.3329	0.8096

* The square root of the AVE is greater than the correlation of the variable with any other.

Source: authors' calculations.

existing customers. Thus, it confirms the hypothesis that undisputed advantages of mobile banking, such as round-the-clock and remote access to services, act as the main incentives for their use in the Russian market.

These findings are also characteristic of other countries.[8] Judging by the results of the 55 studies [*Shaikh, Karjaluoto*, 2015] carried out in various countries between January 2005 and March 2014, this effect was 38% on average, which is 7 percentage points lower than in the Russian market. Expected usefulness was the strongest factor in the American [*Luo et al.*, 2010], German [*Koenig-Lewis et al.*, 2010] and Chinese models [*Zhou*, 2011], as well as in the model developed for Taiwan [*Wang et al.*, 2006]. This factor was also significant in the Korean [*Gu et al.,* 2009; *Kim et al.,* 2009] and Iranian cases [*Hanafizadeh et al.,* 2014].

Another important and statistically significant effect in the model constructed by the authors is the demotivating influence of the expected effort factor. A higher anticipation of the effort required in using mobile banking, caused by complex navigation features, need for high concentration levels when working on the small screen of a mobile device, or insufficient technical and information support from the bank, serves as a major disincentive. Most studies encounter the 'opposite' incentive: ease-of-use [*Gu et al.,* 2009; *Luarn & Lin,* 2005; *Hanafizadeh,* 2014; *Shaikh, Karjaluoto,* 2015]. Hence for commercial banks it is entirely justified to develop native, i.e. specially developed applications that help accustom clients to various mobile services, and regularly update them. Competing pressure from social networks and electronic money systems assign ever greater importance to regular online interactions with users. Banks are starting to attach special value to opportunities to inform customers of changes to legislation and tariffs, and cross-sell classic banking products even outside normal business hours.

Table 5. **Testing of the research hypotheses**

	Hypothesis	T-statistic	Accepted
H1	Expected usefulness has a positive impact on intention to use mobile banking	5.266	Yes*
H2	Expected effort has a negative impact on intention to use mobile banking	3.111	Yes*
H3	Expected effort has a negative impact on the expected usefulness of using mobile banking	4.615	Yes*
H4	Expected effort has a positive impact on the perceived risk in relation to mobile banking	8.971	Yes*
H5	The perceived risk has a negative impact on intention to use mobile banking	1.304	No

* At 1% significance.

Source: authors' calculations.

[8] It is important to note that the national specifics of certain countries are outside the scope of this study, namely the structural and institutional developmental circumstances of their banking sector and science, technology and innovation spheres.

One of the most significant findings of the model was the negative influence of the expected effort incentive on the expected usefulness incentive. The simpler the features of mobile banking, the more useful it would seem to the customer. This relationship has already been established through studies of users in Germany [*Koenig-Lewis et al.*, 2010], Korea [*Gu et al.*, 2009] and Singapore [*Riquelme, Rios,* 2010]. If using mobile banking requires a greater effort, then the speed advantage for transactions predictably falls. Banks should see increasing the convenience of specialist mobile applications as a priority. This refers not only to the design (fonts, structures), but also the ability to personalize the interface according to the customer's needs, which in turn may relate to strategic management of small business and household finances.

It is also worth noting the influence of the expected effort incentive on the risk incentive as one of the most significant effects. Banks are mindful of the advantages of phone technology applications such as geolocation, fingerprint recognition, cameras, and scanners optimal, as these options allow them to tie in a customer's financial management with their lifestyle, and costs with needs and current consumption. However, as our survey shows, it is becoming fundamentally important for banks to observe a certain balance: the more difficult a user finds mobile banking services, the less transparent their interaction with the bank is, leading them to perceive a higher risk of technical errors or personal data theft.

Although studies in Germany [*Koenig-Lewis et al.*, 2010], Iran [*Hanafizadeh et al.*, 2014], Singapore [*Riquelme, Rios,* 2010] and the US [*Luo et al.*, 2010] have shown that the risk incentive is significant, the hypothesis regarding its negative influence on intention to use mobile banking has not been corroborated. Perhaps this result was shaped by the specific nature of the sample. For example, mobile Internet users are less inclined to experience misgivings regarding the use of a mobile device which has become customary for them, and are less inclined to think about the threat of loss (theft). Many experts suggest that the current risks involved in mobile banking may be significantly lower than, for instance, Internet banking. In reality, in Russia the number of users of mobile banking falls behind those using Internet banking, and so interest among swindlers in mobile banking is lower. The main target of criminal attacks are companies which, as a general rule, do not use mobile applications [*Kostylev*, 2013]. Users themselves often consider security measures redundant and even see them as shortcomings of mobile banking applications [*Deloitte*, 2014].

Conclusion

Our research was devoted to studying the preferences of mobile banking customers in Russia. Special attention was paid to which of the specific features of this service (the functional content of the application, the convenience of the interface, ease-of-navigation, and difficulties in use) have an impact on users' intentions in making regular use of mobile banking. Expected usefulness turned out to have the greatest impact. Thus, this paper recommends that banks focus primarily on increasing the perceived usefulness of their mobile banking amongst customers. For consumers, the speed and ease with which their banking transactions can be accessed are important; they demand broad functionality that is comparable with other forms of banking services. The key question is whether users themselves consider using mobile banking worthwhile. Banks could offer various bonuses and partner programmes and conduct a targeted marketing campaign to further explore this area.

The level of awareness regarding mobile banking could be raised through measures to increase a population's financial literacy, primarily focusing such instruction on school pupils, students, and their parents.[9] The second factor in terms of its impact on motivation to use mobile banking was expected effort. This means that

[9] Successful examples include the project 'Development of additional educational programmes to promote financial literacy among students at general education establishments and primary and secondary professional education institutions', carried out in 2012–2014 by the Russian Ministry of Finance with support from the World Bank (http://www.minfin.ru/ru/om/fingram/, accessed: 21/08/2015) and the measures planned jointly by the Bank of Russia (http://www.cbr.ru/press/pr.aspx?file=02062015_105534if2015-06-02t10_53_01.htm, accessed: 21/08/2015) and the Ministry of Finance (http://www.minfin.ru/ru/press-center/?id_4=33224, accessed 21/08/2015) to raise the population's financial literacy.

in order to promote mobile banking services, banks should strive to simplify the application software. Complex interfaces and navigation within the application reduce incentives to use the application, devalue the advantages of the service, and increase the potential risks in the eyes of the user. Therefore, banks need to ensure that their mobile application interface is as amenable and simple as possible, adapted to the small screens offered by mobile devices, and provide technical and IT support for users.

Banks may find it useful to review, consolidate, and approve the results of foreign studies on the mobile banking market in relation to the Russian context. As a result, prospective areas to develop these products such as their relative advantages as a means to access bank accounts, allow customer-bank interactions and cross-sell payment, and deposit and credit products, will become clear.

Our study has revealed several restrictions. The need to overcome these restrictions inevitably shapes future areas of development. The survey sample is only representative of the group of mobile Internet users, so the model requires additional testing on a larger sample covering a cross-section of social strata. Moreover, intention to use was the main variable rather than actual mobile banking use. It would only be possible to move over to a new variable when running longitudinal studies. Some indicators in the model might be reformulated and new factors could be included. A number of works have established that the expected financial cost factor has a negative impact on intention to use mobile banking [*Shaikh, Karjaluoto,* 2015; *Zhou et al.,* 2010; *Hanafizadeh et al.,* 2014], while in the US [*Luo et al.*, 2010] and Korean [*Gu et al.*, 2009] mobile banking markets, the studies identified self-efficacy as a factor with a positive impact. Analysing these and other new factors makes it possible to increase the explanatory potential of the model and evaluate new incentives to further propagate mobile banking services. F

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Patent Landscape for Nanotechnology

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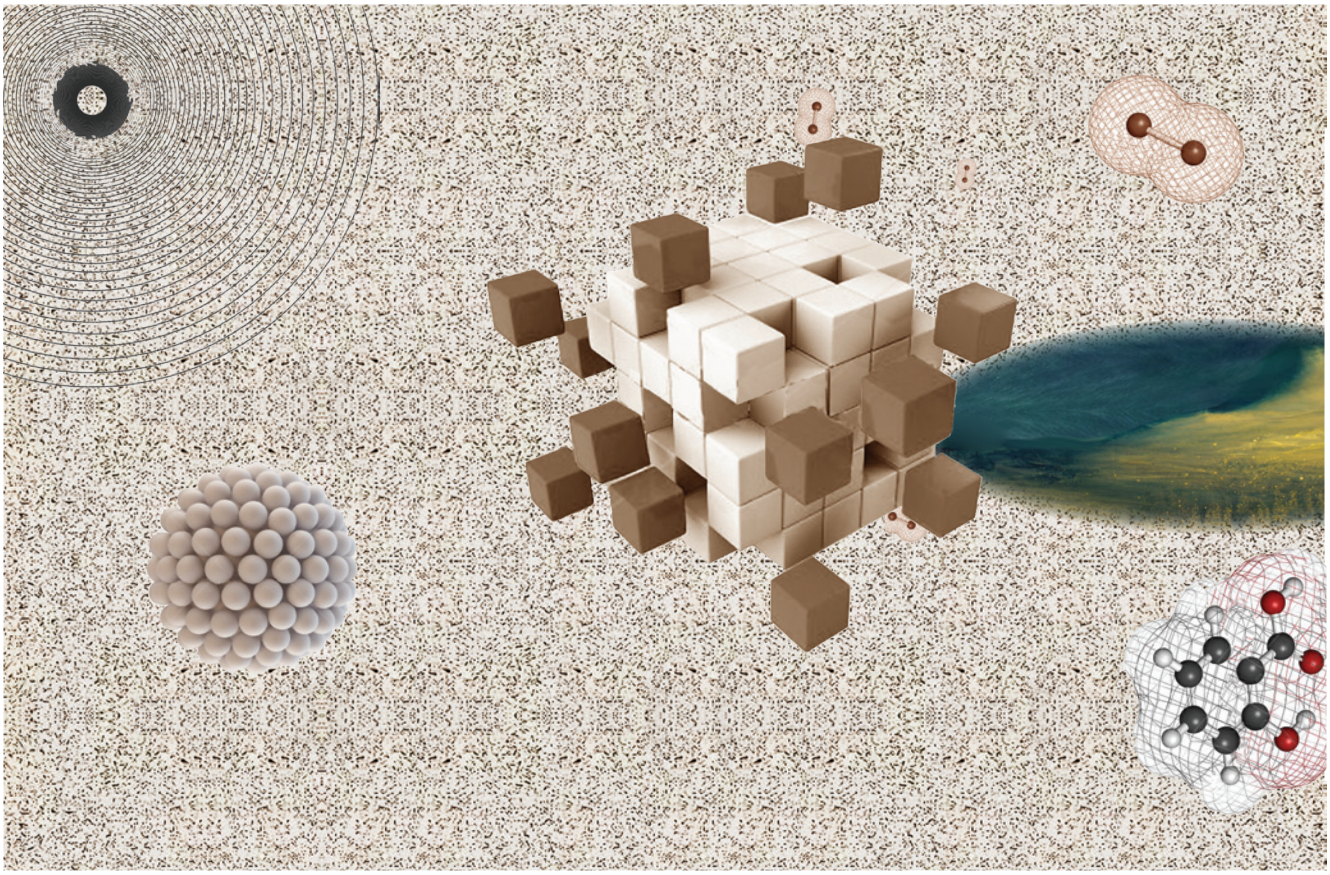

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Abstract

A methodological approach to patent landscaping for nanotechnology is considered in this paper. In the opinion of the authors, nanotechnologies have precedence over other technology trends that are confirmed by evaluation of the present and future market size of nanotechnology productions. An analysis of patent activity in Russia and the world is performed using patent landscape for nanotechnology as well as for metallurgy in the field of nanotechnology. A new methodological approach is based on a relevant patent search of nanotechnology solutions with nanotechnology keywords and relevant interdisciplinary terms. The practical significance of the methodological approach is confirmed by the activity of the Fund for Infrastructure and Educational Programs (FIEP) in terms of: the determination of the thematic scope for newly developed educational programs; the development of the joint intellectual and material recourse base for the needs of the teaching and learning activities; the selection of the potentially interested company-partners, which can provide the relevant structure and guarantee the quality of the program of manufacturing requirements and labor market.

Keywords: nanotechnology; metallurgy; patent landscape; patent mapping; index IPC; nanotechnological terms

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According to recent studies, with the industrial revolution in England, five technological waves of innovation have succeeded one another in the world's technical and economic development. The fifth wave, which dominates today and is linked to the surge in computing and telecommunications, is coming to an end in its life cycle, and in many ways has exhausted opportunities for economic growth [*Lvov*, *Glazev*, 1986; *Polterovich*, 2009]. At the same time, a sixth-wave production system — the dynamics of which will shape the global economic trends of the next two to three decades — has been slow in the making. At the centre of this wave is a complex of nano-, bio-, genetic, molecular, information and communication technologies [*Glazev*, 2008].

One of the first mentions of the methods which are now referred to by the general term 'nanotechnology' was in a 1959 talk by Nobel laureate Richard Feynman who, in his lecture 'There's Plenty of Room at the Bottom,' spoke about a 'staggeringly small world' [*Feynman*, 1960]. The term itself was introduced to the scientific community in 1974 by the Japanese physicist, Norio Taniguchi [*Taniguchi*, 1974]. In global practice, the term 'nanotechnology' is understood to refer to all of the methods used to study design and produce materials, devices and systems including targeted control and alteration of the structure, chemical make-up and interaction of individual components of nanotechnology elements at scales of 100 nm or less as the minimum in one dimension (GOST R 55416-2013; ISO/TS 80004-1:2010). These methods are helping to improve and reveal additional operational and/or consumer characteristics and properties in the products that are produced.

Technology priorities

Achieving the fifth and sixth technological waves of innovation in one form or another is specifically stipulated in the development strategies of the US, EU, Japan, South Korea, Russia, and other countries for the period up to 2030–2050. In every case, scientific research in breakthrough fields such as new materials, ICT, space, environmental, nano- and biotechnologies and medicine are listed as priorities [*Kuzyk et al.*, 2011]. As a result, the role of nanotechnologies in these countries is critically high, as it is precisely with these technologies that we can conquer fundamentally new frontiers in information science, molecular biology, genetic engineering, and medicine. Investment in research and development (R&D) into various types of nanotechnologies has remained consistently high in these countries in recent years. In 2012, 18.5 billion dollars were spent on nanotechnology R&D, which is 8% higher than equivalent spending in 2010 [Lux Research, 2014]. However, there was a slight reduction in the percentage of public and private (venture) investment by 5% and 10% respectively, while corporate spending on R&D in nanotechnology grew by more than 20% [Lux Research, 2014]. The number of scientific publications and patents increased significantly and thousands of companies producing or using nanoproducts were set up. These include at least 80 consumer goods groups and more than 600 types of raw materials, components, and industrial equipment[1].

Priority of nanotechnologies

We expect nanotechnologies to have a significant impact on the global economy; a reliable indicator of which is the size of the corresponding market. Assessments of this impact depend on the adopted definition of nanotechnologies, measurements of their contribution to added value in the end product, and the level of optimism of analysts and differs by considerable amounts. Most experts, however, trace the beginning of the rapid growth of the nanotechnology market back to 2010 and outline the sectors which will have a leading role in this

[1] The nomenclature for the corresponding goods and services was adopted under Resolution No. 1192-r dated 7 July 2011 of the Government of the Russian Federation for the state to statistically monitor the production and sale of nanoindustry products and services. Rosstat Order No. 496 dated 13 December 2011 'On Approving the Statistical Toolkit for Statistical Observation of the Activities of Businesses and Organizations in the Nanotechnology Industry' made provisions for a quarterly form for federal statistical monitoring: Form No. 1-NANO 'Information on shipments of goods, work, and services linked to nanotechnologies' (with the amendments and addenda introduced by Rosstat Orders No. 232 dated 26 June 2013 and No. 547 dated 4 September 2014).

sphere in the future. It is expected that electronics, new materials, medicine, and biotechnology, and, to a lesser extent, energy and the environment, will dominate demand in the nanotechnology market in income terms [Lux Research, 2014; GIA, 2014].

Total sales of products manufactured using nanotechnologies amounted to 731 billion dollars in 2012, and by 2018 this figure is forecast to grow to 4.4 trillion dollars (Lux Research, 2014], which is equivalent to more than 5% of global GDP for 2014, compared with 0.9% in 2012 [EconomyWatch, 2015]. At least half of this figure is attributable to final products based on modern semi-conductors. This segment of the market is not classified as fundamentally new products and technologies, but rather it belongs to the previous technological wave: semi-conductor technologies transitioned from micro- to nanoelectronics and were limited to the 100 nm mark of the early 2000s. We are now pushing beyond the 10 nm frontier. The remaining sales from this figure, totalling roughly 1.5 trillion dollars, can be broken down into two parts: 5% for breakthrough technologies allowing for the development of fundamentally new products and 95% for technologies used to improve the consumer characteristics of existing products. Nanotechnologies in the second group are used in already well developed industries and account for a certain proportion of a product's final value. In order to calculate these specific values, the proportion of materials and intermediate products, which on average account for 1/3 of the good's price, are taken into account; from this figure the direct nanotechnology component is singled out: coatings, films, or powders which are used to improve the consumer characteristics of a particular good. Experts consider this share to be 10% on average. This approach explains, among other things, the actual value given in Russian translated publications for the global nanotechnology market that uses data from BCC Research & Development et al.: 12 billion dollars in 2009 and 27 billion dollars in 2015 (forecast). These assessments only take into account first-generation nanomaterials (particles, carbon tubes, new materials, and composites), nanoinstruments (lithography and probe microscopy), and nanodevices (sensors and electronics).

The priority of nanotechnologies in different countries is well illustrated by global patent dynamics [*Igami*, *Okazaki*, 2008; *Jordan et al.*, 2014]. From 2000, the growth in the number of patent applications for nanotechnology inventions exceeded overall patent dynamics. Virtually any important innovation in this field gives rise to a surge in patents. For example, the discovery and study of new allotropic carbon modifications — fullerene [*Kroto*, 1985], carbon nanotubes [*Iijima*, 1991], and forming and studying graphene [*Novoselov et al.*, 2004] — caused a wave of patents linked not only to new materials based on carbon nanoparticles, but also various types of microelectronic devices using nanotubes, graphene, etc. [*Jordan et al.*, 2014].

Patent landscape

A patent is a legal document certifying authorship of an invention, utility model, or prototype and the exclusive right to use them. It is also a unique source of science and technology information, not limited to a description of the invention, but also reflecting the level of current research and innovation long before the product reaches the market. To evaluate current trends and select areas to support in nanotechnology, extensive use is made of statistical analyses of patent activity, comparing the number of applications by region, field of application, and citations [*Igami, Okazaki*, 2008].

Another way to study the characteristics of patent activity surrounding a particular technology in a particular region or on a global scale is to analyse the patent landscape, referred to as patent landscaping [WIPO, 2015]. This method involves compiling a statistical sample of bibliographical data and analysing a large set of patent information followed by visualizing the results (Fig. 1).

In patent landscaping, technological solutions described in the patent documentation are depicted on a map in the form of isolated 'islands'. Even when there are only weak links among the general collection of documents, they show certain trends in research activity, the most popular of which are shown as large

Fig. 1. **Key stages of patent landscaping**

Source: compiled by the authors.

'continents'. The map makes it possible to see how close the 'islands' of certain patent holders are to one another and how they are distributed across the spectrum of technological solutions. Using patent data, it is possible to identify areas displaying applicant activity and changes in intellectual property portfolios both in terms of content and time, and to reveal the leading countries in various thematic areas [EPO, 2015].

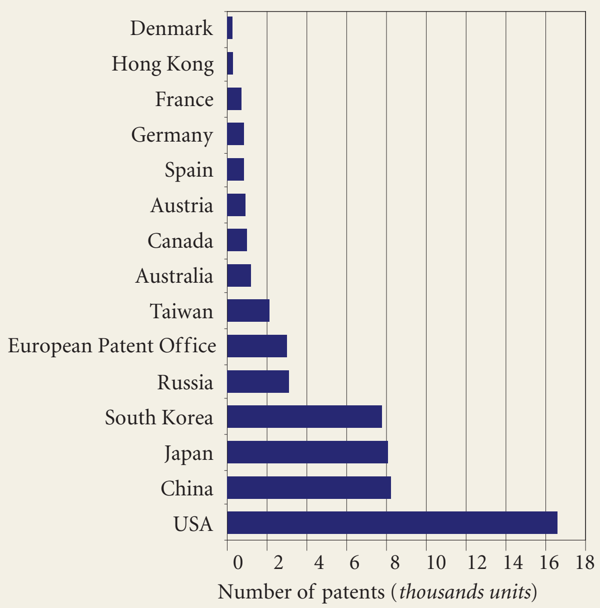
An example of effective patent landscaping is the open-access publications by the UK Intellectual Property Office (IPO) which analyze nanotechnology innovations and detail the patent activity of commercial organizations and universities in nanotoxicity, among other things [IPO, 2009]. Another example is the IPO's studies on the activity of those holding patents to materials based on graphene [IPO, 2013], where patent landscaping clearly shows the dynamics of technologies such as graphene synthesis, semi-conductors, LEDs, and memory by year and geographical affiliation of the applicant.

Our paper focuses on the sections and classes of technologies in which nanotechnology methods and microstructure innovations are used. According to the Technology Concordance Table [WIPO, 2013], technologies registered in the following International Patent Classification (IPC) subgroups are classified as 'Nanotechnologies':

- B82B — nanostructures formed by manipulation of individual atoms, molecules, or limited collections of atoms or molecules as discrete units; manufacture or treatment thereof;
- B82Y — specific uses or applications of nanostructures; measurement or analysis of nanostructures; manufacture or treatment of nanostructures.

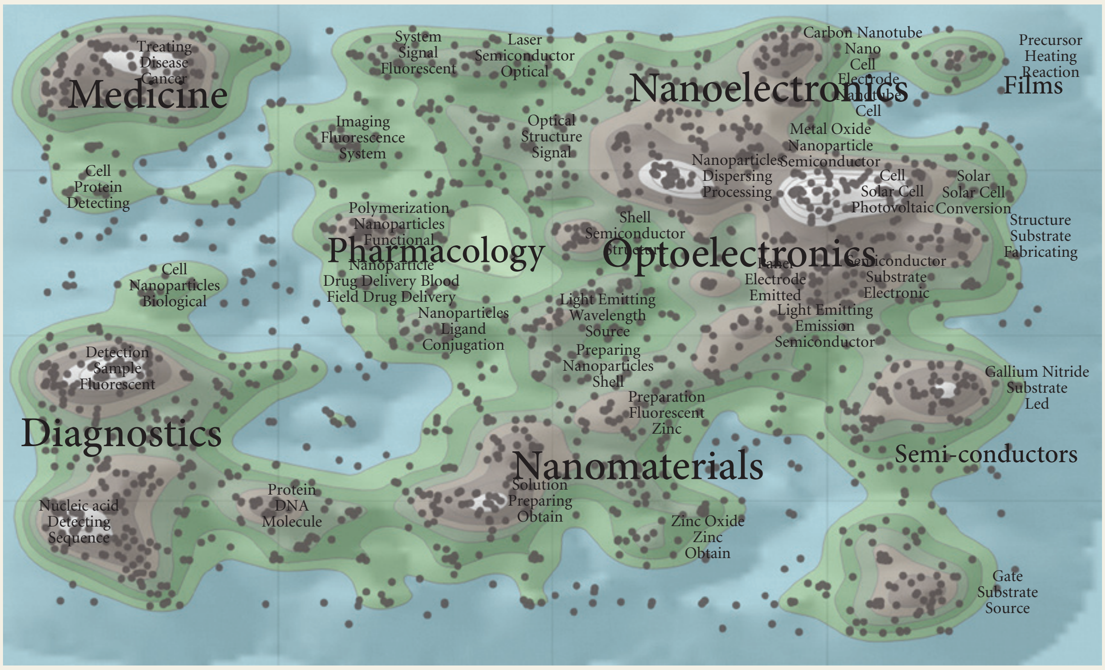
Russia's contribution to global patent activity in the sphere of nanotechnology is still relatively modest (Fig. 2). Out of the roughly 57,000 invention patents is-

Fig. 2. **Number of invention patents in the 'Nanotechnology' group by applicants' country of affiliation for the period since 1994**



Source: [Minesoft, RWS Group, 2013].

Fig. 3. **Patent landscape in nanotechnology based on subclass IPC B82 'Nanotechnology'**



Source: compiled by the authors from [Thomson Reuters, 2015].

sued by all the main patent offices globally, only 5.4% were Russian applicants. Based on this indicator, Russia occupies fifth place behind the US, China, Japan, and South Korea. The structure of nanotechnology patents held by Russian residents is homogeneous due to their orientation in the domestic market. The number of applications submitted to foreign registering bodies is low, which can be explained by the low competitive value of Russian developments and a lack of resources, primarily financial, to undergo all the necessary procedures. While Russian patent activity in microstructures and nanotechnologies over the period 2008-2013 demonstrates some growth, the proportion of inventions of the overall structure of patents published by the main Russian patent office (> 0.5%) [WIPO, 2015] shows that this field is not yet a priority.

The very task of searching for promising nanotechnology solutions is a complex one due to the following objective reasons [*Negulyaev, Nenakhov*, 2007; *Sazonov*, 2011]:

- nanotechnologies are for the most part so new that they are mostly discussed in non-patent publications; in other words *there is not enough information in patents to analyse a nanotechnology component*;
- patentable technologies, including in the nanotechnology sphere, are classified by specific experts; in other words, such technologies are subjective in many ways, which explains *the significant dispersal of patents across IPC classes;* IPC's class B82 ('Nanotechnology') is relatively new and does not sufficiently specify the technological area to which a particular patentable object belongs. Therefore, any analysis of documentation in a specific field requires the use of IPC indexes as well as other methods, such as key terms for each specific type of nanotechnology [*Porter et al.*, 2008; *Wang, Guan*, 2012].

In this paper we analyse current patent activity within the Russian Federation and across the world. We have developed patent maps of the fields in which nanotechnologies under subclass B82 are used (Fig. 3), using relevant key words (Table 1, Fig. 4), including for metallurgy separately. The data for this study were sourced from the Thomson Innovation system, which is connected to the Derwent World Patents Index (DWPI) database [Thomson Reuters, 2015]. This database contains information on more than 80 million patent publications from national patent offices in the US, Europe, China, Japan, Russia and South Korea, the World Intellectual Property Organization (WIPO) and others.

Table 1. **Terms used to search for nanotechnology solutions**

Search query	Terms
1. Nano* (with the prefix 'nano-')	nano*
2. Quantum (quantum terms)	(quantum dot* OR quantum well* OR quantum wire*) NOT nano*
3. Self-Assembly	(((self assembl*) OR (self organiz*) OR (directed assembl*)) NOT nano*
4. Terms implying the presence of 'nano-'	((molecul* motor*) or (molecul* ruler*) or (molecul* wir*) or (molecul* devic*) or (molecular engineering) or (molecular electronic*) or (single molecul*) or (fullerene*) or (coulomb blockad*) or (bionano*) or (langmuir-blodgett) or (Coulomb-staircase*) or (PDMS stamp*)) NOT nano*
5. Terms related to electron microscopy	((TEM or STM or EDX or AFM or HRTEM or SEM or EELS) or (atom* force microscop*) or (tunnel* microscop*) or (scanning probe microscop*) or (transmission electron microscop*) or (scanning electron microscop*) or (energy dispersive X-ray) or (X-ray photoelectron*) or (electron energy loss spectroscop*)) NOT nano*
6. Other terms directly related to nano	(biosensor* or (sol gel* or solgel*) or dendrimer* or soft lithograph* or molecular simul* or quantum effect* or molecular sieve* or mesoporous material*) AND (MolEnv-R)) NOT nano*

Source: [*Porter et al.*, 2008].

To filter out irrelevant data from the search queries, certain terms were excluded with the prefix 'nano': nanometer,* nanosecond,* nanomolar,* nanogram,* nanoliter,* nano-second, nano-meter, nano-molar, nano-gram, nano-liter, nanomeli,* nanophyto,, nanobacteri,* nano2,* nano3.*

Figure 5 shows the detailed thematic structure of Russian patents in nanotechnology.

Nanotechnology patent landscaping in metallurgy

To analyse technological solutions in the metallurgy industry which make use of nanotechnologies, a filter was introduced based on the following key terms:

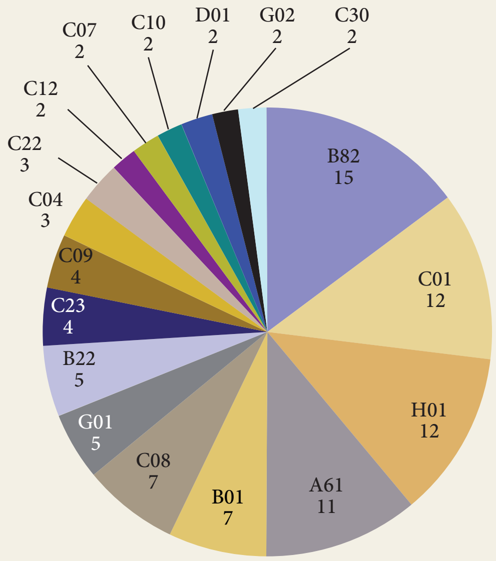
1) those linked to the presence of nanostructure elements: nano/microstructure, ultrafine grain, subgrain, crystallite, crystalline, coherent scattering region, and intermetallides;

2) those describing the controlled formation of nanostructures and properties of metals and intermetallides through deformation, thermal or combined pro-

Fig. 4. **Patent landscape in nanotechnology based on key words**

Source: compiled by the authors from [Thomson Reuters, 2015].

Fig. 5. **Distribution of patents in nanotechnology in Russia by thematic area for the period since 1994 according to the IPC indexes (%)**



		Number of patents
B82	Nanotechnology [7]	1926
C01	Inorganic chemistry	348
H01	Basic electric elements	284
A61	Medical or veterinary science; hygiene	279
B01	Physical or chemical processes or apparatus in general	249
C08	Organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon	156
G01	Measuring; testing	156
B22	Casting; powder metallurgy	123
C23	Coating metallic material; coating material with metallic material; chemical surface treatment; diffusion treatment of metallic material; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general; inhibiting corrosion of metallic material or incrustation in general [2]	107
C09	Dyes; paints; polishes; natural resins; adhesives; compositions not otherwise provided for; applications of materials not otherwise provided for	92
C04	Cements; concrete; artificial stone; ceramics; refractories [4]	91
C22	Metallurgy; ferrous or non-ferrous alloys; treatment of alloys or non-ferrous metals	77
C12	Biochemistry; beer; spirits; wine; vinegar; microbiology; enzymology; mutation or genetic engineering	61
C07	Organic chemistry [2]	54
C10	Petroleum, gas or coke industries; technical gases containing carbon monoxide; fuels; lubricants; peat	43
D01	Natural or man-made threads or fibres; spinning	41
G02	Optics	40
C30	Crystal growth [3]	38

Source: compiled by the authors from [Thomson Reuters, 2015].

cessing of special-purpose high-strength steels and alloys: microalloy, precipitation for strengthening or hardening of structures, plastic deformation, cold deformation, deformation or dispersion hardening, mechanical or deformation hardening, and strain ageing of alloys;

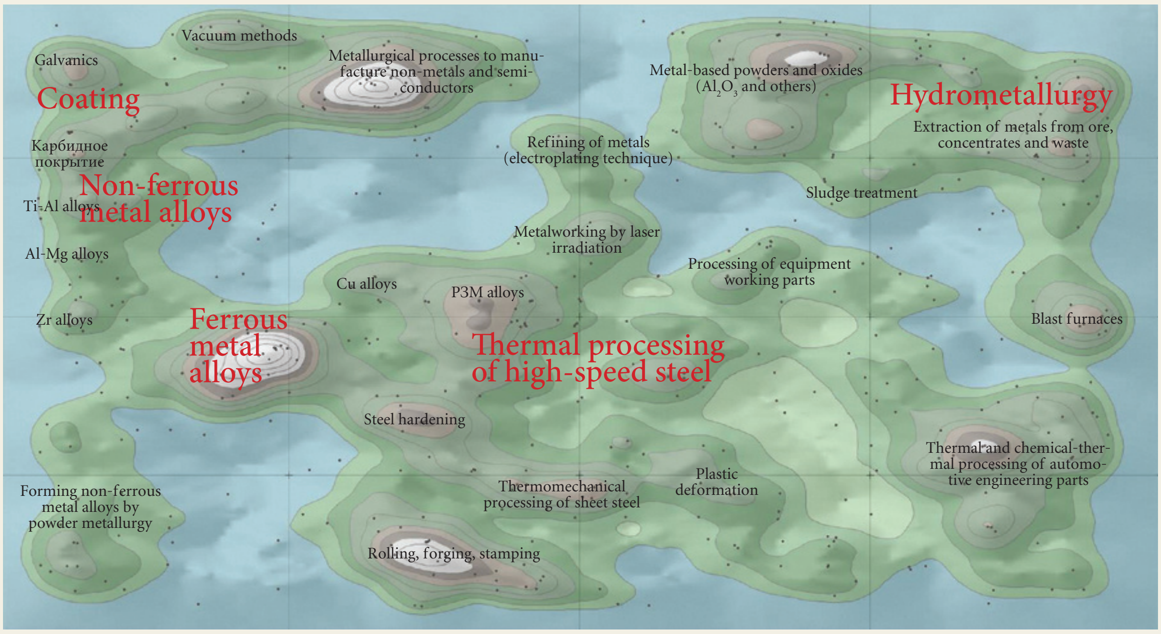
3) those used to describe other methods used to create voluminous nanostructure materials by compacting superdispersed powders that are obtained using physical or chemical methods or pulverizing in a ball mill: nano/micropowder, milling, or sintered aluminium powder (SAP).

The development of the patent landscape involved searching under the following classes of IPC section C 'Metallurgy':

- C21 'Metallurgy of iron';
- C22 'Metallurgy; ferrous or non-ferrous alloys; treatment of alloys or non-ferrous metals';
- C23 'Coating metallic material; coating material with metallic material; chemical surface treatment; diffusion treatment of metallic material; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general; inhibiting corrosion of metallic material or incrustation in general';
- C25 'Electrolytic or electrophoretic processes; apparatus thereof';
- C30 'Crystal growth'.

The analysis covered data for all countries. The results obtained for each of these classes were compiled into a single dataset which was used to form preliminary maps representing key terms and thematic affiliation of documentation. The data were refined through additional searches in patent documents for the last 20 years. The resulting datasets were combined using the logic operator AND.

Fig. 6. **Patent landscape of IPC section C 'Metallurgy' based on key terms which may be associated with nanotechnologies**

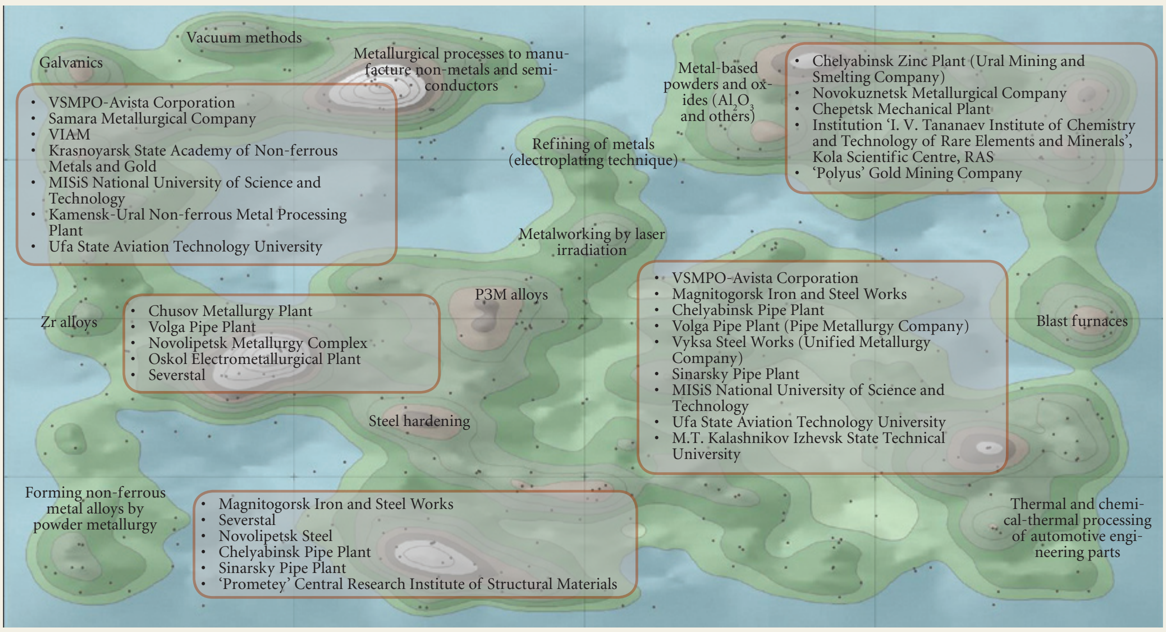


Note: Patents held by Russian organizations are shown as red points..

Source: compiled by the authors from [Thomson Reuters, 2015].

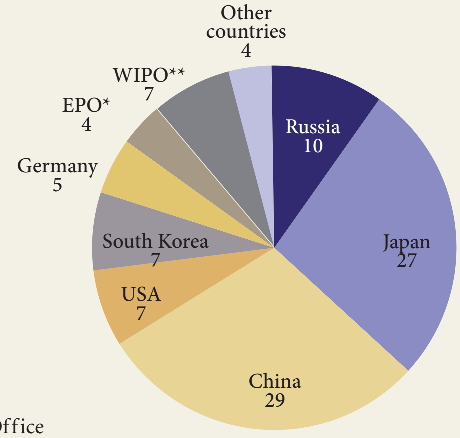
Thus, the patent landscape for IPC section C 'Metallurgy,' which shows the distribution of terms potentially associated with nanotechnologies, *was developed following an analysis of the repetition of key words in patent documents.* The relationship between the 13,198 documents containing these words is represented graphically in Fig. 6. The following map makes it possible to see how close technological fields are to one another and which technological fields the documentation datasets of various Russian patent holders belong to (Fig. 7).

Fig. 7. **Patent landscape of IPC section C 'Metallurgy' indicating the Russian patent holders**



Source: compiled by the authors from [Thomson Reuters, 2015].

Fig. 8. **Geographical distribution of global patent activity for the period 1992-2013 (%)**



* European Patent Office
** World Intellectual Property Organization

Source: compiled by the authors from [Thomson Reuters, 2015].

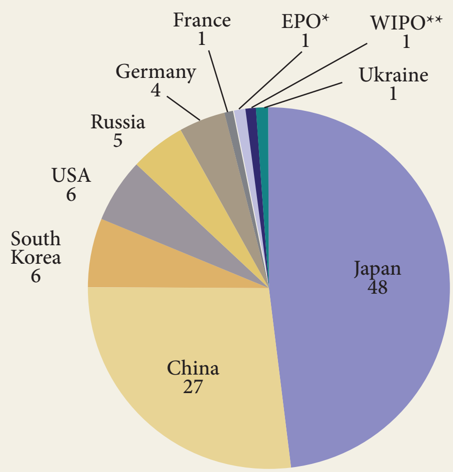
Analysis of patent documentation in metallurgy

Assessments of global patent activity in metallurgy broken down by country (Fig. 8) make it possible to locate the global leaders in R&D. The leaders are primarily China and Japan, followed by Russia, USA, South Korea, and Germany.

In Russia, ferrous and non-ferrous metallurgy (classes C21 and C22) are one of the leading areas of patent activity over the period under consideration, while in the US more high-tech fields and fundamental R&D are the priority [NBK Group, 2013]. According to WIPO data, US patent activity in the 'materials and metallurgy' area is 1.7 times higher than the figure for the Russian Federation, and in terms of patenting volumes it is more than ten times higher.

However, in some technological sectors, the number of patents in the two countries is on the whole comparable. For example, in the subclass C21D 'Thermal processing (modifying the physical structure of ferrous metals)' and C22C 'Alloys,' the number of priority applications in the period from 1992 to 2013 was roughly the same (Fig. 9). It is in these areas that the use of filters for key words

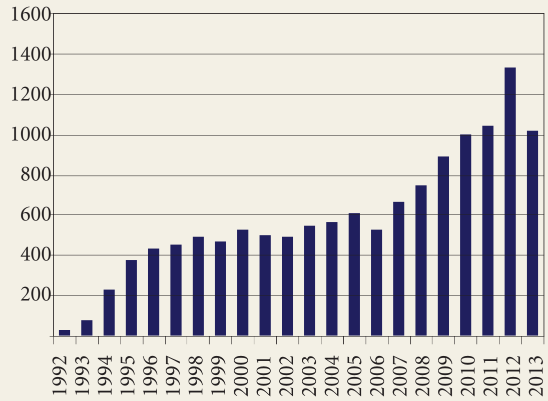
Fig. 9. **Total number of priority applications in metallurgy to patent offices in different countries for the subclasses C21D and C22C in the period 1992-2013**



* European Patent Office
** World Intellectual Property Organization

Source: [Minesoft, RWS Group, 2015].

Fig. 10. **Patent activity in metallurgy globally** (number of patents registered, *units*)



Source: compiled by the authors from [Thomson Reuters, 2015].

whose meanings are compatible with nanotechnology solutions reveals the comparatively high proportion of Russian patents.

The dynamics of global invention activity in metallurgy reflect the number of patent applications submitted over this period (Fig. 10). It is worth noting that over the last 15 years stable growth in patenting activity was not registered in the metallurgy industry in Russia (Fig. 11).

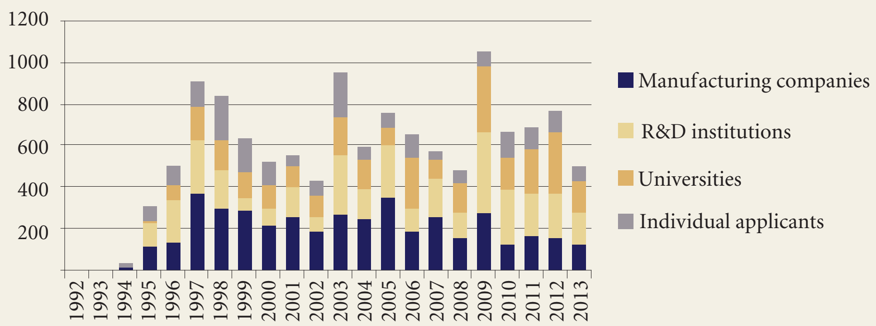
The breakdown of key technologies across all applications was based on the classification of patents under a particular IPC class — for the world as a whole (Fig. 12) and for Russia (Fig. 13).

Patent activity by Russian organizations in metallurgy

Russian players have a strong position in R&D in the metallurgy industry with a 10% share of the global patent market, behind only Japan (27%) and China (29%). Primarily, this research includes thermal processing technologies and technologies to form ferrous and non-ferrous metal alloys (Table 2).

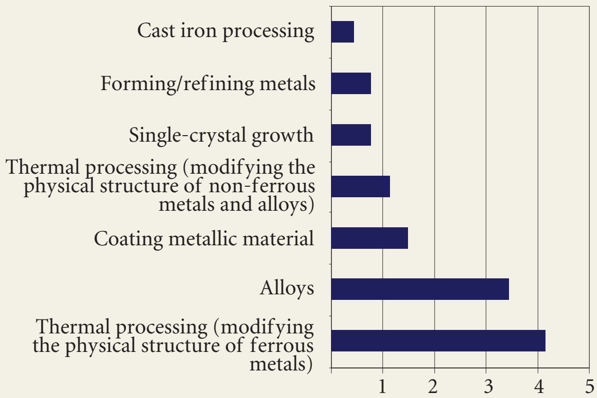
Judging by patent statistics, Russian industries are competitive in R&D in several technological areas, including: cast iron processing (Nizhniy Tagil Iron and Steel Works), modifying the physical structure of ferrous metals following thermal processing (Magnitogorsk Iron and Steel Works, Novolipetsk Steel, Severstal, and others), and forming, recovering and refining metals (Krasnoyarsk Non-ferrous Metals Plant, Krasnoyarsk Zinc Plant) (Table 3).

Fig. 11. **Patent activity and patent structure in metallurgy in Russia** (number of patents registered by applicant type, *units*)



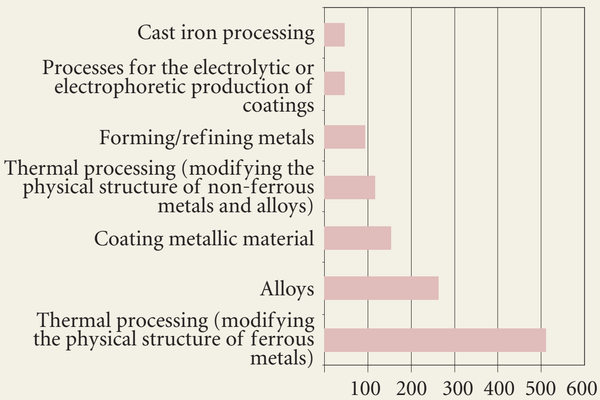
Source: compiled by the authors from [Thomson Reuters, 2015].

Fig. 12. **Key technological areas of patent activity in metallurgy globally** (number of patents registered, *units*)



Source: compiled by the authors from [Thomson Reuters, 2015].

Fig. 13. **Key technological areas of patent activity in metallurgy in Russia** (number of patents registered, *units*)



Source: compiled by the authors from [Thomson Reuters, 2015].

Table 2. **Patent activity by Russian organizations in metallurgy in key IPC classes**

IPC class	Name	Number of patents (*units*)
Manufacturing companies		
C21D	Thermal processing (modifying the physical structure of ferrous metals)	211
C22C	Alloys	69
C22B	Producing/refining of metals	31
C30B	Single-crystal growth	8
C25C	Electrolytic production, recovery or refining of metals	7
Research organizations		
C22B	Producing/refining of metals	103
C21D	Thermal processing (modifying the physical structure of ferrous metals)	90
C22C	Alloys	30
C25F	Processes for the electrolytic removal of materials from objects	15
C23D	Enamelling of, or applying a vitreous layer to, metals	8
Educational institutions		
C21D	Thermal processing (modifying the physical structure of ferrous metals)	109
C22C	Alloys	33
C25D	Processes for the electrolytic or electrophoretic production of coatings	27
C22B	Producing/refining of metals	10

Source: compiled by the authors from [Thomson Reuters, 2015].

Table 3. **Leading patenting organizations in metallurgy**

Name	Number of patents (*units*)
Manufacturing companies	
Magnitogorsk Iron and Steel Works	23
Severstal	20
Novolipetsk Steel	15
Nizhniy Tagil Iron and Steel Works	14
Sinarsky Pipe Plant	11
Chelyabinsk Pipe Plant	11
V.A. Degtyarev Plant	10
West Siberian Metallurgical Plant	10
GAZ	9
Nosta (Orsk-Khalilovsk Metallurgical Plant)	8
Research organizations	
All-Russian Scientific Research Institute of Aviation Materials	53
A.A. Baikov Institute of Metallurgy and Materials Science RAS	20
Ural Division of the All-Russian Railway Research Institute	19
‘Prometey’ Central Research Institute of Structural Materials	14
Institute of Metal Physics, Ural Division of the Russian Academy of Sciences	11
I.P. Bardin Central Scientific Research Institute of Ferrous Metallurgy	9
All-Russia Institute of Light Alloys	7
Institute of Solid State Physics RAS	7
‘Elektrokhimpribor’ Industrial Complex	7
‘Salut’ Moscow Engineering Production Centre	7
Irkutsk Scientific Research Institute of Precious and Rare Metals and Diamonds (‘Igriredmet’)	2
Educational institutions	
Voronezh State Technical University	18
Ufa State Aviation Technical University	18
MISiS National University of Science and Technology	16
I.I. Ivanov Kursk State Agricultural Academy	14
I.I. Polzunov Altai State Technical University	8
Samara State Technical University	7
B.N. Yeltsin Ural Federal University	7
Belgorod State University	6
Kaliningrad State University	5
R.E. Alekseev Nizhny Novgorod State Technical University	4
S.R. Korolev Samara State Aerospace University	4

Source: compiled by the authors from [Thomson Reuters, 2015].

Scientific research and scientific production organizations show the highest level of patent activity in the following technological areas:

- ferrous and non-ferrous metal alloys (All-Russia Institute of Light Alloys, All-Russian Scientific Research Institute of Aviation Materials, and others);
- modifying the physical structure of non-ferrous metals and alloys through thermal processing (Igriredmet and others).

The R&D of Russian higher education institutions in metallurgy is focused on technologies for coating metallic materials (Voronezh State Technical University, Ufa State Aviation Technical University, and others). The ratio of the number of patents obtained by industrial enterprises and by higher education institutions is 45% to 55%. This suggests a high level of research activity at higher education institutions, for which R&D serves as a step towards subsequent commercialization of research results and implementation of the innovation in question.

The absolute leaders in patenting scientific and technological achievements among businesses, academic and industrial scientific research institutes are the All-Russian Scientific Research Institute of Aviation Materials, the A.A. Baikov

Institute of Metallurgy and Materials Science RAS, the Ural Division of the All-Russian Railway Research Institute, and the 'Prometey' Central Research Institute of Structural Materials. The highest number of patents in the higher education sector are seen at Voronezh State Technical University, MISiS, Ufa State Aviation Technical University, and Kursk State Agricultural Academy. The Magnitogorsk, Novolipetsk, Nizhniy Tagil Iron and Steel Works, and Severstal are all implementing an active patenting policy.

Use of the patent landscape

The approaches developed in this article to assessing the current level of patent activity in nanotechnology can be used, among other things, to develop an array of programmes for further education, professional re-training, and increasing qualifications in the nanoindustry. They allow us to determine the structure and theme of new educational programmes (a thematic educational plan), partner companies who may potentially be interested in such programmes, possible developers of these programmes whose skillset in this field can be confirmed through patent portfolios, scientific publications, and corresponding scientometric indicators.

Following a comprehensive analysis of patent landscapes developed through a joint project between the Fund for Infrastructure and Educational Programmes (FIEP) and the 'Skolkovo' Intellectual Property Centre in 2014, it was possible to identify those areas of metallurgy R&D that are most in demand based on nanotechnology solutions. Taking this into account, the following areas of educational training geared towards developing the metallurgical industry can be put forward:

- construction steel with nanostructural perlite and production technology based on new high-strength viscous materials;
- nanostructured stainless steel obtained through cryogenic deformation and thermal treatment;
- nanostructured diffusion intermediate and surface layers of metal coatings that provide fundamentally higher performance characteristics for mass production of metals (tin, galvanized sheets, etc.);
- nanostructured coatings produced by vacuum application on carbon steels;
- high-performance tubular steel produced using an innovative combination of metallurgical technologies based on ultrafine microstructures;
- super heat-resistant and heat-resistant alloys based on intermetallides for next-generation aircraft gas-turbine engines that use nanotechnologies.

Patent landscaping also makes it possible to identify technological niches, which have been poorly explored at present and which hold promise from the perspective of developing start-ups, state investment, and international cooperation.

Conclusions

Our paper considered some methodical approaches to patent landscaping by using the database of Thomson Innovation and utilizing these searches to solve the problem of determining thematic educational initiatives.

Patent landscaping can serve as an effective tool to analyse the state of any technological industry, although the quality of the conclusions is directly dependent on the methodological accuracy with which the landscapes are created. A patent landscape must, above all else, reflect not only core and widely distributed technologies, but also innovative niches that have arisen in recent years. An important indicator of the demand for and the promise of a particular R&D area is the dynamics of references to terms linked to innovative technologies in patent documentation.

To carry out an effective patent search, the accuracy of the chosen key words is of critical importance, including new and interdisciplinary terms. This then makes it possible to minimize the impact of subjective appraisals when using thematic headings of patent databases.

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Master Class

Foresight for Science and Technology Priority Setting in Korea

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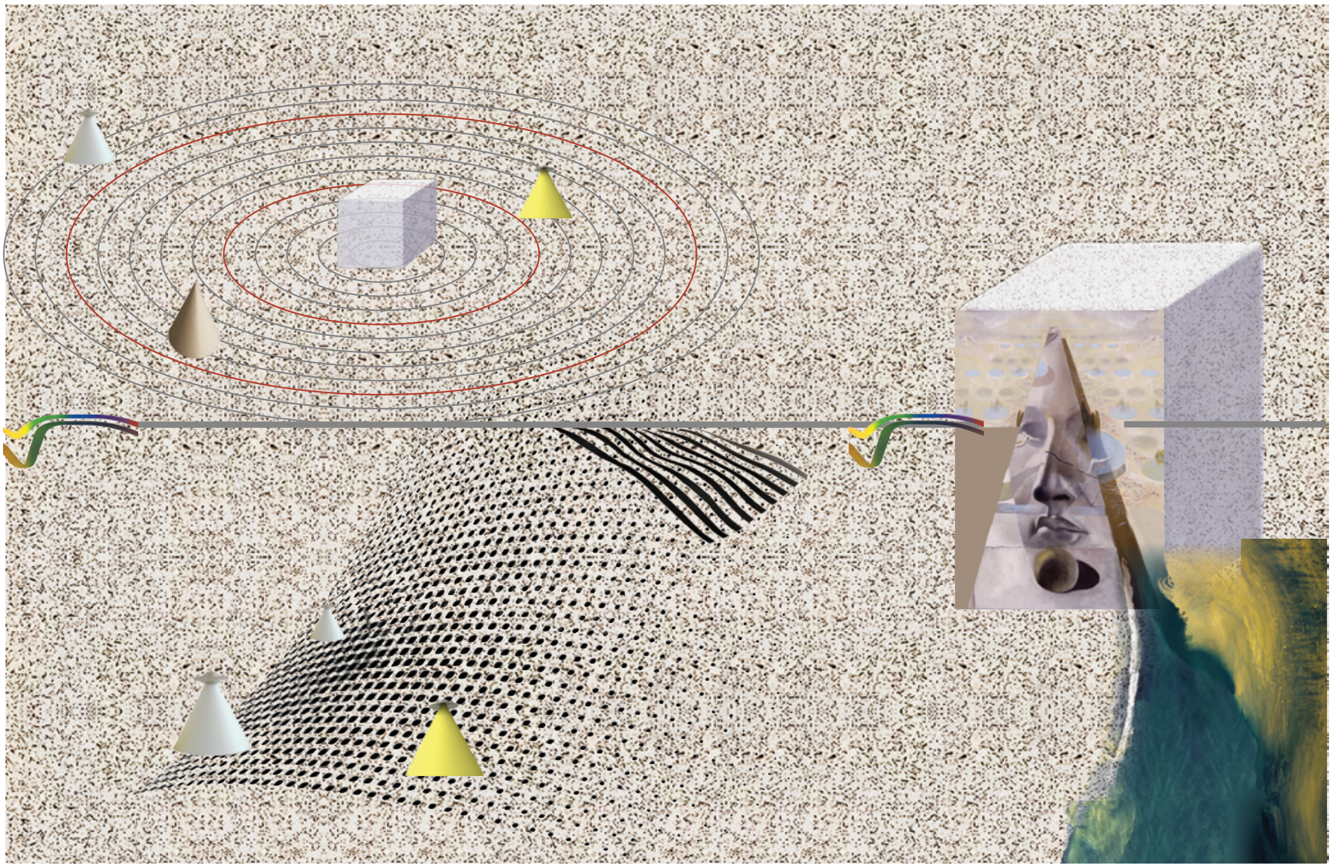

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Abstract

The main purpose of Technology Foresight (TF) in Korea is to predict the development of S&T and use the results in developing S&T policies. However, informing the public about what the future holds based on the development of S&T is an equally important role of TF.

Since the introduction of the first TF in 1994, Korea has conducted four such studies. TF in Korea has become a key process in setting S&T policy, such as the Science and Technology Basic Plan (S&T Basic Plan). The S&T Basic Plan determines the national strategic technologies by reflecting on future technology. The S&T Basic Plan is a mandatory legal planning process established every five years by the Korean government. It is the top-level policy document affecting S&T-related policy making in Korea.

TF in Korea primarily utilizes the Delphi method. The third and fourth TFs have strengthened the links between S&T and society by determining future technologies capable of solving future needs. The fourth TF presented scenarios and special illustrations to show members of the public the future technologies and their implications for society. Additionally, the fourth round of TF analyzed the potential negative impacts of future technologies.

Keywords: technology Foresight; science and technology (S&T) policy; Delphi method; technology assessment; S&T strategies

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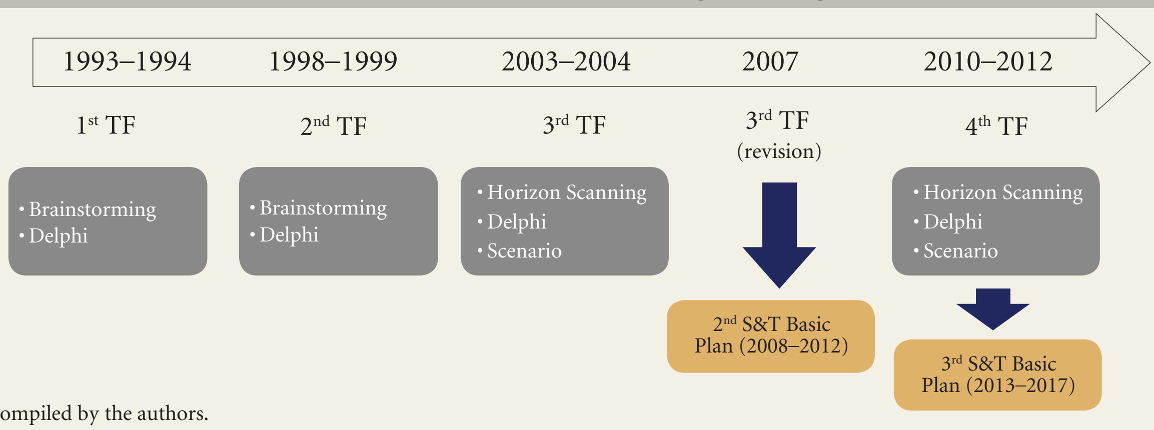
Since the implementation of the first TF in 1993–1994, TF in Korea has continuously advanced in response to society's increasing demands. Since the Framework Act on Science and Technology in 2001, which specified regularly carrying out TFs, national TFs have been conducted every five years. Thus, from the third TF onwards, Korea carries out TFs every five years. In 2007, the third TF was revised to increase complementarities with the S&T Basic Plan, the nation's top-level plan in the field of S&T. The results of the revised TF were directly reflected in the second S&T Basic Plan. Furthermore, the results of the fourth TF (conducted during 2010–2011) found expression in the third S&T Basic Plan. All four TFs performed to date have primarily used the Delphi method. Since the third TF, future social trends were first identified and then future technologies predicted based on these trends; moreover, scenarios were developed founded on the results of the TF (Figure 1). Currently, the Ministry of Science, ICT and Future Planning (MSIP) is responsible for TFs while the Korea Institute of S&T Evaluation and Planning (KISTEP) conducts the TFs.

Outline of Korean Technology Foresight

The first TF aimed to identify a long-term development strategy for S&T. At the same time, Korea launched a large-scale, inter-ministerial R&D project (1992) which aimed at "raising the level of Korean S&T in the 2000s to the level of the G7 countries". In 1993, Korea's national R&D budget exceeded one trillion won for the first time. In the first TF, S&T professionals determined 1,174 future technologies over the next 20 years (1995–2015). Using the Delphi method, this TF surveyed the importance of future technologies, as well as their implementation time and technological level. In addition, the TF identified the factors hindering the creation of future technologies and the main actors in the development of future technology [*Shin*, 1998].

The year 1999 saw the release of the results of the second TF. A Ministry for S&T had been created in 1998, and the National S&T Council was set up in 1999. The purpose of the second TF was to study the future developments of S&T and to compare Korea's level of technology with that of more developed countries. This would enable policy makers to set goals for S&T policies and acquire the data needed for preparing a S&T strategy. In other words, the goal of the TF was to present a portfolio for the distribution of S&T resources nationally and to establish strategies for R&D projects based on the results of the TF. The second TF categorized the overall field of S&T into 15 areas, set the forecast period at 25 years from 2000 to 2025, and identified 1,155 future technologies. As in the first round of TF, the 1999 round employed the Delphi method to examine the importance, implementation time, and technological levels of future technologies. The 1999 TF also identified the main actors and the necessary policy measures for implementing future technologies [*Lim*, 2001].

Fig. 1. **Outline of Korean technology foresight**



Source: compiled by the authors.

Table 1. **An example of future needs and issues in the third TF (individual level)**

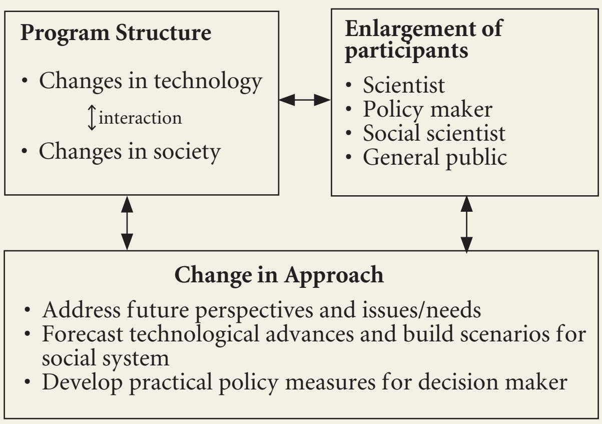
Actor	Need		Need or issue
	Main theme	Detailed theme	
Individual	Healthy life	Dealing with diseases	• Prevention, diagnosis and treatment of diseases that are hard to cure • Geriatric diseases • Chronic diseases • Contagious diseases • Artificial organs • Application of biotechnology
		Quality health service	• High quality healthcare system (ICT) • Alternative medicines • Secondary infection in hospitals
		Healthy normal life	• Comfortable daily life • Health-maintaining system
		Safe foods and consumer products	• Safer foods • Safer consumer products • Environmentally-friendly foods and consumer products

Source: [*Park, Son*, 2010].

Figure 2 below indicates the conceptual diagram of the third TF, conducted from 2003 to 2004. Unlike the previous two TFs, the third TF considered the relationship between technology and society. In addition, the scope of participation expanded from S&T experts to include policy makers and social scientists. The third TF had three stages. The first stage identified the future issues and needs of society and the future technologies to address these needs. To organize future society's needs systematically, the TF separated them into individual, social, national, and global needs. Table 1 shows examples of future needs associated with individuals. Eight specialized divisions in the field of S&T were configured to determine future technologies; the forecast covered the period from 2005 to 2030, and identified 761 future technologies. The second stage evaluated the impact of various factors such as the implementation time of future technologies via the Delphi method. Finally, the third stage created scenarios about likely future challenges in education, health, labor resources, and security [*Park, Son*, 2010].

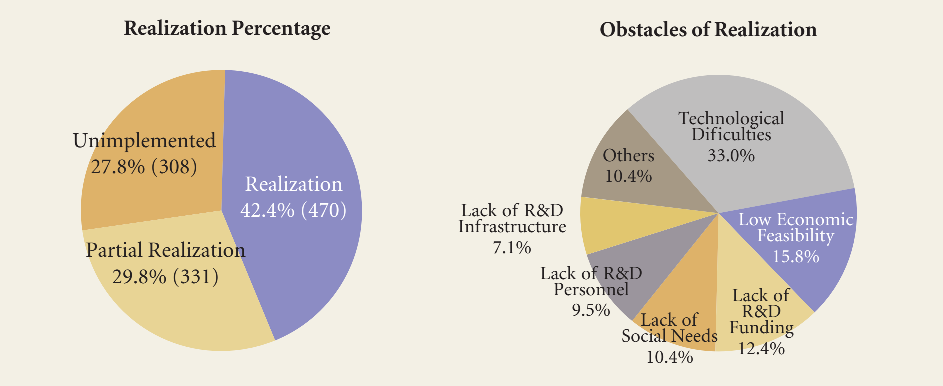
How reliable have the previous TFs been in their predictions about future technologies? An evaluation of the 1,109 future technologies predicted to exist by 2010 according to the first TF of 1994 found that 470 of these technologies were

Fig. 2. **Conceptual diagram of Korea's third TF (2003–2004)**



Source: [*Park, Son*, 2010].

Fig. 3. **Implementation percentages and obstacles to implementing the future technologies as identified by the first TF**



Source: calculated by the authors.

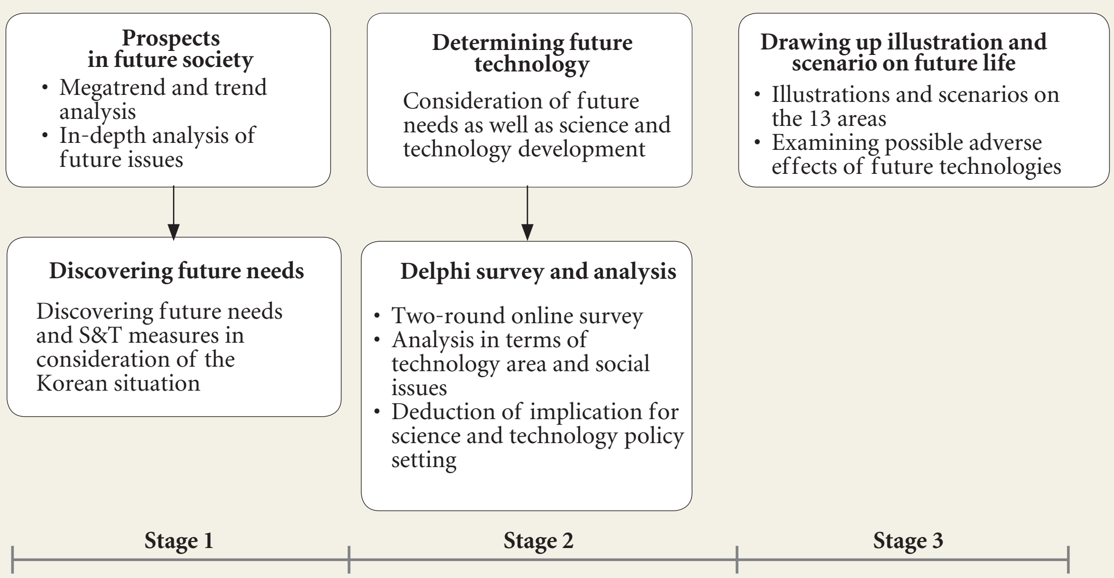
fully implemented and 331 partially implemented. This means the first TF's accuracy rate is 72.2%, when we include the partially implemented technologies.

The partially implemented technologies include cases where the assessment of implementation depended on the viewpoint of the evaluation because any one future technology is determined by multiple technical factors or the concept of the future technology is ambiguous. Using the Delphi method, the major obstacles for implementing future technologies were found to be, in descending order: 'Technological Difficulties' (33.0%), 'Low Economic Feasibility' (15.8%), 'Lack of R&D Funding' (12.4%), followed by 'Lack of Social Needs' (10.4%) (Figure 3).

The Fourth Korean Technology Foresight

The fourth TF forecasts the future up to 2035 and had three stages (Figure 4). The first stage forecast the future of Korean society and examined future needs. The second stage identified future technologies and conducted the Delphi survey to examine factors such as the technological implementation time and the time for socially distributing future technologies, Korea's level of technology,

Fig. 4. **Procedure of the fourth TF**



Source: [*Choi et al.*, 2014].

the main actors for technological development, and governmental policies required for implementing technologies. The third and final stage created scenarios and illustrations depicting the shape of the future world that would be changed by implementing and distributing future technologies divided into 13 different areas, such as home and school. In addition, the fourth TF presented the possibility of various social changes caused by the development of future technologies by drawing up scenarios on the negative impacts of technological development.

Forecast for the Future Society and Discovering Future Needs

The fourth TF identified the most significant global trends that will affect societies up to 2035, or 'megatrends'. These megatrends are: i) further globalization; ii) increasing conflicts; iii) demographic changes; iv) greater cultural diversity; v) depletion of energy and resources; vi) greater climate changes and associated environmental problems; and vii) development and convergence of S&T. Furthermore, the continuing rise of China can also be considered a megatrend in its own right, which further accelerates the seven other megatrends. Table 2 below shows these eight megatrends, along with the 25 trends comprising the eight megatrends. For each trend, the TF examined the risks and opportunities for Korean society. Based on this analysis, the TF drew up the future society's needs.

Determining Future Technologies

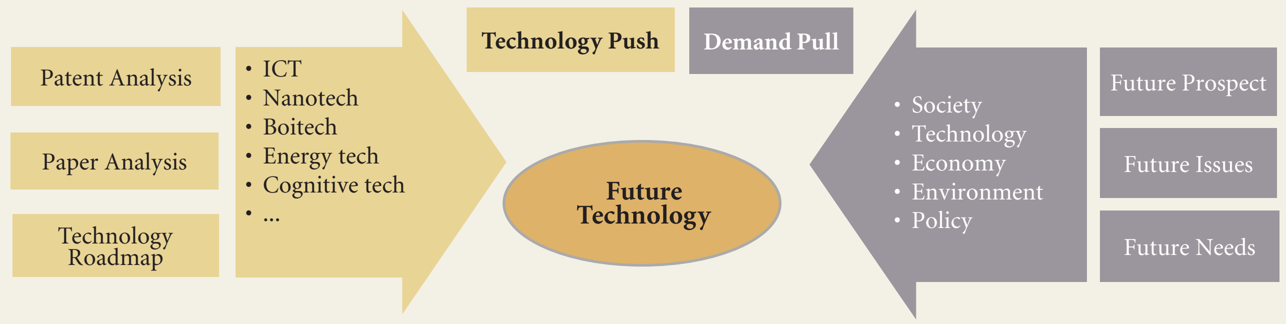
The fourth TF defined future technologies as the 'technology that can be implemented technologically or distributed socially by 2035 and has the potential for significant impacts on S&T, society, or economy.' [NSTC, KISTEP, 2012b]. S&T experts determined future technologies in two ways, as shown in Figure 5. One way is the Demand Pull type future technology, where future technologies capable of addressing the needs of future society are determined through predicting the characteristics of future society. Another method is the Technology Push

Table 2. **Megatrends and trends of the fourth TF**

Megatrend	Trend
Further globalization	• Integration of the global market • Multi-polar world order • Globalization of workforce • Extension and diversification of the governance concept • Rapid spread of epidemics
Increasing conflicts	• Deepening of conflicts between peoples, religions, and nations • Increase in cyber terrorism • Increase in risks of terrorism • Greater polarization
Demographic changes	• Continuously low birth rates and ageing populations • Increase in urban population globally • Changes in the concept of family
Greater cultural diversity	• More cultural exchanges and multicultural socialization • Improvements in women's status
Depletion of energy and resources	• Increased demand for energy and resources • More shortages of food and water • Greater use of energy and natural resources as weapons
Greater climate changes and environmental problems	• Greater global warming and increases in abnormal weather phenomena • More environmental pollution • Changes in ecosystems
Continuing rise of China	• Increase in China's economic influence • Increase in China's diplomatic and cultural influences
Development and convergence of science and technology	• Development of information technology • Development of life science technology • Development of nanotechnology

Source: [*Choi et al.*, 2014].

Fig. 5. **Methods to identify future technologies used in Korea's fourth TF**



Source: [*Choi et al.*, 2014].

type future technology, where future technologies are expected to emerge from the development of S&T regardless of social needs. Technology Push type future technologies include technologies expected to emerge due to the accumulation of S&T knowledge, as well as technologies that currently only exist in conceptual form yet will become visible in the future. The fourth TF used methods such as patent trends, analyses of scientific papers, and technology roadmaps to determine Technology Push type future technologies.

This method enabled a list to be compiled of the 652 future technologies expected to emerge by 2035. As shown in Table 3 below, 601 (92.2%) of the 652 future technologies are expected to emerge to address the needs of society in the future, while only 51 technologies (7.8%) are expected to appear because of developments in S&T. In addition, 394 technologies are related to more than two future trends, which means that more than 60% of future technologies will address future needs related to plural trends. Examining the distribution of future technologies by sector reveals that there are over 90 technologies related to each of the following sectors: machinery, manufacturing, aerospace and astronomy, agriculture, forestry and fishery, and materials and chemical engineering. This is a relatively high indicator. In contrast, the fields of information, electronics, and communication had the lowest number of technologies at 55 each (Figure 6). The reason for the low number of technologies in the latter fields is that technologies utilizing information and communication technologies (ICT), such as biosensor technology, are included in their field of application rather than in the ICT field. Table 4 below gives examples of detailed fields included within their respective fields.

Delphi Survey and Analysis

The fourth TF included a two-round online Delphi survey, which twice collected the opinions of experts. Responses were received from 6,248 people in the first round and from 5,450 in the second round. The number of respondents who participated in the first and second rounds increased significantly compared to the first three TFs (Table 5). Table 6 summarizes the Delphi survey questions used in the fourth TF.

Table 3. **Future technologies identified by Korea's fourth TF and the distribution correlation between future trends**

	Number of future trends related to each technology						Total
	Technology Push	Demand Pull					
Number of technologies	51	207	262	99	29	4	652
Proportion (%)	7.8	31.7	40.2	15.2	4.4	0.6	100.0

Source: calculated by the authors.

Table 4. **Examples of the detailed fields within each field of the fourth TF**

Field	Detailed Field
Machinery, Manufacturing, Aerospace and Astronomy	manufacturing and process, robot, space and exploration, satellite, aircraft, unmanned aerial vehicle, automobile, shipbuilding, defense, counterterrorism, etc.
Agriculture, Forestry and Fishery	crop production, animal science, animal disease, zoonoses, fish farming, tree breeding, forest environment, customized food, etc.
Construction and Transportation	construction material and equipment, building control management system, railroad, aviation, distribution, safety management, etc.
Life and Healthcare	brain science, pathogen measurement, medical engineering, cancer diagnosis and treatment, medicine, artificial organ, oriental medicine, etc.
Materials and Chemical Engineering	functional alloy material, nano-sensor, semiconductor material, medical material, battery, carbon nanotube, chemical process, etc.
Energy, Resources and Extreme Technology	smart grid, electric power, nuclear energy, resource and exploration, solar energy, extreme technology, etc.
Information, Electronics and Communication	virtual reality and augmented reality, display, sensor, telecommunication, information protection, information theory, etc.
Environment and Earth	weather and climate, air quality management, ecosystem restoration, carbon capture and storage, eco-friendly material and process, earthquake, marine environment, etc.

Source: compiled by the authors.

Table 5. **Number of Delphi survey respondents in four TFs**

		1st TF	2nd TF	3rd TF	4th TF
Number of future technology		1174	1155	761	652
Response	1st round	1590	1833	5414	6248
	2nd round	1198	1444	3322	5450

Source: calculated by the authors.

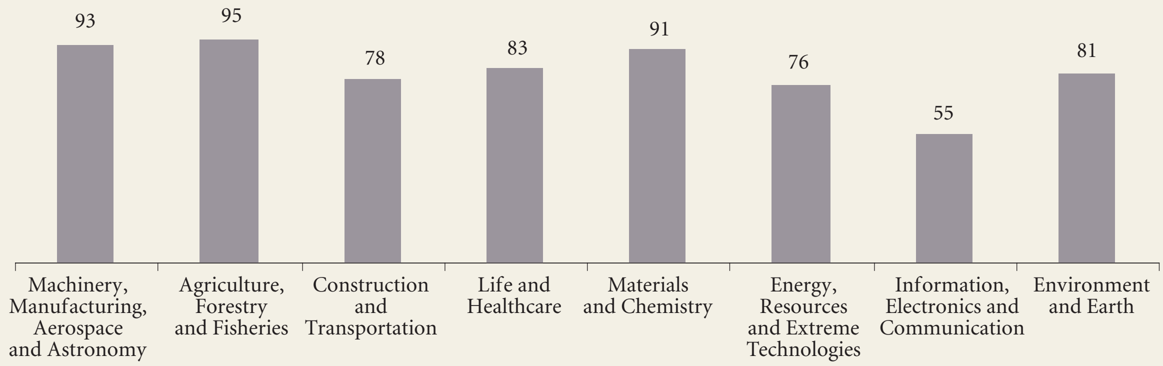
Table 6. **Delphi survey items of the fourth TF**

Survey item	Survey content
Technology level	Nation at the forefront of the technology level
	Korea's technology level
Technological implementation time and social distribution time	Implementation time, and general public use time in Korea
	Realization time and general public use time in most-advanced technology nations
Technological implementation measures	Main actors in R&D
	The need for collaborative research
Role of government	The need for government investment
	Government priority measures to be implemented
Importance in future society	• Contribution with respect to technology aspects • Contribution with respect to public benefits • Contribution with respect to economy and industry
Possibility of negative effect	Possibility of negative effect caused by general public use
Institutions involved in research	Local and international research institutions
Interrelationship with future trends	Relationship to 22 future trends*

* Three technology-related trends were excluded from the 25 future trends.

Source: compiled by the authors.

Fig. 6. **Future technology distribution according to Korea's fourth TF**



Source: calculated by the authors.

The average time for technological implementation of future technologies as determined by the fourth TF was by 2021. The TF predicted their widespread distribution across society to occur in 2023.

When comparing each field's results with the average technological implementation time estimates, the field of information, electronics and communication was the fastest (2019), while the field of life and healthcare was the slowest (2022). Experts surveyed agreed that 519 future technologies (79.6% of the total identified) will be technologically implemented in Korea within the next 10 years (by 2022). Furthermore, they predicted that 294 technologies would be distributed across society within the same period of time. The predicted average time for future technologies to be widely implemented across society is 2.7 years.

When examining the current state of countries with the highest level of technology in relation to the 652 future technologies, the fourth TF found that the United States possesses the highest level of technology in 495 technologies. Japan was second with 141 technologies, and the EU was a distant third with 32 technologies. The research revealed that Korea's average technology levels were 63.4% of the leading countries regarding the 652 future technologies. The level of technology for 18 future technologies was above 80%, which indicates that Korea leads the field in these technological areas, with nine included in the field of information, electronics and communication, which is more than that in any other field. At the same time, the study found that the levels of 22 technologies were below 40% and thus were part of the 'lagging' group, among which nine were in the field of machinery, manufacturing, aerospace and astronomy. Of the 652 future technologies, Korea's highest technology level was in 'terabit level next-generation memory device technologies' (90%).

When examining the priority policy measures that the government should enact to help implement future technologies, the survey results showed that most respondents felt increased R&D funding was highest priority (31.6%). The next most important policies stated were greater collaboration, training for staff, and infrastructure construction. The need for system improvement ranked the lowest; however, it was higher in the construction and transport field (13.8%) and environment and earth sciences (10.4%) than other fields. Future technologies with faster implementation times placed more value on infrastructure construction and system improvements, while future technologies with longer implementation times placed relatively more value on staff training and greater collaboration (Table 7).

Table 7. **Priority policies to support the development of future technologies by time needed for technological implementation based on the results of Korea's fourth TF**
(share of respondents who chose each option, %)

Technological implementation time	Increased R&D funding	Greater collaboration	Staff training	Infrastructure construction	System improvements
Short(-2017)	28.5	20.0	16.9	22.1	12.5
Medium (2018-2022)	31.7	22.9	18.9	18.9	7.6
Long (2023-)	31.9	23.7	22.3	18.3	3.8
Total	31.6	22.8	19.5	19.0	7.1

Source: calculated by the authors.

Unlike the previous TFs, Korea's fourth TF asked about any unintentional negative impacts on society, culture, or the environment of the widespread social distribution of future technologies. Some examples of future technologies with relatively high likelihoods of negative impacts are:

- Technology for building underground waste storage
- Personal life log technology which can create a database by saving one's personal life with sound and image data (Write scenario)
- Gene therapy technology for fetus
- Electro Magnetic Pulse (EMP) bomb disturbing electronic parts in the enemy's weapon system by detonating it in the air of the enemy
- Technology of developing functional transgenic fish species that can produce useful substance (nutritional contents, medicine and medical supplies)
- Conversion technology from uranium-238 to plutonium-239 using the liquid metal reactor.

Six of these technologies were included in a future scenario, accompanied by an analysis of both the positive and negative effects.

The World of the Future Changing through S&T

The main purpose of TF in Korea is to predict the development of S&T and use the results in developing S&T policies. However, informing the public about what the future holds based on the development of S&T is an equally important role of TF. For this purpose, the future world is divided into 13 different areas (home, school, hospital, office, factory and plant, transportation, fishing village, farming village, city, disaster, space, war and terror, and underground) and each area is connected with the future technologies. The scenarios and accompanying illustrations are composed by classifying the future into ten years later (year 2022) and the year 2025 to compare the future world over time (Figure 7). The periods of time when the future technologies are likely to be widely distributed — as determined through the Delphi survey — were used as the reference points for selecting the future technologies specific to each point in time.

Policy Implications

By analysing the Delphi survey results about future technologies as part of Korea's fourth TF, we identified the following policy implications.

First, the share of Korea's technologies belonging to the leading group (level of over 80%) or the next group (level of 61–80%) is 72% of the 478 technologies that experts expect to be implemented within the next five to ten years. Korea has the possibility of joining the world-leading group if it pursues R&D more actively. However, Korean technologies are not yet at the highest level. Therefore, policy support for developing unique technologies is necessary. Creating future

Box 1. **Scenario of a future society (a family in 2035)**

The phone rings while Jung-Hoon and his wife are watching TV. Their daughter appears, smiling brightly, on the TV screen. For a second, Jung-Hoon and his wife think that the drug which their daughter has been taking for three months for depression caused by her inability to become pregnant is effective. The drug their daughter takes is a **non-addictive** chemical that she can take any time **to enhance positive emotions, such as happiness, without causing harm to her body**. The drug regulates crime-related emotions in a calculated manner and improves brain capacities, such as reasoning skills, creativity, and memory storage abilities; therefore, it is used in rehabilitating criminal offenders and rehabilitation education as well as a supplement food for students preparing for a test.

The daughter's news that they hear as soon as they answer the phone brings joy greater than her bright face. 'Dad, Mom, I'm pregnant!' The daughter says that the device she received a while back from her friend greatly helped, and she begins to explain the process one by one, from the strange feelings she was getting these days to visiting the hospital and hearing the news of her pregnancy. The friend's present is **a portable device that tells the user her biological cycle, and it diagnoses the bio-molecular changes related to pregnancy and predicts the possibility of pregnancy to inform her when she is at her optimal fertile period.**

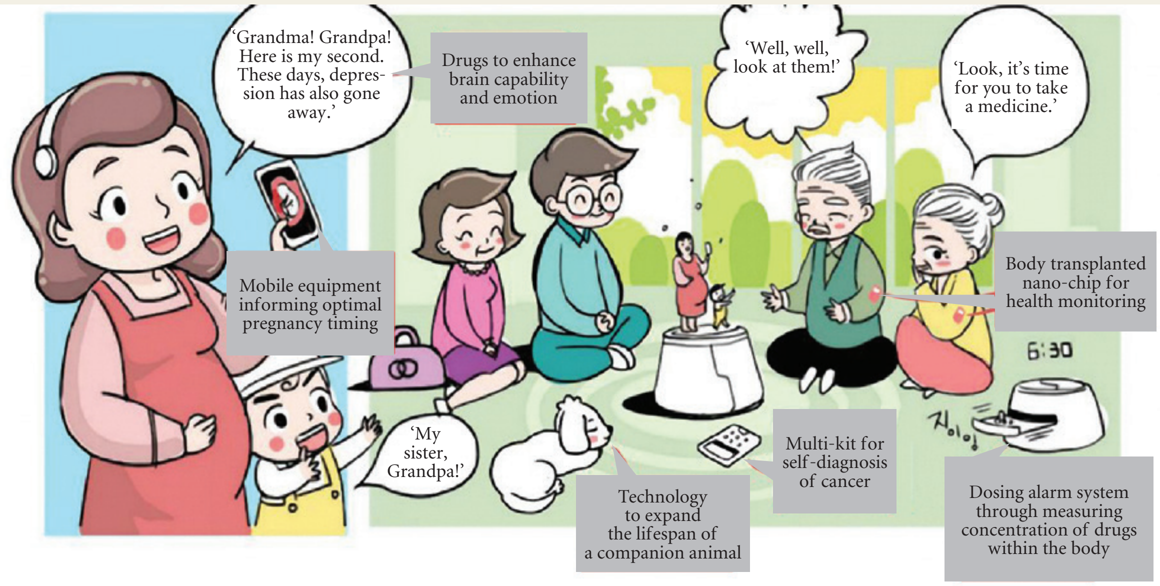
After the phone call with her daughter, Mi-Young runs into the room. "What are you up to?" asks Jung-Hoon as Mi-Young opens the drawer looking for something. 'We must stay healthy if we want to see our grandchild… Found it!' Mi-Young heads to the bathroom holding a cancer diagnostic kit. **The cancer diagnostic kit is a self-diagnostic kit that is able to identify the five major cancers from urine and even helps the user discover cancers with very few early symptoms, such as liver cancer.** 'What are you doing? You should also get tested.' As Jung-Hoon holds the diagnostic kit waiting for the results, a smile spreads across his face as he thinks about the new family member they will soon meet.

Source: [NSTC, KISTEP, 2012b].

technologies requires a diversity of 'technology sprouts' as successful development and the ripple effects of success remain largely uncertain.

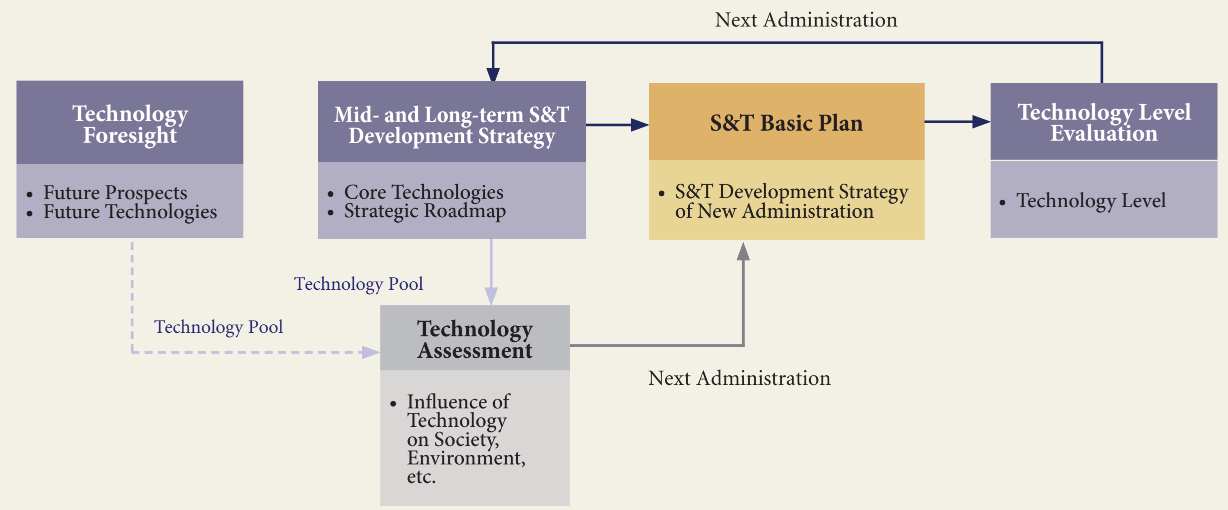
Second, achieving advanced technologies effectively is possible through joint research between industry, universities, and research institutes as well as through international collaborative research. Furthermore, the high demand for staff training and infrastructure construction, as identified by our analyses, indicate that future technologies require systemic support in the medium and long-term. At the same time, it is important to implement policies to minimize the adverse effects of certain future technologies through Technology Assessment mechanisms.

Fig. 7. **Illustration of the scenario (a family in 2035)**



Source: [NSTC, KISTEP, 2012b].

Fig. 8. **S&T planning activities in Korea**



Source: compiled by the authors.

Third, it is important to pay sufficient attention to the social aspects of S&T, given the importance and possible consequences (the ripple effect) of social problems in the future. By carrying out national R&D projects that address these kinds of issues, the effectiveness of S&T in responding to future issues will be strengthened (together with other solutions). To achieve this goal, it is necessary to analyse future issues and existing factors, including the implementation time of future technologies, the level of technology, and the R&D Plan. Furthermore, an optimal technological development strategy is required that would set out the priorities taking into account the roles of each technology in solving specific issues, and clarify the roles and accountability mechanisms of various government departments and research institutes.

Technology Foresight and S&T Planning

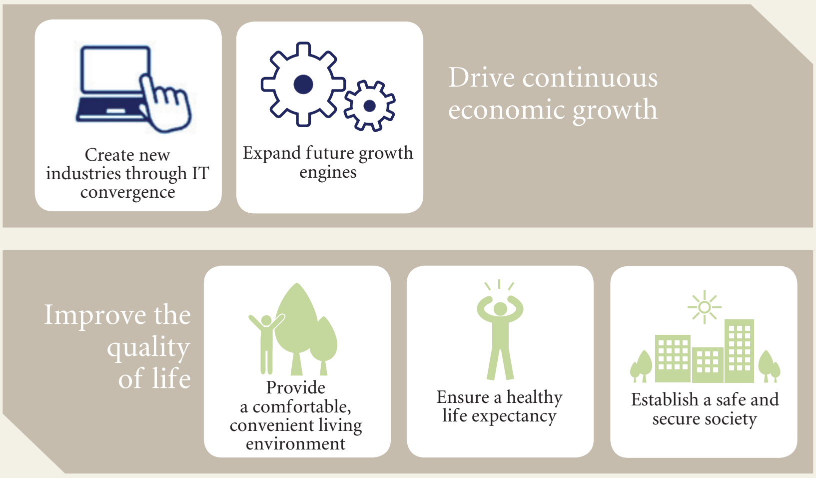
Korea develops a new S&T Basic Plan every five years alongside the launch of a new administration. All S&T planning activities at the national level are connected with the S&T Basic Plan (Figure 8). The National Mid- & Long Term S&T Development Strategy selects the national core technologies based on the future technologies determined by the TF and establishes a strategic roadmap for these technologies. These results are reflected in the focused initiatives related to the technological development of the S&T Basic Plan. The 652 future technologies identified by the fourth TF went through a reviewing process by committees responsible for the national R&D budget as well as by R&D-related ministries. As a result, a list of 120 national strategic technologies was compiled; these technologies were also identified by the third S&T Basic Plan (Figure 9).

The importance attributed to Korea's technology foresight (TFs) has grown with every round of TF. Accordingly, the third TF — in contrast to the two preceding TFs in which only scientists and engineers participated — examined future social development and factors of demand to identify future technologies that could address society's demands. Moreover, the third TF was modified to ensure closer integration with the 5-year S&T Basic Plan and help provide a systemic basis for national level S&T planning. In this process, TFs have consistently provided background information that feeds into policies and medium and long-term S&T strategies.

In addition to the TF, Korea regularly conducts Technology Level Evaluation and the Technology Assessment exercises (Figure 8). The Technology Level Evaluation targets the national strategic technologies as indicated in the S&T

Fig. 9. **The third S&T Basic Plan: Developing national strategic technologies**

Cultivate 120 national strategic technologies in five key areas



Source: [MSIP, KISTEP, 2013c].

Basic Plan, and takes place every two years. The Technology Level Evaluation exercise compares the technological levels of Korea, the United States, China, Japan, and the EU using Delphi survey methods, patent analyses, and research paper analyses [MSIP, KISTEP, 2013b]. Those who devise strategic roadmaps for national core technologies use the results of this evaluation as inputs.

The Technology Assessment evaluates the positive and negative impacts caused by new S&Ts on areas such as the economy, society, culture, ethics, and the environment. It also suggests ways to enhance the positive impacts and avoid the adverse effects. Korea conducts a Technology Assessment annually, and as part of this assessment surveys not only experts from the humanities, social sciences, and S&T, but also members of the public. Recently, the country undertook a Technology Assessment on big data [NSTC, KISTEP, 2012a] and 3D printing [MSIP, KISTEP, 2013a]. The process of selecting a target technology for Technology Assessments draws on the list of future technologies identified by TFs. The results of the Technology Assessment are reflected in the research plans regarding R&D projects in the corresponding fields. Furthermore, the results of the Technology Assessments are not only taken into account when formulating the S&T Basic Plan but also when devising policies to minimize the negative impacts of new technologies. F

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Priorities Setting with Foresight in South Africa

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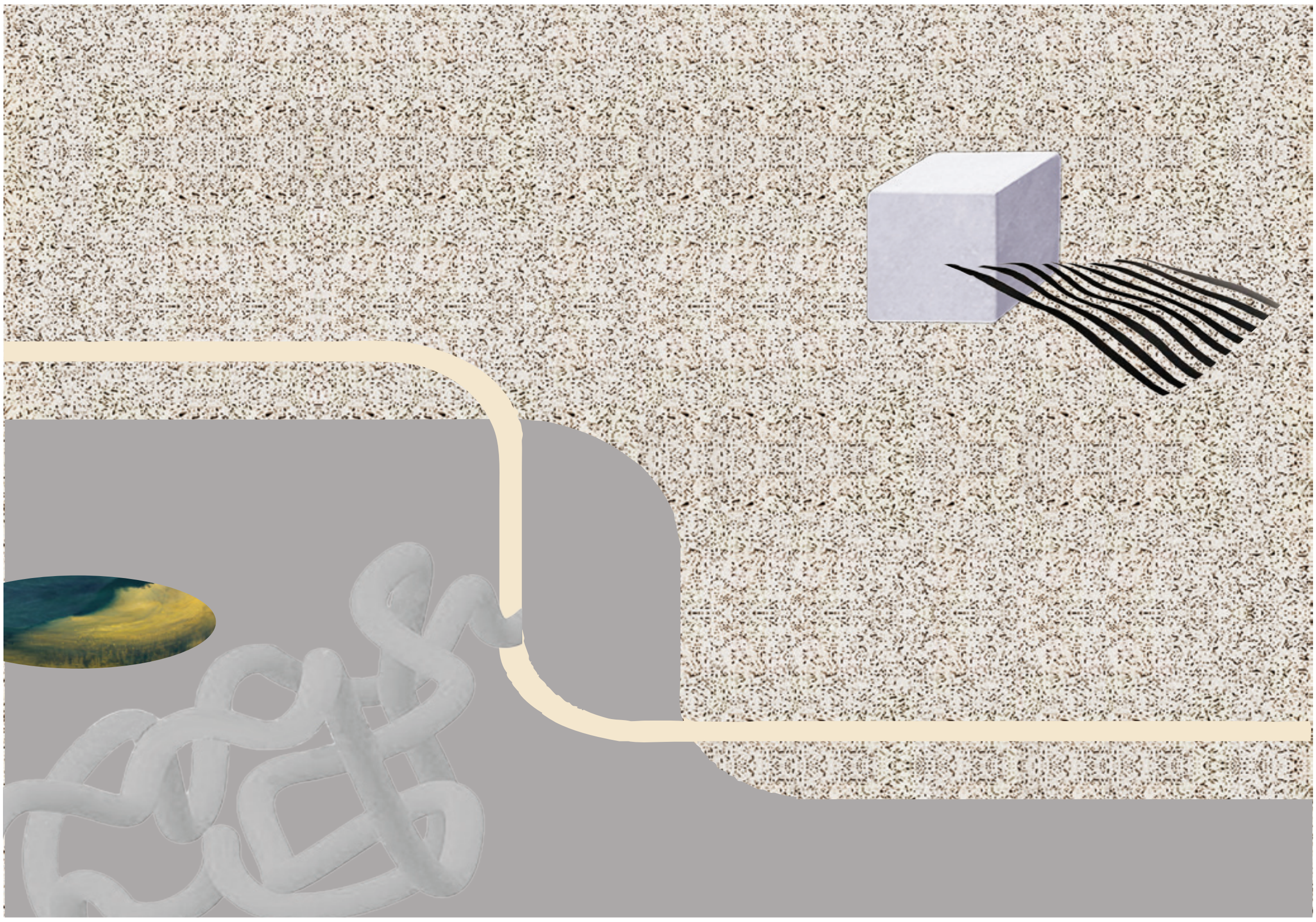

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Abstract

South Africa has only irregularly undertaken exercises to identify priority technology areas, despite government recognition of their importance. Moreover this activity has no institutional frameworks. This article reviews past efforts in this field in South Africa.

In the end of 1990s, the Department of Arts Culture, Science and Technology announced the results of the National Research and Technology Foresight. One of the key implications of these results was that, in contrast to the rest of the world, South African stakeholders fail to recognize the importance of emerging technologies such as nanotechnology, micro-production as well as simulation technologies as cost-effective components of new product and process development. These results appear to have permeated the STI policy and as a result, the country appears to be lagging in terms of research in emerging technologies.

The main focus of the authors is on the findings of the most recent effort supported by the Department of Trade and Industry to identify changes in industrialists' opinions related to technology priorities. The recent results indicate that the country is integrating into the global economy, as national priorities are converging with priorities elsewhere.

Keywords: Foresight; science and technology (S&T) priorities; national innovation system; South Africa
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The broad field of futures research has evolved from the United States since the 1950s and 1960s. There is an extensive list of names used in this field interchangeably when referring to futures research such as long range planning, technology assessment, technology forecasting, technology Foresight and others. The term 'technology Foresight' is used in this study.

Irvine and Martin's seminal work provided one of the first definitions and understandings of Foresight and led to a proliferation of relevant exercises [*Irvine, Martin,* 1984].

Foresight took off in the 1990s as European and then other countries began to concentrate their investments in promising areas of science and technology [*Martin*, 1995]. Several countries including Japan, United Kingdom, France, and Germany have undertaken their own large-scale Foresight exercises. Some of these countries began to establish relevant organizations with a mandate to inform policy. The practice has spread widely and many developing countries have launched their own Foresight exercises.

According to [*Martin,* 2002], technology Foresight is defined as a 'process that systematically attempts to look into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the emerging generic technologies and the underpinning areas of strategic research likely to yield the greatest economic and social benefits'.

Japan has been one of the leading countries in identifying future technologies since the 1970s. Foresight activities have been institutionalized in the shape of the National Institute of Science and Technology Policy (NISTEP), which is an organization affiliated with MEXT (Ministry of Education, Culture, Sports, Science and Technology) [NISTEP, 2010].

Foresight exercises are widely recognized as an appropriate tool in science, technology and innovation (STI) policy design and decision-making processes [*Havas et al.,* 2010]. The results of the exercises are often used to identify research priorities, orient policies, and to advise on promising areas for policies. According to Meissner and Cervantes, there is a correlation between the use of technology Foresight and a country's innovation performance, indicating that technology Foresight has a positive economic impact on a country's innovative potential in the long-term [*Meissner, Cervantes,* 2008]. Furthermore, Pietrobelli and Puppato argue that the successful development trajectories in both Korea and Brazil were partially due to the efforts to link Foresight exercises with industrial strategies [*Pietrobelli, Puppato*, 2015].

The objective of this article is to review a number of such efforts in South Africa and to report the findings of a recent survey. The recent survey aimed to identify the opinion of relevant stakeholders/industrialists related to the technological needs of the country and to confirm or refute the findings of the dated national Foresight exercise.

The paper outlines the Foresight projects carried out in South Africa over several decades. The latest survey identified the opinions of industrialists and other stakeholders related to the technological priorities of South Africa and updated the findings of the previous national Foresight exercises.

Strategic Priority Areas in Technology Development in South Africa: lessons from the 1990s and 2000s

South Africa has undertaken processes to identify priority areas in technology irregularly. The earliest investigation was undertaken by the Foundation for Research Development (now the National Research Foundation) in the early 1990s [*Blankley, Pouris*, 1993]. The investigation first identified the critical technologies of importance that have been developed in other countries. Next, the respondents — representing large companies with their own research and development (R&D) departments, the then South African Scientific Advisory Council, and others — were asked to rate the various technologies by perceived importance.

Figure 1 shows the results of the ranking. Over 50% of respondents identified environmental technologies as being the most important. Computer Networks and communication systems followed closely behind (49%). In third place were software development (42%) and advanced materials and composites (40%).

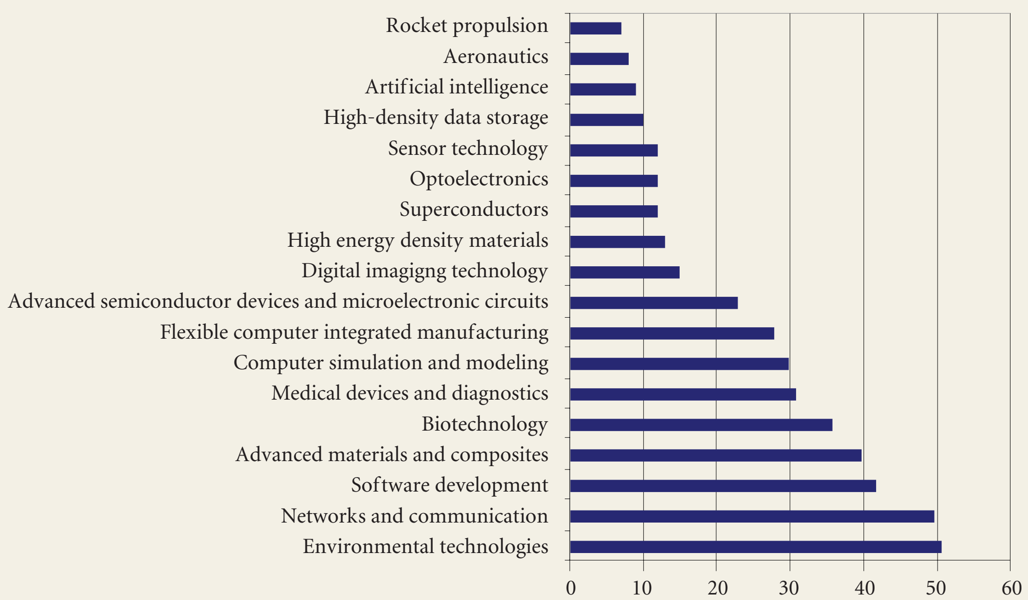
The first official Foresight exercise was undertaken by the Department of Arts, Culture, Science and Technology (DACST). DACST undertook and published the National Research and Technology Foresight (NRTF), which was inaugurated in July 1996 and conducted over a two year period between 1997 and 1999. The results were published in 2001.

The government intended to utilize the results of the Foresight exercise Foresightas inputs in government and private sector R&D investment decision-making, and to strengthen the capacity for research in the higher education sector [DACST, 1996].

The NRTF study focused on the following sectors of science and technology policy:

- Agriculture and Agro-processing;
- Biodiversity;
- Crime Prevention, Criminal Justice and Defence;
- Energy;
- Environment;
- Financial Services;
- Health;
- Information and Communication Technologies;

Fig. 1. **Distribution of Critical Technologies Rated as Extremely Important by Top Decision Makers: Results of a Foresight Exercise in the early 1990s**
(share of respondents who rated each technology as most important, %)



Source: [*Blankley, Pouris*, 1993].

- Manufacturing and Materials;
- Mining and Metallurgy;
- Tourism;
- Youth.

The concept of the survey was based on similar work carried out in other countries. Of the 1500 questionnaires distributed to representatives of the manufacturing sector, 150 were returned. The response rate was hence 10%. The relevant committee accepted this was a good response. To analyse the statements, we developed three indices: wealth creation (WC), quality of life (QL), and a combined index (an average of the first two indices). As a representative example, Table 1 below shows the statements that received the most support from respondents in the manufacturing sector.

The majority of the top-voted statements are policy related. By this we mean that tertiary education institutions, for example, will be transformed to ensure the high quality of appropriate skills, or that industry specific clusters will be created.

The future technologies identified are listed in Tables 2–3 below. The technologies rated as most important were: intelligent communication systems; design and fabrication technology; and concurrent engineering technologies such as CIM, CAD, CAM, etc. The experts considered the least promising technologies to be: biological structures (biotechnology); semiconductor manufacturing technologies; bio-mimetic systems; 'smart' energy buildings; micro- and nano-technologies for fabrication processes; and ceramic materials for high-temperature gas turbines.

It is worth pointing out that respondents did not consider 'futuristic technologies' important. Likewise, the significance of simulation technologies, which are acknowledged worldwide as a cost-effective component of new product and process development, was given limited prominence. The report stated that the typical issues (such as nano-technology and micro fabrication) recommended for future development by Foresight exercises of Pacific Rim countries were only given moderate importance; in some cases, they made up some of the ten least important issues. Moreover, the report highlighted the need for South Africa to improve decision making and the development of niche production.

The next large-scale Foresight project was carried out in South Africa in 2004 by the Department of Trade & Industry (DTI). The resulting report entitled 'Benchmarking of Technology Trends and Technology Developments' study aimed to encompass the following industrial sectors: ICT, tourism, chemicals, biotechnology, automotive industry, aerospace, metals and minerals, culture, clothing & textile and agro-processing. The study endeavoured to identify global technology development trends, specific current and emerging technologies, and the role of such technologies in sectoral development [DTI, 2004].

Within the ICT sector, the most important future technologies were estimated to be wireless network technologies, open source software, telemedicine, and grid computing. In the tourism sector, mobile, environmental, and cultural heritage technologies were considered as highest priority (Table 4).

Strategic Priority Areas in Technology Development in South Africa: up to 2020

The year 2012 marked a new round of updating the country's industrial technology needs with future planning up to the year 2020, a process carried out by the Department of Trade & Industry. A preliminary list of

Table 1. **Evaluation of statements by respondents in the manufacturing sector for the NRTF Foresight Exercise**

No	Topic	Combined Index	WC Index	QL Index	Constraints*
54	Tertiary education institutions (universities and 'technikons') will be transformed to ensure high quality, appropriate skills development that can support a strong manufacturing base	91.94	93.55	90.32	HR, P, F, Soc/Cul
06	Widespread availability of venture capital to enhance the innovation of new products and processes in South Africa	89.29	83.33	82.14	F, P
04	Practical implementation of industry-specific clusters in South Africa to enable the clusters to innovate and compete on world markets	85.63	93.48	77.78	P, HR, F, M
58	Government's appropriate trade and legislative framework will support local industry to meet the challenges of international competition	85.42	87.50	83.33	P
07	Widespread use of intelligent communication systems that will enable SMEs to effectively integrate their skills and knowledge with their chosen industrial partners to form wealth-creating businesses	74.32	78.38	70.27	F, HR, T
60	International transfers and relationship building in the public and private sectors will tangibly help South Africa to use leapfrog technologies to forge ahead	74.32	75.68	72.97	P, HR, F, Soc/Cul
32	Management of new process innovation will be key success factor for most South African companies in the future	74.07	81.48	66.67	HR, T, Infrastr
08	South Africa's manufacturing production will be predominantly characterized by raw material beneficiation through training of downstream processors on value chain management, design and fabrication technology	72.55	78.43	66.67	HR, T, F
03	Practical application of free-trade zones that will facilitate a regulatory framework for importers and exporters to maintain manufacturing standards in the country of product origin leading to the world economy	69.71	81.08	58.33	P
11	South Africa becomes niche-focused in its manufacturing industry and thus becomes a world leader in a limited number of products	67.27	70.91	63.64	T, HR, Infrastr, F
09	Mass customization of products, reduced product life cycle, shorter lead times etc. will become an important driver for South African suppliers to maintain market share on a global basis	65.63	77.08	54.17	T, HR, F
25	Widespread use of practices to eliminate variability in practices and processes is fundamental to competitive manufacturing	61.46	72.92	50.00	HR
61	Widespread use and adherence to international environment and quality standards such as ISO9000, ISO14000 and QS9000, VDA6, SABS series, etc. by South African companies to become competitive and internationally recognised	60.29	62.12	58.46	HR, P, F, Soc/Cul
57	In the future, access to mainstream economic and social activities will discriminate between technologically literate and technologically illiterate individuals and groups	58.47	56.41	60.53	HR, Soc/Cul, P, F
12	South Africa's manufacturers develop small-batch manufacturing capabilities for a competitive edge	58.16	65.31	51.02	T, HR, F, M
31	Development of recycling industry (water, raw materials) that will result in waste-free manufacturing	57.14	42.86	71.43	T, P, F
46	Widespread use of concurrent engineering technologies (CIM, CAD, CAM, etc.) to improve time-to-market by South Africa's manufacturing industries	53.41	68.18	38.64	HR, F, T
29	Widespread use of industrial design skills where designer materials will be a fundamental part of new products in the future	53.13	62.50	43.75	HR, T, F

* HR – human resources; P – political; F – financial; T – technological; M – market; Soc/Cul – socio-cultural; Infr – infrastructure.

Source: compiled by the authors.

Table . 2. **List of future technologies from the 1999 Foresight exercise: short-term horizon**

Group of technologies	Components
Continued process and product development of basic materials	• Alloy development; • Polymer development, especially through indigenous coal-based technologies; • Indigenous biomaterials, e.g. natural fibres; • Further processing of precious metals e.g. Platinum group
Downstream product technologies for metal products (e.g. stainless steel, aluminium, precious metals)	• Near-shape processing technologies; • Deeper knowledge and research in optimized technologies for metal forming and joining; • Design and integration of materials in optimum products
Downstream product technologies for polymer products	• Advanced moulding technologies; • Computer-based analysis to support product and process design; • Life-cycle management; • Simulation, modelling and visualization
Computer-based support technologies	• Product design optimization (including virtual prototyping); • Process design and optimization (including plant operation and layout); • Tooling design
Design/product data interchange in value chains	• Development of more energy-conserving processes for raw materials treatment and usage

Source: compiled by the authors.

technologies that are significant for certain sectors up to the year 2020 was developed based on the experiences of the United Kingdom [Government Office for Science, 2010].

Methodology for selecting technology priorities

We developed an open-ended questionnaire related to technology trends and distributed it to several stakeholders, including representatives of key sectors under the remit of the Department of Trade & Industry. The questionnaire was also sent out to researchers possessing close ties with industrial associations, the Technology and Human Resources for Industry Programme (THRIP), and the Council for Scientific and Industrial Research in South Africa (CSIR), and other organizations.

The response rate was 22%. Compared to similar exercises, this response rate is satisfactory. The first national Foresight exercise in South Africa got a response rate of just 10%. Most responses came from experts in the chemicals and pharmaceuticals industries (10), followed by the automobile sector (8), textiles, clothing and footwear industry (7), energy (6), and heavy industry (6). An analysis of sectors' current characteristics allows

Table 3. **List of future technologies from the 1999 Foresight exercise: long-term horizon**

Group of technologies	Components
Development of capabilities to implement 'miniaturization' and 'smartness' into products	• Increase precision manufacturing and near-shape technologies; • Direct manufacturing technology ('free-form manufacturing without tooling'); • Integrated sensor/actuator technologies into products
Development of customized materials designed for specific product needs	• Improved methodologies for materials design and development; • Designing with environmentally-friendly/recyclable materials
Development of a manufacturing industry aimed at niche 'information-age' products based on local strengths, despite having essentially missed out on the opportunities of the semiconductor/active materials era in the 1970–1990s	
Introduction of biotechnology development methods to natural fibre optimization for structural composite applications	

Source: compiled by the authors.

Table 4. **Priority technologies identified in the 2004 Foresight exercise by the DTI**

Sector	Technology
ICT	• Wireless Network Technologies • Home Language Technologies • Open Source Software • Telemedicine • Geomatics • Manufacturing Technologies • Grid Computing • Radio Frequency identification (RFID)
Tourism	• Mobile Technologies • Wireless Technologies • Internet • Human Languages • Environmental Technologies • Cultural Heritage Technologies
Chemicals	• Extraction of minerals from coal ash and low value slag • Fluorine generation and fluorinated organic chemical intermediates, • New performance chemicals improving the recovery of minerals in the mining sector such as polymer used in solvent extraction processes • Technologies decreasing economies of scale for chemical plants and hence enabling smaller production facilities to compete against the mega plants • Low-cost diagnostics and aroma chemicals production • Development of biodegradable and high-performance polymers • Bio-diesel and products from alpha-olefins • Generic pharmaceuticals for meeting future demand for antibiotics and/or anti-retroviral
Biotechnologies	• Recombinant therapeutic products and production of generic medicines • Vaccines against important infectious diseases such as HIV/AIDS, TB, malaria, rotavirus and diarrhoea • Diagnostics methods used for screening, diagnosis and monitoring or prognosis of diseases by laboratory methodologies • Commodity Chemicals from Biomass • Energy from Renewable Resources like plant biomass • Biocatalysts
Automotive Industry	• Development of lightweight materials • Development of alternate fuels e.g. fuel cell technology • Sensors, electronics and telematics • Improved design and manufacturing processes
Aerospace	• Development of composite materials • Development of hyper aero-thermodynamics • Development of sensor usage • Health and usage monitoring systems • Noise abatement • Improved manufacturing processes
Metal & Minerals Sector	• Light materials extraction • Alloy technologies, especially in magnesium • Process improvement
Cultural Sector	• Product Technologies • Internet • Online Marketing • Mobile Technologies • Wireless Technologies • Advanced Materials • Human Language Technologies • E-Commerce • Environmental Technologies • Portals

Table 4 (continued)

Sector	Technology
Clothing & Textile	• Intelligent Textiles • High-performance and technical textiles • Value-Added Natural Fibres - testing systems for foreign fibres in Mohair and wool; yarn formation; dying and finishing technologies • ICT for product and process improvement
Agro Processing	• Real-time detection of micro organisms in food • Sensors for online, real-time control and monitoring of food processing • DNA / RNA chip technologies to speed detection and analysis of toxins in foods • Food pathogen sensors • Separation modules that force molecules into confined environments • Real-time detection systems for verification and validation of intervention technologies used in Hazard Analysis and Critical Control Points (HACCP) systems • Better understanding of tolerable intake levels for nutraceuticals/dietary supplement components • Techniques to inactivate micro organisms to yield safer foods with extended shelf lives • Standardized edible food packaging films • Biological (e.g. bacteriocins) and chemical inhibitors to prevent or slow growth of pathogens in food • Technologies for food traceability

Source: [DTI, 2004].

us to draw the following picture. The majority of respondents were in the manufacturing industry, while a smaller proportion was in distribution and assembly. The average age of respondents' companies was 33 years old. Companies employed 900 people on average. Almost two thirds (63%) of companies declared that they exported their products in sectors such as metallurgical and chemical products, textiles, electronic components and equipment, etc. Approximately a quarter of respondents claimed to be importers, primarily in semi-processed chemical materials, metallurgical rolled stock, power facility and electronic components, medical and pharmaceutical products, etc. Most imported products come from the US and Europe, although a significant share of imports is from Japan, China, and India.

Respondents identified the US, and countries of Europe, Asia, and Africa as potential markets. Respondents said that their companies' turnovers ranged from one million to more than two billion South African Rand (approximately USD 77,416 to USD 155 million).

Main results

From the 20 technologies in the list, advanced manufacturing technologies were most often identified as key technologies (58% of expert respondents). The second most frequently cited key technologies were those connected to modelling and simulation for improving products and processes, reducing the design-to-manufacturing cycle time, and reducing product implementation costs (34% of respondents). Intelligent sensor network and global computing technologies came in third place (16%).

The technologies in various sectors that respondents identified as being of most importance at both the current time and in the next 5–10 years are shown in Table 5 below.

Table 6 shows the barriers to technological innovation as identified by respondents. The most frequently cited barriers were the high costs for innovation, inadequate funding, and lack of necessary resources. It is note-

Table 5. **Technologies perceived by respondents as important today and in the next 5-10 years, by sector**

Sector	Most important technologies	
	Today*	In the next 5–10 years
Aerospace and defense	• Industrial robotics (we are consumers and purchase products from overseas suppliers) • Micro-manufacturing (infancy) • Precision mechanical manufacturing (very important) • Data fusion software (in process) • Infrared optical systems (in process) • Electro-chemical processes • High-speed machining • Additive manufacturing technologies • Space grade sub-systems (in process) • Radar, radio frequency, microwave, electro optics	• Infrared imaging technology manufacturing • Laser communication systems • Embedded software for space systems for radiation tolerant systems • Improved industrial robotics • More energy and eco-friendly systems • Radar, radio frequency, microwave, electro optics
Electronics and ICT	• Biometrics (limited) • RFID (limited) • PDA's (available but without local support) • Geographic register for South Africa • Secure and reliable communications • Precision mechanical manufacturing (very important) • Space grade sub-systems (in process) • Linux software development (mid to high importance for free software)	• Biometrics • Infrared imaging technology manufacturing • Laser communication systems • Geographic register for South Africa • Secure and reliable communications • Embedded software for space systems for radiation tolerant systems • Space grade sub-systems
Clothing, textiles, leather and footwear	• Energy efficient processing machinery • Industrial robotics (imported) • Colour physics • Micro-manufacturing (infancy) • Micro-processor controlled machinery with interactive capability	• Flock printing • Coating • Anti-microbe technology • Alternate means of treatment and disposal of factory process effluent • Micro fluidic sensors and diagnostics, lab on a chip • Improved industrial robotics • More energy and eco-friendly systems • Renewable energy
Automobile	• Biotechnology-specific application that are industrially relevant • Stainless steel manipulation • Automation of the manufacturing process • High speed machining • Hybrid Injection moulding machine (advanced) • Robot Welding (available) • Vacuum Forming (available) • Electro-chemical processes • Powder technology/sintering • Automobile raw material supply chain and value add (not nearly sufficiently available) • Automobile tier 1&2 manufacturing supply upgrade technologies (not nearly sufficiently available) • International partnerships for technology (not sufficiently available) • GRP manufacturing processes (not fully available in South Africa) • Film for covering glass for security and heat load (not available in South Africa) • Better utilization of available energy resources, including solar energy and fuel cell technology	• Develop further use of polyurethanes • Metal pressing • Manufacturing expertise for renewable energy • Automobile tier 1 & 2 manufacturing facilities • World class infrastructure manufacturing support • High temperature sintering • 5-axis high speed machining (HSM) • Additive manufacturing technologies • Material technology change • Manufacture of plastic canopies • Polyurethane technology

Table 5 (continued)

Agro-processing	• Electronic human interaction platforms (technology available only in imported third and fourth tier end user devices and applications. No visible first or second tier end user support for ICT in the sector) • Modern can & closure manufacturing (status evolving) • Modern metal deck printing technologies • Barrier technologies for safer food storage (not available in South Africa) • Food biotechnology	• Oil stabilisation • Catalysis to upgrade fuel • Water gas shift • Hydrogenation of pyrolysis oils • Modern can and closure manufacturing equipment • Tool & die design and manufacturing • Modern metal deck printing technologies • Emulsifiers • Gasification
Chemicals and Pharmaceuticals	• Barrier technologies for safer food storage (not available in South Africa) • Biopolymers, antibacterial polymers (not available in South Africa) • Sensing and smart polymers (not available in South Africa) • Advanced process control systems (chemical transformation unit operations) • Powder technology/sintering • Sterile manufacturing • Biotechnology (industrially relevant applications)	• Biotechnology (industrially relevant applications) • Pyrolysis, oil stabilization, catalysis to upgrade fuel, gasification, water gas shift • Hydrogenation of pyrolysis oils • Micro fluidic sensors and diagnostics, lab on a chip • Polymers based on bio-sources • Sensing and smart polymers • Automated sterile manufacturing
Creative Industries (Craft, film, television, music, games etc.)	• IT Security • Digital animation • Secure Communications • Secure Printing (personalized and tamper-proof documents)	• Secure fast internet lines • Visualization of complex data • Secure printing (personalized and tamper-proof documents) • Secure communications • Co-creation tools
Energy	• Renewable solutions, design and manufacture • Small wind turbine design and manufacture • LED lighting technologies • Induction cooking for mainly residential market • Heat pumps for water heating high in both residential, commercial and industrial markets • Renewable technologies for mainly residential market	• Small wind technology • LED lighting technologies • Hot water systems • Renewable sources • Improved industrial robotics • Plasma technology, nuclear technology, nanotechnology, mineral beneficiation • Small wind technology • Manufacturing expertise for renewable energy • Better utilization of available energy resources, including solar energy and fuel cell technology
Metallurgy, Capital and Transport Equipment	• Router moulding, plastic injection moulding • Complex brackets using different materials • Robot welding • Casting, forgings manufacturing • On-board computer electronics • Display modules • International partnerships for technology (not sufficiently available) • Automobile tier 1 & 2 manufacturing supply upgrade technologies (not nearly sufficiently available) • Automobile raw material supply chain and value added (not nearly sufficiently available) • Casting • Wear casting (available) • Electro-chemical processes • High speed machining • Additive manufacturing technologies • Industrial robotics (we are consumers and purchase products from overseas suppliers) • Micro-manufacturing (infancy)	• Router moulding, plastic injection moulding • Complex brackets using different materials • Robot welding, casting, forgings manufacturing, on-board computer electronics, display modules • World class infrastructure manufacturing support • Automobile tier 1 & 2 manufacturing facilities • Improved industrial robotics • Plasma technology, nuclear technology applications, nano-technology, mineral beneficiation • More energy and eco-friendly systems

* The status of technologies stated in brackets is as described by respondents.

Source: compiled by the authors.

Table 6. **Barriers to technological Innovation** (share of respondents who chose each option, %)

Barriers to technological innovation	Degree of influence		
	Low	Average	High
Innovation costs too high		10	18
Inadequate funding		11	20
Lack of necessary resources		12	18
Excessive perceived economic risk	4	11	15
Licensing constraints	19	7	2
Lack of qualified personnel	3	15	12
Lack of customer demand for new goods and services	8	14	8
Insufficient flexibility of standards regulation	11	9	10
Organizational inertia within company	8	12	6
Lack of marketing information	12	10	5
Lack of technology information	13	8	6
Lack of cooperation with other firms	12	12	5
Other (specify)			2

Source: calculated by the authors.

worthy that more than 50% of respondents identified a lack of financial resources as a critical barrier.

56% of responses stated that they acquire technology through their own R&D (Table 7). The next most commonly used approaches are by having formal agreements with local companies (13%) and with foreign companies (12%). Only 18% of the companies mentioned acquire technology through imitation. It should be emphasized that a number of companies mentioned that their research was done abroad.

Table 8 shows the policy measures identified by stakeholders as useful for their sectors. The most frequently cited measures were fiscal incentives (23%), innovation programmes (21%), and technology platforms (20%).

Participants of the survey offered several suggestions to promote and support local production, including:

- Provide more training on local product development skills;
- Boost exports;
- Improve skills in fundraising to attract investment;
- Make raw materials available at globally competitive prices;
- Provide financial and time resources for concept testing;
- Liberalize labour laws;
- Modernize transport and logistical infrastructure;

Table 7. **Acquisition of Technologies** (share of respondents who chose each option, %)

Undertake own research and development	22
Through formal agreements with companies abroad (e.g. licensing)	12
Through formal agreements with local companies	13
From universities and research councils	10
Through embodied technology in equipment and machinery	9
Through imitation	7

Source: calculated by the authors.

Table 8. **Useful policy measures**
(share of respondents who chose each option, %)

Question: Which policies could help your organization's activity?

Cluster Initiatives	11
Technology Platforms	20
Innovation Programmes	21
Regulation	10
Competition Regulation	5
Quality Regulation (Labelling, Procurement)	8
Fiscal Incentives	23

Source: calculated by the authors.

- Reduce duty exemptions for Southern African Development Community (SADC) countries.

Almost half of respondents (47%) said they participate in government technology support programmes. Suggested ways to improve such programmes included:

- Increase funding for R&D;
- Provide funding for purchase of capital equipment;
- Increase the salaries for postgraduate students;
- Improve the quality of skills and educational programmes;
- Respond more quickly to enquiries from business;
- Reduce bureaucracy;
- Provide R&D commercialization opportunities for local developers and inventors.

Conclusions

Over the last three decades, the concept of Foresight has become one of the most important tools for priority-setting in science and innovation policy. Typical rationales for Foresight exercises have included exploring future opportunities and reorienting science and innovation systems in parallel with building new networks and bringing new actors into the strategic debate [*Georghiou, Keenan*, 2006]. It should be emphasized that Foresight exercises are pursued at different levels, ranging from the organizational to the supranational.

Developing countries or countries with small innovation systems have the potential to benefit from Foresight exercises as well as more developed countries. Selectivity is important for these countries, however, as the costs of offering uniform horizontal support to all industrial sectors would be too high and probably not feasible [*Lall*, 2004]. Similarly, technologies are not freely available and can only be absorbed if the country is willing to assume the associated costs and risks. Foresight exercises can undoubtedly provide valuable guidance on the above issues.

In South Africa, in contrast to the rest of the world where prioritization exercises are institutionalized and regular, prioritization efforts are undertaken intermittently and are usually the result of efforts by individual government departments and/or government agencies. This lack of prioritization and coordination of research and innovation agendas has exaggerated the imbalances within the country's system of innovation. Furthermore, industrial enterprises are forced to set up their own technology monitoring mechanisms which leads to substantial diseconomies of scale within the system.

It is interesting to discuss the findings of the most recent survey (2012) in light of the results from the 1999 Foresight exercise and international experiences. An important finding of the 1999 Foresight exercise was that the participants/stakeholders did not see 'futuristic technologies' as important. The most frequently mentioned technologies recommended for future development in Foresight processes in the world's leading countries were only given moderate importance in South Africa in 1999 (and in some cases were among the ten least mentioned technologies, e.g. nano-technology and micro-production). Similarly, the power of simulation technologies, which are acknowledged worldwide as cost-effective components of new product and process development, was given limited prominence. It should be mentioned that the results of the 1999 Foresight appear to have permeated the scientific and technological system and as a result, the country appears to be lagging in terms of research in emerging technologies [*Pouris*, 2012].

In contrast, the 2012 survey found that stakeholders recognized the importance of emerging and enabling technologies. ICT related technologies (such as secure internet communications, biometrics, robotics, sensors, etc.), biotechnology, and clean energy technologies) were identified by stakeholders as of current importance. Similarly, stakeholders identified 'advanced manufacturing technologies', 'modelling and simulation for improving products, perfecting processes, reducing design-to-manufacturing cycle time and reducing product implementation costs', and 'intelligent sensor network and global computing' as of critical importance for their companies' operations. It should be mentioned that these technologies are at the forefront of priorities internationally. Advanced manufacturing technologies and on-demand manufacturing now attract the attention of most governments around the world in the same way as nanotechnology attracted international support in the early 2000s. The US government is the world leader in terms of allocating substantial resources for advanced manufacturing technologies [*Hewitt*, 2012].

It is clear that the priorities identified during the 1999 Foresight exercise are not necessarily the current STI priorities. In this context, it is important to mention that — in contrast with other countries which monitor and disseminate information related to new technologies — South Africa has no such mechanism. Most countries have institutionalized the monitoring of international priorities and the development of local priorities, and Japan's Foresight exercises are perhaps the most well-known. As discussed here, the lack of South African efforts in the field may be detrimental to the country's manufacturing sector and the performance of its national system of innovation. South Africa has a relatively small national system of innovation with only 0.76% of gross domestic product spent on R&D [HSRC, 2014]. Furthermore, the Department of Science and Technology [DST, 2015] now seeks to encourage the business sector to spend more on R&D to increase the country's overall R&D expenditures. Foresight exercises, among others, may provide the guidance needed by the business sector to fulfil this task.

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