SKOLKOVO
Moscow School of Management

International Labour Organization

USING TECHNOLOGY FORESIGHTS FOR IDENTIFYING FUTURE SKILLS NEEDS

SKOLKOVO-ILO GLOBAL WORKSHOP PROCEEDINGS

The Moscow School of Management SKOLKOVO's Education Development Centre (SEDeC) — International Labour Organization

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Foreword

In June 2010 at the Toronto Summit the *G20 leaders welcomed the G20 Training Strategy for a Skilled Workforce for Strong, Sustainable and Balanced Growth* developed by the International Labour Organization (ILO). In preparing this strategy, the ILO worked closely with employers and workers, consulted other international organizations, and drew on the *Conclusions on skills for improved productivity, employment growth and development* adopted by the International Labour Conference in June 2008. In Seoul, in November 2010, leaders pledged to support developing countries in implementing national strategies on skills for employment, building on the G20 Training Strategy.

The project *Applying the G20 Training Strategy*, initiated in late 2012 and implemented in line with Russia's Development Cooperation Strategy, is a response to interest indicated by the Russian Federation to work with the ILO in supporting the application of the G20 Training Strategy to the skills development and employment needs in a range of countries.

The partnership between the Russian Federation and the ILO in applying the G20 Training Strategy will deliver an innovative skills development programme in selected countries aiming to bridge education and training to export growth, economic diversification, and the creation of more and better jobs. The assistance provided will improve the quality and relevance of vocational training and education and entrepreneurship in order to better meet the labour market needs of today but moreover to prepare the workforce and enterprises for new market and trade opportunities.

The G20 Training Strategy sets out the critical building blocks for linking education and training to the world of work and for matching skills provision to labour market opportunities. The technical interventions of the project will, among other, focus on anticipating future skills needs and encouraging sectorial approaches.

The G20 Training Strategy also recognizes innovation and technological change as powerful drivers of economic growth: "This has been the case in the past, is a salient feature of the world today, and will no doubt continue to be so in the future. What is particularly notable about today's environment is the rapidity with which innovations spread into mass use" (ILO 2010).

Skills anticipation and technology foresight have until very recently existed as separate fields in more-or-less isolated expert and policy-making environments. As part of the project *Applying the G20 Training Strategy*, the ILO and Moscow School of Management SKOLKOVO started to develop *Skills Technology Foresight*, a new tool of skill needs anticipation. It is an attempt to bridge the two areas of research and planning to introduce a technology foresight-based method of skills anticipation built around international best practices.

The present publication is the result of discussions between experts at a two-day international workshop *"Using Technology Foresights for Identifying Future Skills Needs"*. The workshop was organized in Russia in July 2013, and brought together leading skills anticipation and high-level national technology foresight experts from Brazil, China, the Czech Republic, Germany, India, Japan, Korea, Romania, Russia and Switzerland. Throughout the workshop, national and regional cases of skills anticipation using technology foresight were presented. Participants also discussed a potential convergence of disciplines and an integrated new approach to skills technology foresight. These fruitful discussions have become instrumental for further work on pioneering the method of identifying future skills needs based on a technology foresight.

The method is pending implementation in two pilot countries in selected sectors, with particular attention to building policy recommendations applicable to the contexts of developing countries. The results are expected to be of substantial value for governments, sectorial bodies, employers and workers organizations in their efforts to bridge the gap between the skills demand and supply, which arises out of technological change.

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Introduction to Skills Technology Foresight Method

Designing a Technology Foresight-based Skills Anticipation Method

"It is no longer sufficient to train workers to meet their specific current needs; we should ensure access to training programmes that support lifelong skills development and focus on future market needs".

The G20 Pittsburgh Summit Leaders' Statement

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Promoting sustainable employment, economic growth and social development represents particular attention in the context of collaboration of the International Labour Organization (ILO) with its constituents. The same priorities remain within the focus of the G20 Training Strategy created in an attempt to build an employment-oriented framework for future economic growth[1] by closing the gap between the labour market development and capacity of the education and training systems.

As progressive education policy-making contributes to the improvement in all the three areas of ILO's interest, design of future-oriented education policies becomes a priority area of research. In this context, skill needs anticipation becomes the practice that improves the harmonization of the labour market through informed interventions into educational policies: in the mid- and long-term horizon the labour market receives professionals with competencies needed to close the gaps.

The problem of identifying future skills needs is becoming more and more acute in the context of the current dynamics of the global economy. In the turbulent times the speed of change is growing while the global competition in numerous sectors is further becoming tighter, with former leaders leaving and new actors joining the game. To avoid disorientation caused by the pace of the economic globalization, governments need to look forward to the long-term development of the critical sectors of the national economy. In particular, of interest are the technology-driven industries – as the focal points concentrating research and development, foreign direct investment, talent and cutting-edge technology. The use of technologies increases labour productivity and economic competitiveness and may potentially fuel growth with a positive impact on employment. The technology can partially substitute the labour thus influencing the structure of the demand: skill-intensive jobs become more sought-after while jobs with routine tasks can be fully substituted by the technological solutions.

Technology context

It is widely acknowledged that introduction of new technologies can have a positive impact on competitiveness of economic agents. This can happen directly, as introduction of a new technology helps to decrease total operation costs per hour. And indirectly via spillovers: for instance, introduction of IT in the context of developing country can lead to improved competitiveness of SMEs[2] through informed decision-making by eliminating information asymmetry. The development of the ICT allows SMEs to take advantage of opportunities in a market that is increasingly interconnected and that also facilitates the generation of local and global business opportunities.

Technology-driven sectors are an environment which is strongly associated with most rapid change and therefore uncertainty. While investors wander across global industrial hubs searching for the next big market, national governments strive to apply relevant strategies to foster every next generation of workers through the TVET and higher education systems.

The developing countries' efforts to build a knowledge economy with technological innovations can only lead to sustainable economic growth when the governments rely on technical, vocational education and training (TVET) and higher education (HE) systems relevant to labour market demand.

With the strong connection between skills and technologies (Fig. 1), new tools are required to assess future skills needs which would accurately take into account the specifics of technology-driven sectors.

Until very recently skills anticipation has existed as a separate field in more or less

1 A Skilled Workforce for Strong, Sustainable and Balanced Growth: A G20 Training Strategy. International Labour Office – Geneva, 2010. ISBN 978-92-2-124278-9
2 Growth and Jobs in a Hyperconnected World. The Global Information Technology Report 2013. World Economic Forum and INSEAD. ISBN-13: 978-92-95044-77-7

isolated expert and policy-making environments, there having been no juxtaposition with technology foresight as one of the established tools for designing effective long-term development policies. However, these dynamics is changing and the technology aspect has gained more presence in skills anticipation approaches.

Global Workshop "Using Technology Foresights for Identifying Future Skills Needs"

With the launch of Skills foresight project under the auspices of the G20 Training Strategy, an attempt was made to bridge the two areas of research and planning to introduce a technology foresight-based method of skills anticipation built around international best practices.

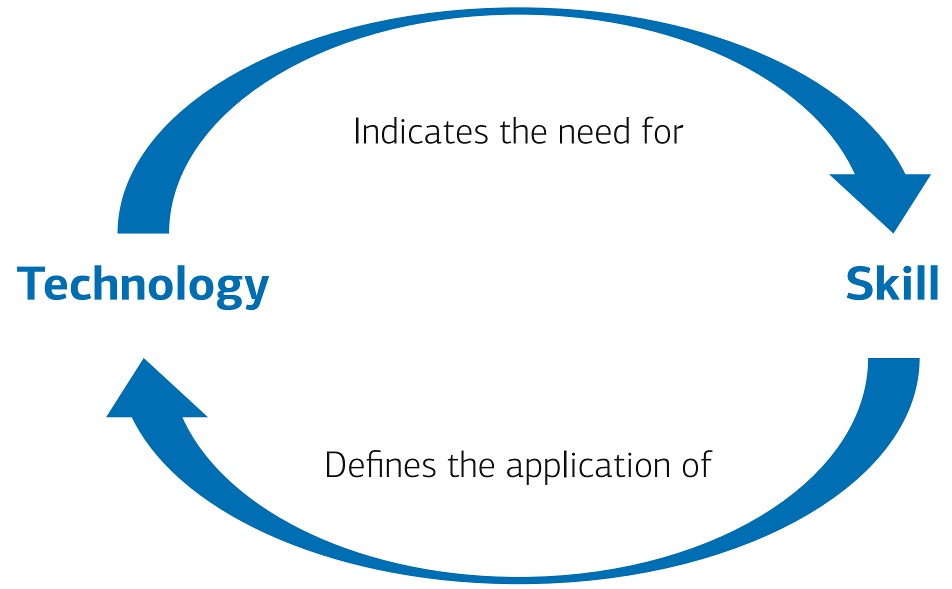
One of the key landmarks of the project was the Global Workshop "Using Technology Foresights for Identifying Future Skills Needs" which featured leading skills anticipation and technology foresight experts across the globe. The workshop resulted in set of requirements to the new method for technology-foresight based skills anticipation.

In July 2013 leading international experts and national technology foresight programme architects from Brazil, China, the Czech Republic, Germany, India, Japan, Republic of Korea, Romania, Russia and Switzerland gathered at SKOLKOVO to discuss the convergence of skills anticipation and technology foresight.

During Day 1 of the Global Workshop entitled "Using technology foresights for identifying future skills needs" a comprehensive review of national and international foresight cases was conducted, featuring discussions of studies on various methods of identifying skill needs and changing and emerging occupations in key sectors in the context of changing technology landscape.

Day 2 featured a collective collaboration as participants jointly developed the basic parameters of the new international techniques to forecast future skills with the use of technological foresight.

Figure 1: Technology—Skill Impact Cycle



The objective of the session was to formulate requirements for an international methodology of technology competence foresight while identifying best practices, most appropriate methods and solutions to address some of these requirements.

The method is pending implementation in two pilot countries in selected sectors, with particular attention to building policy recommendations applicable to the contexts of developing countries. The results are expected to be of substantial value for governments, sectorial bodies, employers and workers organizations in their efforts to bridge the gap between the skills demand and supply, which arises out of technological change.

The chapters 1-10 of this publication contain the reports made by leading skills anticipation and high-level national technology foresight experts participating in the workshop, while the Summary and Conclusions contain the results of the Day 2 activity with description of the skills technology foresight method.

Anticipation of Skill Needs and Technology Foresight: Points of Alignment and Potentials

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Abstract

Technological innovations and the capacities/skills which they demand are of critical importance in achieving positive economic development. New technologies and changes in work organisation are two examples of situations engendering the need for new/evolving knowledge and skills. It is in this context that the German Federal Ministry of Education and Research (BMBF) supports the initiative for the anticipation of skill needs. Work and research undertaken as part of this initiative, are linked up through the FreQueNz network and intended to identify new or changing skill needs as early as possible. This work is accompanied by programmes and processes relating to technology foresight programmes and processes. With a view to the possibility of strengthening the links between vocational education and training on the one hand, and technological development on the other, this article ponders the overlaps and possible points of alignment between anticipation of skill needs and technology foresight.

Keywords:

skills anticipation, technology foresight, skills anticipation initiative

1 Approaches adopted by the BMBF to the anticipation of skill needs

A good starting-point for looking at overlaps and alignment points between skill needs anticipation of technology foresight is the model of industry maturity, work-organisation technology, product and service innovation.[1] This model distinguishes between *emerging, future, new* and *mature* industries, and also differentiates three stages relating to new ways of arranging work process and technological developments, as well as product or service innovations. These stages include: a) the development stage at which ideas (or, for example, technological advances) continue to be worked through, b) the dissemination stage at which planning, (e.g. innovation marketing) takes place, and c) the application stage at which products are marketed.

All three stages can be identified in emerging/ future/ new / mature industries, although in different percentage (as shown in the figure below) for each case. Research projects undertaken under the BMBF skills-anticipation initiative, aim at pinpointing, at the earliest possible juncture, those new or changed medium-level skills which, – as researchers are fairly certain – will be widely relevant at the application stage in the next three to five years. For the purposes of the BMBF anticipation initiative, the staff with medium-level qualifications are primarily those who have completed a training course in a nationally recognised trade or profession, as well as trained employees who have completed continuing training for the level of a master craftsman or a technician. In this respect, anticipation is not focused on the potential industries of the future or development stages at which primarily higher qualified professionals are employed. Ideally, the projects are located in the spectrum between the change dissemination and application stages in emerging, new and mature industries. With its short-term horizon and focus on quality and content-related requirements, anticipation differs from quantitative forecasts of skill demand with their typical time horizon of 10 to15 years. On the other hand, the difference between a present needs and an anticipation approach is that the latter is forward-looking and not focused on

1 Cf. Ferrier, F./Trood, C./Whittingham, K. (2003): Going boldly into the future. A VET journey into the national innovation system, Adelaide: NCVER, p. 27. URL: http://www.ncver.edu.au/research/proj/nr9036_vol1.pdf.

immediate utility. Anticipation adopts a much broader perspective which should ideally embrace as many developments, expectedly relevant in the future, as possible. The FreQueNz network openly disseminates project results, which provide forward-looking information to players involved in vocational training policy and vocational training itself. In this way, anticipation insights can not only be used to accommodate future requirements for the training profiles of skill-intense occupations, but can also help in ensuring that firm-based and inter-company skill profiles and continuing professional development activities are tailored much more closely to current needs.

2 Technology foresight and anticipation of skill needs

The ongoing correlation between technological advance and development of new skills is the context in which we begin (at this point) to consider ways in which technology foresight and skill needs anticipation might be aligned. The paraphrase provided describes "technology foresight" as the *"ongoing observation of technological developments for the purpose of identifying promising future applications at an early point in time and of evaluating their corresponding potential"*.[2] Technology foresight and skills anticipation are undertaken from regional, national and European starting points. Firms also engage in technology foresight, in many cases with an explicit relationship to innovation capabilities.

As is the case with identifying skill needs, technology foresight also involves both a short-term and a long-term forecast which extends for a period of 15 years and over. In the model referred to above, which classifies the maturity of innovations, this perspective corresponds most closely to an early phase of the development stage. Shorter-term technology foresight looks forward over a period of three to five years before a technological innovation reaches market maturity. As far as potential intersections between skills anticipation and technology foresight are concerned, the time horizon of shorter-term technology foresight appears to overlap substantially with the spectrum between the dissemination and application stages in which anticipation of skill needs should ideally take place. This might, for example, correspond roughly with the future perspective of the BMBF's innovation and technology analysis (ITA) of five to seven years. It means that one potential point of alignment between technology foresight and anticipation of skill needs might involve addressing topics which have been identified as important for the future in the course of short- to medium-term technology foresight. In relation to the BMBF initiative, the topics addressed ought to be those which are fairly certain to concern broadly relevant changes in skill needs.

3 One option: The Fraunhofer TechnologyRadar

The *Fraunhofer TechnologyRadar* is offered to companies and institutions as a form of consulting service which aims, based on the specific requirements of each organization, at identifying and assessing new opportunities, technologies and application at an early stage, and thereby complementing the technology management and minimizing the development risks. To companies /organizations it shows the discrepancies between their own technological position and the status quo in technology.

Based on the receiver-orientated requirements profile, the Fraunhofer TechnologyRadar helps coping with the following tasks of the technology planning:

- From a technological perspective, foresight and scouting of potential threats from the users' environment ("Are there technologies which could be applied in my market in the future?")
- Identification of potential new competitors who offer the same technologies but with an extended function profile ("Are there other competitors in/within/regarding my technology?")
- Identification of substitution technologies ("Does a technology exist which could substitute my technology in the future?")
- Ensuring prolonged planning-cycles and more flexible responsiveness to technological changes ("Does it pay off to invest in a particular technology?")
- Identification of "strategic windows" in order to take advantage of temporary constellations, e.g. regarding the market environment ("Can I address new markets with my technology combined with other ones?")

The main feature of the Fraunhofer IAO methods is the functional perspective onto the technologies. By recording the functions and attributes of a technology in a structured way, an individual profile can be created which can be used as a basis for identifying relevant markets. Thereby, the function represents the link between the market information and the technical properties of (emergent) technologies. By abstracting the requirements of both fields onto the level of functions, an interface results which enables a holistic assessment of the technology. In the function profile the characteristics and properties of a technology can be captured well, and on that level of abstraction a technology can be described independently of the technology field at large. In this case, the functions represent the users' requirements and consolidate the suitability and the utility from the customer's view-point with the feasibility and the effectiveness of a technical system. In addition to functions, the attributes (in the sense of physical characteristics) can be interpreted as environment-specific conditions to be converted into requirements.

Another key aspect of the IAO method is the user-specific applicability of these methods. In this context, companies (industry), research institutions, and the policy (state) were identified as target groups.

As already mentioned, enterprises conduct technology intelligence, especially in order to recognize (technological) trends, possibilities and threats, and - on an adequate information base, – to achieve strategic competitive advantages and minimize risks. In the course of an extensive competitive analysis (direct and indirect) potential possibilities for technology substitution are detected. Moreover, options for technology addition or technology integration can be identified.

On the other hand, research institutions focus their technology intelligence especially on detecting potential opportunities for acquisition of research funds (public or private). Further, they are interested in knowing who is active in which field of research, in order to adequately align their own efforts and to identify potential cooperation opportunities.

Eventually, the state also requires a broad information basis of technological developments (e.g. as part of its technology policy) in order to allocate the funding properly, in accordance with the purpose of diverse funding of programmes and projects. This can mean funding of individual technologies and technology fields as well as branches or regions, and setting-up of technology businesses.

According to the generic process of technology intelligence, the procedure of the Fraunhofer TechnologyRadar is subdivided into five steps in which emergent technologies, market potentials and trends from the environment are considered particularly. The following five phases are passed through:

1. Technology analysis:
   Determination of the company-specific technology requirements profile
2. Semantic technology research:
   Web-based technological search into the 'visible' and the 'invisible' concerning the company-specific created semantics.
3. Technology assessment:
   Assessment of the technologies regarding attractiveness and implementation efforts
4. Planning of measures:
   Deduction of concrete measures for technology substitution, integration or addition

2 The précis description of "technology foresight" is based on Holtmannspötter, D./ Zweck A. (2002): Monitoring of Technology Foresight Activities in Europe. In: Zukünftige Technologien No. 37.

5. Dynamic TechnologyRadar:
   Continuous implementation of the technology search and assessment within periods of time to be defined

Phase 1: Technology analysis
As part of the workshops, the goals of the project are determined at the beginning. Starting from the identified relevant fields of technology and the topics, the technology requirements profile is elaborated. It serves as the basis for determining the information needs, the provision of information and its assessment. Based on the determined "function verbs" and the "attribute adjectives", and in combination with synonyms of the term "technology" (e.g. "active principle", "technical solution principle") – a semantic search algorithm is set up.

Phase 2: Function semantic technology search
The semantic technology search is executed as a three-step process. First, the relevant accessible databases for the TechnologyRadar user have to be sought. In the next step, within these databases, the data basis is determined, – which means that proceeding from the function profile those documents are searched in the databases which are likely to contain information about potentially relevant technologies. Eventually, the semantic search is conducted based on that data.

Phase 3: Technology assessment
The goal of this phase is to assess and classify the identified technologies and topics in the context of (and depending on) the focus of the TechnologyRadar user's interest. Therefore, technologies and trends, based on the technology fields/topics found so far, are formatted and analysed regarding the market aspect as well as the project goals. Here, inter alia, a market assessment is carried out involving an analysis of the technology potential. Optionally, moderated workshops with selected experts can be conducted; the selection of experts is based on the results of the preceding phase. The result is a company-specific estimation of the application readiness/maturity and the forecasted further development of relevant technologies. With this, the *TechnologyRadar* user is enabled to select the best-fitting technology for the proposed project goals, based on the technology attribute matrix, and to plan the measures for technological integration and development. The data can be illustrated in the form of detection and a distance-measuring system (radar).

Table 1: Methodological portfolio of the Fraunhofer TechnologyRadar

Methods for determining the technology requirements profile	Methods for knowledge transfer
• Trendscouting • Scenario methods • Use of case method • Function analysis • Cross impact analysis • Technology influence analysis • Value chain analysis • Core competence analysis • Lead user questioning • Market research • Strengths and weaknesses checklist	• Identification of experts • Technology potential analysis • Market potential analysis • Creativity techniques • Technology roadmapping • Delphi studies • Expert interviews • Moderation techniques

In the course of the *TechnologyRadar* project, data on branches, markets, development of the client etc. are analysed and formatted in a structured manner using the method catalogue. This catalogue (see Table 1) includes common methods from scientific/ specific literature, methods which are specified for the needs of the *TechnologyRadar*, as well as new approaches such as the technology-potential analysis.

Phase 4: Action/ measurement planning
The technology-attribute matrix (with its contained information) frames the basis for decision-making in the strategic technology planning. Here, it supports the *TechnologyRadar* user in deducing user-specific roadmaps of selected technologies. Measurements for the identified relevant technologies are deduced from the roadmap. There is also a possibility of conducting the *TechnologyRadar* as a rolling procedure, -e.g. in annual cycles. This 'dynamization' is taken into account in the following (fifth) phase. In particular, it is recommended to companies acting in (and respectively, facing) highly dynamic fields of technology. Aided by this method, those companies are enabled to identify new and relevant information about the dynamic fields, - continuously corresponding to a company-specific technology requirements profile.

Phase 5: Dynamic TechnologyRadar
The approach in the 'dynamic' *TechnologyRadar* differs slightly from the 'initial' TechnologyRadar one, because some preliminary work is needed for the initiation of the dynamic *TechnologyRadar*. On the other hand, the technology-analysis phase may be skipped when the *TechnologyRadar* is executed again at a later point in time, – in so much as the results (technology requirements profile, function and attribute profile) gained originally, are still valid. Hence, a continuous identification of relevant information (regarding fields of technology) can be conducted in a time- and resource-saving manner.

The results of the Fraunhofer *TechnologyRadar* per se (the profiles for a specific technology, the technology assessments, the technology roadmaps) can then serve as a starting point for induction and anticipation of future skill needs with regard to the corresponding technologies.

4 An initial stocktaking

Now that the initial projects have been completed and, given that studies which are bold enough to look into the future are characterised by uncertainty, we wish to take stock of the project work which has been carried out on the topics of *Web 2.0, Internet of Things* (three projects) and *"public private health"*. The maturity model referred to above, which is capable of pinpointing more than merely technological topics, is a useful stocktaking tool in this context. The "public private health" field is a very broad topic and the scenarios elaborated from it can be placed at different levels of the maturity model, although they primarily become effective in the medium- to long-term perspective. In businesses, the subject of *Web 2.0* is relevant at a variety of different skill levels. Now that *Web-2.0* applications have become established at higher skill levels, their use is also becoming increasingly prevalent at and along medium skill levels. The topic has now clearly reached the application stage. The situation is somewhat different as regards the *Internet of Things* and the key fields of logistics, industrial production and "smart house": While the subfields of logistics and industrial production are still largely at the development stage, – the "smart house", by contrast, appears to have reached the ideal anticipation "target area" midway between the dissemination and application stages. This is particularly apparent from the successful interaction between technology foresight and anticipation of skill needs in this project. In general, the future will show in which direction the *Internet of Things* is likely to develop: will activities at the medium skills level tend to become more or less demanding?[3]

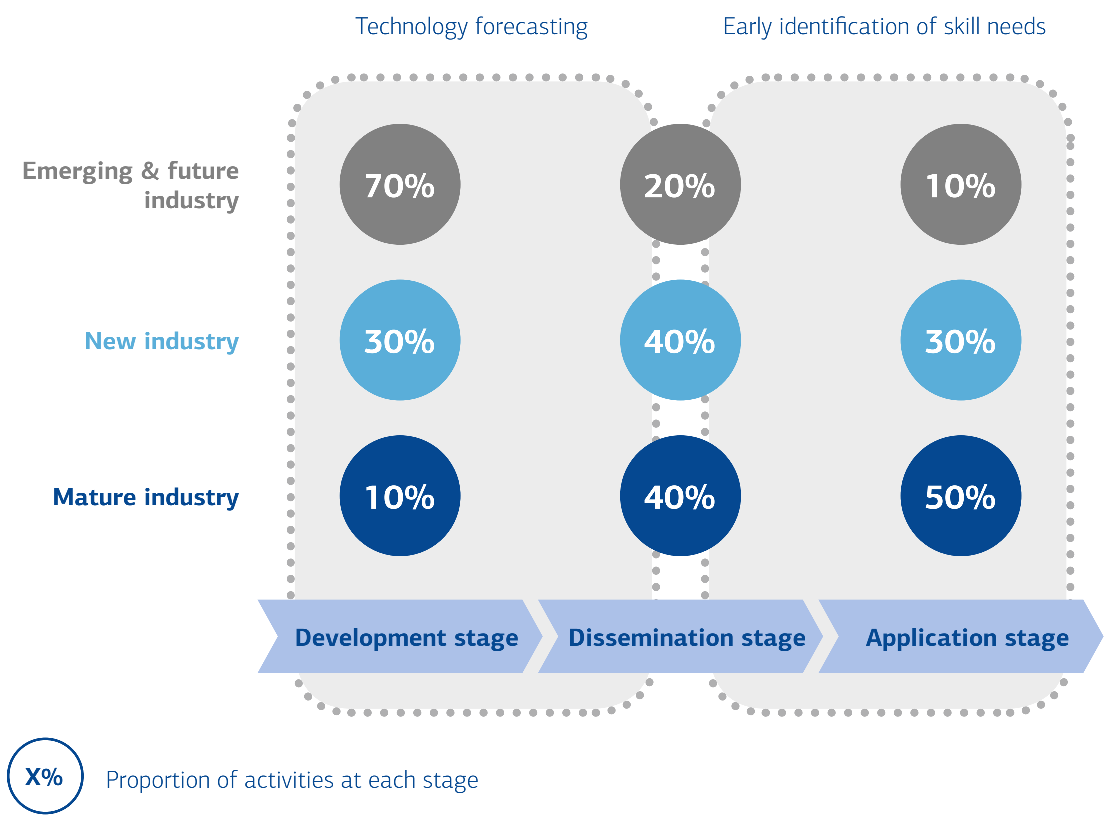
3 All final reports and summaries of studies on "Web 2.0" and "Internet of Things" are available at www.frequenz.net > Projektergebnisse.

5 Potential of skill needs anticipation

The study of the *Internet of Things* in the field of logistics in particular, confirms that, depending on development directions and types of application, new technologies can have a countervailing impact, – in particular, on the medium skills required. Anticipation of skill needs may help to take greater account of the interactions between different types of technology use and skills needs at a relatively early period of time.

One particularly important advantage of combining skills-needs anticipation with technology foresight pertains to the potentially broad coalescence of new technology and the need for (new or changed) medium skills, – which it often brings along. If too few of such skills are available, it can prove to be the decisive obstacle for establishment of technical innovations.[4] If the skills anticipation is tied in with the process of short- to medium-term technology foresight, it could be focused on topics considered to have major potential for the future, – well ahead of the fusion threshold (this kind of study would reduce obstacles for the coalescence and establishment of technologies referred to above).

Figure 1: Industrial maturity and implementation stages



4 Cf. Thielemann, A. et al. (2009): Barriers to the establishment of new key technologies. Innovationsreport, TAB Working report No. 133. URL: http://www.tab-beim-bundestag.de/de/pdf/publikationen/berichte/TAB-Arbeitsbericht-ab133.pdf.

Skills Needs Analysis for “Industry 4.0” Based on Roadmaps for Smart Systems

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Abstract

The advent of a fourth industrial revolution has been suggested, based on distributed Smart Systems integrated in the Internet of Things. A methodology for skills needs analysis is suggested, containing the following steps. Firstly, roadmaps for Smart Systems are analysed, taking up documents provided by the European Technology Platform for Smart Systems (EPoSS), and the International Electrotechnical Commission (IEC). From these roadmaps, first generic skills demands can be derived, serving as hypotheses for further analysis.

The next steps are organisation scenarios and technology/sector matrices as tools for qualitative and quantitative skills needs analyses. Some of these steps have already been taken with respect to Industry 4.0, while others are suggested, providing examples from other contexts.

The whole methodology is embedded in an approach encompassing (technological) foresight, skills needs analysis, and development of educational frameworks, all within the context of R&D programme management.

Keywords:

skills needs analysis, Industry 4.0, smart systems roadmaps

1 Introduction

In this paper, a methodology for skills needs prognosis based on technology roadmaps is proposed. This methodology is conceptually applied to an innovation domain called ‘Industry 4.0’ in Germany.[1]

The propounded methodology as a whole has not yet been applied in practice in Industry 4.0 or any other domain, so, in this regard, it is yet a proposal describing how skills needs prognosis based on technology roadmaps can be implemented in general, and how it could be applied specifically in Industry 4.0. However, almost each methodological element has already been applied in various contexts, so practical examples will be provided for these steps.

The following section includes some context information on relevant aspects of the innovation systems in Europe and Germany, then follows the introduction of the conceptual application domain (Industry 4.0). In terms of describing the general landscape, the foresight, the skills needs analysis, the implementation of educational structures, offers and programmes can be related to the development phases of emerging technologies, - all these are dealt with in section 5. Section 6 contains the information core of this paper, describing all steps of the methodology, all of which (except one) being illustrated with practical application examples.

2 European and German context

Regarding the foresight, the skills needs analysis and the implementation of educational structures in the context of public R&D policies it could be useful to look at some aspects of European and German innovation systems so that the proposed line of argumentation should be more convincing.

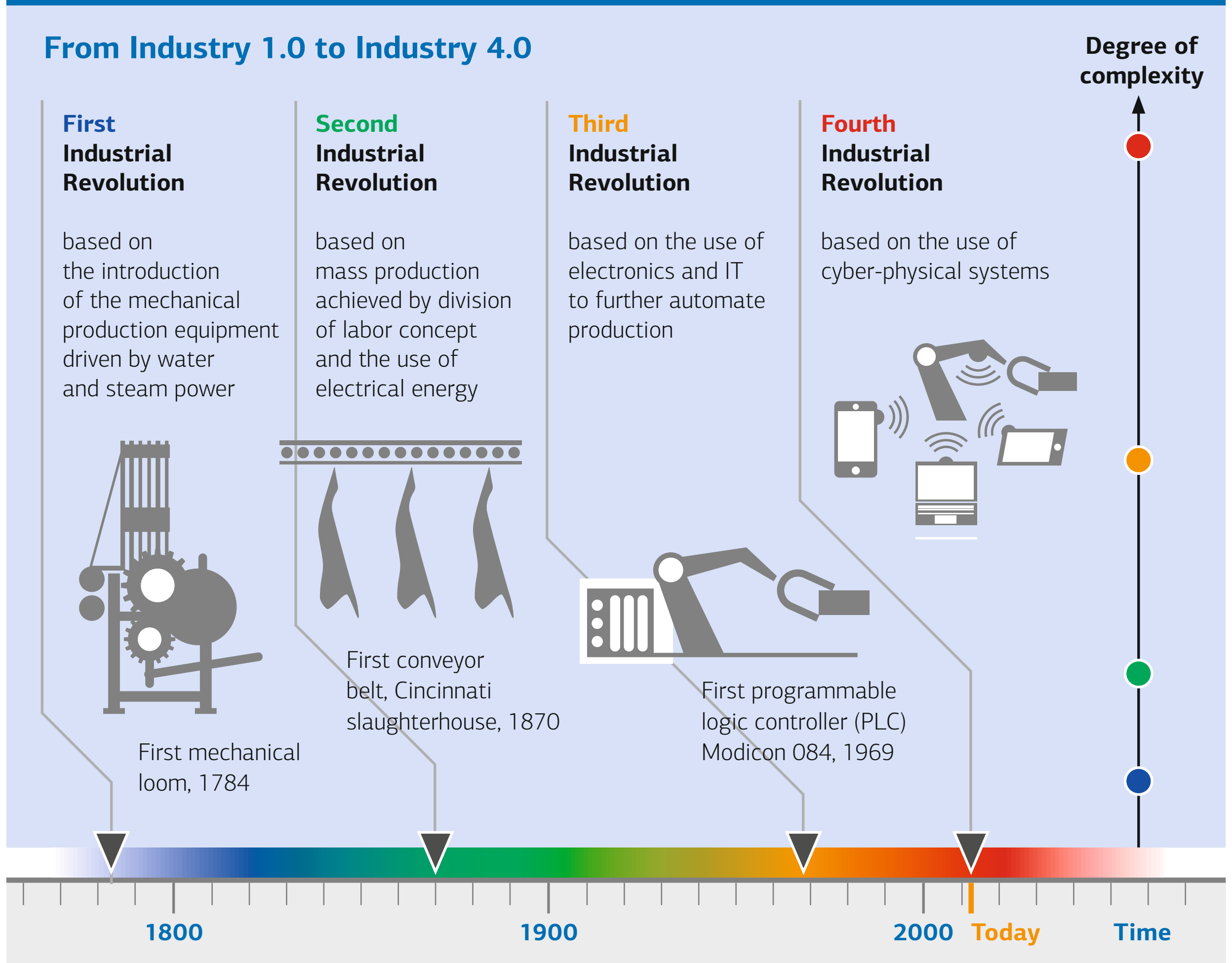
European Technology Platforms (ETPs) play the crucial role in European research, development and innovation policies[2]. ETPs provide a framework for stakeholders, led by industry, to define research priorities and action plans

1 Promotorengruppe Kommunikation der Forschungsunion Wirtschaft – Wissenschaft (ed.) (2013): Deutschlands Zukunft als Produktionsstandort sichern – Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0. Abschlussbericht des Arbeitskreises Industrie 4.0, online: http://www.bmbf.de/pubRD/Umsetzungsempfehlungen_Industrie4_0.pdf
2 http://cordis.europa.eu/technology-platforms/

on a number of technological areas relevant for European R&D policies. Some European Technology Platforms are loose networks that come together in annual meetings, but others are establishing legal structures with membership fees. Presently, there are almost 40 ETPs, in various innovation domains from energy and ICT to production technologies and transport. ETPs set up Strategic Research Agendas (SRAs) which can contain technology roadmaps or, at least, material from which technology roadmaps can be (re-)constructed. For the purposes of this paper, the most important SRA[3] is the one published by EPoSS, the European Technology Platform on Smart Systems Integration,[4] playing the key role for Industry 4.0.

Within the German innovation system, shared-budget R&D programmes play a major role. They are usually co-funded by public and private bodies and cover a broad variety of domains, target groups, and purposes. There are technology- and domain-specific programmes

Figure 1: The fourth Industrial Revolution (DFKI/SIEMENS)



Source: DFKI (2011)

3 IRISS Deliverable 6.4 Strategic Research Agenda on Smart Systems Integration, to be published.
4 http://www.smart-systems-integration.org/public

addressing e.g. production technologies, electronics or life sciences. Other programmes are provides for Small and Medium-sized Enterprises, regardless of sector or domain. These programmes are managed by Programme Management Agencies ('Projektträger' in German), on behalf of ministries and other public bodies.

Within the discussed context, these programmes and agencies are relevant in (at least) two ways:

- Programme Management Agencies play a role in setting up roadmaps (or similar projections) regarding the R&D programmes and domains they administer. In this process, other roadmaps – e.g. those of related ETPs – are taken into account.
- Sometimes, the programmes include measures for development and implementation of educational structures. This may relate to programmes explicitly tuned towards educational issues. But of, perhaps, greater interest are the cases when it occurs within technology or sector-oriented programmes, including measures for development and implementation of the educational elements relevant for the respective technologies or sectors.[5]

3 The fourth Industrial Revolution

Recently, the Forschungsunion Wirtschaft – Wissenschaft, a consulting body relating to the High-Tech Strategy of the German Federal Government, has proposed 'Industry 4.0' as the crucial domain for future research, development and innovation in Germany.

The future project Industry 4.0 relates to an approach to industrial history, proposing four industrial revolutions.

The first of these revolutions was based on the introduction of water and steam power. The second one focused on electrical energy and industrial forms of organisation, emphasising the division of labour. In a way, these two early revolutions depend crucially on innovative form of power supply.

In contrast, the third and fourth revolutions relate primarily to Information and Communication Technologies (ICT). In this context, the third industrial revolution used ICT for automatic control of production machinery. The upcoming fourth industrial revolution takes this to a qualitatively new level characterised by the employment of Cyber-Physical Systems (CPS).

CPS are distributed smart systems – microsystems or MEMS (Micro Electro Mechanical Systems) – including electronic, mechanical and possibly also optical or fluidic components. Usually, they also include sensing, information processing and (rather often) actuating functions and are embedded in communication networks; this is also how CPS relates to the Internet of Things (IoT) paradigm. They are able to perform processes in perception, cognition, and action which are said to become increasingly closer to human performance. The 'intelligent' capacities of CPS usually emerge from – more or less flexible – cooperation of distributed systems. In this regard, CPS are also related to the concepts of Pervasive Computing and Ambient Intelligence. There are broad potential domains for the application of CPS, including everyday life and housing, transportation and logistics, and health care.

Industry 4.0 is concerned with the implementation of CPS in industrial production. Beyond CPS themselves, aspects of Human-Machine-Interaction (or, eventually, even Human-Machine-Cooperation) as new forms of industrial organisation and rather socio-economic phenomena need also to be taken into consideration for successful implementation of Industry 4.0.

4 Development Phases of Emergent Technologies

Regarding the scope of this paper, three functions or processes need to be regarded:

- General foresight processes, concerning future developments, either in aspects more narrowly focussed on technological,

5 An example will be given in section 6.7.2

or embedding technology in a broader socio-economic framework
- Skills needs prognosis
- Development and implementation of education and training structures, offers and programmes

Over time, these three processes correspond to development phases of emergent technologies – from the initial technology trigger via market introduction to market saturation – as depicted in figure 2.

5 A Methodological Framework for Skills Needs Prognosis

5.1 Overview

For skills needs analysis based on technology roadmaps, a methodological framework is proposed here. Figure 3 gives an overview of the individual steps. All these steps will be described and illustrated in the following sections.

5.2 Identifying and Using Technology Roadmaps

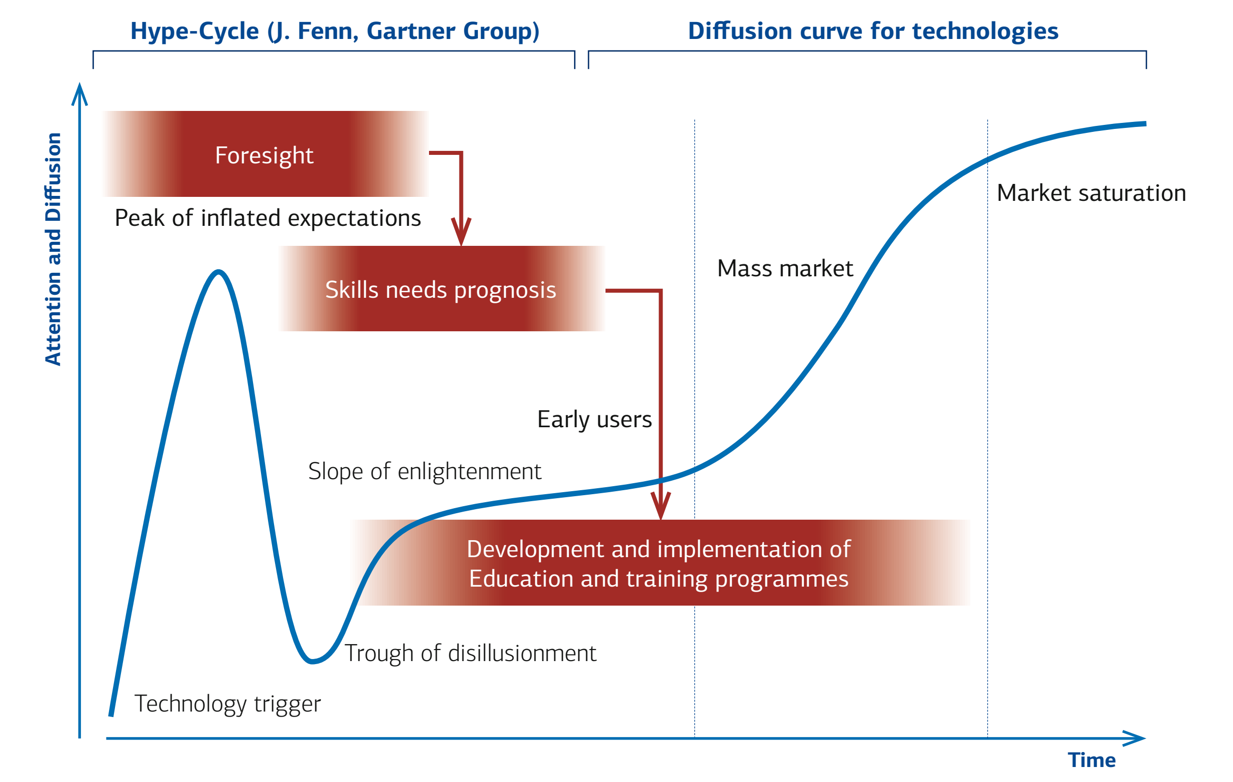
5.2.1 Introduction

Usually, there is a variety of sources for technology roadmaps, as well as a variety of methods for their development and description. In the following, some examples of methods and sources – referring to Industry 4.0 – will be presented.

5.2.2 The Visual Roadmapping method

In order to archive a comprehensive overview on future changes and needs, a method is needed that allows to figure out even complex interplay of technological and societal developments/progress (co-evolution)

Figure 2: Development phases of emergent technologies



in a clear and well-structured way. At the same time, the method should be sufficiently robust and efficient in order to generate reliable results. Following these preconditions, the Visual Roadmapping method has been developed and successfully applied in a large variety of projects.[6]

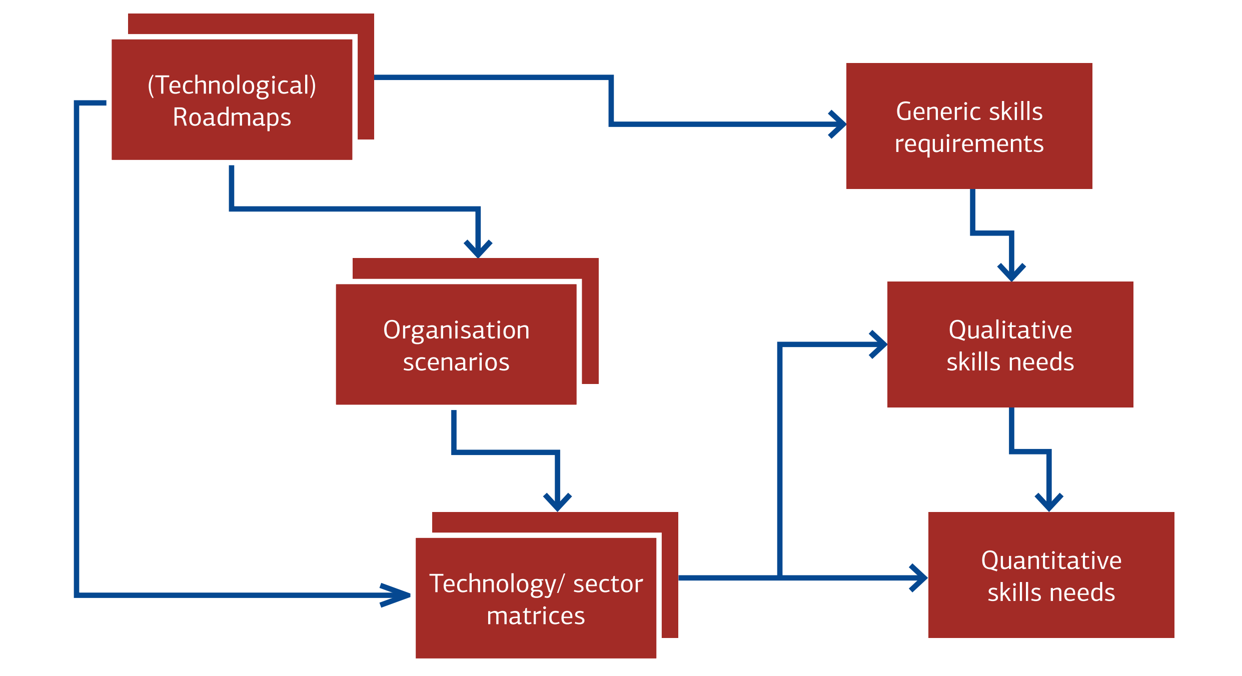
The Visual Roadmapping method is particularly suitable for the identification of perspectives and milestones along the way from "today" towards the future. The approach allows of identification of possible future options in "open" scenarios", as well as the outline of future pathways in "normative" scenarios (missions). Thus, the Visual Roadmapping method is an ideal tool which can be used in roadmapping and ex-ante evaluation of trends, which facilitates the identification of key factors in future developments, the assessment of strategic potentials and the deduction of needs and actions to be taken.

Using the method, the complex interplay of the topic investigated and significant factors can be analysed regarding future developments. For this purpose, four relevant dimensions are represented in a visual roadmap:

- Socio-economic factors (legal, economic, social conditions),
- Enabling Technologies (scientific and technical progress),
- Development of the topic itself (central aspects and milestones),
- Effects and implications (economic and social effects, as well as new products and services).

The genesis of the roadmap is an expert-based procedure which can be carried out with single experts or in groups of up to 10 persons.

Figure 3: A methodological framework for skills needs prognosis



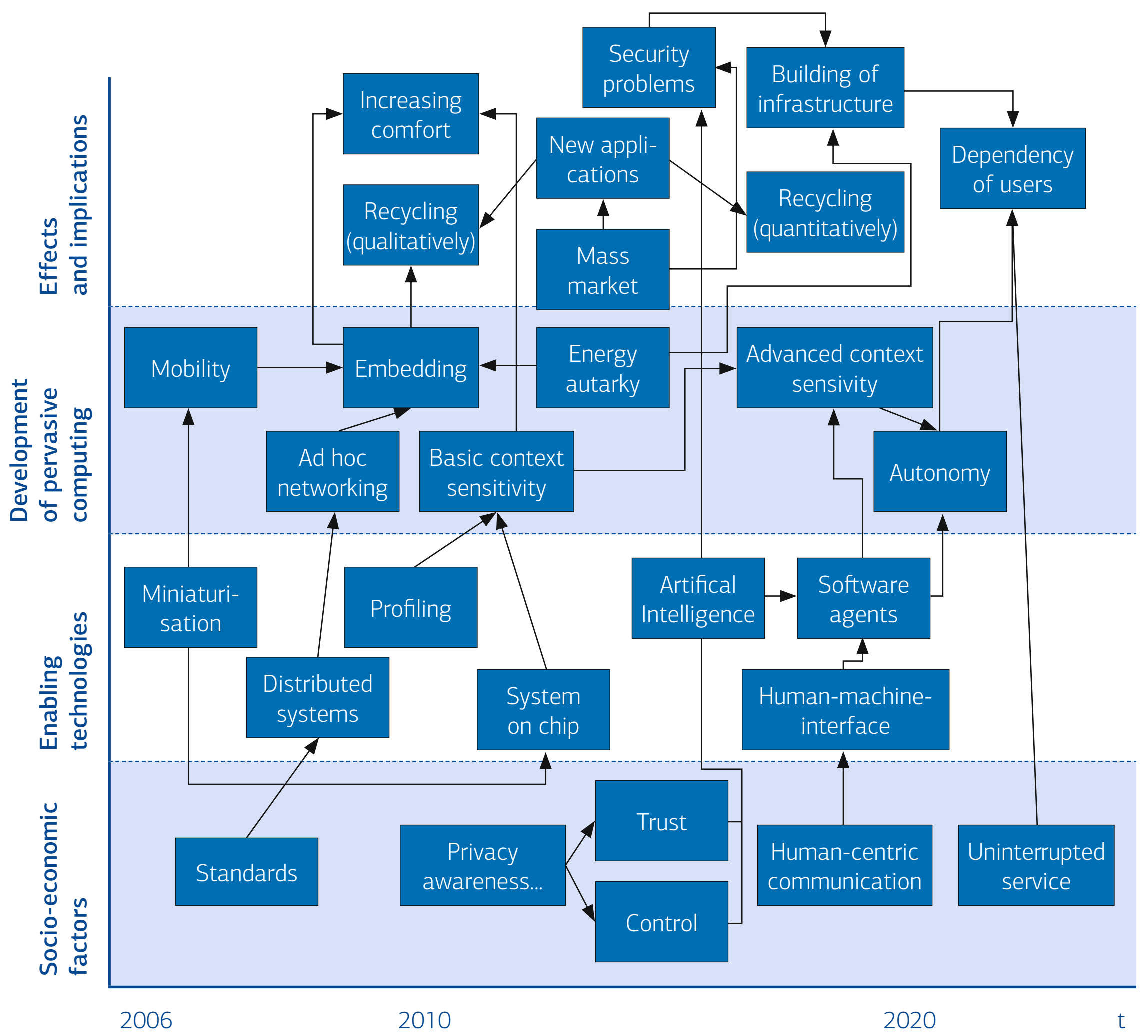
6 Kind, S., Hartmann, E.A., Bovenschulte, M. (2011): Die Visual Roadmapping Methode für die Trendanalyse, das Roadmapping und die Visualisierung von Expertenwissen. iit perspektive 4, Berlin/Germany

Starting with an empty matrix (the four dimensions vs. a timeline of approximately 10 years from today), the experts are asked to discuss the topic and to identify single aspects/key issues of the future development concerning the four dimensions. These aspects and issues are written on "event cards" and placed in the matrix. Step by step, the matrix is filled with additional cards, while existing cards can be rearranged or split-up (e.g. when an aspects needs to be divided into two distinctive sub-aspects) etc. At the end of the session, the set of cards is finalised and prominent connections and dependencies – especially cross-dimensional ones – are indicated by lines and arrows.

With the described procedure, the implicit knowledge of experts can be extracted and clearly structured by relating different dimensions to each other. While using the matrix with corresponding "event cards", there is a need to classify the identified aspects/issues in an unambiguous way (point in time, dimension) that enhances the informative value of the resulting roadmap. Figure 4 provides an example of a Visual Roadmap concerning Pervasive Computing[7], a precursor of Cyber-Physical Systems.

Figure 5 shows a Visual Roadmap for Production Technologies in the time span from 1995 to 2025.[8] Here, the general developments in the domain of Pervasive Computing – as shown in figure 4 – are regarded with respect to industrial production as application area. Also, developments specific for this domain are taken into consideration.

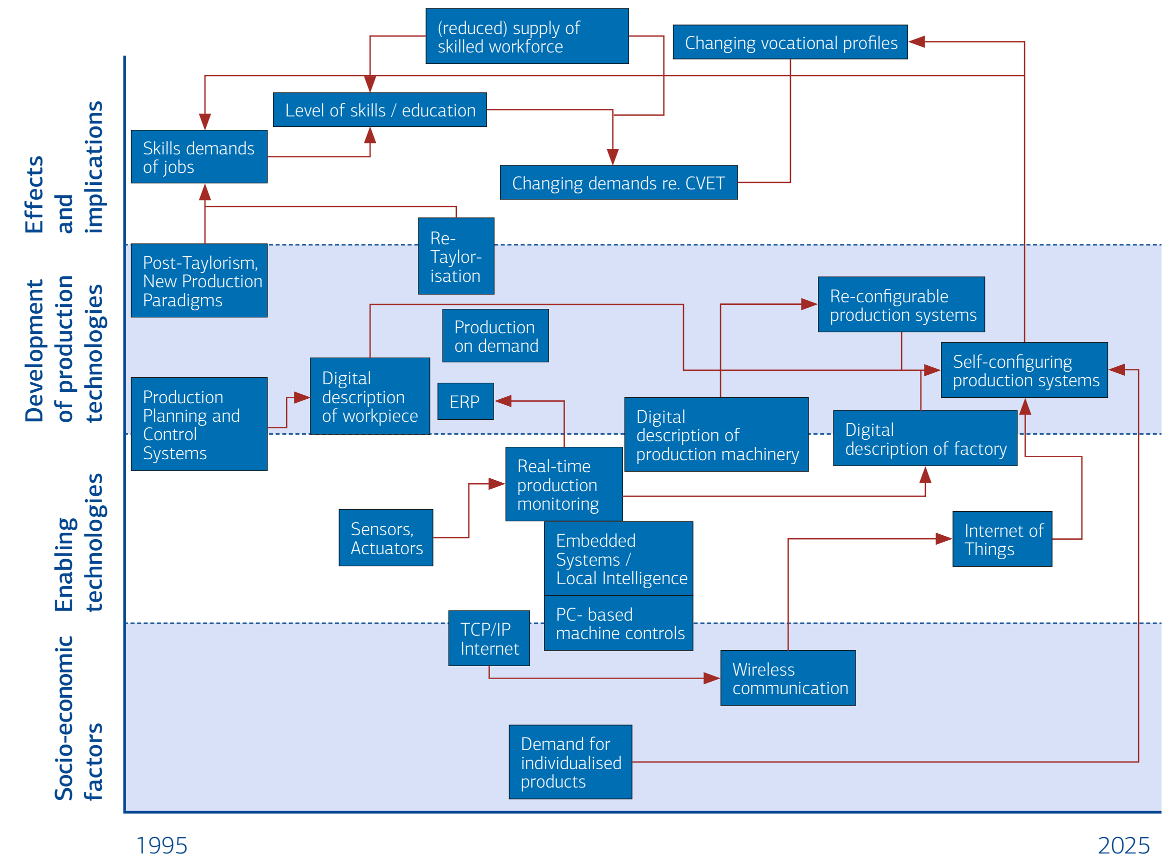
Figure 4: A Visual Roadmap for Pervasive Computing (Gabriel, Bovenschulte, Hartmann et al., 2006)



5.2.3 Roadmaps from European Technology Platforms and the International Electrotechnical Commission

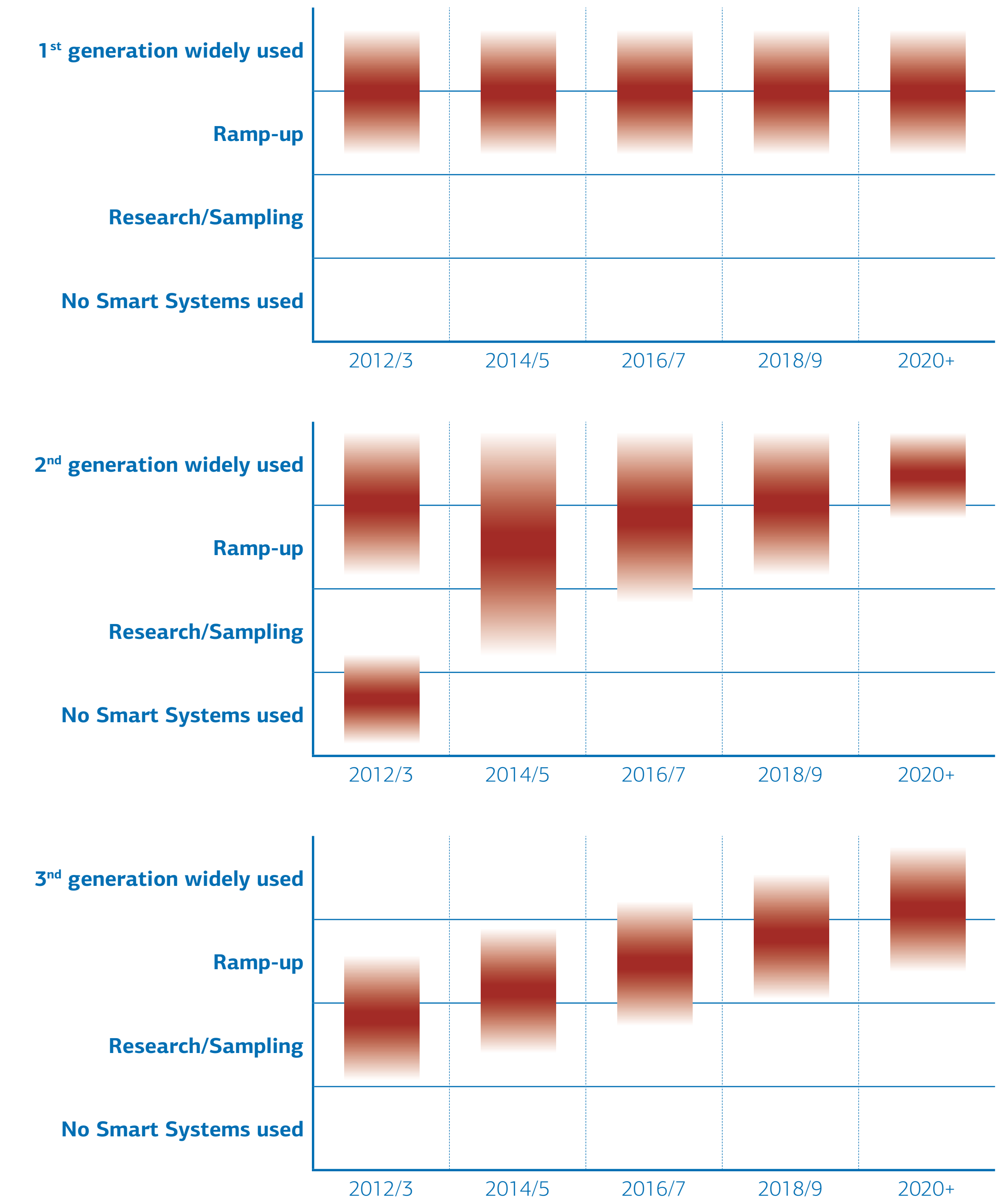
Visual roadmaps as described in the previous section are especially useful for a general,

Figure 5: Visual Roadmap for Production Technologies (Hartmann, 2009)



7 Gabriel, P., Bovenschulte, M., Hartmann, E.A. et al. (2006): Pervasive Computing – Trends and Implications. Study of VDI/VDE-IT in cooperation with FhG-SIT and Sun Microsystems on behalf of the Federal Office for Information Security; SecuMedia Verlags-GmbH, Ingelheim/Germany
8 Hartmann, E.A.: Internet der Dinge-Technologien im Anwendungsfeld ‚Produktion – Fertigungsplanung'; in: Botthof, A. and Bovenschulte, M. (Hrsg.) (2009): Das ‚Internet der Dinge': Die Informatisierung des Alltags und der Lebenswelt. Hans-Böckler-Stiftung, AP 176, Düsseldorf/Germany

Figure 6: Smart Systems for Robotics / Factory Automation: Perspective (IRISS Deliverable 6.4)



'bird´s-eye' view of a domain. For more specific aspects, other formats and sources may be required. As mentioned above, concerning Industry 4.0, the Strategic Research Agenda (SRA) of EPoSS, the European Technology Platform on Smart Systems Integration is specifically useful. This SRA, developed in the IRISS project[9], covers a broad range of application domains. For the purposes of this paper, of particular relevance is the section on industrial production covering the following sub-domains:

- Manufacturing equipment
- Process control
- Robotics and Factory automation
- Prototyping equipment
- Test and Inspection

All these domains are described according to a common framework of smart systems's 'generations'. Put simply, the first generation refers to cutting-edge automatic control technologies for automated production as used today. The second generation technologies will, for example, include more advanced features of machine learning. Finally, the third generation will be characterised by functions close to human perception, cognition, and behaviour.

In the five sub-domains as described above, different dynamics of development are predicted. With respect to the third generation smart systems, the sub-domain 'Robotics and Factory Automation' is regarded as especially dynamic (figure 6).

Some additional aspects concerning the implementation of Smart Systems in the domain of Robotics / Factory Automation can be found in the SRA provided by EUROP, the ETP for robotics[10]. Here, future scenarios are provided for several sub-domains. Especially interesting among these are 'Cooperating Robots and Ambient Intelligence' and 'Planning'. In these regards, specific features of future robotic technologies include:

- Distributed control
- Inter-agent communication
- Application of swarm theories / swarm intelligence
- Skill-based / learning-based automation
- Autonomous planning for tasks of high dimensionality
- Interactive learning from human partners

Finally, some more developments are covered in a recent study performed by VDI/VDE-IT on behalf of the International Electrotechnical Commission (IEC)[11]. A 'technology radar' developed in this study predicts, for example, the following developments in the domain of Smart Systems:

- Artificial Organs
- Multi-Material Hybrid Organic / Inorganic
- Cognitive Based Control Systems
- Muscular Interface
- Neuro-Interface
- Bio-Engineering
- Bio-Electronics

This very brief overview of technology roadmaps may give a first impression of how these different sources and formats look, and what kind of information they convey. The first comparative analysis of different sources provides a high degree of consistency. The preliminary results, therefore, indicate a robust and reliable future perspective for the development of central building blocks for industry 4.0. In the following, it will be discussed how this information can be used as basis material for skills needs prognosis.

5.3 Generic Skills Requirements

An integrative view across the technology roadmaps allows of the identification of some generic skills requirements. One of these requirements relates to the convergence between mechanical / electronic / software-based components or systems, which will be occurring across scale levels (macro/meso/micro). The focus domain of these developments appears to be robotics, with core aspects such as cooperating robots and 'soft automation'(e.g. inherent safety by soft and flexible actuators of robotic

9 http://www.iriss-csa.eu
10 http://www.robotics-platform.eu/cms/upload/SRA/2010-06_SRA_A3_low.pdf
11 IEC Study: Evaluation of roadmaps, technology trend studies, and research agendas – Final Report; not yet published.

systems). Furthermore, bionics will probably play a more pronounced role in developing future robotic systems with human-like perception, cognition and behaviour.

Regarding flexible division of work between a human and a robot in the context of Human-Machine-Cooperation, safety-related competences will become more important: When there are no fixed processes, safety considerations need to be part of the work process itself re-considering every situation anew according to safety aspects.

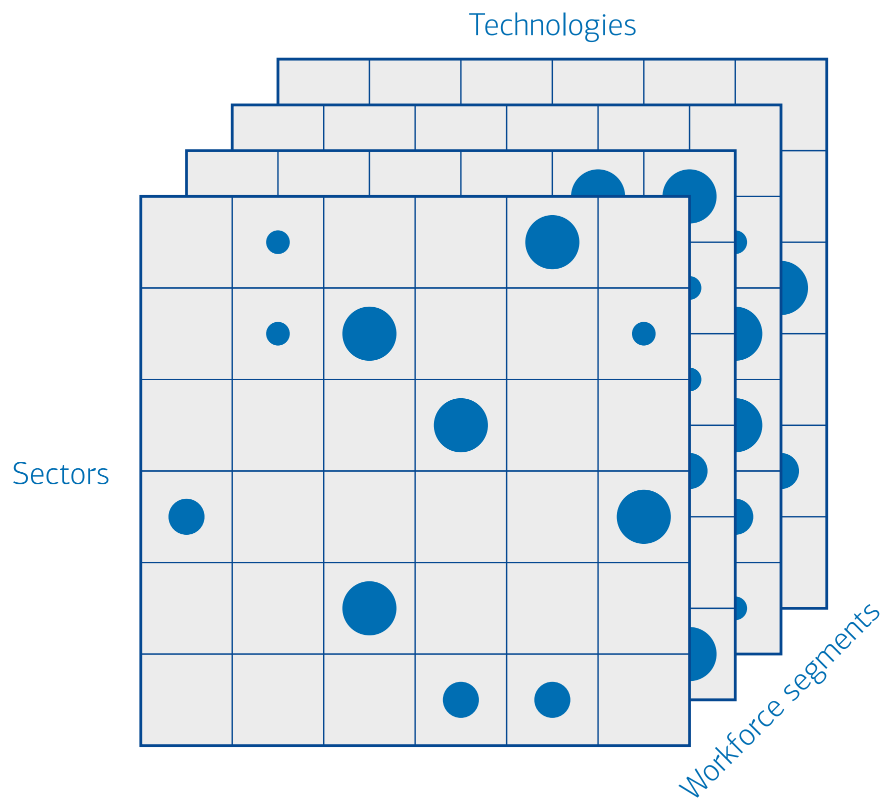
5.4 Qualitative skills needs

With respect to these generic skills requirement, some initial hypotheses can be set up regarding qualitative skills needs.

In the German context, a to-be-developed vocation might be the Industrial ICT Specialist, combining expertise in electronics and ICT (hardware/software). Open questions would concern the relation of this new vocation to the already existing Mechatronics Specialist. Furthermore, it might be asked whether this should be an initial vocation, or a qualification to be gained within CVET, e.g. as a continuing education perspective for Mechatronics Specialists.

Within Higher Education, a future specialisation – e.g. as a Master programme – could be something like 'Industrial Cognitive Sciences', with distributed sensor/actuator networks, robotics, perception (e.g. 3-D vision), cognition (e.g. action planning, cooperation; swarm intelligence) as focus domains.

Figure 7: Technology / sector matrix



Similarly, a programme called 'Automation Bionics' might also cover robotics, with emphasis on actuators (e.g. artificial muscles, limbs and organs), and perception/cognition aspects, but rather from a biological perspective, in order to facilitate an "organic" cooperation between humans and machines.

5.5 Organisation Scenarios

As a basis for skills needs analysis, organisation scenarios are required. Different paradigms of industrial organisation will yield very different skills needs, as the following fragments from organisation scenarios may illustrate. These texts are taken from a study by IIT for the Confederation of German Trade Unions (DGB).[12] Among more fact-oriented material, a 'story-telling' element was also included, describing a fictive dialogue between shop stewards around the year 2020, exchanging experiences from their different kinds of 'smart factories'. The first one would tell this story:

"I'll explain it referring to our machine setters. They've all got smart glasses now. If something's to be done anywhere, the setters will get a message displayed in their glasses, e.g. 'go to unit 13, milling machine'. When they arrive there, all the tools they need will already be there on automatic trolleys. They don't need to think very much anymore. The tools they will need next are highlighted in their glasses. If they need any more information, it will also be displayed there. In a way, these colleagues are now remote-controlled by their smart glasses".

His colleague from another company would answer:

"We don't have specific machine setters. All colleagues in our production team can do the setting-up, and also some maintenance. Because everything's connected to everything, we can pretty well monitor, at our info-terminals, what's going on in production. Even better: What will be going on, we will see whether our supply parts are still on the motorway, or already in our company. Thus, we can organise and coordinate our work just fine."

From these examples, it should become obvious that even very similar or identical technologies may be embedded in very different organisational environments, implying different skills needs.

5.6 Technology/Sector Matrices

Finally, skills needs analysis has to take into account different effects of the same technologies in different sectors. This may, firstly, concern different organisational paradigms, as presented in the previous section, which may occur more or less frequently across sectors. Furthermore, technologies will lead to different skills needs in sectors producing these technologies, as opposed to those using them; some sectors might be producers and users at the same time. Within the sectors, the skills needs might – and most probably will – differ between workforce segments (e.g. R&D vs. production; vocationally vs. academically educated staff, etc.). To our best knowledge, a systematic technology/sector analysis, with respect to skills needs, has not yet been undertaken. Thus, this methodical element is, for the time being, a mere proposal.

6 Implementation within R&D Programmes:

6.1 Introduction

Results of skills needs analysis may be used in different contexts, driven by different users. In Germany, a typical use context would be within vocational education. Social partners might pick up results from such analyses (in fact, they sometimes do) and ask the Federal Institute for Vocational Education and Training (BIBB) to facilitate a process leading to a modification of an existing, or the creation of a new vocation.

Another context might be publicly funded programmes, either such tuned towards educational issues, or others covering (technological) innovations. The following example stems from this latter context.

12 cf. footnote 8

6.2 Training and qualification for age-related assistive systems

Being one of the countries that is most affected by demographic change, Germany seeks for solutions to cope with the impact of this exceptional challenge. Apart from "classical" issues concerning education, social and pension systems, work force development, child care etc., one option is to make use of the potential of high technology to contribute to a society of longer life expectancy. This technology-oriented perspective which gained European and international attention is known today as Ambient Assisted Living (AAL) encompassing advanced computer technologies, software developments, interface design and robotic approaches in order to assist older people leading an independent and self-determined life. To a certain degree, AAL can be seen from a technological point of view as the "caring and living" counterpart to industry 4.0/Cyber-Physical Systems for production.

Due to the development of advanced technological solutions and their embedding into, for example, existing caring scenarios, AAL systems require state-of-the-art knowledge concerning operating, maintenance and interaction in a traditional "low tech" environment. Many of the systems are still prototypes that wait for a broad market roll-out (final hurdles being not so much technical specifications as missing business models).

Regardless of the sketched situation, experts from academia and enterprises expect a broad introduction of AAL systems within the next few years. To make these systems a success, a technologically qualified work force has to mirror technological progress. The central issue in this context is that the existing professional careers have to be widened in order to include sound knowledge on AAL. This means that nurses using the systems and craftsmen installing and maintaining AAL solutions need skills complementary to their existing professional expertise; an aspiration which is not accomplished so far.

In order to react to this foreseeable qualification shortfall, since 2011 the German Federal Ministry of Education and Research (BMBF) has promoted nine interdisciplinary educational and training projects that aim at conceptualising advanced training courses in higher education for non-academics and academics. The overall budget for these projects amounts to up to 5 million Euros.

Based on the analysis of future technological developments, future needs mainly arise in sectors of care and handicraft. After the validation of the identified and qualified tendencies and elaborated roadmaps, a set of curricula for extra-occupational and full-time training (theory and practical elements) has been developed. Professionals as well as undergraduates and post-graduate students can achieve a Master of Science in Ambient Assisted Living or be trained as consultants for Ambient Assisted Living in their special fields of work.

7 Conclusions

A proposal has been made here for skills needs analysis/prognosis based on technology roadmaps. It has been conceptually applied to Industry 4.0 as an important future innovation field. A similar approach has been applied to AAL.

Within this scope, it was argued that existing technology roadmaps from different sources and in different formats provide substantial input for skills needs analysis.

Two aspects were specifically emphasised. Firstly, organisation scenarios are a necessary element of skills needs prognosis, because there is no 'technological determinism': Similar technologies may lead to different skills needs, depending on the organisational environments.

Secondly, a technology/sector-matrix should be used as conceptual grid to address different skills needs in different workforce segments in different sectors depending on different subsets of the technologies under consideration.

Finally, among various contexts for using results of skills needs analyses, publicly funded (innovation) programmes have been identified as promising 'biotopes'.

Utilizing Patent Data in Identifying Future Skills Needs: Case of Network and System Information Security

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Abstract

Objectives: Identification of future skills needs has emerged as a crucial subject for education and training amid accelerating technological changes. For achieving this target, patent data can be used as analytical benchmark for future technological trends. This study will propound such methodology and assess the appropriateness of forecast on future skills needs as based on patent data. Basically, the suggested method includes the analysis which relates the information on past patent data to the current job data and prospective skills needs. The exploration also involves: deduction of skills needs from current job analysis; matching the IPC bundle to the skills needs; analysis of IPC time horizon; forecast of the future skills needs as based on the IPC time horizon and evaluation of the appropriateness of the forecast skills needs in reality.

Keywords:

future skills needs, network information security, patentometrics, job analysis

1 Foreword

Amid accelerating technological changes, identifying future skills needs has emerged as a critical subject for education and training; the issue is how to execute such identification. For that matter, this study argues that some information derived from patent data can be used for identification of future skills needs as a measurement for future technological trend. Besides, an attempt is made to test the appropriateness of such patent data-based forecast. In contrast to conventional studies which analyze or 'interpret' changes of skills needs that have already happened or are currently taking place, this study focuses on the needs for new skills required in the future as related to the pace of technological innovation.

The required analysis should contain the detailed contents of required skills, which can be called a *qualitative* forecast as differentiated from the existing *quantitative* forecast on workforce demand and supply. Conventionally, this kind of qualitative forecast can be executed through analysis of expert panel discussion. However, this kind of analysis can raise several issues of weakness regarding the possibility of verification. Therefore, this study will conduct a verifiable qualitative analysis on the specific and measurable basis of patent information and could be regarded as another quantitative approach. However, in the aspect of interpretation and linkage by related experts to job analysis and curriculum analysis, it might be called a limited quantitative approach, even though it uses patent data.

This study will review (in Chapter 2) the possibility of analysis on future skills needs through patent data analysis at a theoretical level. It will discuss knowledge base and knowledge network, along with the possibility of skills needs analysis through patent data. In Chapter 3, skills needs will be derived from current job analysis in the area of information security technology, and a link between IPC and skills needs will be established. Chapter 4 will analyze the IPC time horizon, provide a skills needs forecast, and verify the appropriateness of forecasted skills needs in reality (verification is still an on-going process). In the conclusion, the achievements, limitations and future research direction of analysis on future skills needs through patent data analysis, presented in this study, will be discussed.

2 Possibility of patent-data analysis of future skills needs

2.1 Necessity and limitation of future-skills-needs analysis

Discussing technological innovation skills change is not only a theoretical subject but also a practical task. While skills change is not only the result but also a carrier accelerating technological changes [the classical adaptation hypothesis by Nelson and Phelps (1965), which asserts that appropriate level of workforce is necessary for employing new technology, and the complementarity hypothesis by Griliches (1969), which asserts that technological change requires high-skilled labour], developed countries require analysis of the new skills which will arise in the future according to the progress of technological innovation. But, rather than detailed foundation or theoretical discussion, the need for policymaking is being raised. Perez (1983) asserted the necessity of skills change accompanied by technological development by focusing on the changes of system and environment in the birth and spreading of new technology and considering human resource as one of the key environmental factor for acceleration in spreading of technology, but did not present it with exhaustive details.

Developed countries are elaborating alternative plans for creation of new jobs and skills in accordance with the emergence of new industry, and the European Centre for the Development of Vocational Training (CEDEFOP) has been the focal point for continuous discussion on future skills needs (CEDEFOP, 2008), but the qualitative forecast or detailed contents for future skills needs is unsatisfactory. Conventional analysis focuses on Labour Market Information, which utilizes trend-effect information, and that is useful for analysis of the present time and the near future, but it has a limit on the analysis for newly emerging technology beyond trend-effect information. This limit is commonly present because the conventional forecast on workforce demand and supply is mainly focused on quantitative demand changes by industry and occupation.

2.2 Knowledge theory & skills

Before proceeding further to a future skills need analysis, a review of the concept of *skill* is necessary. In this study, skills include *technology* and dexterity, and as a concept are interchangeable with knowledge. In its turn, knowledge in this context focuses on the knowledge-as-competence and knowledge-as-acquaintance rather than propositional knowledge.[1]

When focusing on the knowledge-as-competence and knowledge-as-acquaintance, the discussion of Gibbons et al (1994) and the review on its development, which analyzed the changes on knowledge production method focusing on modern science and technology, are useful. Gibbons et al discussed the transition of the knowledge production method while naming traditional method of knowledge production as *Mode 1 knowledge*, and the new method of knowledge production which transformed the traditional one as *Mode 2 knowledge*. While Mode 1 designates knowledge formation happening within a circle of a certain discipline, Mode 2 designates knowledge formation happening through inter-disciplinarity /trans-disciplinarity. Nowotny et al (2003) regarded Mode 1 as the development of the existing science and technology based on the distinction in the academic system, while Mode 2 is regarded as the new paradigm of knowledge creation.

In rapid technological progress, Mode 2 type of knowledge is also expanding. Simple restructuring of existing knowledge is not sufficient and requires continuous knowledge creation. This kind of knowledge creation enhances the characteristics of knowledge convergence, and absorbing converged knowledge, as a response, has a limitation because participation in the continuous knowledge convergence is necessary.

2.3 Knowledge network and Patent data analysis

Saviotti (2004, 2007) argued that knowledge has two different attributes in knowledge creation and utilization: (P1) Knowledge has co-relational structure; (P2) Knowledge has retrievable/interpretative structure. (Refer to Hwang et al (2011) for detailed review). Such attributes of knowledge can symbolize knowledge as a network (Saviotti, 2009: 25-26), and this transitional knowledge-networking displays the dynamics of the process. The 'advent of new technology' and the more recent 'convergence of knowledge' can be regarded and analyzed as such a knowledge-network.

Patent data can actualize the analysis of this knowledge-network, i.e. through quantifying and structuring patent data, understanding of the knowledge development and structure becomes possible. The structure of data hidden in theses and patents can play a critical role as a 'proxy meter' in understanding the structures of R&D activities and related knowledge.

Conventionally, due to skills needs following the technological innovation process, the analysis of patents which are per se the products of technological innovation can provide keys to the analysis on future skills needs.

3 Job analysis as linked to IPC of 'Information Security' area

3.1 'Information security' as a subject of analysis

The ICT area which recently underwent significant technological advancement and has a relatively well-organized, in the current viewpoint, skills needs analysis through jobs, was selected for the purposes of methodology development in the course of pre-consideration, while selecting the subject for analysis and method application. The consistently rapid technological advancement of the ICT sector since the 1990s was confirmed by the annual trend in a number of patents registered at the U.S. Patent and Trademark Office.[2] It then went through the expert consultation regarding the validity of technological advances identified in the ICT patent data. Since the job description of the ICT technology sector was relatively clear, it was judged to be suitable for the analysis on current skills needs. As an area with a relatively easy comparison for forecasting skills through patent analysis from significantly advanced skills needs analysis within the ICT sector, the information security area was finalized.[3]

In this study, physical security is beyond the scope of interest. Since the application service security and convergence security can be regarded as a utilized area of information security, this study defines the range of information security by focusing on network and system security, including common-base security. The technology of common-base security was not analyzed separately but included and reviewed in the analysis for the network and system security.

3.2 Job configuration And Necessary knowledge for Information security sector

Before analyzing the job configuration and skills needs in information security, the current situation and prospects of human resources were classified. The information about the analysis on job configuration and required knowledge was organized through expert advice and materials from within the country and outside. The required knowledge on information protection and education certification programmes were reviewed from the United States, while the related research into information security job analysis was summarized in Korea. The required skills for information security jobs were classified by experts.

3.3 Patent elicitation

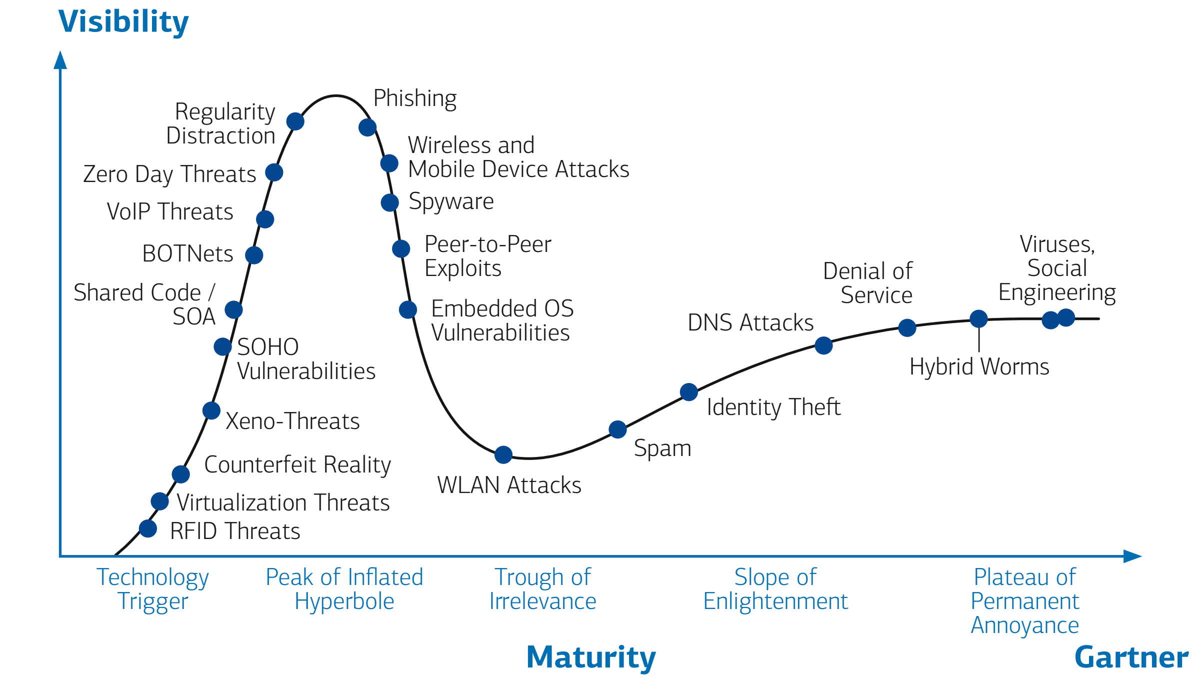
The full (per year) patents from the Korean Intellectual Property office provided the basic materials for patent analysis (accessed on June 25, 2013), which were extracted through KIPRIS DB (http://kpat.kipris.or.kr/). The search formula employed the basic search by using the IPC code as the 1st step, and re-extracted the appropriate IPC code (7 digit level) from the 1st step, while combining the keyword in

1 Besides knowledge as competence and acquaintance, there are areas of transcendent knowledge and logical knowledge which are closely related to propositional knowledge. In the dimension of Epistemology, knowledge can be classified into the following three. (Balconi et al., 2007: 6-7). Firstly, knowledge means ability to do something (knowledge as competence) from simple behavior to complex cognitive behavior, i.e. from use of a simple hammer to use of complex language. Secondly, knowledge is a familiar behavior of getting to know someone or something through past experiences (knowledge as acquaintance), like remembering the faces of frequently encountered people. Thirdly, there is a concept of propositional knowledge, which means recognizing the necessity of modifying a certain information at hand. This is an inherent nature of mankind as a supreme specie.

2 In the early stages of this study, analyzing U.S. patents was attempted but switched to Korean patents in consideration of ease of analysis during the process (including context analysis) and correspondence to skills needs according to Korean trends and specifics of security technology. Utilizing U.S. patents was left as a task for a future project.

3 Gartner's information security and IT trends

Gartner's information security and IT trends (2005)



Gartner's information security and IT trends (2012)

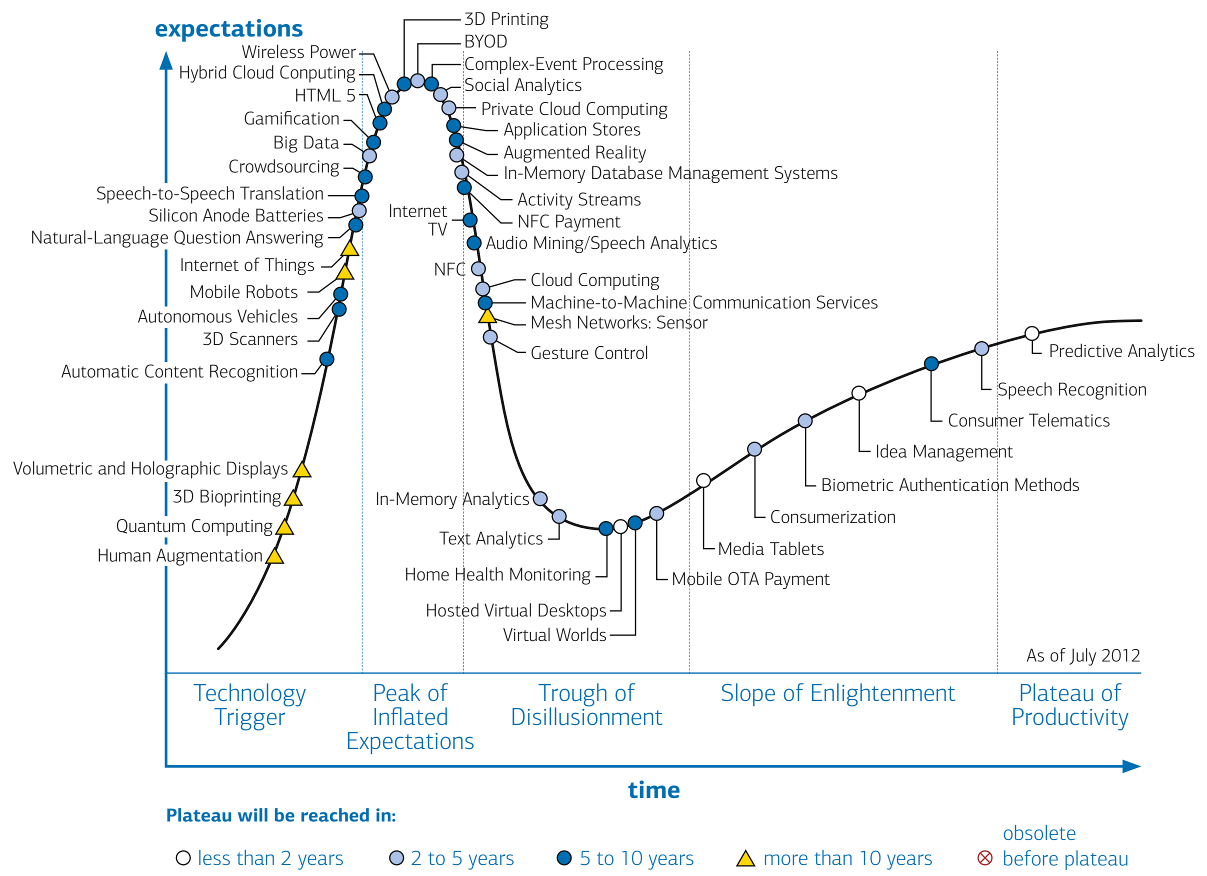


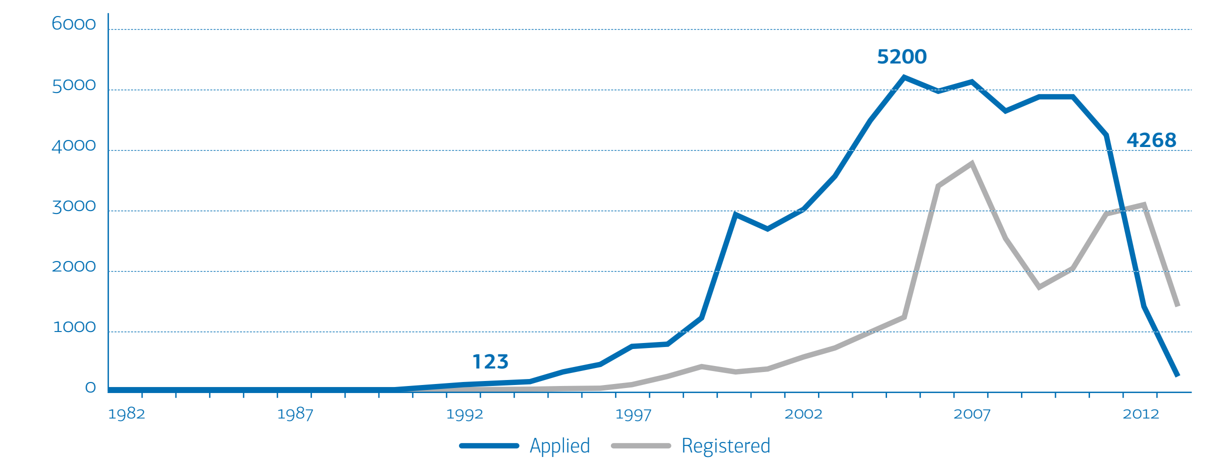
Table 1: Job configuration & required skills for Information security sector

Classification		Required skills (Limited to technical items)
Category	Sub-category	
Strategy & planning	(A) Risk analysis	(A-1) Security weakness analysis
		(A-2) Network security scanner
		(A-3) Pilot hacking, simulated infiltration
	(B) Establishing information protection policy & plan	(B-1) ISMS (Information Security Management System)
		(B-2) Security policy
		(B-3) Security management on outsourcing
		(B-4) Task Identification
		(B-5) Inspection logging
		(B-6) PC security
		(B-7) Data security
		(B-8) Network security
		(B-9) Server security
	(C) Privacy protection management	(C-1) Privacy protection law
		(C-2) Privacy information encryption
Marketing & sales	(D) Marketing management	
	(E) Technical sales	
R&D, Implementation	(F) R&D	(F-1) Encryption algorism
	(G) Implementation	
Education & training	(H) Public & user education	
	(I) Expert education	
Management & operation	(J) Project management	(J-1) Security architecture
	(K) Information infrastructure security management	(K-1) Firewall configuration
		(K-2) Virus vaccine
		(K-3) Spyware
		(K-4) Phishing
		(K-5) Spam
		(K-6) (DB security encryption
		(K-7) OTP(One Time Password)
		(K-8) PKI(public key infrastructure)
		(K-9) VPN(Virtual private network)
		(K-10) DDoS (Distributed Denial-of-Service attack)
		(K-11) MDM(Mobile Device Management)
		(K-12) IPS(Intrusion Prevention System)
		(K-13) Certification service
	(L) Physical security	
Emergency response	(M) Monitoring & responding	(M-1) Weakness analysis
		(M-2) Log analysis
		(M-3) Security control
		(M-4) APT(Advanced Persistent Threat)
	(N) Digital forensic	N-1) Understanding forensics
		(N-2) Cryptology
		(N-3) Hacking technique
		(N-4) Cyber attack
	(O) Job continuance management	
Evaluation & certification	(P) Evaluation certification & quality assurance	
	(Q) Information system security inspection	(Q-1) Security inspection
		(Q-2) Information security event management

'or' condition in consideration of the possibility of omission from searching only with the IPC code. Keywords were applied to the patent abstract.

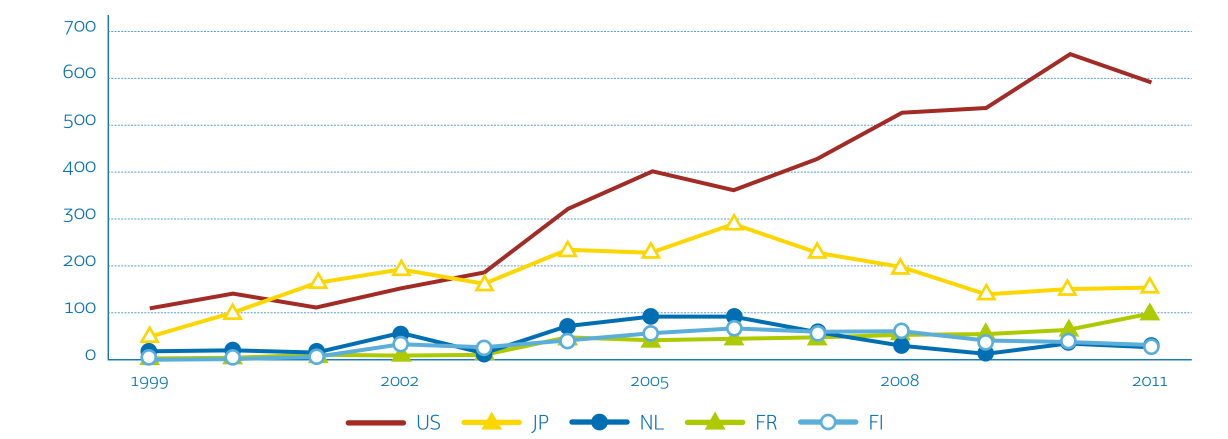
As of June 25 2013, the results of a search for 56,657 patent cases are represented in the graph below. The patent first appeared in 1982, and more than 100 patents per year were first filed since 1993, with 123 cases, from which it had increased rapidly. After exceeding 1,190 cases in 1999, it had reached 5,200 cases in 2005, from which it has displayed a downward trend, decreasing to 4,268 cases in 2011. The rapid decrease from 2012 can be considered to be caused by the patents that have not been exposed and remain in the review process.[4] On the other hand, the registered patents were indicated with dotted line, which means that there is a certain time gap between the registered patents and patents pending.

Figure 1: Patents pending for Information security



Source: arranged by author by extracting from http://kpat.kipris.or.kr/ (accessed on June 25, 2013)

Figure 2: Comparison of Patent filed countries



Source: arranged by author by extracting from http://kpat.kipris.or.kr/ (accessed on June 25, 2013)

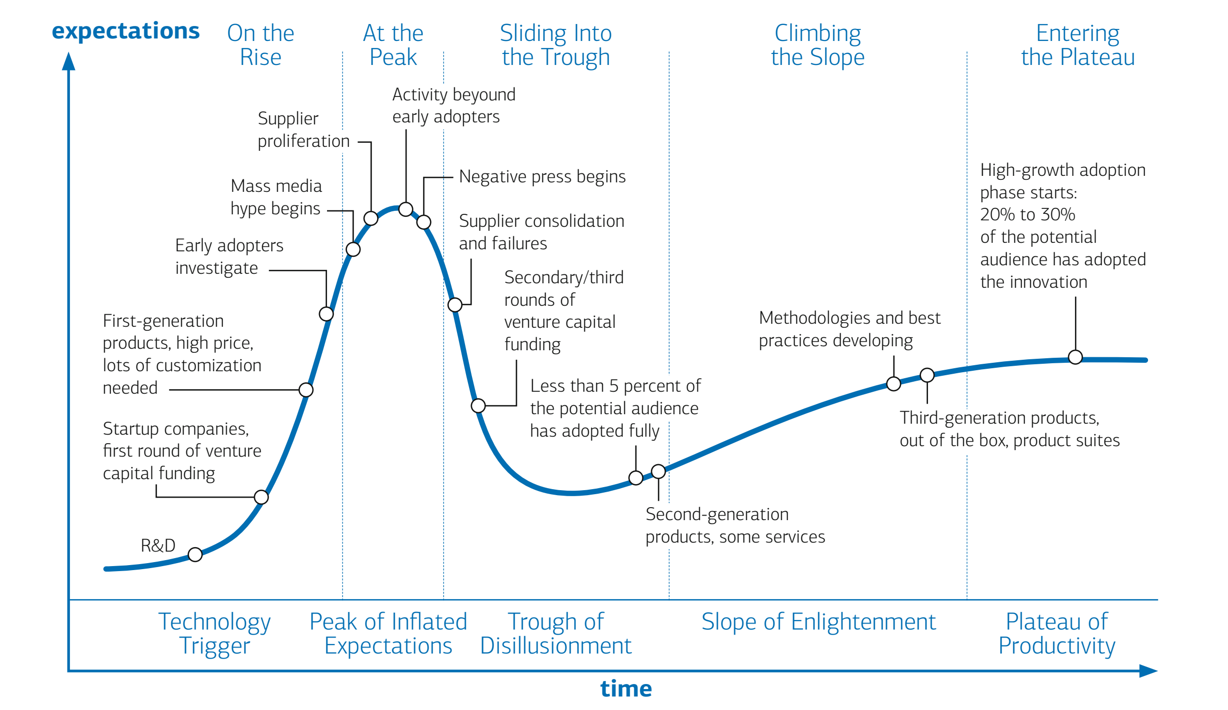
52,030 cases of filed patents from 1999 to 2011 are mainly analyzed in figure 2 below, and the filed countries were briefly reviewed prior to serious analysis. In the countries that had filed more than 100 patents during the same period, Korea had the most with 42,077 cases, followed by the United States (US) with 4,574 cases, Japan (JP) with 2,347 cases, Netherlands (NL), France (FR), Finland (FI), Germany, China, Sweden, Canada, the United Kingdom and Switzerland etc., in order. When looking into the trends of the top 5 countries for patents filed excluding South Korea, the United States exhibited a continuous increase, while Japan had declined since 2006.

3.4 Matching the IPC with required skills of each job

While relating IPC in extracted patents with the required skills, those skills which could not be expressed through IPC were not matched with it, while the IPC which does not refer to information security was ignored. At the same time, matching multiple IPC items with one skill was allowed, as well as matching one IPC with several knowledge elements.

The matching results obtained finally through the co-work with experts, are shown in the following table in which **G06F019** (Digital computing or data processing equipment or methods, specially adapted for specific applications) is related to all of the required skills of '(B-1) ISMS(Information Security Management System)', '(B-2) Security policy', '(C-1) Privacy protection law', '(C-2) Privacy information encryption', '(K-6) DB security encryption' and '(Q-1) Security inspection', while '(B-1) ISMS(Information Security Management System)' is related not only to **G06F019**, but to **G06Q040**, **H04W004**, **H04W008**, **H04W012**, **H04W028** and **H04W064**.

4 There seems to be the decreasing effect of "after peak".



4 Patent analysis-based forecast on the skills needs

4.1 Trend in expected skills needs as based on the patent trend

Under analysis was the forecast on required skills-by-job based on IPC distribution trend as correlated with patent trend. For a required skill S_i, the forecasted required skill during *t* period is defined as S_i^t, while the frequency of S_i^t is $N(S_i^t)$ and $N(S_i^t)$ is the sum of appeared frequency for multiple S_i related IPC during t period. For example, while IPCs related with the skill of (B-1) ISMS(Information Security Management System) are **G06F019**, **H04W004**, **H04W012**, **H04W064**, **H04W008**, **G06Q040** and **H04W028**, S_{B-1}^{2000} forecasted for year

Table 2: Matching the IPC and required skills by job

Required skills (Limited to technical items)	G06F009	G06F017	G06F019	G06F021	G06K007	G06Q010	G06Q040	G06T001	G09C001	H04B001	H04K001	H04L009	H04W004	H04W008	H04W012	H04W028	H04W048	H04W060	H04W064	H04W080	H04W084	H04W088	H04W092
(A-1) Security weakness analysis				1		1																	
(A-3) Pilot hacking, simulated infiltration				1																			
(B-1) ISMS			1				1						1	1	1	1			1				
(B-2) Security policy			1			1									1				1				
(B-3) Security management on outsourcing						1																	
(B-4) Task Identification						1																	
(B-6) PC security				1																			
(B-7) Data security		1		1	1			1															
(B-8) Network security										1	1	1	1	1		1	1		1	1	1	1	1
(C-1) Privacy protection law			1												1								
(C-2) Privacy information encryption			1																				
(F-1) Encryption algorism				1				1	1		1	1								1			
(J-1) Security architecture														1									
(K-1) Firewall configuration														1							1		
(K-5) Spam							1																
(K-6) DB security encryption			1																				
(K-7) OTP															1								
(K-9) VPN							1																
(K-11) MDM													1						1				
(K-13) Certification service							1						1		1			1	1				
(M-1) Weakness analysis													1										
(N-2) Cryptology												1											
(Q-1) Security inspection	1		1																				
(Q-2) Information security event management	1	1																					

Source: arranged by author

2000 is the sum of **G06F019**, **H04W004**, **H04W012**, **H04W064**, **H04W008**, **G06Q040** and **H04W028t** among the patents filed in 2000. The result is presented on the following Table 3. The rates of relative importance of skills derived based on that are presented in Table 4.

Based on the time trend, mainly since 2005, three categories are interpreted: increasing, decreasing and stable patterns. In Figure 3, the increasing skills needs with large demand, mainly since 2005, are expected on '(B-3) Security management on outsourcing', '(Q-1) Security inspection'. '(B-4) Task Identification', '(K-13) Certification service', '(M-1) Weakness analysis' and '(A-3) Pilot hacking, simulated infiltration'. On the basis of the 2011 data, these are showing the demand from 4% to 8%. Other increasing

Table 2: Matching the IPC and required skills by job

Note 1. Relevance is expressed as "1"

2. Code description of IPC is based on "IPC version 2009.01"

G06F009 Arrangements for programme control, e.g. control unit (programme control for peripheral devices G06F 13/10)

G06F017 Digital computing or data processing equipment or methods, specially adapted for specific functions

G06F019 Digital computing or data processing equipment or methods, specially adapted for specific applications (G06F 17/00 takes precedence; data processing systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes G06Q)

G06F021 Security arrangements for protecting computers or computer systems against unauthorized activity (multiprogramming G06F 9/46; protection against unauthorized use of memory G06F 12/14; dispensing apparatus actuated by coded identity card or credit card G07F 7/08; equipment anti-theft monitoring by a central station G08B 26/00; secret or secure communication H04L 9/00; data switching networks H04L 12/00 G06K007 Methods or arrangements for sensing record carriers (G06K 9/00 takes precedence)

G06Q010 Administration, e.g. office automation or reservations; Management, e.g. resource or project management

G06Q040 Finance, e.g. banking, investment or tax processing; Insurance, e.g. risk analysis or pensions

G09C001 Apparatus or methods whereby a given sequence of signs, e.g. an intelligible text, is transformed into an unintelligible sequence of signs by transposing the signs or groups of signs or by replacing them by others according to a predetermined system (cryptographic typewriters G09C 3/00) H04B001 Details of transmission systems, not covered by a single one of groups H04B 3/00-H04B 13/00; Details of transmission systems not characterised by the medium used for transmission (tuning resonant circuits H03J)

H04K001 Secret communication (ciphering or deciphering apparatus per seG09C; systems with reduced bandwidth or suppressed carrier H04B 1/66; spread spectrum techniques in general H04B 1/69; by using a sub-carrier H04B 14/08; by multiplexing H04J; transmission systems for secret digital information H04L 9/00; secret or subscription television systems H04N 7/16)

H04L009 Arrangements for secret or secure communication

H04W004 Services or facilities specially adapted for wireless communication networks

H04W008 Network data management

H04W012 Security arrangements, e.g. access security or fraud detection; Authentication, e.g. verifying user identity or authorisation; Protecting privacy or anonymity

H04W028 Network traffic or resource management

H04W048 Access restriction; Network selection; Access point selection

H04W060 Registration, e.g. affiliation to network; De-registration, e.g. terminating affiliation

H04W064 Locating users or terminals for network management purposes, e.g. mobility management

H04W080 Wireless network protocols or protocol adaptations to wireless operation, e.g. WAP [Wireless Application Protocol]

H04W084 Network topologies

H04W088 Devices specially adapted for wireless communication networks, e.g. terminals, base stations or access point devices

H04W092 Interfaces specially adapted for wireless communication networks

Source: arranged by author

skills needs with small demand are expected on '(B-1) ISMS (Information Security Management System)', '(B-1) Information protection management system ISMS', '(J-1) Security architecture', '(M-2) Log analysis' , '(K-1) Firewall configuration' and '(B-6) PC security'.

On the contrary, in Figure 4, decreasing skills needs with very large demand are expected in '(B-8) Network security', '(B-2) Security policy', '(C-1) Privacy protection law' and '(K-11) MDM mobile device management'. While they have high levels of skills needs, they appear to have declined in those. Still another decrease in skills needs with small demand is expected in '(C-2) Privacy information encryption' and '(K-9) VPN'.

In Figure 5, stable skills needs with very large demand appeared in '(F-1) Encryption algorism'. In addition, '(B-7) Data security', '(A-1) Security weakness analysis', '(K-5) Spam', '(K-6)

Table 3: Trend of skills needs from absolute size of IPC

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
(A-1) Security weakness analysis	22	193	154	147	189	279	215	463	679	882	808	767	873
(A-3) Pilot hacking, simulated infiltration	18	162	110	117	170	245	180	423	637	848	780	725	818
(B-1) ISMS (Information Security Management System)	685	1464	1617	2089	2722	3098	3591	3218	3218	2509	3143	2841	2088
(B-2) Security policy	92	196	255	313	304	452	529	498	624	421	778	618	555
(B-3) Security management on outsourcing	4	31	44	30	19	34	35	40	42	34	28	42	55
(B-4) Task Identification	4	31	44	30	19	34	35	40	42	34	28	42	55
(B-6) PC security	18	162	110	117	170	245	180	423	637	848	780	725	818
(B-7) Data security	43	318	249	260	339	506	429	758	1006	999	981	898	974
(B-8) Network security	947	1772	1987	2562	3413	4219	5201	4453	4674	3802	4614	4295	3645
(C-1) Privacy protection law	75	142	194	256	250	387	461	407	534	360	634	427	445
(C-2) Privacy information encryption	3	4	2	6	2	8	20	32	27	11	14	23	18
(F-1) Encryption algorism	159	412	308	349	413	797	804	997	1440	1556	1515	1324	1564
(J-1) Security architecture	58	158	225	319	407	414	532	403	434	312	333	225	117
(K-1) Firewall configuration	82	185	285	437	475	554	734	588	682	452	544	371	246
(K-5) Spam	21	96	52	51	86	72	85	135	100	139	131	131	115
(K-6) DB security encryption	3	4	2	6	2	8	20	32	27	11	14	23	18
(K-7) OTP	72	138	192	250	248	379	441	375	507	349	620	404	427
(K-9) VPN	21	96	52	51	86	72	85	135	100	139	131	131	115
(K-11) MDM	517	1055	1126	1441	1952	2178	2479	2222	2091	1661	2005	2028	1371
(K-13) Certification service	621	1314	1387	1759	2303	2658	3050	2766	2735	2181	2809	2608	1949
(M-1) Weakness analysis	504	1032	1109	1414	1917	2147	2446	2171	2043	1634	1889	1879	1316
(N-2) Cryptology	127	199	157	188	219	506	539	503	702	650	650	565	700
(Q-1) Security inspection	10	12	12	13	7	38	52	78	82	150	200	178	144
(Q-2) Information security event management	7	8	10	7	5	30	32	46	55	139	186	155	126
Total	**4113**	**9184**	**9683**	**12212**	**15717**	**19360**	**22175**	**21206**	**23118**	**20121**	**23615**	**21425**	**18552**

Unit: frequency

DB security encryption' are expected to be stable in skills needs, while their required skill level is low.

4.2 Forecasting and verification of skills needs (on-going process)

The issues arising from forecasting and verification include: how many years of time-lag should be employed and how many years of accumulated patents should be taken into account. For that matter, target year 2010 (basis of current job analysis) applies 3-years' time-lag (forecast with the patents up to 2007) and 5-years' time-lag (forecast with the patents up to 2005), while the accumulated period utilizes the consolidated patent data of 3-years period and 5-years period. Consequently, the 2010 skills needs are forecast by using 2007~2005 and 2007~2003 data with 3-years' time lag, and 2005~2003 and 2005~2001 data with 5-years'

Table 4: Trend of skills needs from relative size of IPC

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
(A-1) Security weakness analysis	0.5	2.1	1.6	1.2	1.2	1.4	1.0	2.2	2.9	4.4	3.4	3.6	4.7
(A-3) Pilot hacking, simulated infiltration	0.4	1.8	1.1	1.0	1.1	1.3	0.8	2.0	2.8	4.2	3.3	3.4	4.4
(B-1) ISMS (Information Security Management System)	16.7	15.9	16.7	17.1	17.3	16.0	16.2	15.2	13.9	12.5	13.3	13.3	11.3
(B-2) Security policy	2.2	2.1	2.6	2.6	1.9	2.3	2.4	2.3	2.7	2.1	3.3	2.9	3.0
(B-3) Security management on outsourcing	0.1	0.3	0.5	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3
(B-4) Task Identification	0.1	0.3	0.5	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3
(B-6) PC security	0.4	1.8	1.1	1.0	1.1	1.3	0.8	2.0	2.8	4.2	3.3	3.4	4.4
(B-7) Data security	1.0	3.5	2.6	2.1	2.2	2.6	1.9	3.6	4.4	5.0	4.2	4.2	5.3
(B-8) Network security	23.0	19.3	20.5	21.0	21.7	21.8	23.5	21.0	20.2	18.9	19.5	20.0	19.6
(C-1) Privacy protection law	1.8	1.5	2.0	2.1	1.6	2.0	2.1	1.9	2.3	1.8	2.7	2.0	2.4
(C-2) Privacy information encryption	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1
(F-1) Encryption algorism	3.9	4.5	3.2	2.9	2.6	4.1	3.6	4.7	6.2	7.7	6.4	6.2	8.4
(J-1) Security architecture	1.4	1.7	2.3	2.6	2.6	2.1	2.4	1.9	1.9	1.6	1.4	1.1	0.6
(K-1) Firewall configuration	2.0	2.0	2.9	3.6	3.0	2.9	3.3	2.8	3.0	2.2	2.3	1.7	1.3
(K-5) Spam	0.5	1.0	0.5	0.4	0.5	0.4	0.4	0.6	0.4	0.7	0.6	0.6	0.6
(K-6) DB security encryption	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1
(K-7) OTP	1.8	1.5	2.0	2.0	1.6	2.0	2.0	1.8	2.2	1.7	2.6	1.9	2.3
(K-9) VPN	0.5	1.0	0.5	0.4	0.5	0.4	0.4	0.6	0.4	0.7	0.6	0.6	0.6
(K-11) MDM	12.6	11.5	11.6	11.8	12.4	11.3	11.2	10.5	9.0	8.3	8.5	9.5	7.4
(K-13) Certification service	15.1	14.3	14.3	14.4	14.7	13.7	13.8	13.0	11.8	10.8	11.9	12.2	10.5
(M-1) Weakness analysis	12.3	11.2	11.5	11.6	12.2	11.1	11.0	10.2	8.8	8.1	8.0	8.8	7.1
(N-2) Cryptology	3.1	2.2	1.6	1.5	1.4	2.6	2.4	2.4	3.0	3.2	2.8	2.6	3.8
(Q-1) Security inspection	0.2	0.1	0.1	0.1	0.0	0.2	0.2	0.4	0.4	0.7	0.8	0.8	0.8
(Q-2) Information security event management	0.2	0.1	0.1	0.1	0.0	0.2	0.1	0.2	0.2	0.7	0.8	0.7	0.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Unit: %

Figure 3: Decreasing trends of the skills needs based on IPC time-pattern

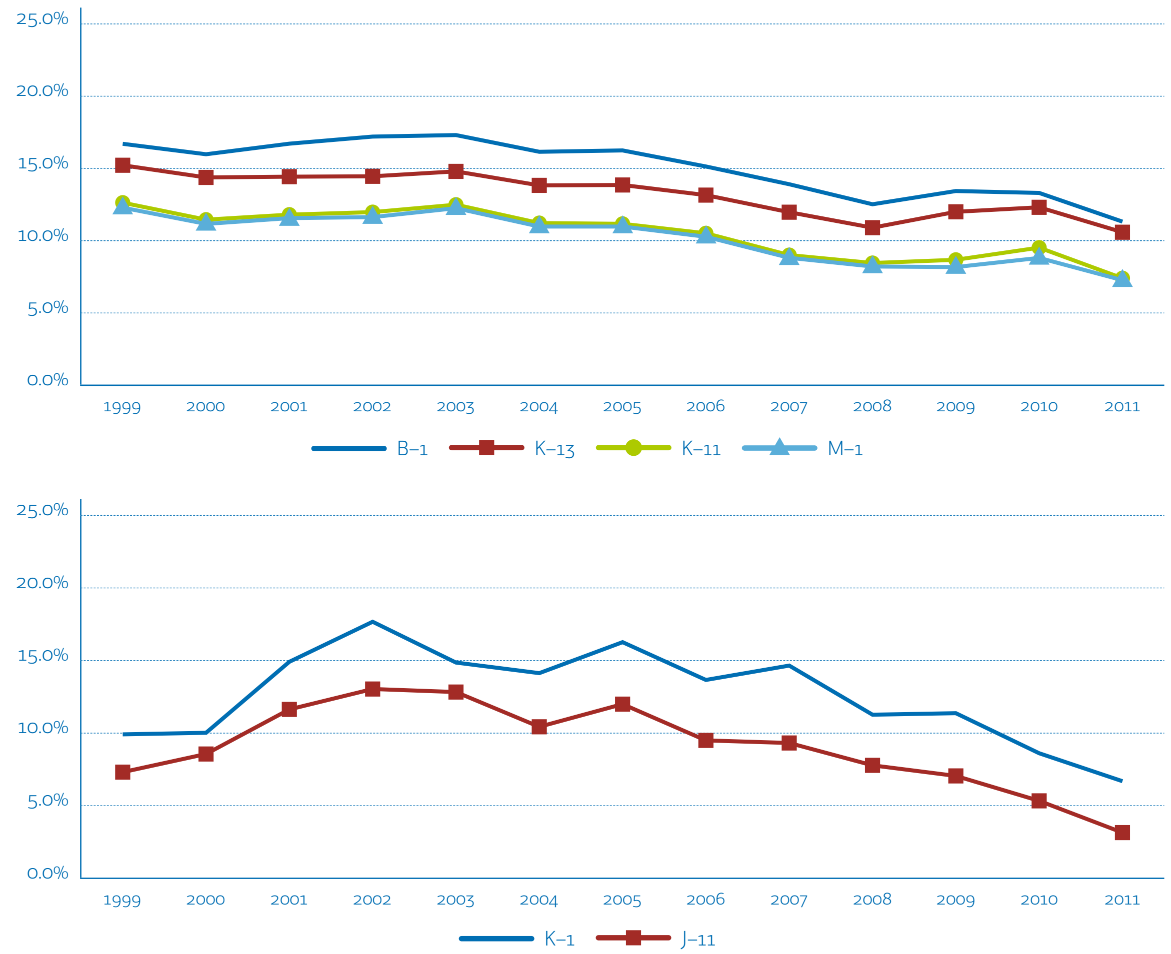


Figure 5: Stable trends of the skills needs based on IPC time-pattern

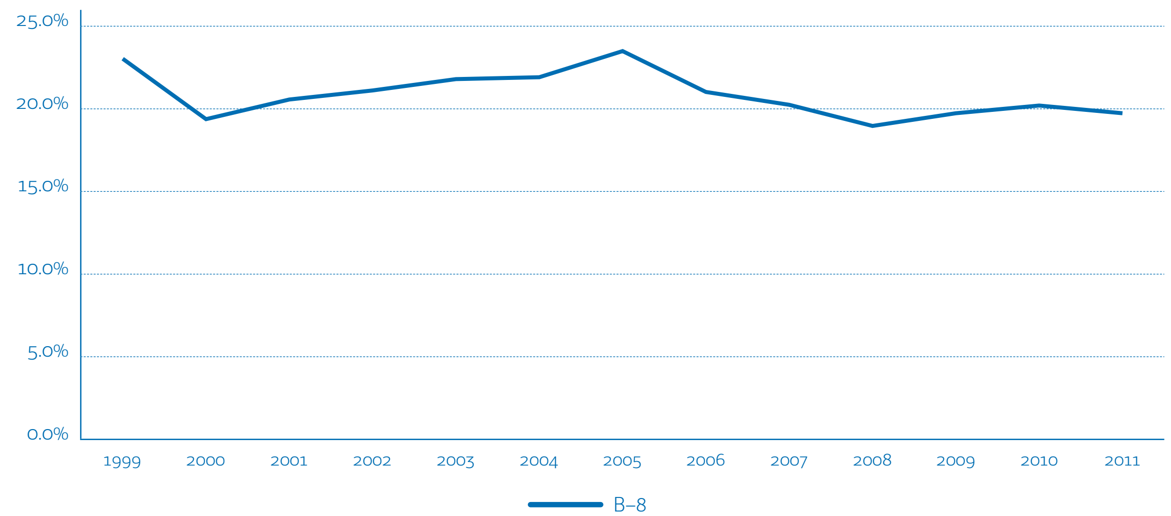


Figure 4: Increasing trends of the skills needs based on IPC time-pattern

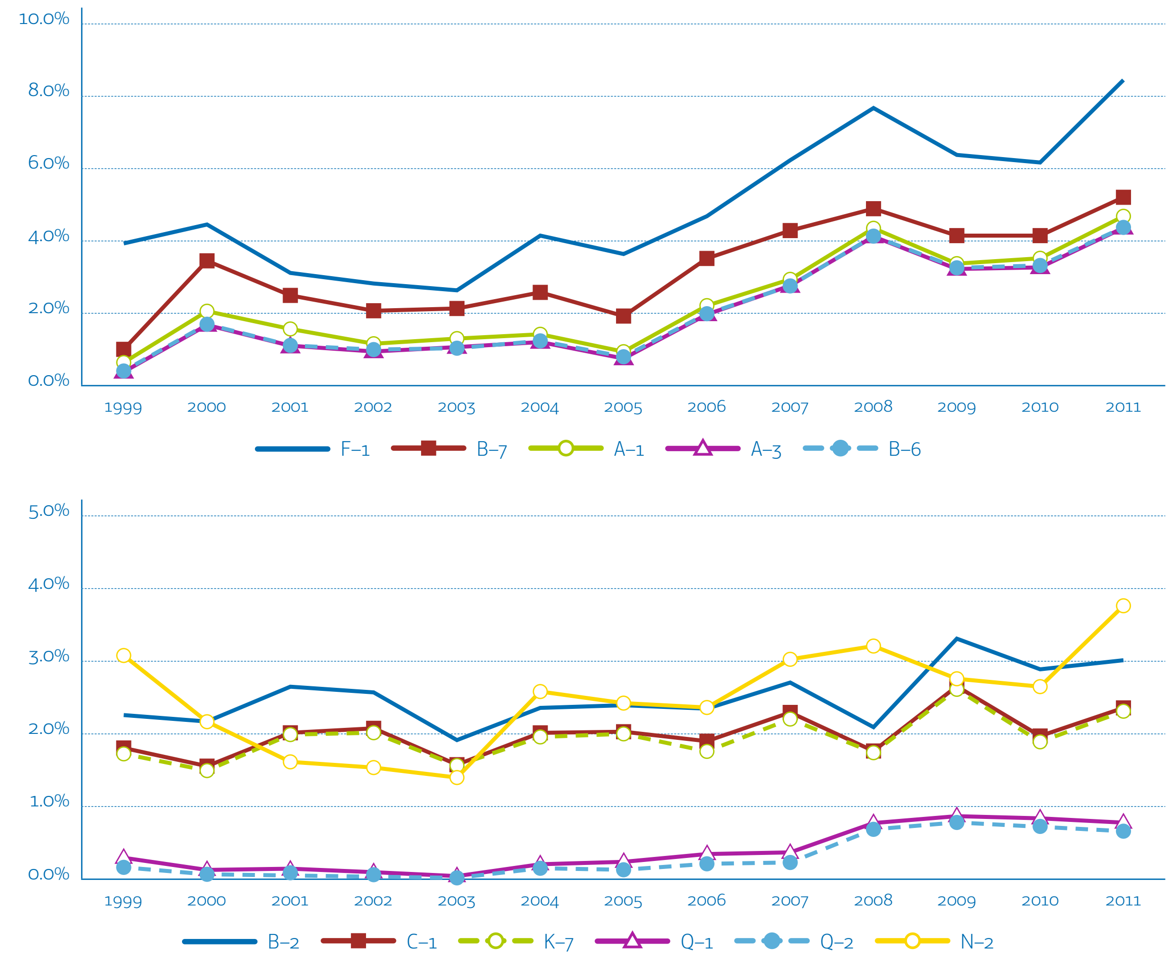


Figure 5: Stable trends of the skills needs based on IPC time-pattern

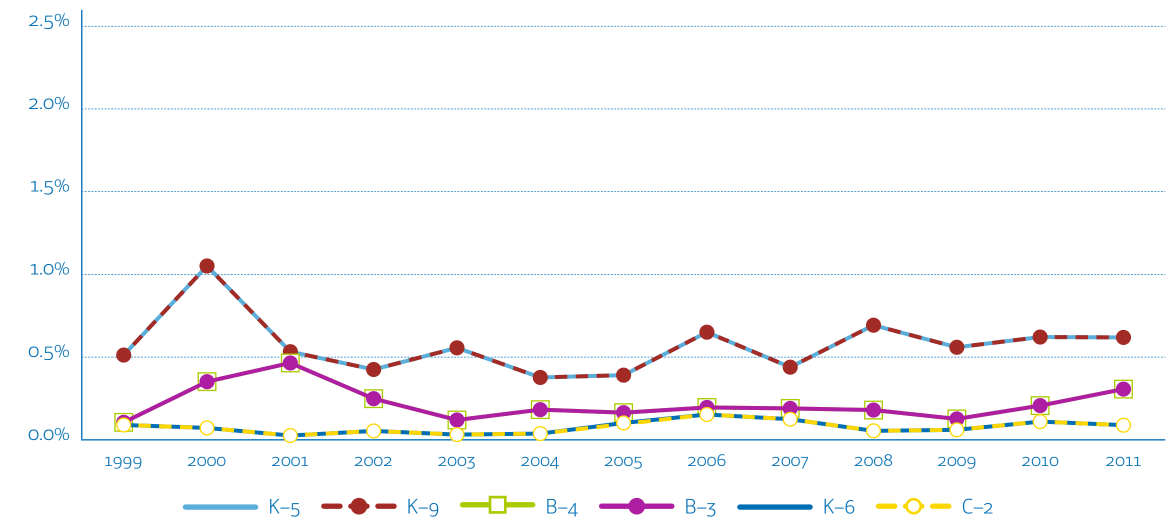


Figure 6: Trends of the skills needs based on 2005~2007 patent

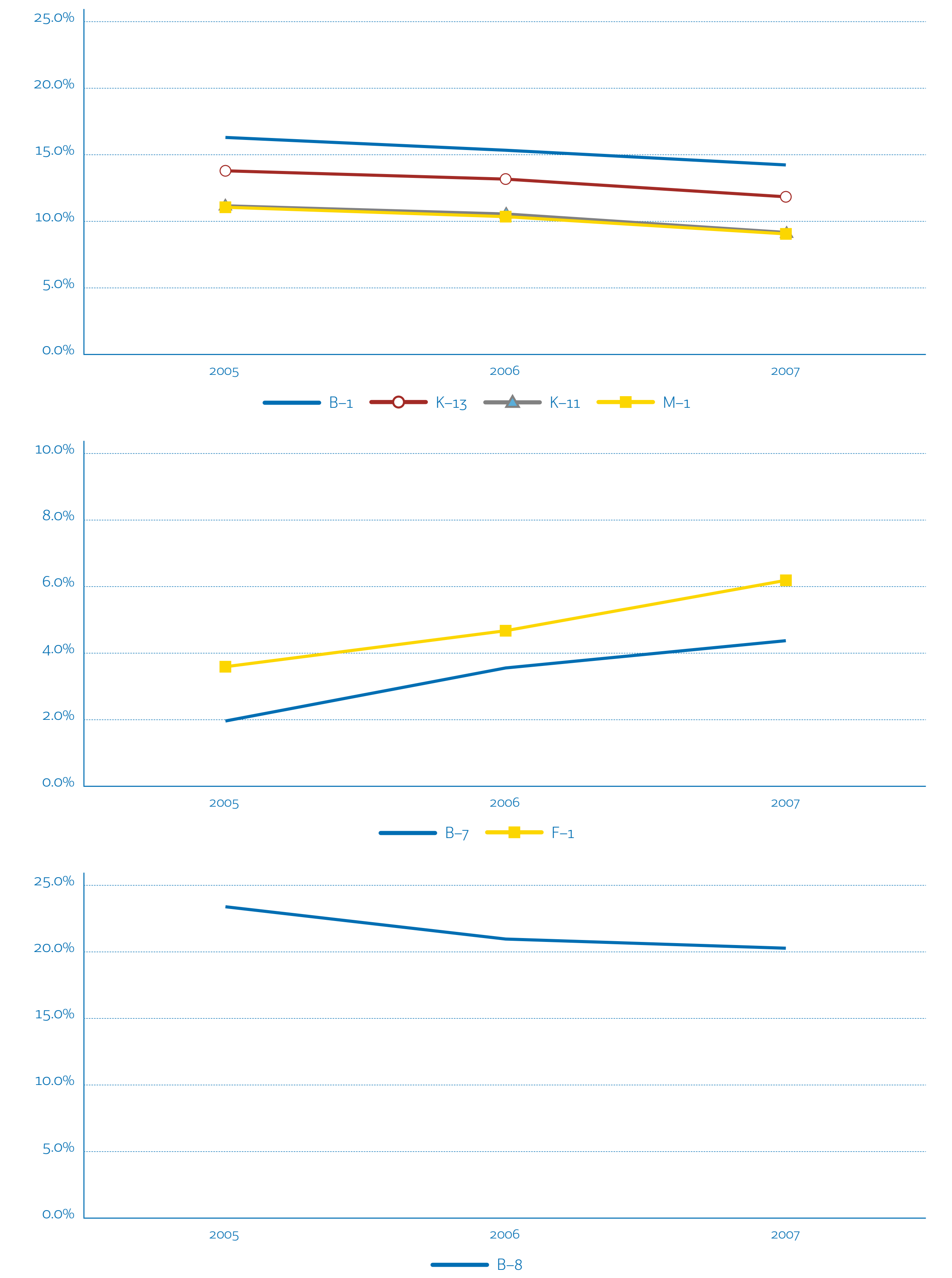


Figure 6: Trends of the skills needs based on 2005~2007 patent

Figure 7: Trends of the skills needs based on 2003~2007 patent

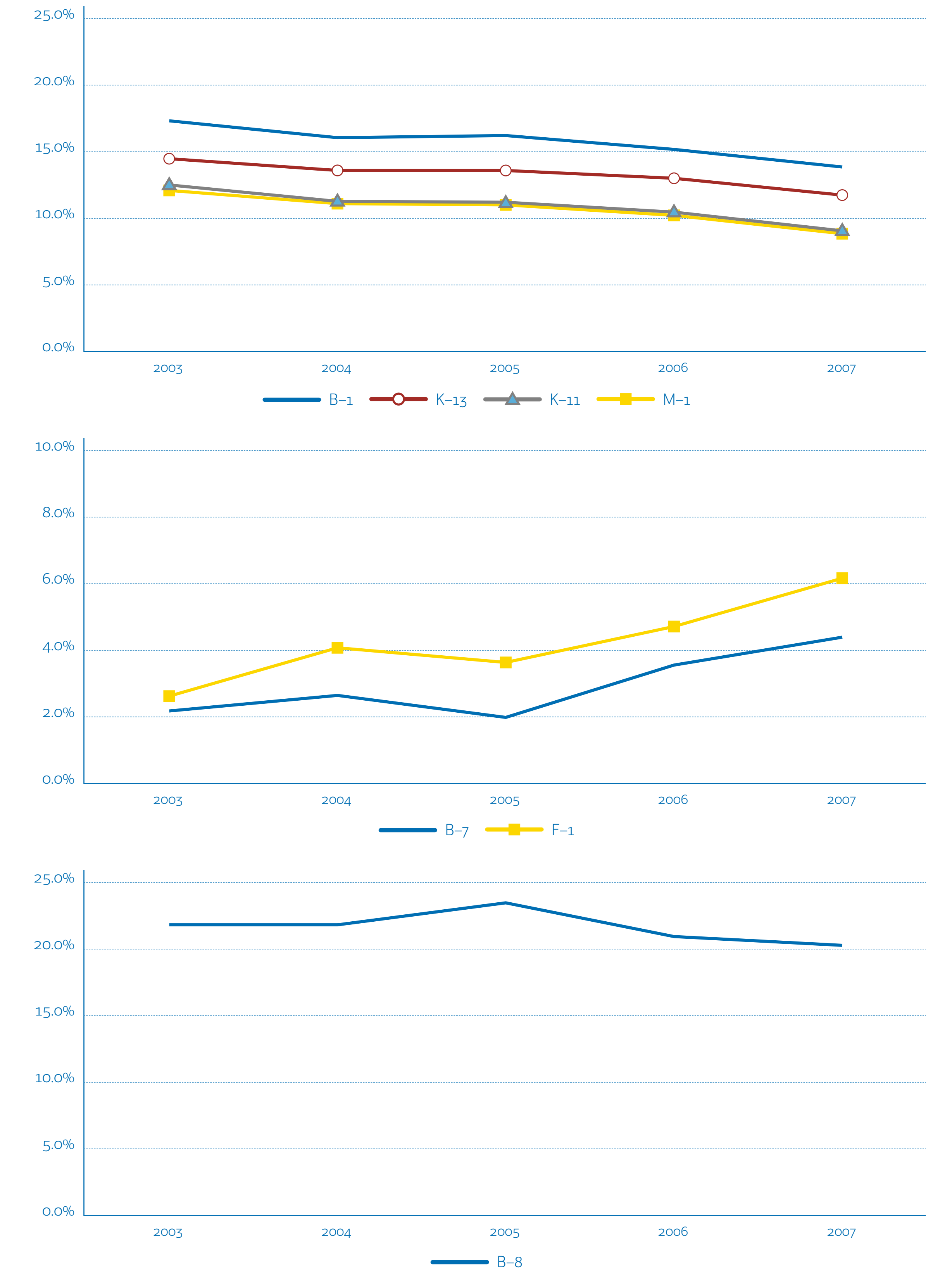


Figure 7: Trends of the skills needs based on 2003~2007 patent

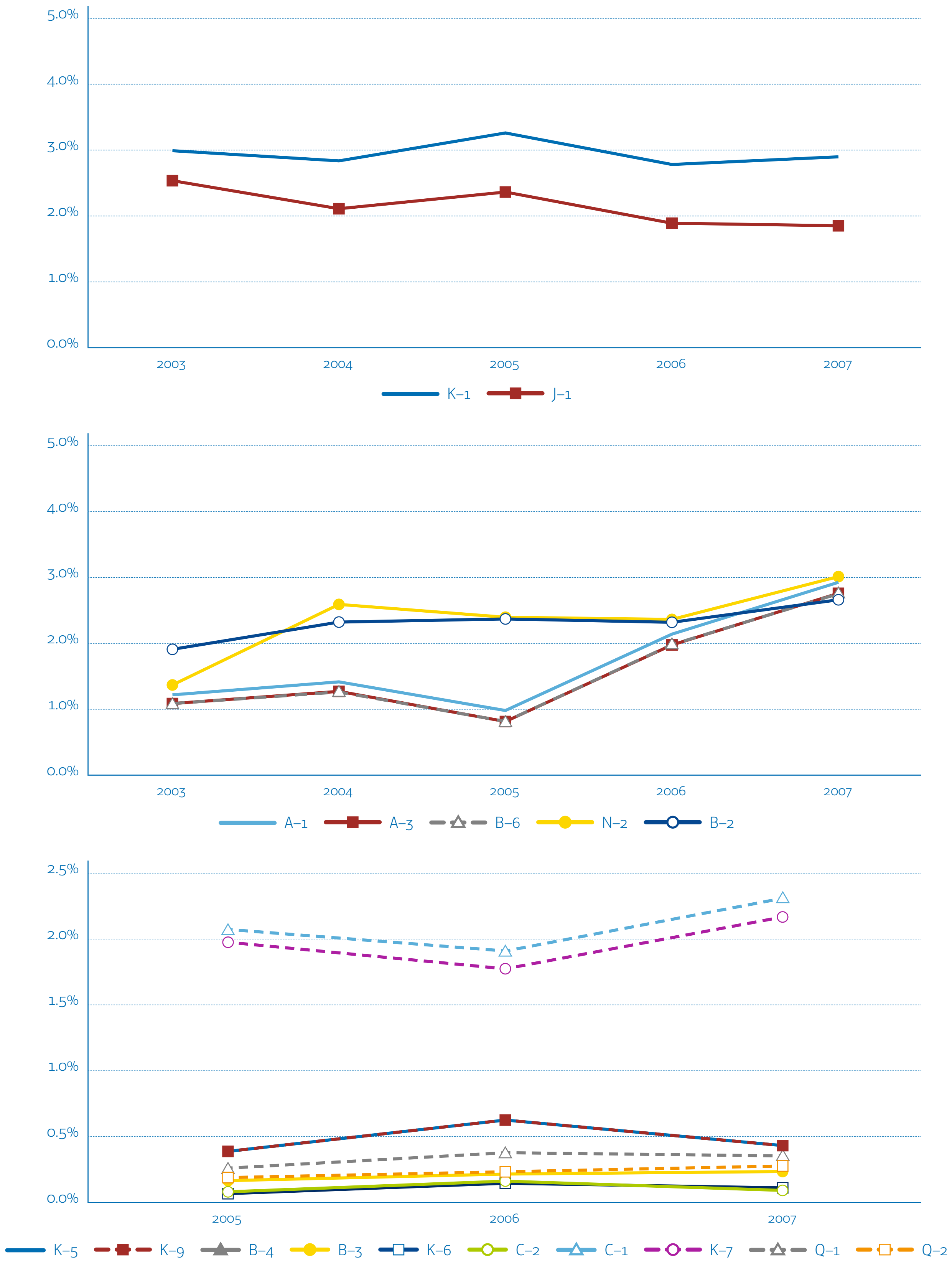
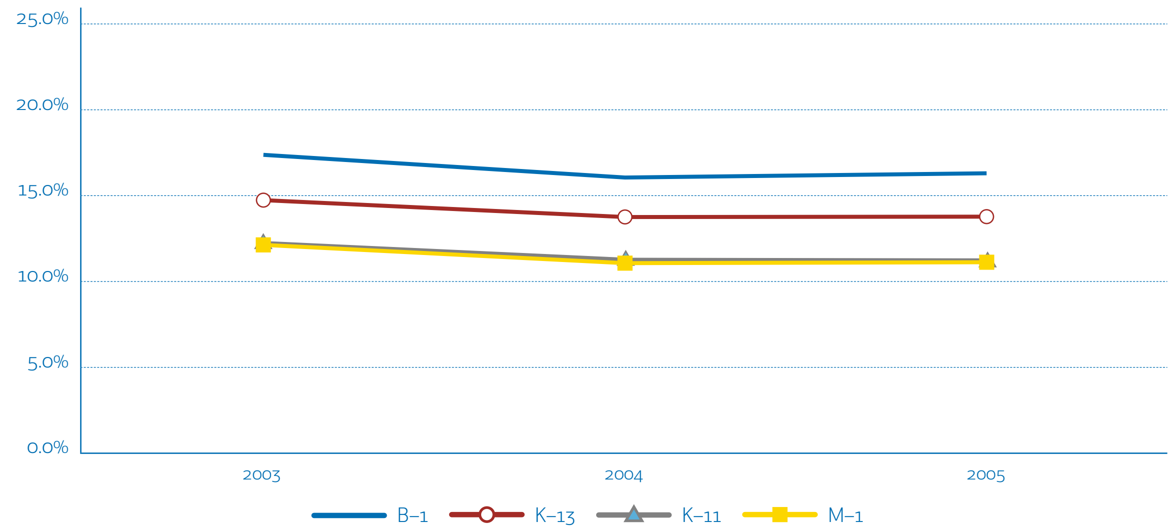
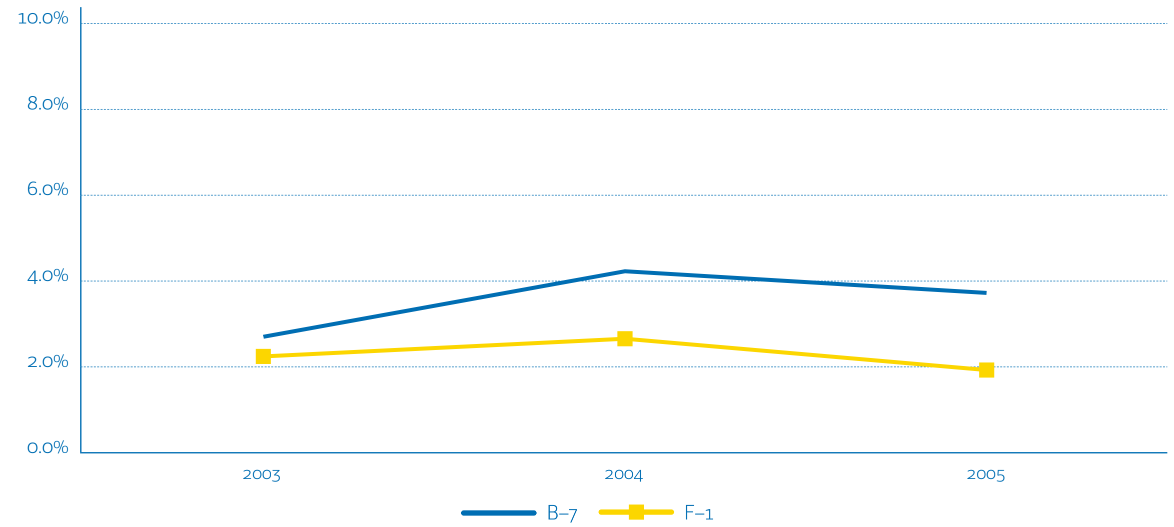


Figure 8: Trends of the skills needs based on 2003~2005 patent





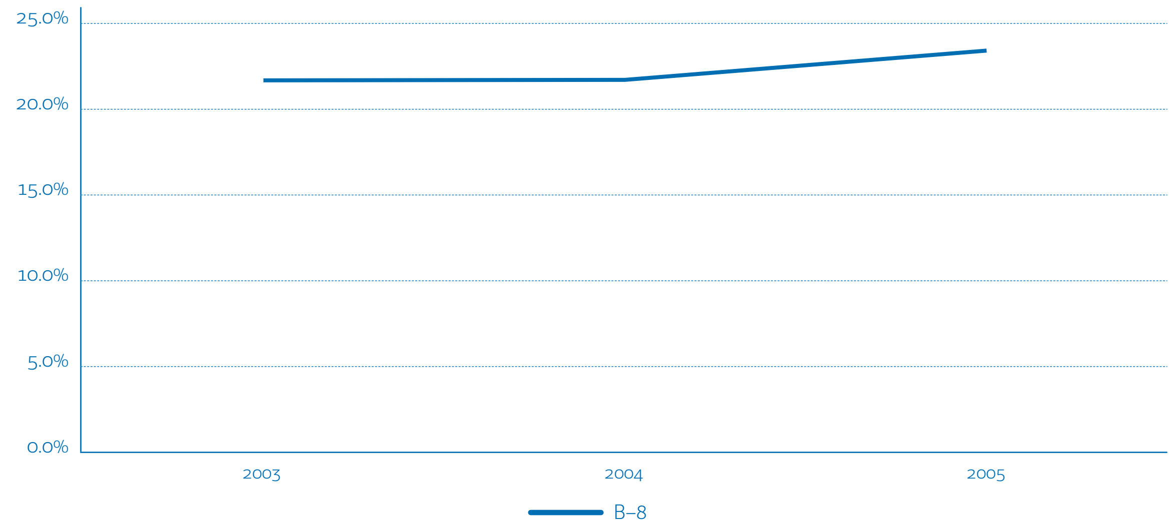
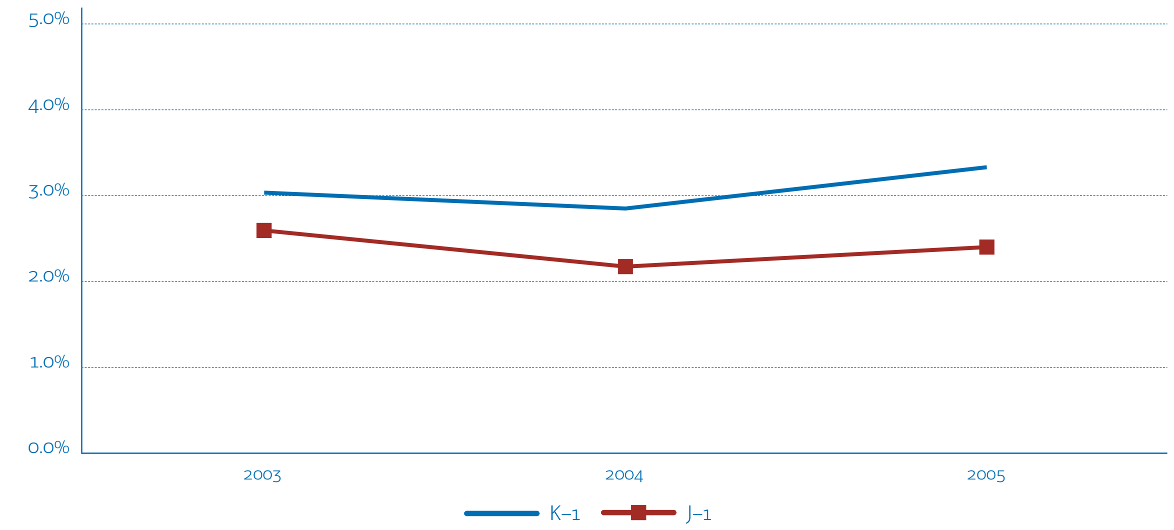
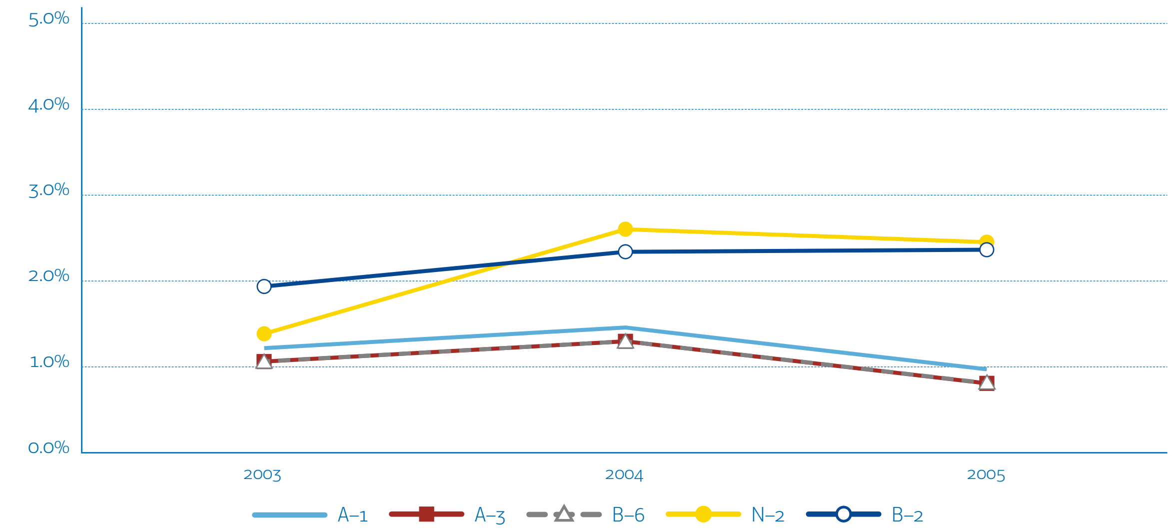


Figure 8: Trends of the skills needs based on 2003~2005 patent





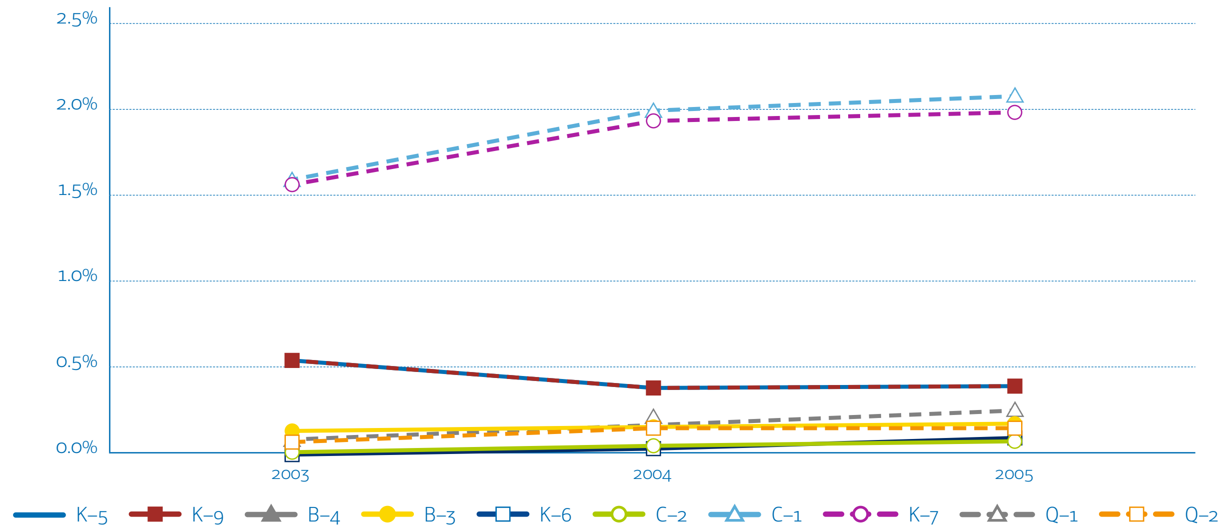
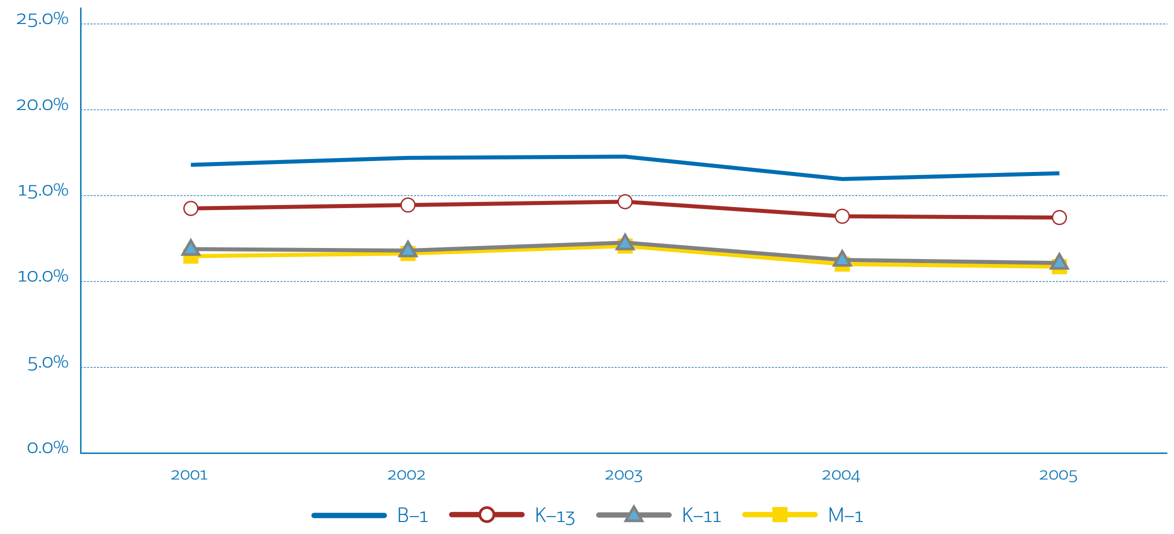
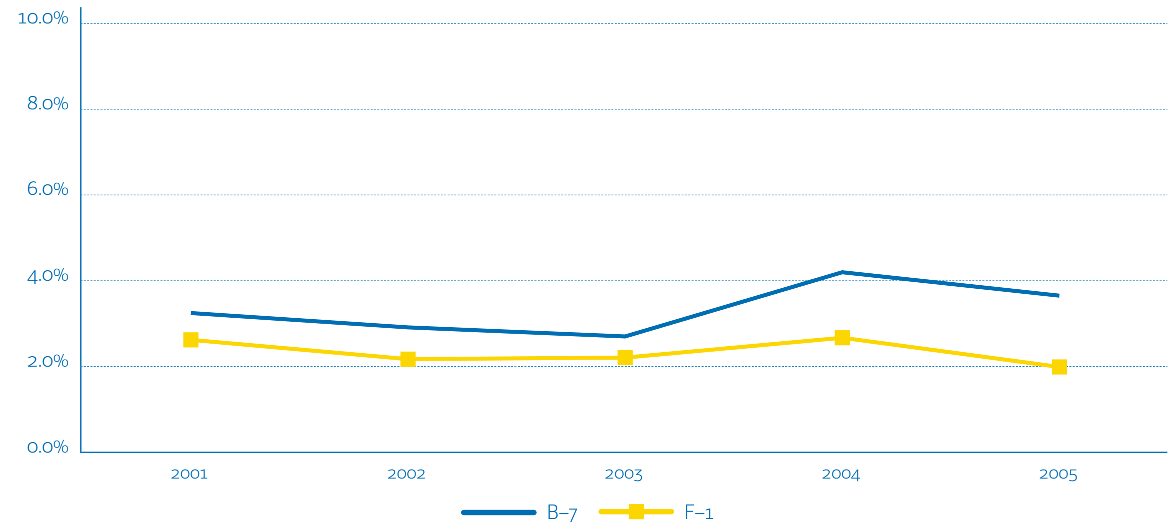


Figure 9: Trends of the skills needs based on 2001~2005 patent





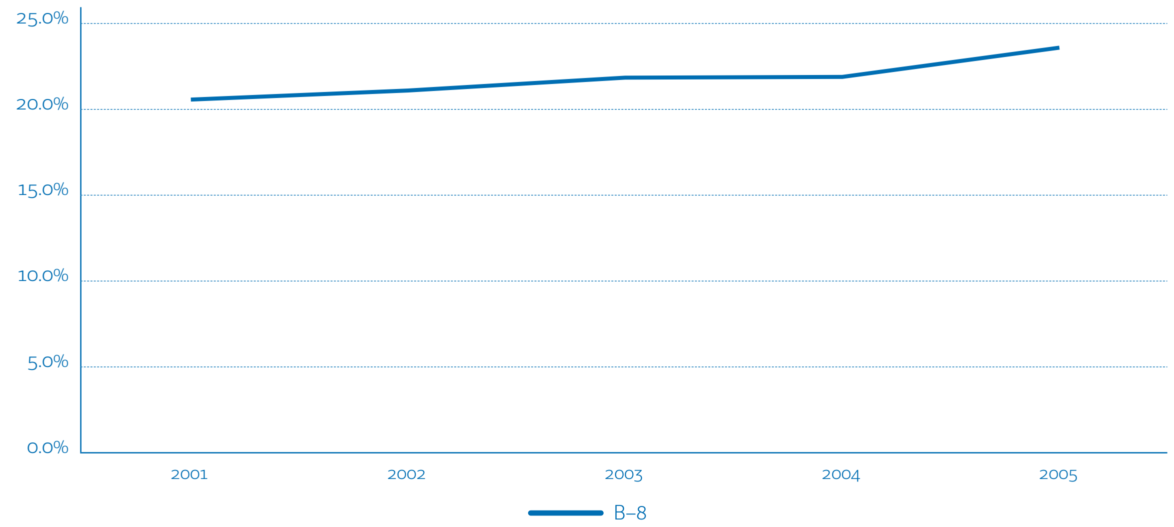


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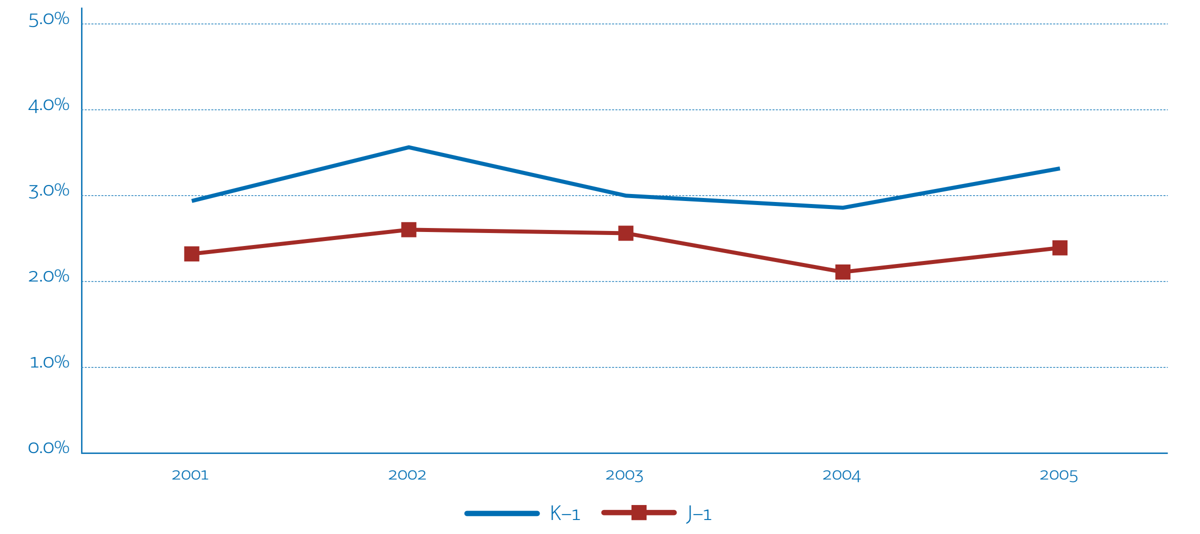
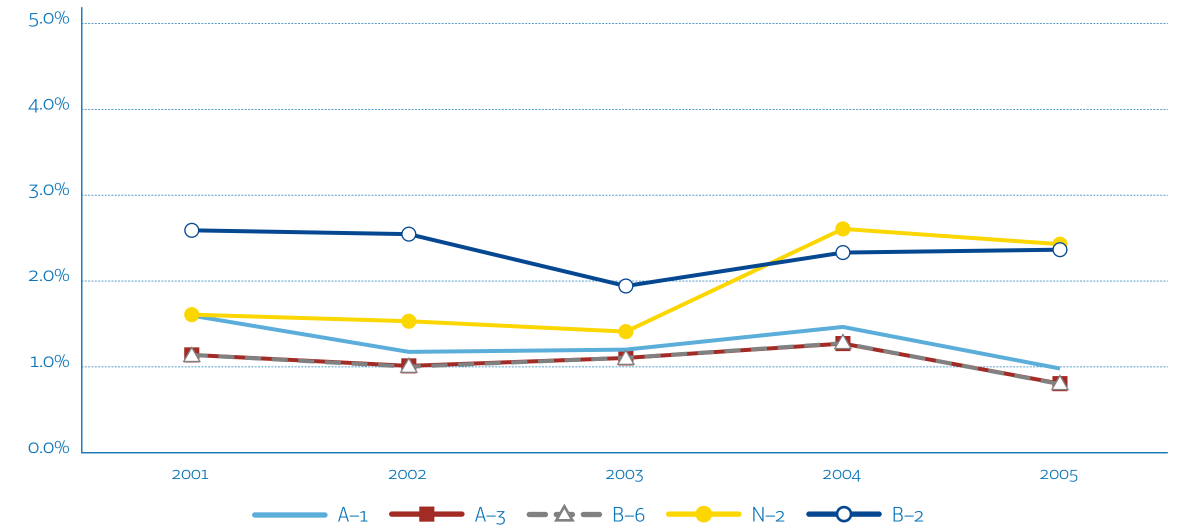
Figure 9: Trends of the skills needs based on 2001~2005 patent





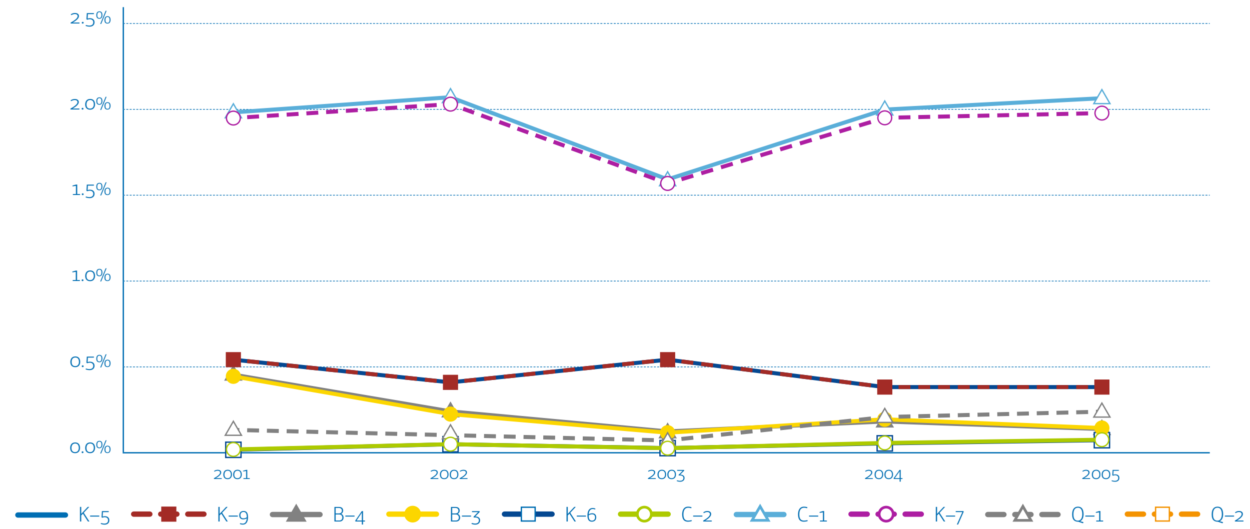


Table 5: Skills needs in 2010: 'size and pattern of IPC during period' vs. 'real skills level in 2010'

Job	Skills	3yrs gap to 2010		5yrs gap to 2010		real skills level in 2010*
		2005–2007	2003–2007	2003–2005	2001–2005	
(A) Risk analysis	(A-1) Security weakness analysis	middle**-up***	middle-up	middle-flat	middle-down	3.67
	(A-2) Network security scanner					
	(A-3) Pilot hacking, simulated infiltration	middle-up	middle-up	low-flat	low-flat	3.67
(B) Establishing information protection policy & plan	(B-1) ISMS (Information Security Management System)	high-down	high-down	high-flat	high-flat	3.20
	(B-2) Security policy	middle-flat	middle-up	middle-up	middle-downt	3.20
	(B-3) Security management on outsourcing	low-flat	low-flat	low-flat	low-down	3.20
	(B-4) Task Identification	low-flat	low-flat	low-flat	low-down	3.20
	(B-5) Inspection logging	low- flat	low- flat	low-flat	low-flat	3.20
	(B-6) PC security	middle-up	middle-up	low-flat	low-flat	3.71
	(B-7) Data security	middle-up	middle-up	middle-flat	middle-flat	3.72
	(B-8) Network security	high-down	high-flat	high-up	high-up	3.81
	(B-9) Server security					
(C) Privacy protection management	(C-1) Privacy protection law	middle-flat	middle-flat	middle-flat	middle-flat	4.02
	(C-2) Privacy information encryption	low-flat	low-flat	low- flat p	low- flat	3.55
(D) Marketing management						
(E) Technical sales						
(F) R&D	(F-1) Encryption algorism	middle-up	middle-up	middle-up	middle-flat	3.39
(G) Implementation						
(H) Public & user education						
(I) Expert education						
(K) Information infrastructure security management	(K-1) Firewall configuration	middle-flat	middle-flat	middle-flat	middle-flat	3.72
	(K-2) Virus vaccine					
	(K-3) Spyware					
	(K-4) Phishing					
	(K-5) Spam	low-flat	low-flat	low- flat	low- flat	3.71
	(K-6) (DB security encryption	low-flat	low-flat	low- flat	low- flat	3.72
	(K-7) OTP(One Time Password)	middle-flat	middle-flat	middle-flat	middle-flat	3.65
	(K-8) PKI(public key infrastructure)					
	(K-9) VPN(Virtual private network)	low-flat	low-flat	low- flat	low- flat	3.72

time-lag. Then the level of accordance between the analysis results and the skills needs in reality is verified (it is still an on-going process).

5 Concluding remarks

This study sought to develop a methodology allowing for forecasting the future skills needs by using patent analysis. Compared to the current analysis method based on existing labour market information, the propounded method attempts to present future skills needs, expected for the advent of new knowledge, as based on technological innovation trend and patent analysis. The proposed study may contribute to raising the usability of patent information analysis and advancement in the future skills needs analysis methodology.

However, the following issues still deem problematic.

- Fundamentally, the 7-digit IPC code is simply regarded as a unit of knowledge

Table 5: Skills needs in 2010: 'size and pattern of IPC during period' vs. 'real skills level in 2010'

Job	Skills	3yrs gap to 2010		5yrs gap to 2010		real skills level in 2010*
		2005–2007	2003–2007	2003–2005	2001–2005	
(K) Information infrastructure security management	(K-10) DDoS (Distributed Denial-of-Service attack)					
	(K-11) MDM(Mobile Device Management)	high-down	high-down	high-flat	high-flat	3.43
	(K-12) IPS(Intrusion Prevention System)					
	(K-13) Certification service	high-down	high-down	high-flat	high-flat	3.6
(L) Physical security						
(M) Monitoring & responding	(M-1) Weakness analysis	high-down	high-down	high-flat	high-flat	3.67
	(M-2) Log analysis					
	(M-3) Security control					
	(M-4) APT(Advanced Persistent Threat)					
(N) Digital forensic	(N-1) Understanding forensics+3					
	(N-2) Cryptology	middle-flat	middle-up	middle-up	middle-up	3.43
	(N-3) Hacking technique					
	(N-4) Cyber attack					
(O) Job continuance management						
(P) Evaluation certification & quality assurance						
(Q) Information system security inspection	(Q-1) Security inspection	low-flat	low-flat	low-flat	low-flat	3.67
	(Q-2) Information security event management	low-flat	low-flat	low-flat	low-flat	3.67

* Yoo, H., T. Kim, 2009. Skills with over 7 yrs. experiences on Table 16, pp. 87.

** high/middle/low means the relative size of IPC during period: over 10%, 1%~10%, under 1%.

*** up/stable/down means the trend of IPC during period: increasing trend, stable trend, decreasing trend.

and skill in this study and the frequency of IPC as a direct proxy of importance in skills. IPC code has a strong attribute of technical classification, and regarding it directly as a knowledge-unit can raise some criticism. As a matter of fact, the uniform definition of an IPC-code attribute is difficult. In certain industries, it appears to be close to attributes for product category, while displaying the attributes of the classification of knowledge in other cases, and sometimes showing an attribute of the job. In the course of the present study, an attempt was made to compose the knowledge unit and the skill by using keywords, but eventually the IPC code was employed due to the difficulty in analysis. So, continuous improvement efforts should be made for yielding the method for extraction of knowledge-unit data and skill data from the patent information.

- Due to the fact that not all patents can be materialized, forecasting skills as patent-based cannot avoid certain information noise.
- The details of technology and IPC code can be changed along with the time. Therefore, there are limits in using IPC for future forecasting.

Even admitting these limitations, it still seems valuable to attempt to explore new methodology for forecasting future skills needs from patent information. The current study has focused on the information security area by using Korean patent DB, but the expansion to the patent data of the United States, Japan and Europe, but certainly analysis of other areas could be possible in the future. In this case, more segmented patent classification codes of each country, UPC of the United States, F1 or F-term of Japan, and ECLA of the EU can be applied.

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Grasping Advantages of Foresight: Creativity, Learning, Futures Literacy and Anticipatory Imagination

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Abstract

Foresight is a complex policy tool engaging various combinations of future-research methods based on the principles of openness, participation and multidisciplinarity. In intense learning societies, the processes of foresight make up a creative and consistent practice which enhances social capacity for making long-term decisions, increasing future literacy and spontaneous explorations. Moreover, the foresight approach constantly challenges the conventional understanding of an individual's value in society, thus making the social foresight (at large) capable of re-shaping.

Keywords:

foresight, learning, futures literacy

1 Foresight – as instrument for identifyng future skills

There exists a vast diversity of opinions as to the future, and various ways of approaching the task of its research and anticipation. In this extensive field, foresight is a type of prognosticating activity lying at the intersection of futurological studies, strategic planning and policy analysis (Gavigan et al., 2001). As an instrument, foresight is used nowadays in a variety of technologies, industries and for solving complicated problems stemming from generational evolution (Georghiou, 2008). When designing a foresight of future skills, one needs to start from a set of common language, regarding definitions and principles to be followed. Foresight has been defined as:

- "the process involved in systematic attempting to look into the longer-term future of science, technology, economy, 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" [...] it is not about "predicting but shaping or constructing the future" (Martin, 2001 p. 7).
- "open and collective process of purposeful, future-oriented exploration, involving deliberation between heterogeneous actors in science and technology arenas, with a view to formulating shared visions and strategies that take better account of future opportunities and threats" (Keenan and Popper, 2007 p. 6). The core principles of foresight are future orientation, participation, evidence, multidisciplinarity, coordination and action orientation (Keenan and Popper, 2007 p. 7).

Over the last decades the tool has been largely practiced and constantly refined. Designing a foresight exercise has been much described in the various guides, handbooks, toolkits, blueprints and scientific journals of the field. Such literature can be very useful when starting to design a foresight for futures skills. The sources include:

- For-Learn online foresight (Cagnin et al., 2005)
- Practical Guide to Regional Foresight (many languages) (Miles and Keenan, 2002); FUTURREG (Project, 2007), Regional Foresight Guide (Gavigan et al., 2001)
- Futures Research Methodology 2.0 (Millennium Project)
- Blueprints for foresight in various fields: FOR-RIS (Klusacek and Toivonen, 2004), UPGRADE (Ollivere et al., 2004), TECH-TRANS (Banthien et al., 2004), TRANS-VISION (Destatte and Van Doren, 2004), AGRIBLUE (Crehan and Downey, 2004), FOR-UNI (Curaj, 2010)
- Handbook of Knowledge Society Foresight (Miles et al., 2003b)

- Practical Guide for Integrating Foresight in Research Infrastructure Policy Formulation (Keenan and Popper, 2007)
- UNIDO Technology Foresight Manuals) (UNIDO, 2005a), (UNIDO, 2005b)
- European Foresight Platform (http://www.foresight-platform.eu/)
- Works of Averil Horton, Ian Miles, Denis Loveridge, etc

However, despite the large array of guidance and literature, there is no fixed recipe in foresight because each exercise has specific objectives, a specific context and availability of resources. Foresight is not a method per se but rather a combination of various methods which are chosen basing on a client's needs, budget, time constraints and availability of participants.

Having presented the fundamentals of a foresight we now pass on to the next step of considering the best way to design a specific exercise for future skills.

2 Context of futures thinking

While thinking of future skills and a prospective approach to the issue, one needs to think in terms of a broader context: not only the one referring to future skills, but also the one referring to the 'future thinking' in general.

It is important to take a look at the approaches and the past researches carried out in regard to the future of learning, education, and personal development. In the context of "learning-intensive society", an individual learns by doing in a highly networked society. In learning societies, people will generate and accumulate more know-how, know-who, know-what, knowwhy on a daily basis over a lifetime (Miller, 2009). The transformations surrounding people in society, change their identity, status and choices. In such context, being provided with vital information on the future makes an individual more adaptive and able to face future challenges and/or become a developer oneself.

The second context to be taken into consideration when designing a foresight of future skills is the large area of disciplines in the field of future-oriented thinking. Since the 1960s, futurological studies have been an ambitious and ever-developing discipline. In principle, foresight and future-oriented studies have many roots in common; future studies can provide necessary tools for creation of future-oriented skills and increase future literacy as well as anticipatory imagination. Another key emerging discipline is anticipation and development of the concept of "future literacy" (Miller Riel et al., 2013).

3 Grasping the advantages of foresight

Foresights are large-scale participatory processes engaging many experts and stakeholders. Often, it is worthwhile saying that this process is as important as the product or even that the process, in fact, is the product. Foresight creates a unique environment for future-oriented thinking and can support the creation of anticipatory imagination and future literacy; creative and participatory methods can enrich these processes. Choosing the methods is a challenge; methods determine the impact as well as the process of the foresight evaluation. Mostly, one needs to have an inclusive conception of both the popular and the less common methods found in futures studies: action research, alternative futures, brainstorming, causal layered analysis, citizen panels, expert panels, forward theatre, futures search, futures workshops, gaming, horizon scanning, methods of identification of stakeholders and experts, identification of trends, images of the future, integral futures, literature review, vision building, scenarios, STEEPV, weak signals and wild cards, world café, etc.

Foresight is not a 'golden tool' that heals or anticipates problems at maximum guarantee; rather, it is instrumental for future-oriented thinking and requires constant practicing. Foresight culture can emerge only where foresight practices have been implemented before, and it can continue its evolution only on condition that foresight processes keep occurring. However, in order to gain more credibility, authority and legitimacy, evaluation of foresight ought to be encouraged. Such evaluations are not an easy task, in fact are rarely done, yet are hugely important.

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A Guide on Foresight of Future Skill Needs

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Abstract

The International Labour Organization in collaboration with the European Centre for the Development of Vocational Training, the National Training Fund in Prague and other international partners has developed a guide on foresight for skills. The upcoming publication should serve as a reference and a toolkit at an early stage of the learning process for countries beginning to develop skills anticipation systems. The Guide is based on successful practice from developed and developing/emerging countries and contains advice on methodology and various implementation aspects of nation-wide foresight programmes for mid to long term horizon.

Keywords:

foresight, foresight guide, skills anticipation, foresight methods, foresight programme

As part of collaborative efforts between the International Labour Organization (ILO), the European Centre for the Development of Vocational Training (CEDEFOP), the European Training Foundation (ETF) and the National Training Fund in Prague (NTF) aimed at better matching of skill supply and demand on the labour markets in transition and developing countries, ILO has developed a foresight Guide for skills anticipation and matching.

It was elaborated by NTF in collaboration with the aforesaid bodies and its overall aim is assistance in developing skills anticipation systems by provision of useful, independent and practical advice and by support of learning process and awareness sharing the experience of countries across the world (both developed and developing ones). Such shared knowledge can be valuable for setting the vision, designing and implementing a country's own specific system. Expectedly, the Guide can be of particularly use at an early stage of the foresight learning process, when it can serve as a reference and toolkit providing basic clarification while setting common ground for stakeholder institutions in countries which are considering /beginning to implement skills foresight programmes. It is designed primarily for sponsors of skills anticipation activities who can initiate or foster the implementation of the necessary structures, as well as for implementers of such programmes. Besides, it is intended to advise a broader range of stakeholders, including policy makers, education and training providers, public employment services, social partners, research and specialist organisations and other subjects that may be involved in the activities.

The provided information covers methodologies and different implementation aspects of mid-to-long-term (5-20 years) foresight approaches, for skill needs applied either at the national level (covering the whole economy) or at a sectoral basis, initially covering one or more sectors within the economy.

Expedient definition of the foresight, indicates its most typical features: action focus, strong future thinking background and participatory nature. These aspects make foresight highly efficient for skills anticipation, since skills are key elements of the social future. However, worldwide mappings of the role of skills in foresight activities demonstrate that in these programmes skills are often underestimated or neglected and skills foresight exercises per se are very rare.

The foresight and scenario methods can be classified into normative, exploratory and supplementary ones. Normative methods - back casting, morphological analysis, relevance trees or roadmapping - start with the desirable future and proceed by seeking ways of achieving it, while exploratory methods start in the present and, based on preconditions, look into different futures (e.g. expert panel, Delphi method, horizon scanning, scenarios or cross impact analysis). Supplementary methods, though not being strictly foresight ones, are widely used in relation to foresight methods for supporting goals of foresight exercises (e.g. literature review, SWOT analysis, brainstorming or focus groups). Since a single method is rarely used in a foresight exercise, particular attention must be given to method combinations, which involves multi-criteria decision making. In practice, as foresight implementers face numerous constraints (e.g. unavailability of experienced experts in a given method), the de facto methods mix can deviate significantly from the desired one.

Implementation steps in a typical foresight programme are, basically, similar to those of any other large-scale projects. A typical programme starts with the definition of the foresight area to be considered, with the key focus or mission being outlined by the sponsor, ideally – in consensus with other stakeholders. On the next step, the purpose of the foresight exercise is clarified, taking into consideration the key context factors including the role of the programme in meeting specified challenges, an assessment of whether invested resources can be justified by the programme's impacts and the fulfilment of stakeholders' expectations. Once it is decided to proceed, the key elements of the programme design should be clarified. These include: objectives' specification of, outcomes, scope, time horizon, expected duration. Special attention is given to enrollment of stakeholders, suggesting some tools for their identification, classification and corresponding communication strategy setting. Methodology should be outlined at the early stages when the viability of the programme is assessed. The following step includes refining and readjustment of the key issues and defining the optimal way to sought answers, i.e. choice of a specific method mix and its parameters (e.g. number of experts). Then all these elements are combined into a coherent design of the programme and become the basis for programme planning. Foresight exercise management includes administering time, resources and programme outcomes within programme organisational structures - e.g. steering committee, project teams, expert groups etc. Once the main tasks have been completed, successful programmes can deliver the desired results to stakeholders. Description of key success factors - such as setting reasonable goals and scope of activities, adequate institutional framework in place, engaged stakeholders, efficient use of available resources, adequate methods or effective dissemination of results - are taken from the case studies.

Rather often insufficient attention is given to the follow-up; in many cases this has lead to implementation gaps. However, the responsibility of foresight programme implementers usually does not go beyond the delivery of programme outcomes to stakeholders or/and users. In fact, stakeholders' expectations should be continuously managed during the programme, so that after its finalization their needs are adequately met. Benefiting from the programme results is a matter of stakeholders' engagement and their ownership of the programme. Those programmes which have highly engaged stakeholders' proprietorship are more likely to result in follow-ups, thus adequately implementing the foresight outcomes. Though, regrettably, these activities are usually "out-of-scope" of the foresight exercises.

The issues to be considered when adapting the programme to other countries' circumstances (based on case studies and successful project management practice) are extracted from presented cases. These summated findings suggest that it is quite possible to draw out lessons from examples of others' "good practice" and that some of the described methods can assist in adopting a particular approach in a particular country; however, careful adaptation is needed to avoid the risk of blind copying, irrespective of local circumstances.

The selection of case studies is based mainly on maturity of foresight processes and products and availability of information. The country cases include Australia, Brazil, Finland, Germany, Japan, Korea, Russia, the United Kingdom and the United States. These are complemented by cases from of the EU and the EU enlargement region which represent available knowledge but definitely not in an exhaustive manner. Some country cases contain only a few elements of skills foresight, while in other cases skills foresight may be a part of wider foresight programmes or skills anticipation activities carried out by other approaches as well.

Thus, Brazil represents a good example of systematic approach to skill anticipation which includes strong foresight element within the national network of vocational training institutions. This institutional setting allows foresight results to be fed into expert and decision-making bodies, and the training provision to be influenced more directly. Russia is a good example of project-based foresight explicitly addressing skills needs issues. Japan is exemplary of an elaborate Delphi method application. The case of Germany shows interesting elements of foresight culture as regards the definition of foresight fields. The EU enlargement case demonstrates the role of international organisation in foresight activities supporting strategic future-oriented decision making.

The cases reveal diverse experience, they suggest that using the foresight for skills anticipation is an incipient discipline rather than common practice.

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Science and Technology Foresight in Japan

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Abstract

In Japan, Science and Technology (S&T) foresights have been conducted every 5 years since 1971, with the 9th survey report summarized in July 2010. This survey employed a combination of methods, including (1) a Delphi survey on topics extracted through interdisciplinary discussions targeting visions for the future society, (2) scenario writing, through several methods, on the potential paths toward the desired future, (3) regional discussions addressing the realization of sustainable regional societies, besides other comprehensive discussions.

In the Delphi survey, 2,900 Japanese experts from every field of study were asked for their predictions pertaining to 832 S&T topics 30 years into the future. The major results of these surveys include a vision of a future society underpinned by the evolution of S&T, its areas of key importance for the resolution of global and national challenges, potential paths toward the realization of this future vision, and a summary of the opinions commonly expressed by the expert groups.

The results of the 9th S&T foresight were used to create a draft of the government's 4th S&T Basic Plan, initiated in 2012. In addition, the technological and social realization times forecasted in this survey led to the setting of R&D targets in governmental and industrial research organizations and universities, which may include S&T education or skill-building programmes for human resources.

Keywords:

science and technology foresight, Delphi survey, green innovation

1 The 9th Science and Technology (S&T) Foresight

Since 1995, Japan has implemented S&T Basic Plans, according to the S&T Basic Law.

Each plan covers a five-year period, and the 4th Basic Plan began in August 2012. Historically, S&T forecast results have been mainly utilized to prioritize research areas in each plan. Under the 4th Basic Plan, green innovation and lifestyle innovation are expected to be strongly promoted, leading to the creation of new markets and jobs.

In Japan S&T foresights have been conducted every 5 years since 1971, and the 9th survey report was summarized in July 2010. In this survey, 2,900 Japanese experts from every field of study gave their predictions pertaining to 832 S&T topics 30 years into the future.

The results of the survey were used to draft the 4th S&T Basic Plan, which was initiated in 2012.The 9th S&T foresight focused on discussions conducive to solving global and national challenges, with a clear view toward the future. Considering current global trends and realities in Japan, the survey narrowed down a specific course of action for S&T into the following four challenges:

(1) To be a central player in the S&T arena
(2) Aim for sustainable growth through green innovation
(3) Develop a successful model for a healthy aging society
(4) Create a secure life for citizens

The survey employed a combination of methods, such as a Delphi survey on topics extracted through interdisciplinary discussion targeting visions for future society, scenario writing through several methods on the potential paths toward the desired future, and discussions on possible approaches toward the realization of sustainable regional societies.

The major results of these surveys are as follows: (1) a vision of a future society underpinned by the evolution of S&T, (2) an outline of potential paths toward realization of the future vision, (3) future visions expressed by the local populace and the youth, (4) areas of key importance in S&T for the resolution of global and national challenges, and (5) a summary of the opinions commonly expressed by the experts groups, extracted from the Delphi survey results.

2 The Delphi Survey

We established 12 interdisciplinary technological subcommittees, which consist of 135 experts from universities, industries, and research institutes. In addition, four broad groups were established for discussing security, safety, international cooperation and international competition.

Within these four groups, interdisciplinary discussions involving members of the humanities and social sciences were held.

These subcommittees and groups set out 832 topics. Figure 1 shows the technological theme of each subcommittee.

Respondents were classified according to age and occupation. 38% of respondents were in their 50s, 25% - in their 40s, and 24% in their 60s. University researchers accounted for 47% of the respondents, industry researchers for 29%, and researchers from public research institutes for 15%.

The main themes of the questions were the importance of R&D, the timing of the occurrence of technological and social realization in Japan, and S&T sectors that will enable the realization. In addition, five items addressed Japan's approach in solving global and national challenges, including items of key importance for the resolution of identified challenges, the R&D required, the international strategy to be implemented, priority items to be addressed by the government, and the R&D needed for sustainable development.

Figure 1: Targets and technological themes in Delphi Survey

№	Technological theme	№	Technological theme
1	Fully utilize electronics, communications, technology, and nanotechnology in a ubiquitous society	7	Handle all kinds of necessary resources, including water, food, and minerals
2	Expand the scope of discussions on information processing technology to the media and contents	8	Develop technology to preserve the environment and build the sustainable recycling society
3	Link biotechnology and nanotechnology, to contribute to human quality of life	9	Develop fundamental technology concerning substances, materials, nanosystems, processing and measurement
4	Make full use of IT to realize people's lives more healthy, with highly advanced medical technology	10	Develop manufacturing technology to comprehensively support the development of industry, society, and science and technology in general
5	Use science and technology to help people understand the dynamism of space and the earth and expand the human sphere of activities	11	Place overall subject matters under stricter management, due to advancements in science and technology
6	Make diversified changes in energy technology	12	Create infrastructural technologies to support infrastructural and industrial bases

Target

Safety
Security
(Int'l) Cooperation
(Int'l) Competition

Source: NISTEP 2010

In the energy field, Delphi survey results from over 400 expert respondents identified a total of 72 R&D items. Figure 2 lists the 10 most important R&D items in the energy field, along with the projected time for each item's technological and social realization. The first item is decommissioning technology, and the second is the development of a solar battery with efficiency higher than 20%. Following them are the development of next-generation high-efficiency lighting, the fast breeder fuel cycle technology, the secondary automobile batteries, the disposal of high level waste, the heat pumps for houses, the next-generation Light Water Reactors, the new material for batteries, and the combined-cycle power generation.

Figure 3 depicts a better quality of living around the year 2025, based on the 9th Delphi Survey results. High-energy electric vehicle battery technology will be realized around 2025. The spread of a residential energy system that integrates renewable energies, such as solar cells and fuel cells, is envisioned to realize around 2019.

Construction technology for energy-autonomous buildings which enable the use of natural energies, natural ventilation, natural lighting, rainwater, groundwater, and other natural resources is predicted to be realized by 2020. Next-generation energy transmission and distribution network technology enabling a stable, low-cost, and low-carbon power supply is envisioned to be realized by 2025, through the optimal management of the entire supply-and-demand balance of large power supplies by utilizing information and communications technology.

People will use a variety of energy resources, selected according to their own values and

Figure 2: Ten most important R&D items in the energy field

R&D Item	%	Technological Realization	Social Realization
Safe and rational decommissioning technology of commercial LWRs	100	2020	2028
Wide-area thin solar battery with more than 20% efficiency	98.9	2019	2027
Next-generation high-efficiency lighting with more than 150 lm/W(LED, organic EL, etc.)	98.6	2018	2023
Fast-breeder reactor cycle technology	97.7	2029	2038
Low-cost secondary battery for automobiles (>100 Wh/kg, >2,000 W/kg), <¥30,000/kwh)	97.7	2019	2025
Land-disposal technology of high-level radioactive waste	96.9	2022	2034
Super high-efficiency heat pump for houses (COP > 8 for AC, COP > 6 for boiler)	96.9	2017	2022
Next-generation light water reactor technology (more than 5% LEU fuel, plant life of 80 years)	96.8	2026	2034
New material technology with higher energy conversion efficiency that Si/Ga-As batteries	96.8	2021	2029
Large-scale combined-cycle power generation using high-efficiency gas turbine (>1,700°C)	96.6	20218	2028

preferences; they will also participate in activities related to environmental protection and the prevention of global warming.

3 Integration of three surveys

Three different approaches were followed for the scenario writing exercise, including scenario writing in a group (group scenario), envisioning a future scenario based on the results of the Delphi survey, and visions of a future society discussed by younger respondents.

Regional workshops were also held in eight locations in Japan, where participants proposed their visions of ideal life in their regions and their ideas about the kind of S&T required to realize that vision. Discussions emphasized green innovation and the creation of new industries and job opportunities through efforts to achieve a low-carbon society.

The integration process following completion of the three surveys involved three steps.

The first step was to create a vision of the future society with an achievable goal, based on the Delphi Survey results and the forecasts made by S&T experts. The second step was to identify the S&T areas considered to have the potential to contribute significantly toward the realization of the future social vision. This process utilized the results of the Delphi Survey ("areas of key importance for the resolution of challenges") and the relation map which links the Delphi topics with the scenarios created by expert groups. Based on the results of the three studies, the third step was to attempt extracting and discussing the social requirements necessary for promoting these changes.

4 Future business in green innovation and life innovation

Through the promotion of green innovation and associated job opportunities, group scenarios predicted growth in industrial sectors which would construct this new infrastructure (i.e., electric vehicles and smart meters). These scenarios particularly emphasized global deployment of green businesses to secure Japan's market advantage, proposing out-of-the-box thinking to design the social infrastructure, along with the necessary underlying systems and industries. Many possibilities were suggested for the utilization of resources such as biomass (animal waste, forest), snow and cool energy, geo- and subsurface-thermal energy, and recyclable energy. Such possibilities leverage geographical conditions and regional industrial structures to contribute to a reduction in CO_2 emissions by major local agricultural, forestry, and fisheries industries. Another suggestion pertained to the construction of environment-friendly and regionally compatible social infrastructure to bring about, for example, a compact city, a transportation system low in CO_2 emissions, and an array of new services.

For life innovation, group scenarios envisioned the evolution of new businesses related to medical and nursing care which reduce healthcare costs through new, cost-effective techniques and accelerate the introduction of new medical techniques to eliminate drug/device lag and the vaccine gap. Items mentioned for health management and preventive medicine included the development of safe food products which would promote enhanced health and wellbeing, the construction of barrier-free households, and living environments equipped with a variety of sensors. A plan was also proposed whereby local regions would consider their natural environment as not only a tourism resource but also as a vital community resource enabling the local population to maintain healthy bodies and minds and to use this concept to create new industries and services.

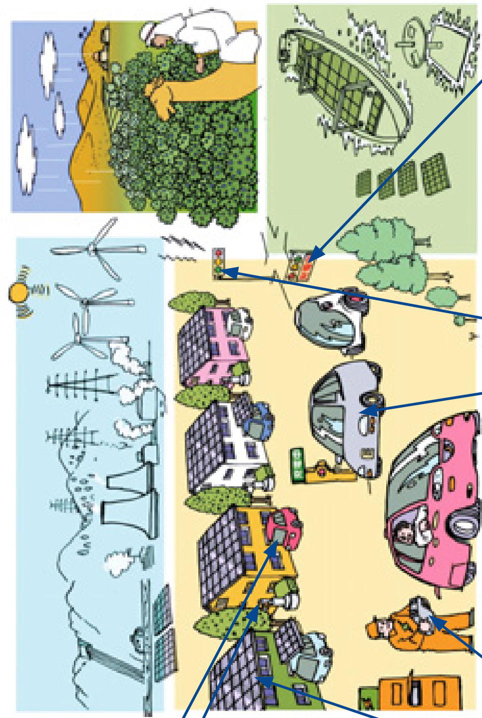
Group scenarios emphasized the necessity of business deployment into Asian countries to develop colossal future markets. Specific proposals included the implementation of projects such as the analysis of gene polymorphism, a characteristic of the Asian population. The promotion of medical tourism is also included in this category.

5 Reliability of Delphi surveys

Reliability can be estimated by investigating the number of past Delphi survey topics identified which have subsequently been realized.

Figure 3: Depiction of a better life around 2025 based on the 9th Delphi Survey results

People will use a variety of energy sources selectively based on their own values; they will actively participate in activities related to environmental protection and the prevention of global warming.



Source: NISTEP 2010

The realization ratios (number of topics realized/total number of target topics) for surveys conducted from the 1970s to the early 1990s indicate that approximately 70% of the topics identified have been realized in some form, while full realization required a longer time. Approximately 30% of the topics are unlikely to be realized or are likely to evolve differently than initially conceptualized.

Fields relating directly to the daily life of citizens, e.g., medical care and environment have shown generally high ratios of realization, while fields relating to information and communications have shown reasonably high ratios of full realization, although the ratios of partial realization were not especially high.

In contrast, fields relating to social infrastructures, such as transportation and energy, have generally shown lower ratios of realization. As systematic planning is essential for successful realization of topics in these fields, the low realization ratios indicate that the larger the scale of the vision, the more frequently they should be reviewed.

Topics in fields related to the life sciences, medicine, and healthcare tend to have long-standing and consistent objectives, which remain unchanged despite multiple rounds of surveys. Considering the ratios of earlier realizations, life sciences and medical care show the largest and second-largest percentages of realization ratios, respectively. For example, 20 years ago, we could not have forecasted the creation of IPS cells and the realization of regenerative medicine.

In general, the Delphi survey is considered to be weak in predicting breakthrough achievements. Fields such as life sciences and medical care deserve continued attention.

If the Delphi surveys are used, the tendencies shown here can serve as a useful guide for the future.

6 Delphi survey and future skill needs

Two reasons exist for the S&T foresight survey not being directly used to guide future skill-building programmes in Japan. First, S&T forecasts have historically attained only 70% accuracy. Second, especially in S&T, many innovations continuously occur in each organization, and the skill-building requirements for each new technology must be constantly met. Therefore, it is not easy for the government to accurately predict and design the entire plan of skill-building programmes necessary for Japanese workers.

In Japan, each organization devises its own R&D plan considering the results of the government's S&T forecast. Based on its R&D plan, each organization develops a future skill-building plan for its employees, including researchers and technical staff.

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Professsional Profiles for the Future of Paraná's Industry

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Abstract

The study presents the most relevant aspects of the project Professional Profiles for the Future of Paraná's Industry, developed by the Industry Federation of the State of Paraná System (Fiep System), located in southern Brazil. The project aims at introductory provision of professional-profiles training which can yield new perspectives for the industrial development and social progress of Paraná. In the context of the study, professional profiles are understood as sets of technical skills required from professionals-of-the-future and enabling them to perform activities currently yet non-existent/embryonic. The employed research method was based on the Strategic Prospective identifying possible futures and consolidating strategies and actions to be taken for achieving the desired situation. The research findings are now being systematized, yet the following can already be highlighted: 12 sectors and areas covered; 13 Expert Panels accomplished; 291 experts involved; 227 professional profiles identified and presented in data sheet; 12 publications, resulting in approximately 500 pages of information.

Keywords:

professional profiles, future, strategic prospective

1 Introduction

The Industry Federation of the State of Paraná System (Fiep System) comprising the Industry Federation of the State of Paraná (Fiep), the National Industrial Learning Service (Paraná's Senai), the Social Service of the Industry (Paraná's Sesi) and the Euvaldo Lodi Institute (Paraná's IEL) is located in the south of Brazil and has the mission of serving and strengthening industry with a view to improvement of people's life quality. The Federation's vision of the future is in consolidating itself as a reference for sustainable industrial development.

The targeted living standard improvement on a daily basis, underpinned by sustainable development premises, poses immense new challenges for the Fiep System. With commitment to sustainable development of Paraná's industry, Senai and Sesi, in collaboration with Fiep System and relying on operational capacity of the Sesi/Senai/IEL Onservatories, initiated (in 2005) the prospective projects trajectory. At that time, it was necessary to seek orientation regarding the prospective studies on Paraná's future. Therefore, the project **Promising Future Sectors for Paraná's Industries – Horizon of 2015** was conducted, resulting in identification of the areas and sectors promissory for the state.

Aiming at creation of necessary conditions for realization of the desired future, Sesi and Senai (Paraná) implemented the project **Strategic Routes for the Future of Paraná's Industry** in 2006 – 2011. Under it, 13 trajectory maps were designed with a view to developing (for over a ten-year period) the potential of each area/sector identified as highly promissory. Through that reflection, the issue of professional formation emerged as the fundamental factor for achieving success. So, for the optimal development of the areas/sectors identified as promissory, it was necessary to understand their transformation process and create strategies guaranteeing provision of professionals with adequate new profiles.

As a result, the project **Professional Profiles for the Future of Paraná's Industry** came into being, with the objective of shaping courses for professional profiles, capable of bringing new perspectives to the industrial development and social advancement.

This article presents the crucial aspects of the project in six sections: the first one - introductory, the second - presenting the project overview, the third – elaborating on the methodological approach, the fourth – featuring some panoramic results being consolidated, the fifth – exposing the conclusive considerations and the sixth one – indicating the references used.

2 Project overview

Professional Profiles for the Future of Paraná's Industry is a prospective project with a multi-sectoral and participative approach, statewide coverage and the time horizon of 2030, presenting professional profiles for 12 promising industrial sectors and areas for the state of Paraná (SESI-PR; SENAI-PR, 2013).

Under the project, professional profiles are understood as the sets of complementary /or similar technical skills necessary for professionals-of–the-future and enabling them to perform the yet nonexistent/embryonic activities. These sets are presented in files framed by the following contents:

- **Positioning Indicators** — summarized actions containing information on professional profiles' positioning in relation to the sector they refer;
- **Justification** — scenario which contextualizes the professional profile needs for the industrial sector/area;
- **Activities** — set of functions/tasks/actions within the responsibility of the particular professional profile;
- **Knowledge Skills** — set of necessary knowledge for the professional profile;
- **Trends** — social or technological phenomena of high impact power, whose development, sometimes already taking place, indicates durability in future time horizons.

Industrial sectors and areas under the project comprise: Agriculture, Food and Beverage; Biotechnology (including forestry, agricultural and animal biotechnology); Construction; Energy; Environment; Metalworking; Pulp and Paper; Plastic; Consumer Goods; Health; Information and Communication Technology (including Microtechnology) and Tourism.

The project aims at providing veritable information for educational institutions and individuals concerned with valorization of human capital, in regard to anticipating the needs of professional training.

3 Methodological approach

Accomplishment of the project **Professional Profiles for the Future of Paraná's Industry** (along the Strategic Prospective guidelines) is based on five stages presented below:

3.1 Strategic Prospective

According to Godet (2000), the Strategic Prospective is a reflection aimed to shed light over the action, especially one with a strategic characteristic. Besides identifying the opportunities and potentials of the analyzed object, the Strategic Prospective exposes the adversities and uncertainties regarding the future, identifying possible outcomes and aligning strategies to the actions to be implemented to reach the desired situation. Therefore, the prospective works in both a pre-active and proactive form, promoting actions to design the desired future.

Godet (2004) emphasizes that there are four possible attitudes of individuals when facing the future: (i) passive – experiences the change; (ii) reactive – waits for the changes before acting; (iii) pre-active – prepares himself/herself for the changes; (iv) proactive – acts to incite the desired changes. The attitudes (iii) and (iv) are the ones in which the Strategic Prospective structures itself to create the environment and the conditions to consolidate the necessary changes.

Instrumentally, the Strategic Prospective consists of several tools that can be used in a logical sequence or in an isolated form, depending on the particular case. It is important to develop a prospective process consistent with the available resources, the qualified personnel, and the necessary time to obtain the first results.

The Strategic Prospective can be developed as a continuous cyclic process, mainly due to the speed of the business transformations and to the interrelations between variables, stakeholders and systems. The Strategic Prospective process also enables the results to continually follow the tendencies related to the sector or organization, provides subsidies to the identification of the desired opportunities, and blocks or reduces the possible threats of the process (RUTHES; DO NASCIMENTO; SOUZA, 2007).

In addition, the result of the Strategic Prospective can trigger the necessity of new studies due to the capacity of objectifying and glimpsing new forms and aspects of the problem.

Technically, the Strategic Prospective uses the base studies (trends survey, social and economic studies, etc.) and the structural tools to organize the necessary data and information for the development of the collective reflection aimed at identifying future challenges and, eventually, at evaluating strategic options. As there is no available data and statistics on the future, the personal judgment, though subjective, is, generally, the only means of obtaining information related to ruptures and radical changes.

In summary, the prospective works with a mix of tacit and explicit knowledge. The prospective technicians and the experts involved in the process of collective reflection contribute with the tacit knowledge and elaborate, based on the available science (explicit knowledge), the fundaments to identify the uncertainties and the risks facing the future (RUTHES; DO NASCIMENTO, 2006).

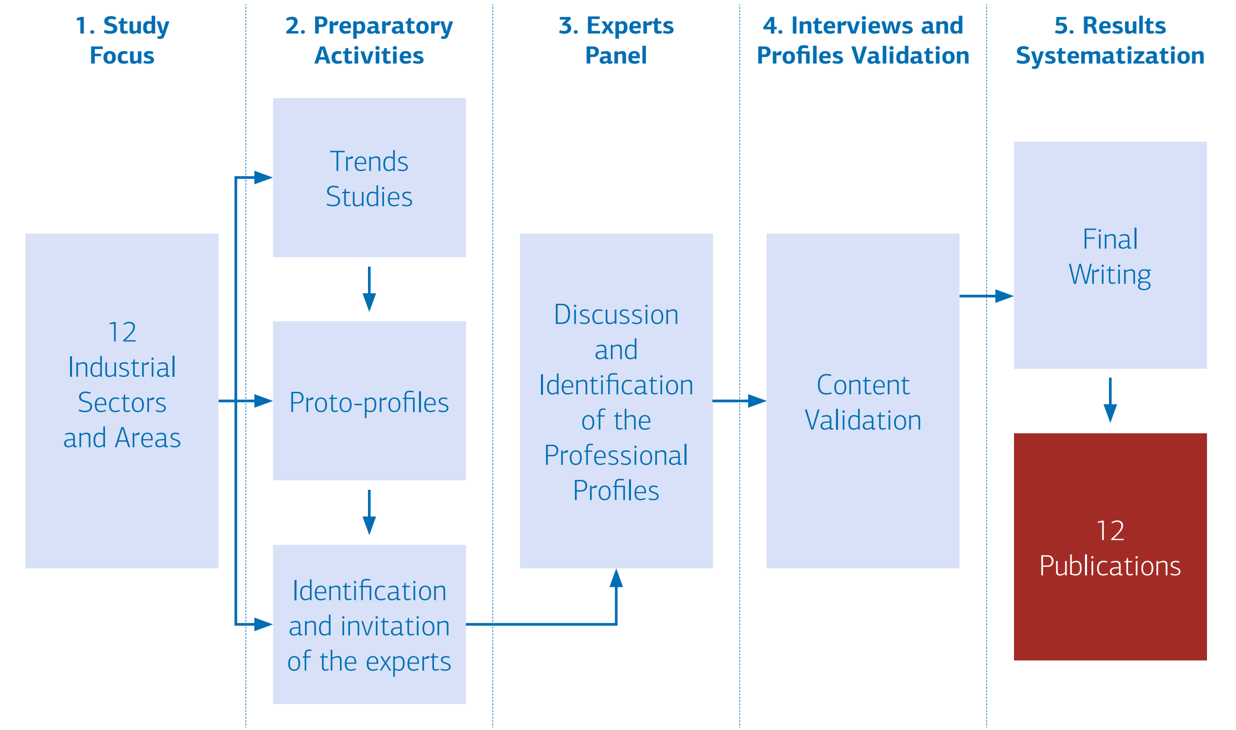
3.2 Project Stages

The development of the project involves the stages presented in Figure 1 which will be sequentially detailed below.

Stage 1 — Study Focus

The sectors/areas, indicated by the project, *Promising Future Sectors for Paraná's Industry* are selected. The Construction, Information and Communications Technology (ICT) sectors, appearing to be relevant for the state, were also covered in the study.

Figure 1: Professional profiles for the future of Parana's industry stages



Source: Sesi-PR; Senai-PR (2013)

Stage 2 — Preparatory Activities
Basic documents are produced by the Observatories Sesi/Senai/IEL Team to subsidize the Professional Profiles selection. The process involves the following materials:

- Trends Study – research on the social and technological phenomena related to the industrial sectors and areas of the Project;
- Proto-profiles – prototyping of the Professional Profiles by sector (an initial draft).

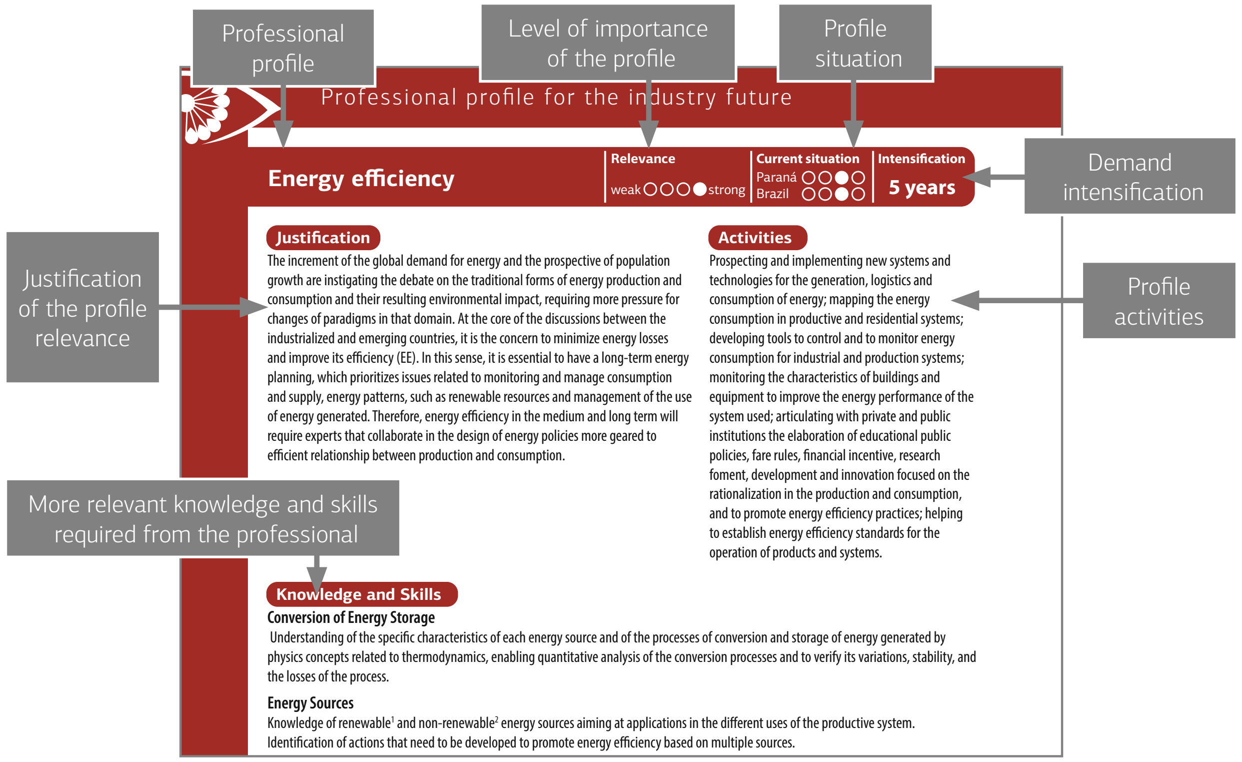
Identification and Invitation of strategic stakeholders to participate in the Experts Panel, with subsequent submission of the Trends Studies and of the Proto-Profiles to the event's public.

Stage 3 — Experts Panel
Conduct of the reflexive process by a select group of experts to identify the professional profiles in different industrial sectors under the project.

Strategic stakeholders, with relevant sectoral knowledge, participate in the event. This group was formed of representatives of industry, educational and research institutions, government, community and human resource management institutes. 13[1] Expert Panels were accomplished, involving 291 strategic stakeholders of the whole country.

Stage 4 — Interviews and Profiles Validation
Individual interviews with strategic stakeholders of the state of Paraná, aimed at validating the content of professional profiles.

Figure 2: Professional profiles presentation model (front)



Source: Sesi-PR; Senai-PR (2013)

1 The sector Communications and Information Technology had 2 Experts Panel, one being oriented to the microtechnology and hardware areas and the other to the software area.

Stage 5 — Results Systematization
Processing of information on the previous stages and systematization of the results in 12 sectoral publications, with the professional profiles presented in data sheet.

4 Main results

The project results are being finalized, and they will be disseminated electronically and in printed matter until the end of 2013. The website hosting the project is: http://www.fiepr.org.br/observatorios/.

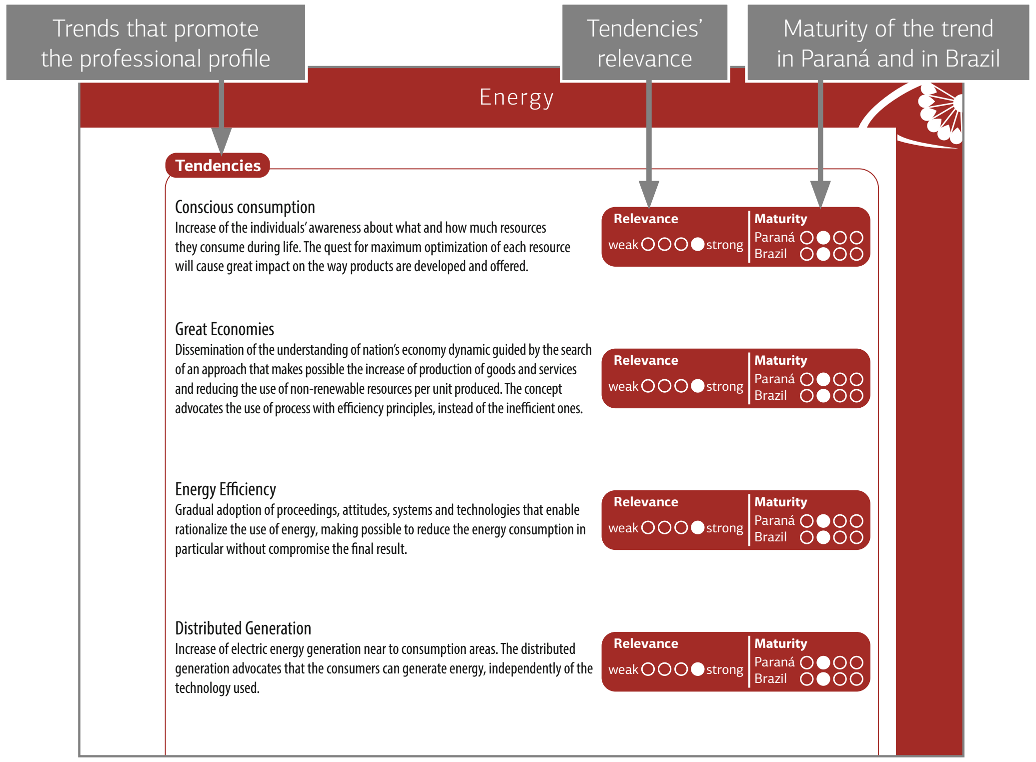
So far, among the main results obtained, the following can be highlighted:

- 12 covered sectors and areas;
- 13 Expert Panels accomplished;
- 291 experts involved;
- 227 professional profiles identified;
- 12 publications being finalized, resulting in approximately 500 pages of information.

227 professional profiles will be published as data sheets, each of them being structured in two pages, as shown in Figures 2 and 3.

While carrying out this prospective analysis, the team involved realized that most of the gained results require further consideration in diverse research publications, though some conclusions can already be shared. Thus, we highlight that Sustainability, Quality of Life and Open Innovation are the trends with the greatest impact in the industrial sectors/areas studied under the project. Besides, noteworthy is the fact that the trends related to

Figure 3: Professional profile presentation model (reverse side)



Source: Sesi-PR; Senai-PR (2013)

balanced practices in what concerns environment, culture and people's life, take an influential position in the professional profiles propositions.

Another relevant achievement is the finding that technical skills under study were accumulated in three principal areas: (i) knowledge skills involving theoretical and practical foundations focused on the production and storage of knowledge; (ii) skills related to the management of processes and activities concerning the analyzed industrial areas and sectors; (iii) skills related to the specific productive industrial sectors and areas.

5 Final considerations

Sesi and Senai (Paraná state) see in the results of the project **Professional Profiles for the Future of Paraná's Industry** an inspiration to innovate the education scenery of the state. Without intention to point out deterministic recommendations, this detailed research aims at encouraging all individuals and institutions concerned for reflection on the processes of formation and valorization of human resources. Moreover, provided the adequate adaptation, the project's method could also be applied in other localities, sectors and areas.

To follow the publication of the project's results, all further efforts will be focused on their dissemination in educational institutions. Although, necessary changes in professional formation also require the mobilization of other stakeholders, within the scope of their responsibilities, aligning the new training offers to social and technological transformations already under way. With such mobilization, of which Fiep System has already become a part, it is promising that the professional formation pioneered in Paraná may grow nation-wide, or even become internationally relevant.

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Skills Anticipation Methods in Denmark: a Case Study

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Abstract

This paper provides, first, a brief introduction into the socio-economic context of skills anticipation in Denmark and then gives an overview of macro-economic methods typically deployed in policy-planning context in Denmark. This data is followed by a detailed presentation of the mixed-method approach deployed by Danish Technological Institute, the center for Policy and Business Analysis within the Copenhagen CFIR cluster for finance/ICT. The cluster secretariat commissioned the study with the view to improving their strategic capacity to fully exploit the potentials of digital technologies from the service-innovation perspective, and to enable the partners concerned to get a better understanding of what the implications could be, in terms of future supply and demand for skills within the cluster. The paper concludes with a critical discussion of the methods typically applied in skills anticipation, and argues that it is time to rethink methodological approaches to better capture skills supply-and-demand dynamics within globalized labour markets.

Keywords:

Denmark, skills anticipation, forecasting methods, qualitative methods, future skills needs, finance/ICT

1 Economic and social context

Denmark is a small, open economy highly dependent on trade with other countries. It has a population of about 5.5 million. Foreign trade accounts for almost two thirds of the GDP. Around 70% of Denmark's total foreign trade is with other EU Member states. Outside the EU, the US is an important partner, but the BRIC countries are growing in importance as trade partners. Export to the BRIC countries has almost doubled since the crisis.[1]

After a long consumer-driven upswing, Denmark's economy began to slow down in 2007, with the end of a housing boom. Housing prices dropped markedly in 2008-2009[2,3]. The global financial crisis has exacerbated the cyclical slowdown through increased borrowing costs and lower export demand, consumer confidence, and investments. The global financial crisis cut Danish real GDP in 2008-09. Denmark made a modest recovery in 2010 with real GDP growth of 1.3%, in part because of increased government spending on construction and infrastructure investments to spur job creation. The kick-start of the Danish economy in 2010 was driven predominantly by fiscal stimulus. In 2008, there was almost full employment, with a net unemployment of 1.8%. Historically, low levels of unemployment up to the financial crisis benefitted in particular the semi-skilled, including low-skilled immigrants. The Danish Adult continuing vocational education and training system (AMU), governed by the social partners, has traditionally played the central role in ensuring that the training offers matches labour market needs, and thus ensured a high degree of labour market mobility, both for the skilled workers and for those having completed only a compulsory education. Through the labour market training system, many have become highly specialized, and some have also completed a full qualification as a skilled worker.

Denmark has traditionally had a high job turnover rate in the labour market, as part of the on-going structural adaptation. Since the crisis, about 160,000 full-time jobs have been lost, but without the same replacement rates in new or emerging sectors – as seen previously. In the

1 http://www.dst.dk/da/Statistik/emner/udenrigshandel.aspx
2 Statistisk ti-årsoversigt- Danmark statistik 2010
3 Danmark i tal 2013- Danmarks statistisk. http://www.dst.dk/pukora/epub/upload/17953/dkinfigures.pdf

second quarter of 2013 there has been a drop in unemployment of 11,000 persons, so that there are currently 196,000 registered unemployed persons. One of the reasons for this drop is, however, that 8.000 persons have left the labour market for good. (AKU – labour force survey)

Across industries, employees have been hit by the crisis. The public sector, which traditionally has employed about 30% of the workforce, has been forced to cut costs at all levels of governance. This has led to major layoffs in health and elderly care, in the education sector, and among civil servants. The government is investing heavily in further digitalization of services in the traditional areas of welfare, which has implications for future skills demands.

Lower demand in the home market and lower levels of export to some of the traditional export markets have affected both manufacturing and commerce and trade, and have led to layoffs that have particularly affected low-skilled workers. As the global economy again begins to pick up, it is expected that companies will invest heavily in robotic automation technologies and further digitalization as a precondition to competing effectively in globalizing markets. It is also expected that industry will continue to outsource high value-added activities to cut costs and to gain better access to global markets and centers of excellence. If more Danish companies position themselves as strategic sub-suppliers in global value chains, this will have implications on the future skills demands to the workforce at all qualification levels, and could imply that more Danish companies will choose to take advantage of the mobility of a growing global high-skilled workforce. A study conducted by the Danish Technological Institute for the Danish Ministry of Science, Innovation and Higher Education shows that SMEs which successfully operate in global markets do so on a broad-based innovation strategy, in which the skills and competences of the skilled workforce are key to success and continuing improvements. On the other hand, access to new TVET graduates with the right mix of competences constitutes one of the most important barriers to continued growth – even more so than access to engineers.[4] The table below shows the innovation strategies perceived by high-performing manufacturing SMVs compared to well-performing manufacturing SMVs in DK, but with lower levels of productivity and lower turnover.

Investments in technologies across the private and the public sector are likely to lead to productivity gains which are of top priority in the policy debate, given the size of the public sector and the on-going debates about labour wages and competitiveness. However, they could also lead to a sluggish job recovery, once the global financial crisis lingers off, so that changing-skills profiles for a range of occupations will probably be necessary in order to achieve the full innovation gain from these investments.

The division of responsibilities between the Government and the social partners constitutes the cornerstone of the Danish labour market model. The philosophy behind the "Danish model" is that the social partners have the best insight into the problems that occur in the labour market. The tripartite model has been under pressure due to a lower level of union organization in recent years – particularly among the confederation of unions representing the skilled and the semi-skilled workforce. In the past year the Confederation of Unions (LO) lost 23,000 members, which corresponds to a drop of 1.9 %. In contrast to this, unions for high-skilled workers have experienced a membership increase.[5]

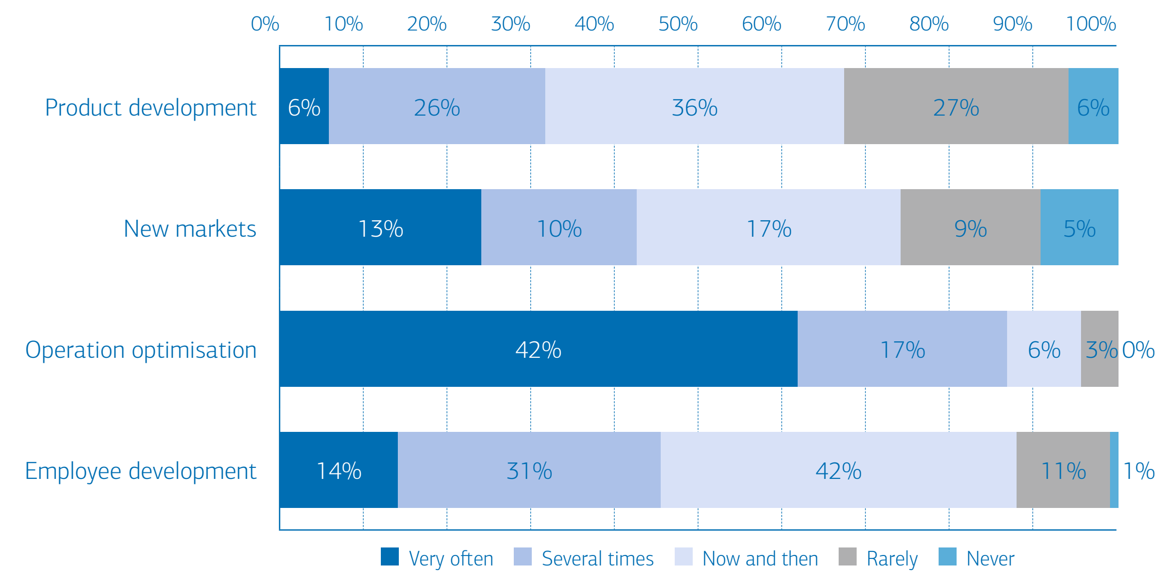
Unemployment Insurance (UI) and Social Assistance (SA) in Denmark date back to the end of the 19th century and are deeply rooted in corporatist structures of the Danish political system. Since the 1930s the unemployment benefit system has had a two-tiered structure: the UI-system for the insured unemployed, which the unions and the state administer, and the SA-system for the uninsured unemployed, which has been, by and large, the mu-

4 The Hidden champions, Danish SMV manufacturing companies in globalised markets, conducted for the Ministry of Science, Innovation and Higher Education

5 Berlingske Business 4 maj 2013 http://www.business.dk/arbejdsmarked/faerre-er-medlem-af-en-fagforening

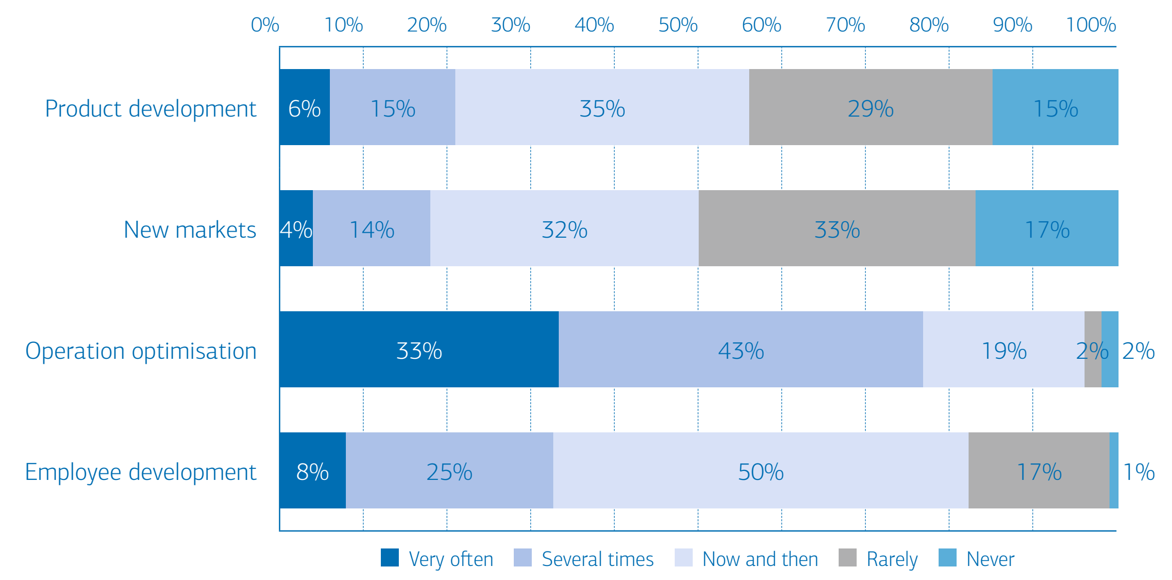
Figure 1

Adaptation strategies — hidden champions



Source: Survey of medium-sized manufacturing enterprises

Adaptation strategies — core enterprises



Source: Survey of medium-sized manufacturing enterprises

Source: Jakobsen Leif, Yding Stig Shapiro Hanne (2013) The hidden champions-DK. Ministry for Research, Innovation and higher education nicipalities' responsibility. The unemployed who are members of an unemployment insurance scheme can receive benefits at a level that mostly favors those with the lowest salary structures. The system has been tightened in recent years. While the benefit level has remained rather stable, the duration of benefits has been reduced from four to two years, and requirements have tightened for regaining the right to benefits if they expire. As a part of a new tax reform, which has just been negotiated between the Government and two opposition parties, the indexation of the benefits will furthermore be made less favorable, thus leading to a gradual decline in the rate of compensation in the future. Thus, while the basic elements of the Danish model are still intact, there has been a growing debate as to whether the Danish flexicurity model is slowly being eroded. In spring 2013, the government was forced, due to the growing debate, to introduce a temporary extension of the maximum benefit period by half a year to avoid around 30,000 unemployed and mainly low-skilled ones losing their benefits due to the current economic crisis (Kongshøj Madsen 2012).

2 Policy concerns

Even if qualification levels in the Danish population have increased dramatically during the past 30 years, one of the major concerns is the relatively high number of workers without a formal qualification above compulsory education, as shown in the table below.

Since the summer of 2008, the Danish unemployment rate has increased considerably from its lowest level of 2.5% in June 2008 (seasonally adjusted) to 7.6 % in April 2012, according to the Labour Force Survey. This steep rise in unemployment mirrors the drop in GDP since 2008. While the level of unemployment increased steeply during the first years of the crisis, overall unemployment has not increased further since the spring of 2010 (Kongshøj Madsen 2012). However, the number of the long-term unemployed has continuously increased. The Danish long-term unemployed increased from 7.6% of the total unemployed labour force in the second quarter of 2009 to 27.3% in the second quarter of 2012.[6]

The groups most affected by long-term unemployment are the older of the young unemployed (aged 25-29 years). Other groups with an above average rate of long-term unemployment are the low-skilled and those aged 55-59 years. Distributed by source of income, long-term unemployment rates are significantly higher for recipients of social assistance than for members of an unemployment insurance fund (ibid).

A study from the Ministry of Employment (2010) shows that ethnic background has a major effect on long-term unemployment. Thus, the rate of long-term unemployment for immigrants and descendants from non-Western countries is more than five times higher than the rate for unemployed of Danish origin. Educational qualification levels also play a role. Those with only a compulsory education background have a rate of long-term unemployment which is twice the average for all groups (ibid). The study just published by the Economic Council of the Labour Movement clearly shows that skilled workers can increase lifetime earnings substantially if they complete a short-cycle or medium-cycle vocational higher education qualification. Nevertheless, the number of skilled workers which complete it, has dropped in recent years. It is expected that the OECD PIAAC data will give new impetus to the debate about the design of skills initiatives in Denmark.[7]

However, the low-skilled are not the only group at risk due to structural changes in the labour market which result in an increase in service, knowledge- and technology-intensive jobs and automation or outsourcing of many routinized job functions.[8] Recent statistics show that the unemployment rate for university graduates has increased significantly. In June 2013, the unemployment rate for the current cohort of new graduates was 32.1%, corresponding to 4.639 persons.[9] The Minister of Higher Education has recently announced, in conjunction with the new financial bill, that he plans to put pressure on the higher education institutions to ensure that the supply of graduates matches changing skills demands in the labour market, and that degrees offered are more focused on the needs of the private labour market – particularly the needs of SMEs.

One reason for the high unemployment of university graduates is the stagnant labour market in the public sector, which traditionally has employed 30% of the labour force but which has also been marked by major layoffs across the sector since the crisis. Thus, the rate of unemployment for those who have graduated from a university within the past year is currently 28 %, while the corresponding rate for those who graduated between 13 and 24 months ago has tripled from 2008 to the spring of 2012, and is currently 15 % (AC 2012). To overcome the growing challenges of long-term unemployment, a reform of the public unemployment system is foreseen in the autumn of 2013[10], and the Danish government has furthermore allocated about 1 billion DKK to increased continuing education and training activities in 2014–2017. The government has also allocated resources to invest in a series of infrastructure projects to kick-start the economy and boost employment. For each of the regions a forecasting has been made of projected employment effects at the occupational level.[11]

The major policy focus concerns, on one hand, structural reforms which can create a new foundation for the welfare state with a growing number of the elderly and which can increase the active labour force over time. On the other hand, policies focus on raising the qualification levels in the population, and on improving the quality of education at all qualification levels. This is expressed, for example, in the recent reform of compulsory education and in the innovation strategy for higher education from 2012.[12]

Another major concern is the overall productivity – particularly in retail trade and in the public sector. The government formed a Productivity Commission,[13] which has drawn up a series of recommendations for further action.

Table: Highest level of education (% of 25–64 year-olds)

	1981	1985	1991	2000	2010	2011
Total	**100**	**100**	**100**	**100**	**100**	**100**
Basic school — 8th — 10th class	41	43	38	30	22	21
General upper secondary education	3	3	4	6	6	6
Vocational education and training	30	33	36	38	38	37
Short-cycle higher education	3	3	4	5	5	5
Medium-cycle higher education	9	10	11	13	15	16
Bachelor	0	0	0	1	2	2
Long-cycle higher education	3	3	4	6	9	9
Not stated	12	4	2	2	3	4

Source: www.statbank.dk/hfu1 and krhfu1

6 http://www.dst.dk/pukora/epub/Nyt/2012/NR527_1.pdf

7 Interview Chief Consultant Jan Reitz Jørgensen Danish Ministry of Education
8 Noes Piester Henrik, Shapiro Hanne, Moltesen Josina (2008) Oursourcing of ICT and services- impact on skills. DG Enterprise
9 Akademikernes Centralorganisation
10 http://www.danskmetal.dk/Nyheder%20og%20presse/Metal%20i%20medierne/2013/juni/Corydon%20lover%20stor%20beskaeftigelsesreform.aspx
11 See for example: http://brhovedstadensjaelland.dk/da/Det%20regionale%20Beskaeftigelsesraad/Moeder%20og%20konferencer/~/media/AmsRegionSite/HovedstadenSjaelland/Graphics%202011/Viden-om-arbejdsmarked/Sammenfatning%20af%20infrastrukturanalysepdf.ashx
12 For an overview of initiatives in HE se for example http://fivu.dk/uddannelse-og-institutioner/politiske-indsatsomrader/politiske-indsatser-pa-uddannelsesomradet
13 http://produktivitetskommissionen.dk/

The strong decline in employment in the private sector during the crisis has raised the issue of where the new jobs will be created. The government has formed a series of Growth Panels across industries where Denmark is perceived to have particular assets that could be strengthened further by improving framework conditions.

Very surprisingly, there have been no systematic attempts to forecast future skills requirements (or any changes in skills requirements) which could be critical for spurring growth and innovation in the identified industries with growth potentials.

3 Key institutions, methodologies, processes

A range of macro-oriented quantitative forecasting models focusing on occupations or qualifications have been implemented by government authorities as planning tools in labour market and education policies, and with an ongoing collection of data at certain intervals. A number of foresights have been implemented in the last 10 years by the Ministry of Science, Technology and Higher Education.[14] Organizations such as the sector research Institute Risø, which is now merged with Danish Technical University, Rambøll, and the Danish Technological Institute have been commissioned to carry out these studies after open calls for tender.[15] The studies have primarily informed technology and innovation policies, and have had very limited or no focus on future skills. In recent years, no national foresights have been implemented – most probably, due to cost reasons. Apart from the more macro-oriented models, a number of institutions (such as Aalborg University-CARMA, Rambøll, New Insight, Oxford, and the Danish Technological Institute) have adopted mixed-method approaches in order to achieve a more granular approach to capturing skills changes within and across occupations. These studies are typically commissioned by social partners on an ad hoc basis – for example, for regional authorities or to support educational trade committees in their planning. The mixed-method approaches often include a series of interviews or case studies sometimes including surveys depending upon the size of the budget, a scenario process which may build on the data collected, and the involvement of stakeholders to explore the assumptions and validity of the scenarios as the basis for further action.

In the following, some of the more macro-oriented approaches will be briefly described, based on research conducted by Professor Per Kongshøj Madsen for the European Employment Observatory.

4 The Labour Market Balance "Arbejdsmarkedsbalancen"

The National Labour Market Authority[16] and the Regional Labour Market Boards carry out semi-annual detailed assessments of labour demand distributed by sectors and occupations (skills) and by imbalances between supply and demand. The time horizon for the forecasts in the labour market balances is short (six months to one year). The labour market balances make a distinction between five different degrees of imbalance for 1,500 types of occupations. The assessment is based mainly on quantitative data sources including the nation-wide employer survey and unemployment statistics.

The main purpose of the assessment is to act as a practical tool for the job centres (the local employment service centres) in counseling unemployed individuals about the type of training necessary for a return to employment.

5 The Ministry of Education — The Data Bank Databanken

The Ministry of Education has an agency (UNI-C Statistics and Analysis) which produces statistical databases for the educational system as a whole and a number of quantitative forecasts related to education and the labour market. The forecasts focus on the supply side of the labour market, but some modeling exercises also include forecasting future imbalances between the supply and demand for different kinds of labour. The forecasts are used for budget purposes and for planning the intake in different parts of the education system. The forecasts are used short-term for public budget planning, but also with a longer time perspective (10 years or more).

14 http://fivu.dk/publikationer/2003/filer-2003/teknologisk-fremsyn-pervasive-computing.pdf
15 As an example, please see http://fivu.dk/publikationer/2004/teknologisk-fremsyn-om-dansk-nanovidenskab-og-nanoteknologi
16 Arbejdsmarkedsbalancen http://ams.dk/Ams/Balance.aspx

6 The Economic Council of the Labour Movement — Arbejderbevægelsens Erhvervsråd

The Economic Council of the Labour Movement, which is funded by the unions, produces forecasts as inputs for policy debates. The time horizon for the forecasts is typically ten years. They are made both at the national and the regional level with focus on groups at different qualification levels. The forecasts are based on coupling quantitative models for labour supply and demand. Thus, they are dependent on assessments of flows through the educational system and on the demand for labour by occupational profiles, which in turn reflect estimates of the skills demand by different economic sectors. The forecasts of the Economic Council also contain examples of more advanced forecasting methods, where assumptions are made about the kind of substitution which will take place in case of imbalances. Methodological limitations are linked to making reliable estimates of the extent and speed of the relevant adaptation processes.

The following is a detailed description of a mixed-method approach to skills anticipation within the cluster of finance/ ICT in the Greater Copenhagen Region.

7 Context and background

Finance and ICT represent 5% of the Danish labour force and 28% of the gross value added. The industries are characterized by being at the very forefront of digitally-enabled innovation. They are highly globalized and competitive industries. Location and inward investments are to a large extent defined by the quality of their

Figure 2: CFIR member organisations

human resources. A secretariat for the Copenhagen ICT finance region (CFIR) was formed in 2009 to support the profiling and further development and global branding of the cluster. CFIR's members represent more than 400,000 employees, 900 companies in finance and ICT, and about 50,000 students, teachers, professors, and researchers. One of the first decisions taken by the board of CFIR was to carry out a comprehensive analysis of the current and future supply and demand of employees for the cluster's industries and to identify and assess critical uncertainties which could impact future supply and demand.

The Danish Technological Institute was commissioned to carry out the study after a competitive bidding procedure.

The tender brief specified the analytical components to be included in the study, the time frame, the price, and the level of interaction desired with member representatives of CFIR and employees from the secretariat. Based on that, the Danish Technological Institute developed a methodology which included the following elements:

- A statistical delimitation of finance /ICT companies through the deployment of industry classification codes from Statistics Denmark;
- A mapping of existing educational programmes and continuing education and training offers – EQF levels 3–8 – with focus on content and expected learning outcomes in the programmes;
- A member survey conducted with the three main unions representing ICT and financial services. The questionnaire was sent by email to 2,563 members, with the response rate of 35%, and covered such variables as age, gender, and formal qualification levels. The questionnaire dealt participation patterns in continuing education and training for the past five years (formal, informal, non-formal), barriers and incentives to participation in continuing education and training, and data on whether the employee felt that he/she was competent to carry out the existing work functions at present. Employees were inquired about current work tasks which they were asked to rate by importance, and besides – about the expected degree of transformation of their jobs in the next five to seven years, the extent to which, in their view, it would lead to changes in their job profiles and work tasks, and whether they believed that they would need to be further qualified to be prepared for eventual changes in the skills content of their jobs.
- A company survey of 50 companies, with a response rate of 60%. Employers were asked about work tasks within their companies at present and the expected changes in the next five to seven years. Also, the questions dealt with work-organization practices, with particular focus on the role of ICT in processes, services, products now and in the future. They were also asked about their HRM strategies and how these were translated into recruitment policies, how they prioritized continuing education and training, about their assessment of the nature of changing skills needs and underlying drivers, and whether they had any formalized measures to assess this as a basis for planning the skills profiles of future employees and their continuing education and training activities. Finally, they were asked to assess the extent to which they believed that the skills profiles of new graduates (whom they had employed within the past three years) matched their needs, with identifying any specific mismatch areas.
- Finally, an international literature study was undertaken, particularly to identify and assess critical drivers of change in the finance/ICT sectors. Two reports including a scenario exercise were of particularly use: a study on Global Sourcing of ICT and services including financial services which Danish Technological Institute had conducted for DG Enterprise; and a major foresight exercise which the World Economic Forum had conducted with particular emphasis on potential disruptive effects of increased digitalization and globalization of ICT-finance. As part of the study for CFIR, an analysis was conducted of selected qualifications targeting ICT/finance in the Netherlands, the USA, the UK, and Sweden.

Based on the survey data, the data from the statistical agency of the Ministry of Education, and The Danish Coordinated Application System (KOT), – a forecast was drawn up on the future supply of professionals in the ICT/ finance sector through 2030. Variables such as education drop-out rates, retirement age, labour market mobility were used to estimate the supply of future labour force to the finance/ICT sectors. The demand for skilled professionals within the sector was based on the data from the Ministry of Finance – Plan 2015 which was under revision during the study due to the financial crisis. The data from the Ministry of Finance were broken down according to the demand for different qualifications.

All the data sources were analyzed by the Danish Technological Institute in order to create a coherent qualitative and quantitative map of the existing competence base, and to draw up a qualitative and quantitative map of future supply and demand, as well as critical drivers and uncertainties which could influence future skills demands in the ICT/finance industry.

This initial mapping was validated in the seminar with the CFIR secretariat and the steering group of the project which represented all CFIR members.

8 Key findings summary: First part of the Study

The first part of the study showed that it is the large financial institutions which define the skills demands for the cluster as such. The study showed that there would be a marked drop in support and customer face-to-face service functions. Within the finance sector it showed a decreasing demand for IT-system developers, and an increasing demand for professionals who could implement and integrate standard systems.

The motivation to participate in continuing education and training was high (according to the study data) among employers as well as employees. Few of the participating companies have developed strategic alliances with educational institutions. However, the study showed that there was a projected growth in professionals with hybrid qualifications in ICT/finance with focus on developing new digital banking services B2B and B2C.

9 Second part of the Study

The second part of the study included a scenario process and the development of an action plan for the finance/ICT cluster in collaboration with the steering group for the study, representing all main partners.

The central drivers of change were identified through the data collected and international studies, as well as through expert interviews with the steering committee.

Of these, three drivers were selected as the basis for scenario construction:

- The macro economic development in DK for the ICT banking industries
- International harmonization of regulations for the banking sector
- Public investments in R&D specific to the banking and ICT industries.

Three scenarios which were internally consistent and plausible were selected by the steering committee for further elaboration:

Scenario 1: "Made in India"
Scenario 2: World masters in innovation
Scenario 3: A European power center

The scenario process pin-pointed different challenges and critical uncertainties regarding the future supply and demand for workforce in the CFIR cluster. These findings were integrated in the final action plan summing up key points of actions

For the education representatives: the likely demand for a new type of profiles or specializations such as data analysts, finance mobile business applications and focus areas, regarding the future demand for continuing education and training according to qualification levels and job functions;

For the union representatives: focus on early measures to increase major lay-offs due to structural changes; in particular, in the finance sector – emerging new skills profiles and specializations;

For the industry representatives: a Generic job profile and job-tasks approach, with focus on emerging profiles and specializations, in order to identify the emerging skills needs which were unlikely to be covered by formal qualifications of the employees at present; the existing in-house training offers; public supply of continuing education and training or the through-job experience.

10 Consolidated Skills Action plan

Different perspectives of the CFIR partners were drawn up in the action plan which constituted the final report, and which was presented and discussed at the one-day seminar for moulding commitment to the next steps. The action plan included:

- Proposal for joint areas of collaboration between partners on specifically identified emerging competence profiles/ new specializations, at present not covered by the educational offer;
- Proposal for actions for employee groups at risk of lay-off due to sectorial restructuring;
- Proposal for immediate joint measures regarding continuing education and training, with focus on raising the ICT/ business-related skills and on mobile applications development for the finance sector.

11 Summary and Conclusions

Methodologies applied to forecast/anticipate future skills demands hold different inherent weaknesses. First, the sector-based macro-oriented methods do not take into account different forms of substitution which will take place in case of imbalances. Second, the majority of studies focus on formal educational attainment. Third, the macro-oriented models are not well-suited to capturing new emerging occupational profiles and skills needs resulting from technology convergence or sector convergence, – nor are they well-suited to anticipating skills needs in highly globalized labour markets with other type of substitution patterns (such as short/long-term outsourcing or short-term employment of international labour). Developments in data-mining methods may prove to offer new opportunities for understanding structural changes in fast changing occupations characterized by high degree of technology intensity based on real time data. More research is needed, however, to deal with the question of language versioning as well.[17] The more qualitative-oriented methods are characterized by a variety of approaches adopted; furthermore, they tend to be ad hoc and often to have a narrow scope. It is, therefore, hard to use the outcomes for any comparative purpose. When it comes to the deployment of scenario constructs, methods often tend to be flawed by a narrow scope in the trends and drivers in focus; and too often, methods involving real time participation of individuals end up in "the world of the preferred scenario", which weakens the strategic thinking around skills strategies.

The global economy is characterized by a growing connectivity and a growing global specialization, – as seen in studies on value chains. From a sustainable job-creation perspective, it is increasingly important to understand the type of strategies firms pursue to position themselves in global markets and to consider how the cost-quality equation on skills plays out depending upon the strategies pursued[18]. This has major implications for the design of future-oriented skills anticipation methodologies. However, at present, analysis into how global skills webs are formed within global value chains characterized by different governance arrangements, is limited; studies from DUKE University in the USA represent an exception.[19]

17 http://burning-glass.com/
18 See fx brown et all Global Auction of skills, and The Hidden Champions, Danish technological Institute 2013
http://www.dti.dk/the-hidden-champions-the-danish-industrial-motor-of-growth/33938?cms.query=the+hidden+champions
19 This link presents a series of studies on skills anticipation approaches for developing economies tapping into global value chains

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A Foresight Methodology to Develop a Vision for Skills 2020 in the EU Enlargement Countries[1]

Francesca Rosso, Anastasia Fetsi

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1 This paper presents the foresight methodology, developed by ETFunder the coordination of Lizzi Feiler and in cooperation with international and national experts in 2012-2013, within the context of the EU/IPA funded ETF Frame project. The methodological development has also benefitted from the support of an international Advisory Board .

Abstract

In the international context characterised by economic uncertainty and rapid technological change, skills foresight supports the adoption of a more strategic approach to education/training policy, able to adapt to multiple changes. Strengthening the capacity of education/training institutions to look into the future skills demand permits a sound adaptation of training and increases the system performance in the medium term.

The ETF FRAME project is novel in its scope and focus, as it applies a foresight methodology to the education and training sector for the first time in the EU Enlargement region[2]. The approach is to develop a vision for skills policies 2020, identify priorities for action and set up a roadmap for adaptation of the national education and training system taking into account broader issues and trends and building on existing evidence. A qualitative approach was considered to be the most suitable to launch a vision-building activity, given the high number of stakeholders involved in skills policies and the availability of existing data.

Keywords:

foresight, enlargement, skills, TVET, human resources development, employment

1 The Frame project context

During the last 10 years the countries of the EU Enlargement region are making efforts to modernise their education and training systems so as to bring them closer to emerging socio-economic needs. As in other regions of the world, the objective is to ensure that education and training systems are able to develop skills which permanently enhance the employability of all citizens and which are relevant to growth fostering. However, skills mismatch remains the key issue, – while the divide between the world of education/training and the economy still persists, despite the efforts of the countries to set up coordination mechanisms (such as platforms and councils) and processes. Key stakeholders in the countries recognise the need to address skills development in a coherent manner, to understand better the demand for skills in the short and medium term and ensure inter-institutional cooperation. No single blue print has been found on how to make this happen.

Through its EU funded "FRAME" project, the ETF supports the countries of the EU Enlargement region to adopt a forward-looking, evidence-based strategic approach to their skills development with the aim to inform sound education and training policies. In the context of the project, foresight is used as a change management tool aiming at assisting key actors in the countries to (i) formulate a commonly-shared vision for skills up to 2020, (ii) identify priorities for action and (iii) develop a roadmap for the adaptation of the national education and training systems to achieve the vision for skills.

This paper describes the foresight methodology that ETF has elaborated for the purposes of the FRAME project and particularly highlights the lessons learnt through the implementation of the foresight exercise in the first two pilot countries: Montenegro and Serbia.

2 FRAME foresight methodology

2.1 Definition and aim of Foresight within the FRAME project

The common definition of foresight, adopted at European level, emphasises that the process

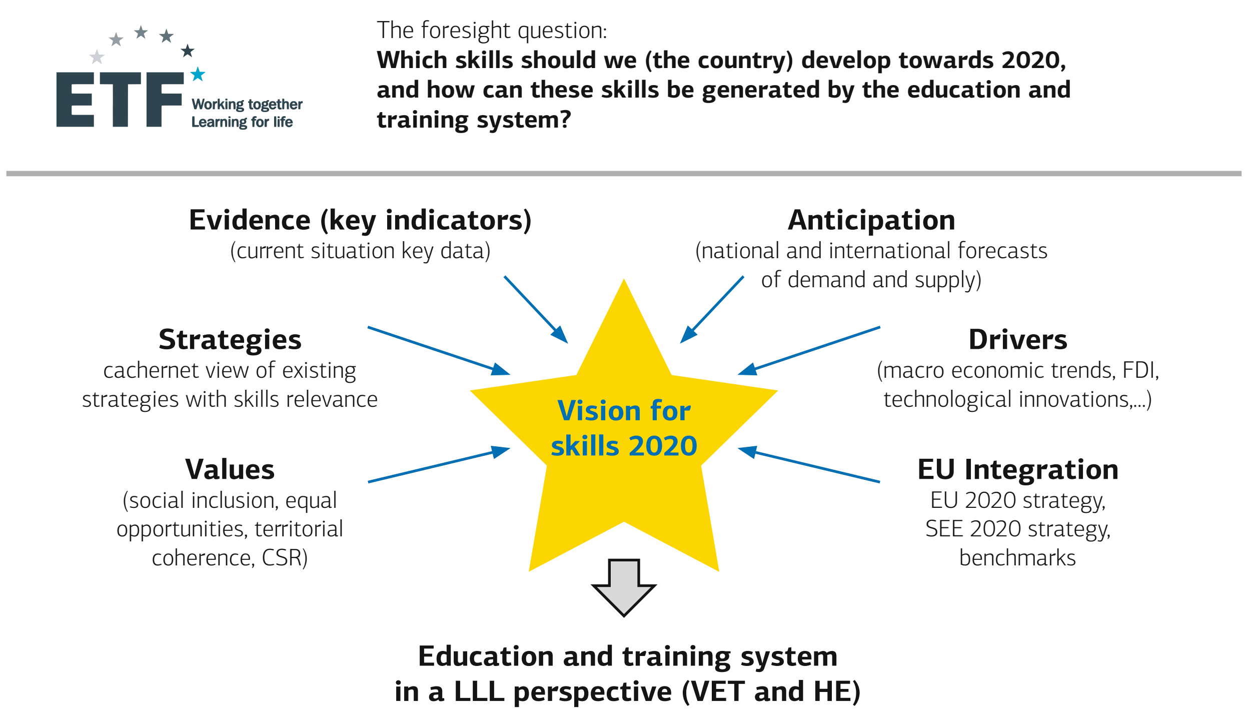
2 The countries which are undergoing a process of accession to the European Union and which are covered by the FRAME project are the following: Serbia, Montenegro, Albania, Kosovo (under UNSCR 1244/99), the Former Yugoslav Republic of Macedonia, Bosnia and Herzegovina, and Turkey.

benefits “systematic, participatory, future intelligence gathering and medium-to-long-term vision-building process aimed at present-day decisions and at mobilising joint actions” (FOREN Guide, 2001).

The ETF FRAME project was novel in its scope and focus as it applied a foresight methodology to the education and training sector for the first time in the Enlargement region. The approach supported countries to develop their own vision for skills policies in a medium-term perspective (up to 2020), with selected priorities and a roadmap for the adaptation of the national education and training systems. Broader issues and trends were taken into account and existing evidence were used to substantiate decisions. A qualitative approach was considered to be the most suitable to launch a vision-building activity, given the high number of stakeholders involved in skills policies and the availability of data.

The key objective of the foresight exercise was to promote a more future-oriented approach to skills policies, involving key stakeholders (public and private) and bringing together different existing country strategies relevant to education, training, skills development, employment and economic development into a coherent vision on skills for the future. Moreover, the process aimed at breaking down silos between ministries in charge of HRD and to develop more joined-up policy approaches to skills development by bringing together the key players in the sector and by identifying the interfaces between the existing strategies related to HRD.

Figure 1: the ETF Frame foresight question and related issues



4 This paper refers to the pilot implementation of the FRAME project in Serbia and Montenegro. The roll out in the other Enlargement countries is planned for the period October 2013-September 2014.

The methodology designed for the project aimed at addressing some fundamental questions, such as:

- Which skills should we (the country) develop towards 2020, and how can these skills be generated by the education and training system?
- What would policy leaders like to achieve in the current situation, what can be achieved by the country?
- What are the feasible and preferred options, based on resources and capacities (available and further developed)?
- Which strategic vision for the complexity of skills (in terms of skills levels and technical/ generic skills) do we have, and for which sectors?

2.2 Preliminary methodological considerations

The elaboration of the ETF foresight methodology took place in 2012 - 2013 and benefited from the expertise of ETF education and training, employment, foresight and statistical experts, as well as from inputs received by international and national experts. Some preliminary methodological considerations need to be drawn to understand better the background and the limits of the methodology.

Firstly, the starting point for the implementation of the ETF foresight methodology in a given country is that the methodology needs to be tailored and fine-tuned to the specific country context. Accordingly, the skeleton methodology that was conceptualised by ETF was implemented on a piloting basis in two countries (Montenegro and Serbia) and adapted to their needs. The lessons learnt can inspire the roll-out in the other countries but cannot constitute a blue print for action. Therefore, the methodology was left “open” for different options on purpose, so that different modalities could be picked according to the needs of each country.

Secondly, due to the specificity of the education and training sector - being at the crossroad of several policies (economic, labour market, social), and to the specific context in the enlargement countries which is characterized by fragmentation and non-optimal institutional cooperation, the participatory and networking dimension needed to be prominent in the approach proposed. For this reason, the methodology is based on the involvement of a wide range of stakeholders while exploring medium-term futures through a holistic analysis, going beyond typical forecasting work. Getting knowledge from different policy areas was considered essential to make sense of the interconnectedness of the economy, the education system, the labour market system, the social dimension and the regional and territorial peculiarities, so as to design more coherent, evidence-based and future-proof policies, which all the stakeholders could jointly agree upon and implement.

Thirdly, given the specific purpose of the exercise – developing a joint vision for skills, with priorities and roadmap for implementation – there was a need to put a particular emphasis on developing a foresight culture and reflecting on alternative future pathways. This aspect was even more important, as a foresight exercise was never before implemented in the Western Balkans and stakeholders needed to develop a sound understanding of strategy development processes and of the relevance of forward-looking activities.

Finally, the exercise had to take into consideration resources constraints, both in terms of stakeholders’ availability, duration of the exercise, financial allocation: the stakeholders could not be overburdened by the exercise and some preliminary results had to be provided within 10-12 months. Therefore, the methodological framework had to combine methods which were relatively simple to implement but which yield policy impacts in a defined timeframe. Realistically, the process could pave the way for longer term strategic thinking on skills development in the Enlargement countries while only constituting the first step towards a fully-fledged forward-looking and anticipatory approach to policy making. It is well understood that further actions should be considered to get deeper foresight results.

2.3 Practical implementation

The FRAME foresight process consists of four main phases: the preparation phase, the system-building phase, the foresight (proper) phase, and the follow-up phase to ensure optimal use of the results.

With relation to the implementation in the two pilot countries, Serbia and Montenegro, during the **system-building phase** (pre-foresight and stakeholders-engagement phases), national government institutions and agencies, social partners and donor organisations were consulted. A government institution responsible for overall coordination of the foresight process was assigned, and further stakeholders consulted and invited to participate in the process. The added value of foresight for skills development and expectations was discussed with the main stakeholders, so as to tailor the practical implementation of the methodology to the concrete context in each country.

The '**foresight proper**' process was mostly based on the organization of three workshops, including a large group of stakeholders in charge of policy-planning and policy-implementation in skills development. A total of about 15 institutions/ organizations were represented at the workshops (about 30-35 participants) and all work was done in local language and translated into English. The group of stakeholders varied in relation to the different institutional setting of each country but, in general, included the Ministry in charge of education and training, the Ministry of Labour and Social Welfare, the Ministry of Youth, the Ministry of Economy and Finance, the Ministry of Science, the European Offices, the Statistical Office, the TVET and the Education Centres, the National Employment Service, the Trade Unions, the Employers Association, the education, the training providers' representatives, and the Youth organization representatives. Main international players were also invited to the meetings with an observatory role, such as the European Union Delegation, the European Commission and the World Bank.

Nonetheless, the process also included an important negotiation work which was conducted both by national leading authorities and ETF experts in-between the events. In particular, the leading institution was extremely active in discussing at high level (Secretaries of State/Deputy Ministers) the main line to be

Table 1: Overview of phases and tasks

Phases	Tasks/ Steps
A. Pre-Foresight	• Scoping phase with basic preparation of the exercise • Preliminary analysis of reference documents in skills development • Information-gathering among a wider group of potential stakeholders
B. Engagement of stakeholders	• Securing political and technical support and resources • Recruiting stakeholders (bringing relevant stakeholders on board) • Teaming (bringing different actors together)
C. Foresight Proper	• Issue analysis, strategic panorama and its skills relevance • Trends and drivers at global and national level • Developing success scenarios • Developing a shared vision, setting priorities and elaborating roadmap
D. Follow-up	• Lock-in (ensuring commitment after the exercise) • Formal debriefing of results for policy makers • Communicating results to a wider audience • Building on this foresight and implementing the high-level plan

taken in the exercise and the strategic direction of the country. This already constituted a great success for the process, as national authorities took full responsibility for the elaboration of the vision document and the attached priorities and measures and increased their level of cooperation on the subject.

During the first workshop, government representatives presented their key national strategies related to skills development, with a specific focus on skills, so as to place the skills vision in the context of the country's macroeconomic development. To complete the wider framework, the main goals and comparative benchmarks of the Europe 2020 Strategy for Growth and Jobs and the South East Europe Regional Growth Strategy 2020 were also brought in. A *strategic panorama*, mapping the core national strategies, was prepared and eventual key issues and gaps were discussed. This underlined the need to develop a coherent and forward-looking approach in a mid-term perspective. Current issues and problems were discussed in breakout groups, covering the supply side as well as the demand side and the cross-cutting issues related to human resource development.

The second workshop started with a further exploration of demand-side issues, debating about existing tools in the countries to anticipate future skills demands. A presentation of economic, social and technological global trends and drivers inspired a debate about their likely relevance and impact on the national skills system. In particular, a brainstorming about the impact of ICT and technology on governance, citizenship and education was held, especially focusing on the existing interconnec-

Table 2: Methods and tools used/to be used in workshop 1

SWOT Analysis	A SWOT analysis was used in the foresight exercise to encourage stakeholders to discuss, map and cluster in a matrix, the current strengths and weaknesses and emerging opportunities and threats. Within each box, different factors influencing skills development were taken into consideration. The SWOT analysis mapped internal and external factors. Strengths and weaknesses were scored on the basis of their significance (high-medium-low). The opportunities and threats were scored on the basis of their probability to occur. In building the vision and the roadmap, the results of the SWOT (especially the challenges) were used to design actions which match strengths with opportunities, and to find effective means to address threats and weaknesses. Identified challenges were included in the final vision report.
Gap Analysis	A gap analysis was used to allow experts and stakeholders to assess shortfalls which impact on the foresight exercise. The main gaps/shortfalls were related to the lack of evidence base (quantitative and qualitative, missing statistics), the proliferation of different strategic documents related to skills, weakly coordinated with one another, the lack of resources and funding instruments to address particular concerns related to skills development, the poor implementation of strategic documents, the complexity of the institutional set up and the lack of effective coordination. A gap analysis was also used to relate the shortfall between the current situation in terms of skills policies and the desired state, identifying the missing elements. In the case of Montenegro, experts and stakeholders identified the factors defining the current state of skills (the so-called "alpha scenario") and listed the factors needed to reach the target (desired) state (Skills 2020, the so-called "beta scenario"). A discussion was held on how to fill the gap between the two states. This was important because it helped to identify the possible reasons behind a sub-optimal performance of the national education and training sector. This also helped to identify flaws in resource allocation, planning, and implementation.

Table 3: Methods and tools used/to be used in workshop 2	
Trends and drivers analysis	As an input for preparing the vision, it was useful to analyse the trends and drivers in order to identify both external (more macro) and internal (micro) factors. The analysis was undertaken in a participatory, interactive mode, with some preparatory work undertaken before the workshop by the ETF experts to identify an initial list of key trends and drivers potentially able to influence the skills demand and supply in the countries. The workshop started with a presentation of key trends and drivers affecting skills, and participants worked in groups of 5-6 persons assessing the comprehensiveness of the list, clustering the trends and drivers and ranking them in terms of degree of importance.
Horizon scanning	Horizon scanning was used to examine potential threats, opportunities and likely future developments, whilst also flagging emerging issues and new approaches. By bringing examples, especially from the EU Member States (but not only), the tool helped to identify and define existing good practices in policy approaches while also exploring and suggesting creative and novel policy design and actions. The regional dimension of skills development and the benefits and influence deriving from the process of enlargement were identified as main opportunities for the countries. Due to time availability and resources, the horizon scanning was not implemented in depth but nonetheless allowed to brainstorm about new or changed skills needs over the medium to long term. In the case of Serbia, the inputs provided by the Ministry of Economy were key to identify main socio-economic trends influencing the national labour market (e.g. demographic change, migration, impact of the crisis, infrastructures, information society, underemployment, etc.), and the priority economic sectors identified for the coming years.
Scenario development	Scenario development entails the elaboration of stories, portraying plausible futures, and is aimed at developing the capacity to consider alternative scenarios. Scenarios may be: (i) exploratory, focusing on alternative futures based on different circumstances, or (ii) normative and aspirational (success scenarios), starting from a desired point in the future and working back to the present to analyse how the desired future can be achieved. The second approach was used in the case of Montenegro, while in the future also the most typical elaboration of alternative futures will be tested (business as usual scenario, worst case scenario, and best case scenario).
Visioning	Visioning is an open, participatory process whereby stakeholders develop a shared picture of a preferred future for skills development in 2020. This tool was the single most important element of the foresight methodology applied in the two pilot countries, as a shared vision among policy makers and main stakeholders for skills development was never discussed in the past. Visioning provided the vital link for advancing through the following phases: Diagnosis-Prognosis-Prescription (understanding where the country is, anticipating what could happen and jointly deciding what should be done). The vision building entailed the following steps: Step 1: sharing the diagnosis for skills by identifying common concerns and interests among stakeholders; Step 2: identifying the shared long-term issues and challenges for building a skills vision, by analysing internal and external trends and drivers in skills and any possible trend breaks and their impact; Step 3: identifying the roles and interests of the stakeholders in this respect; Step 4: ranking the issues and challenges according to their level of importance; Step 5: building the ultimate aims and goals of the common vision for skills by focusing on the priority challenges and the preferred way forward. The vision was developed on a consensus basis among the stakeholders and was therefore a **shared vision**. The format of the vision was, on purpose, very brief – with an ambitious but easy-to-understand message.

tion between different trends and changes and on the need for Governments to respond with flexibility to unforeseen breaks. Consequently, breakout groups worked on success scenarios, developing future visions linked to the main issues and defining main actions to be taken to achieve future visions. The workshop was concluded with first drafts for a skills vision 2020.

The third workshop was the decisive cornerstone of the vision-building process. To ensure policy relevance of the vision, key government institutions were highlighting their core strategic priorities. This was followed by identifying and defining shared priorities which required a coherent approach and cooperation among stakeholders. In one of the two pilot cases, breakout groups – including members from different institutions – worked directly on drafting priorities and measures, which enormously increased the ownership of the process.

During the **follow-up phase**, necessary actions were taken to complete and finalise the roadmap, specifying methods for the concrete realisation of the vision. Clustered in few (four to five) policy priorities, activities and measures were defined, each of them with the specification of the main responsible and coordinating bodies and the objectives to be achieved. The objectives were specified in terms of qualitative and quantitative targets, with result-oriented indicators. Baseline targets and targets to be achieved by 2020, as well as interim targets remain to be fine-tuned in the coming months. Among the priorities, systemic issues related to the institutional set-up of the two countries were also spotted, which will be targeted by

Table 4: Methods and tools used in workshop 3	
Priority-setting	The key purpose of the foresight exercises was to support policymakers in making choices and assigning priority to a particular policy approach, to a mix of policy measures/ actions or to investments in particular sectors or niche areas. Priority-setting was particularly significant in times of economic crisis and budgets contraction so as to avoid, as much as possible, "shopping lists" of actions. Starting from an initial list of options related to priority for skills development (drawing on inputs from previous foresight tools, literature review and brainstorming, national stakeholders clustered and prioritised the options based on discussions and finally developed the list of main priorities.
Road-mapping	Road-mapping was designed to provide a shared understanding among stakeholders of the direction, proximity and degree of certainty in medium and long-term planning. For both countries, the roadmaps were developed in an interactive, consensus-building mode and represented the steps needed to achieve the desired vision. Having formulated the vision for skills 2020, the roadmaps marked out the path from the present situation to achieve the desired end-point. The roadmaps draw on gap analysis to identify the policy actions needed, they built on existing evidence, SWOT, success scenario and vision which had been developed for skills in 2020. Experts and participants followed the steps listed below: Step 1: Identifying barriers impeding the achievement of objectives and the desired end-state. Step 2: Defining the challenges deriving from those barriers. Step 3: Identifying possible solutions by considering different alternatives to overcome the barriers. Step 4: Ranking of alternative actions based on their potential for resolving the challenges. Step 5: Deciding on a list of prioritised actions for achieving objectives. Step 6: Determining the time horizon for implementing the strategic actions identified in the roadmap and attaching specific indicators to measure progress.

some specific work (always under the same project).

3 Key findings and further application of the methodology

Following the implementation of the ETF foresight process, the main key findings can be summarised as follows:

- **Process and outputs**: the foresight works in a process-oriented way, together with key national stakeholders. Cooperation between different stakeholders – involving different government organisations, social partners, civil society organisations and researchers – was not a new practice. However, it was important to acknowledge that foresight works best with a shared understanding and mind-set, that this is a change-management process which requires a regular and long-term engagement.
- **Sustainable impact**: the experience gained enhanced the adoption of a future-oriented mind-set among all stakeholders. The process does not end with the elaboration of a vision for skills; regular monitoring will ensure sustainable results and a tangible impact. The first experience with foresight can serve as a springboard for further exercises. As a management process, foresight helps develop future intelligence which can be applied for further, in-depth foresight studies (e.g. for specific sectors or organisations).
- **Ownership of the foresight process**: coordination of the stakeholders should be done by a national coordinating body (e.g. the Office of the Prime Minister or a Ministry) and person identified by the government to act as a catalyser of different national bodies and institutions. Participating government institutions, agencies, social partner representatives and NGOs are invited together with the national coordinator.
- **Tailor made approach**: the ETF foresight methodology must be adapted to the national context, while taking into high consideration other initiatives in the education and training sector. Previous experiences and – most importantly – parallel activities with similar future-oriented processes need to be considered, and the implementation needs to be discussed and agreed with high-level decision makers in order to be in line with the context and needs of the country.
- **Wide consultation with researchers, employers and NGOs**: it is important to include local experts and researchers to inform the process with national and international evidence. The voice of employers brings additional insights to the discussion, and the direct involvement of HR managers from companies in key sectors enrich the process. Also, it is desirable to include representatives of relevant interest groups (e.g. youth organisations, NGOs, civil society organisations, trade unions, private sectors' representatives, etc.).
- **The foresight process is more than a series of workshops**: foresight involves high-level decision makers and horizontal and vertical cooperation. It enhances the adoption of a future-oriented mind-set among stakeholders and provides a structure to move forward.

A key insight which emerged from the pilots was also that alternative process designs may be considered for the future, so as to get deeper foresight results.

Firstly, the qualitative foresight approach adopted should be further backed by quantitative data and robust evidence on skills anticipation. Quantitative forecasts and coherent labour market information systems need further development in most countries in the Enlargement region.

Secondly, the vision building process may involve wider groups, including larger parts of the business community and civil society. Setting priorities and elaborating the roadmap may nonetheless remain with a smaller group of decision makers and experts, in order to be efficient and achieve good results.

Last but not least, scoping the foresight question with a clear thematic focus for the process may be beneficial. Addressing "skills" as such has advantages in terms of coherence, but addressing specific economic sectors (a specific industry or sub-national region) might lead to additional, concrete and practice-relevant results.

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Case of Russian-Skills-2030 Foresight

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Abstract

This article describes a Russian case of technology-foresight-based skills anticipation. The study provides a qualitative method for assessing future skills needs within different sectors of economy, with particular reference to technology-driven industries. The method features embedded analysis of technological changes and their impact on the future skills needs within these sectors. Proposed is the algorithm for detecting change in working tasks, organizational and managerial contexts within sectors, as well as for defining requirements to specialists, based on these changes. This algorithm allows the educational system to develop training programmes for new industry-specific specialists. The methodology was applied to assess new skills in Russian hi-tech industries; for some sectors, specific requirements for changing training programmes to fit new types of specialists were elaborated (in particular, for transportation and aerospace sectors). We also applied the results of our research to the career-guidance process at school level, with two career-guidance tools developed *(Navigator through 100 jobs of the future, 30 jobs which will disappear in the next 15 years).* Apart from sectorial analysis, new skills maps were created for technology-driven sectors and, on their basis, universal requirements to training content and formats were developed.

Keywords:

skills foresight, technology foresight, Russian Skills-2030, Rapid Foresight method

1 Introduction: context for Skills-2030 Foresight

Similar to most industrialized countries, Russia is currently experiencing a growing mismatch between the demand for labour with specific skills and competencies, and the training and education provided by the vocational and tertiary educational systems. One of the systemic causes of this process is the accelerated technological progress and introduction of new technologies and methods into various industries and economic sectors, due to intensified global competition. The cycle of technological renovation shortens even in more traditional industries (such as agriculture, natural resource extraction, or construction), from decades to years, whereas in new and emerging industries (such as ICT or biotechnology) substantial revision of technologies applied can take just few years, and in some cases as short as twelve to eighteen months.

Accordingly, when the 'normal' process of coordination between the education and training (E&T) system and labour markets takes place, involving recognition of new tasks, adoption of new E&T programmes, and subsequent preparation of new specialists, there is a risk that demand for these specialists will disappear even by the time they complete their education (and additional investment into their training will be required to close the skills gap). In vocational education in Russia, the complete cycle - from communication of new skills demand to a new specialist preparation - can take from two to three years, and in tertiary education – from four to six years. This is not to mention that educational system is often inflexible and unable to recognize new labour market needs timely, so the cycle gets even longer.

The inability of the tertiary education system to adopt to labour market needs has caused a tremendous mismatch: in December 2012, statistics from the Ministry of Labour of the Russian Federation highlighted that only 43 per cent of new specialists in the formal sector of the Russian economy find jobs in accordance with their qualification, whereas in the informal sector the gap is even higher, with only 24 per cent working in accordance with their qualifications.

One of the ways to cope with this challenge is to reorganize the cycle through replacement of demand recognition with demand anticipation (Figure 1). This allows to align industry technological development with human capital development, and to prepare specialists for industry challenges that may unfold in the future. Also, since communication is established between employers and educational institutions through the foresight process, this allows them to synchronize even better for the existing labour demand.

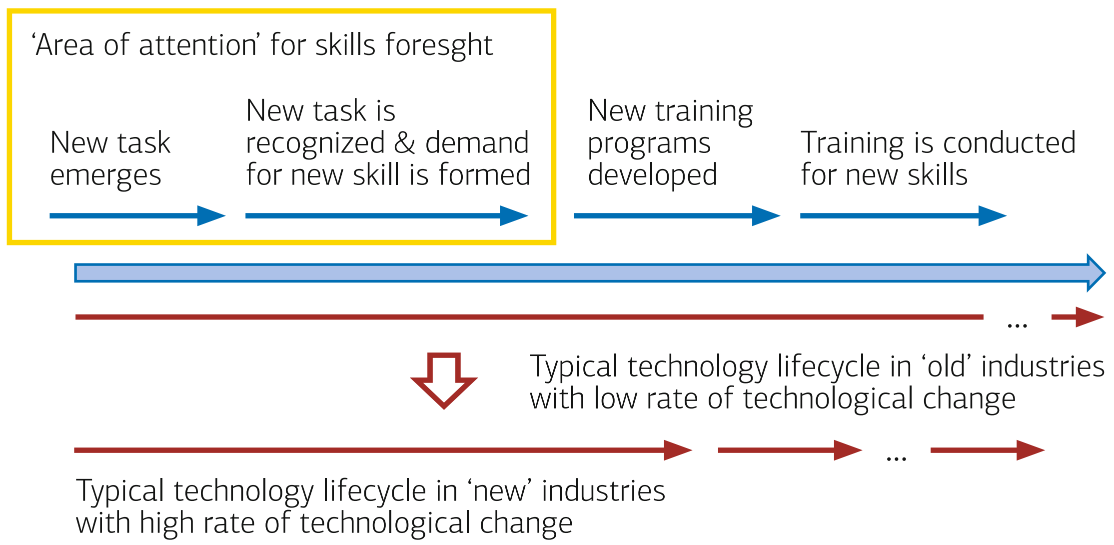
The Skills-2030 Foresight in Russia was launched in 2011 by two government structures:

a. The Ministry of Education and Science of the Russian Federation launched the study of demand for new skills and competencies in hi-technology industries as a part of its Third Science-and-Technology Foresight of the Russian Federation.
b. The Strategic Initiatives Agency for the President of Russian Federation has launched the Competence-2030 Foresight as a part of its initiative to create National System of Qualifications and Competencies. This is a comprehensive project coordinated through the roadmap which involves activities of the Ministry of Economic Development, Ministry of Labour, Ministry of Education and Science, Ministry of Telecommunication and Mass Media, and others.

The team at Moscow School of Management SKOLKOVO has been responsible for the execution of both projects. The scope of project for the Ministry of Education and Science involved key hi-tech sectors, including biotechnology (including agriculture and food industry applications), healthcare, ground transportation systems, aerospace, energy generation and transmission, information and telecommunication, extraction and processing of mineral resources, environmental protection and waste management. Additional sectors for the Strategic Initiatives Agency project involved construction, finance, education, government and public services.

The current context of the Skills-2030 Foresight project is set by the growing pressure to revise industrial policies in Russia. Sectors that have been primary drivers of economic growth through 2000s (oil and gas, steel and mining, and the defense industry) are now stagnating. Technologies in infrastructural sectors (transportation, energy etc.) are obsolete, and substantial investments into modernization will be required through 2010s. The government also considers the possibility of using some of Russia's competitive advantages, such as relatively high quality of its technology and engineering education, for creating new economic growth drivers such as the info/telecommunication sector, or the aerospace sector.

Figure 1: Growing mismatch between training and new skills demand due to increased rate of technological change



Accordingly, four key factors establishing the need for the Skills Foresight in Russia are:

- changing technologies, processes and managerial approaches in economy resulting from technological progress and social innovations;
- increasing global competition for consumer markets and skilled labour;
- government efforts to modernize industries and launch the new 'knowledge economy';
- declining quality of Russian system of tertiary and vocational education and training system, and its lack of ability to cope with international standards.

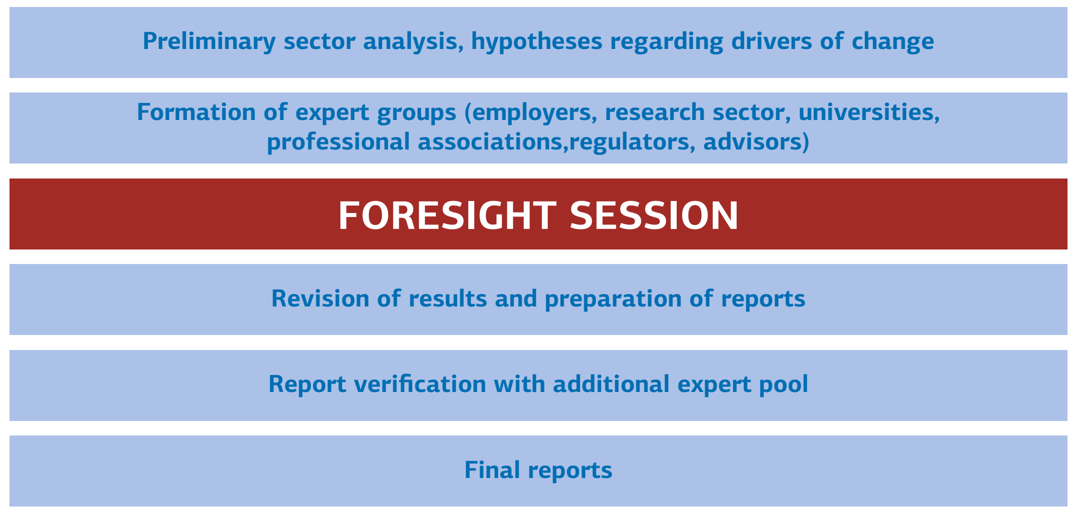
2 Skills-2030 Foresight process

The Skills-2030 Foresight was conducted for sectors where technology is the primary driver of change in skills demand (hi-tech and technology-dependent industries). The main focus of the foresight was, accordingly, to assess how key trends and new technologies change the nature of working tasks, thus shifting the demand for existing and new skills.

The study of the demand for competencies consisted of the following stages (Figure 2):

a. General economic analysis: definition of global and country challenges of the future. This phase was conducted through systematizing key international studies on megatrends and challenges of the future, as well as through a cycle of interviews with leading economists, analysts, and industry experts in Russia.
b. Industry analysis: systematization of Russian and international industry forecasts of scientific, technological and economic development. This stage allowed to determine the technological and social factors driving industrial change.
c. Formation of expert groups. Relevant experts include: representatives of large, small and medium enterprises in the sector (i.e. employers), representatives of research institutions and universities,

Figure 2: Key steps of Skills Foresight study



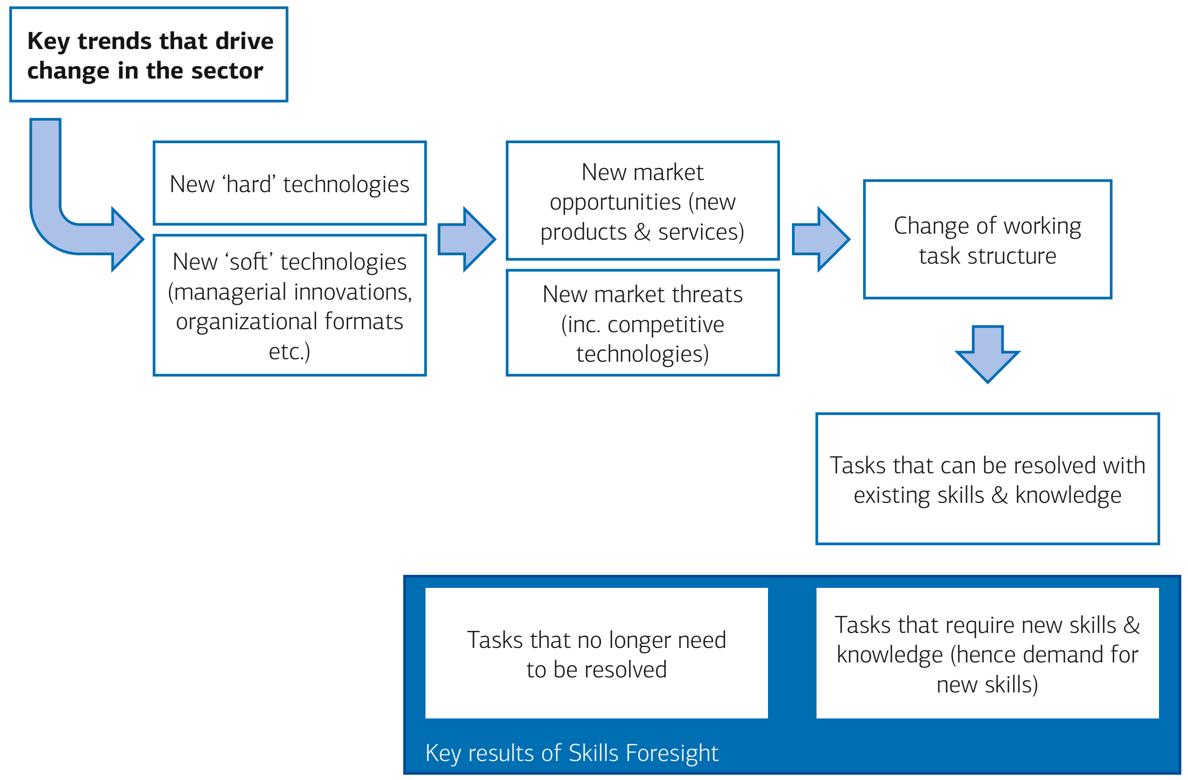
representatives of professional associations, regulators and professional advisors working with the sector. Employer organizations were expected to be listed in industry rankings (including SMEs that were listed in 'most innovative' ranking or were supported by leading Russian development agencies) and were expected to be involved in collaboration with universities on development of new educational programmes. It has also been found productive that between one-third to one-fourth of participants are industry 'outsiders': suppliers, product users, students in industry-related programmes, etc.

d. Foresight session (see below for details).
e. Post-session verifications of reports through round tables and questionnaires.

In the core of this study were foresight sessions focusing on the collaborative design of the industry's 'map of the future' through structured discussion involving the steps indicated below (Figure 3):

a. Analysis of key trends which drive change in the sector, and discussion of new 'hard' technologies (i.e. new equipment, production processes etc.) and 'soft' technologies (i.e. new managerial methods, new organizational formats etc.) resulting from the trends. These 'factors of the future' were analyzed across three time horizons: short-term (next three years: 2012 to 2015), mid-term (the following five years: 2015 to 2020), long-term (the following decade: 2020 to 2030). Around 12 to 15 key trends and soft technologies, and around

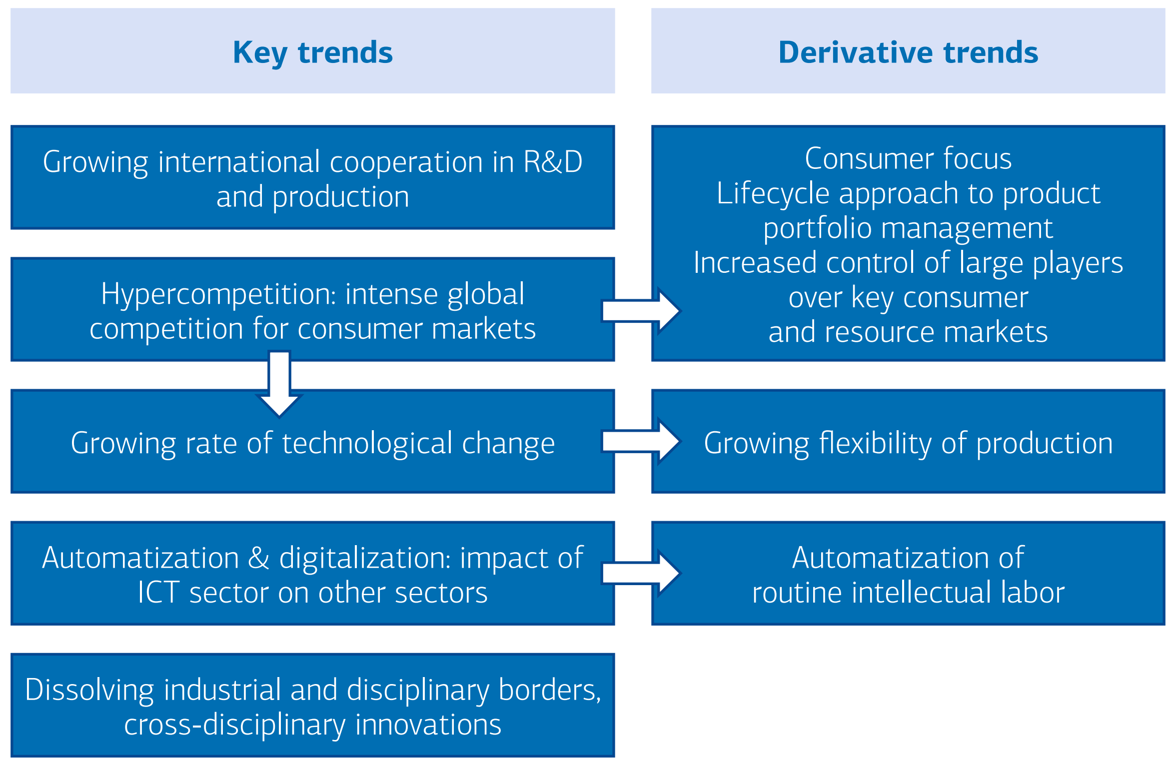
Figure 3: General methodology of foresight sessions



15 to 20 new 'hard' technologies were identified during this discussion.

b. Analysis of new market opportunities (products and services) and threats caused by trends and new technologies. Identification of changes in working tasks due to evolving industry technologies, new opportunities and new threats the industry has to deal with.
c. Identification of working tasks which: (a) are similar to existing working tasks (capable of being resolved with existing skills and knowledge), (b) become obsolete due to technology change and industry context, and (c) emerge due to changing industry context. Working tasks were identified for intellectual and manual labour.
d. For new tasks which cannot be resolved with existing skills and knowledge, new core competencies were identified (some were described through samples of best practices which may exist in other countries or in other industries, and some were described through requirements for new knowledge and skills). Between 8 and 12 new competencies related to technological change were identified in every industry. Also, between 3 and 8 competencies in every industry were either cross-sectorial ones or meta-competencies, which allowed for some of the study generalizations (see below).
e. Accomplished during verification sessions was the following: participants also evaluated whether competencies will be

Figure 4: Key factors changing working tasks in all technology-driven sectors of Russian economy



widespread (i.e. the majority of industry workers are supposed to master them) or narrow (i.e. only few specialists will be required), and how such competencies can be formed (e.g. change of educational programmes, use of simulators, on-job training etc.).

3 Results of the Skills-2030 Foresight

Apart from new competence maps for key hi-tech and technology-driven sectors (which cannot be presented here due to obvious reasons), our study has also produced two generalizations: (a) key competencies which will be required in all technology-driven sectors, and (b) key managerial competencies required in hi-tech sectors which become new drivers of economic growth.

Three factors which influence all technology-driven sectors are (Figure 4):

1. Rapidly increasing competition (sometimes dubbed 'hypercompetition'). This trend leads to increasing innovation (seen as the key competitive advantage) and hence - the higher rate of technological renovation (calling for flexible production systems), and to increased control over consumer and supplier markets (direct economic power as well as indirect influence through sophisticated marketing and supplier network management).
2. Increasing (international) cooperation in R&D and production. Despite increased competition, industry leaders also often collaborate to share investment resources, human capabilities and knowledge pool (hence the phenomenon of 'collaborative competition' dubbed 'co-coopetition'). Industrial innovation and rapid growth often occur on the borders of disciplines or industries, thus dissolving 'traditional' knowledge and production domains.
3. Digitalization / automatization: ICT penetrates all industries and domains of human activities, changing the nature of manual and intellectual labour. All routine operations, whether manual or intellectual, are gradually automatized, and workers shift from actual doing their work to programming the devices to fulfil their work. The proportion of non-routine activities (i.e. creative work, especially in teams, and related communication and management processes) increases, and relevant competencies become mandatory for workers of the future.

Key competencies of the 'worker of the future' resulting from these trends are presented in Table 1. These competencies are divided into technical competencies, competencies for working in global context, cross-professional competencies and meta-competencies.

Another generalization concerned the key skills and knowledge required for creation and development of new hi-tech sectors in Russia, such as ICT, biotechnology, 'smart grids', 'smart transportation' etc. In every industry considered, four 'competence types' have been identified, in addition to industry-specific technology specialists. These 'competence types' are combinations of key competencies required to launch and maintain knowledge-based economy, including design, production, transfer of technologies, integration of new activities, adaptation and standardization of products (see Table 2). All of these competencies require the combination of technological and managerial education, training and experience.

These competence types are required at different stages of industry lifecycle, as the industry environment moves from early growth into more mature stages. On the early stages, integrative competencies (to help launch new enterprises and create business and regulatory environment) are required, then the industry is able to work with evolutionary innovations (which involve minor and gradual product improvements), and on the later stages industry leaders are able, through their innovative ecosystems, to launch and maintain disruptive innovations (that requires the collective effort of supplier and distributor networks, often of hundreds and thousands of independent enterprises).

Summarizing these findings, our team concluded that:

a. A substantial share of new competencies in technology-driven sectors consists of cross-professional competencies or meta-competencies which go beyond the competencies demand in specific sectors. Multidisciplinarity is among the key competitive advantages of the 'worker of the future'.
b. For knowledge-based sectors, 'ecosystemic' approach is most productive: creation/preparation of teams with inter-dependent competencies allowing to invent, design, produce, market and support new products.

Table 1: Key competencies of the Russian worker of the future

Key competence areas	Key competencies
Technical skills & knowledge	Multi-disciplinary background: from T-shaped to m-shaped workers Technical + economic background
Skills & knowledge for global contexts	Foreign languages Cross-cultural competencies Knowledge of global practice domain (e.g. standards, design environments, etc.)
Cross-professional competencies	Creative collaboration (co-creation) in project teams Communication skills Working with large volumes of information
Meta-competencies	Systemic thinking 'Programmer thinking' (working with programmable environments) Rapid learning and re-learning (adaptation to various working contexts) Self-development skills Self-regulation skills

Table 2: Four 'competence types' for knowledge-based sectors of Russian economy

New skill cluster	Work tasks	Key competencies
'Integrators' (including technological entrepreneurs)	End-to-end organization of innovative production from an idea to a product on the market	Business management + technology (understanding innovative activities across the product lifecycle)
'Translators' (cross-discipline / inter-industry)	Cross-discipline / cross-industry transfer of technologies (markets for new products in mature industries)	Understanding technologies & processes at least in two industries Marketing competencies
'Adaptators'	Product adaptation to customer demands; design (incl. interface design & usability)	Requirements management Client behavior patterns Design competencies
'Standardizers'	Development of industry standards (with regulators or through self-regulation)	Management (negotiations, lobbying, promotion) + basic technology

c. Future-oriented approach to skills and knowledge demand is necessary for the development of new industries. However, only an extremely limited share of employers is ready to discuss their future needs. The key problem here is that most industries are lacking 'translators' which could help connect strategic planning, technological development and human resource preparation within the industry domain.

4 Project development

The Skills-2030 Foresight results have been communicated to the Ministry of Education and Science, the Agency of Strategic Initiatives, and a number of innovative forums, where they were highly appreciated. However, the priority of our team is to have tangible results with observable social and industrial impact – or, to take responsibility for our research results through their implementation. Therefore, the Foresight process is planned to continue to the end of 2013 and beyond. Among the key scheduled activities are:

a. 'Grounding' of key foresight findings in the context of specific industries to revise educational programmes for industry-related universities and vocational training institutions.
   - Since late 2012, this work has begun for the aerospace sector in collaboration with United Aircraft Company, the largest aircraft producer in Russia.
   - Since Spring 2013, similar work has begun with the Ministry of Transportation to reorganize the content and formats of transportation and logistics education institutions (tertiary and vocational education and training).
   - Other sectors are anticipated to follow in late 2013, including Information and Communication Technologies sector, and the Nanotechnolgy / New Materials industry.

b. Creation of the career-guidance tools (including 'Navigator through 100 jobs of the future' and '30 jobs which will disappears in the next 15 years') for wide Russian public (youth and their parents) is scheduled to be published in late Summer 2013.

c. Creation of short-term / mid-term and long-term demand-anticipation tools in collaboration with the Ministry of Labour (as a part of the roadmap for National System of Qualifications and Competencies), to be implemented in pilot regions of Russia through 2014.

Figure 5: Emergence of new 'competence types' in knowledge-based sectors of Russian economy

	2012-15	2015-20	2020-30
Key working tasks for knowledge-intense economic sectors	Integrated organization of R&D and production process for knowledge-intensive products	Working with markets to improve existing products (evolutionary innovations)	Creation & implementation of families of new products & solutions (disruptive innovations)
Key competencies	Integrators Translators Specialists to support industrial rennovation process	Adaptators Standardizers	System architects, technologists and safety experts

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Skills Technology Foresight Tool: Results of the Group Discussions

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Abstract

In the course of the Day 1 of the Global Workshop "Using technology foresights for identifying future skills needs" a range of technology foresight approaches used for skills anticipation in different countries was presented.
The Day 2 featured a discussion and a collaborative development of the generic framework of technology skills foresight by the participants of the workshop. The objective of this session was to formulate requirements for an internationally acceptable Skills Technology Foresight (STF) method, and to design a specific framework for this type of studies.
The results of the session can be divided into 4 sections:

- STF method application context
- Basic assumptions determining the STF methodology framework
- STF framework
- Implementation of the STF methodology

1 Skills Technology Foresight application context

While *skills foresight* is a group of foresight methods for skills anticipation, a qualitative identification of future skill needs of the economy, particular sector or industry, *skills technology foresight* (STF) is a new method that bridges together skills anticipation approaches and the methodology of technology foresights. It allows, therefore, to identify future skill needs in the context of technological innovation or proliferation of existing technology through modernization. The method is based around sector-based approach focused on specific sectorial practice transformation through introduction of new technologies.

The problem of identifying future skills needs is becoming more and more acute in the context of the current dynamics of the global economy. Today the speed of change is growing while the global competition in numerous sectors is further becoming tighter, with former leaders leaving and new actors joining the game.

Considering the question on the choice of sectors most suitable for skills technology foresight, it was discussed that the method should primarily focus on technology-driven industries or industries having a high potential of being changed due to the new technologies. This is due to the fact that these sectors not only become the focal points concentrating research and development, foreign direct investment, talent and cutting-edge technology. The other aspect is that technology can significantly change the employment structure in the sector, positively influencing jobs that require specialized and unique skills, while often having negative impact on jobs dominated by routine tasks. New technologies change the requirements to the workforce skills and knowledge thus leading to the growing demand for new competencies. This makes the application of the skills anticipation instruments crucial for such sectors of economy.

However, it should be noted that STF application area should not be constrained to high technology sectors. More traditional sectors, such as agriculture, can envisage significant gains in productivity due to application of modern production technologies and management methods. The main focus is, therefore, on sectors that can increase their competitiveness through technologies, either developed domestically, or transferred from international markets.

The Workshop participants agreed that the process of the sectors selection for STF implementation should focus on the following requirements:

- The sector should have **substantial impact on the country's economic growth and development** – in order to not 'crack a nut with a steam hammer'

- The sector should have **one or several significant employers** in order to provide substantial wokforce demand
- The sector should have **sufficient potential of increasing complexity through technology**. It was emphasized during the workshop that this potential can be fulfilled not only through long, expensive and requiring high-level competencies process of research and development but through technology transfer as well.

During the group work the participants took considered the context of three types of countries:

- countries with well-developed industrial sector, research and analytical services, labour market and vocational education forecasting practices (contingently, OECD-member state);
- countries with evolving management and forecasting practices characterized by a significant informal sector (emerging markets);
- countries with weak administrative infrastructure characterized by the domination of informal sector.

The type of country should be taken into consideration when applying STF. Evidently, it is a practice more suitable for developed or emerging economies, although less developed economies may also have sectors (typically, those sectors with high export potential) that may become the subject of STF.

2 Basic assumptions underlying the Skills Technology Foresight framework

In the course of the Workshop the participants discussed the questions defining the core limitations on for the STF methodology design and implementation.

2.1 Qualitative vs. quantitative approach

The participants agreed that Skills Technology Foresight method represents the qualitative approach methodology focusing on the skill needs across technical and vocational education, training and higher education, taking into account the context of different trajectories between TVET and HE and ranging from sector to multi-sector application. The main argument for using qualitative approach instead of quantitative one is the changing environment of the chosen sector causing discontinuity in the process thus making quantitative methodology hardly applicable.

2.2 Matching skills demand and supply

Skills technology foresight is based around the qualitative approach to be further translated into policy-making recommendations and, where possible, amended curriculum. This defines the approach for the STF methodology: to determine the demand for skills in the future, to recognize the existing supply of the skills and find the ways to close the gap.

On the supply side there're three levels of education and training programmes providing skills and knowledge for future or existing professionals:

- Technical & vocational education & training (TVET)
- Higher education (HE)
- Industry-based education & training: on-job training, short professional advancement courses, international internships etc.

Skills technology foresight focuses on the determining the demand for skills in near-term, mid-term and long term prospective. Comparing the existing situation with specialist training with the future skill needs, the participants of the foresight process are seeking for the answer, what the key actors, namely **the industrial sector stakeholders** (e.g. employers, trade unions etc.), **the education institutions** and **the government**, can work together to close the gap between the labour market needs and capacity of the education and training systems.

To achieve this goal the participants of the process:

- design their shared vision of the future of the sector and the professionals working in the sector or review the existing vision (e.g. government sectorial strategy)
- design or review the projects aimed at the development of the sector through skills improvement
- formulate the requirements for changes in the legislative environment if needed (e.g. the bottleneck for the technology implementation and skills improvement can be poor intellectual property legislation)

Skills anticipation foresight (focused on labour market needs) bridged with technology foresight (focused on industrial sector strategies, research & development plans, industrial policies etc.) has a high potential as an emerging policy-making tool for improving labour market policy, facilitating driving economic modernization and industrial development, producing quality long-term sectoral planning, promoting informed strategic social policy decisions and tackling emerging social problems at the early stage.

2.3 The process is as important as the content

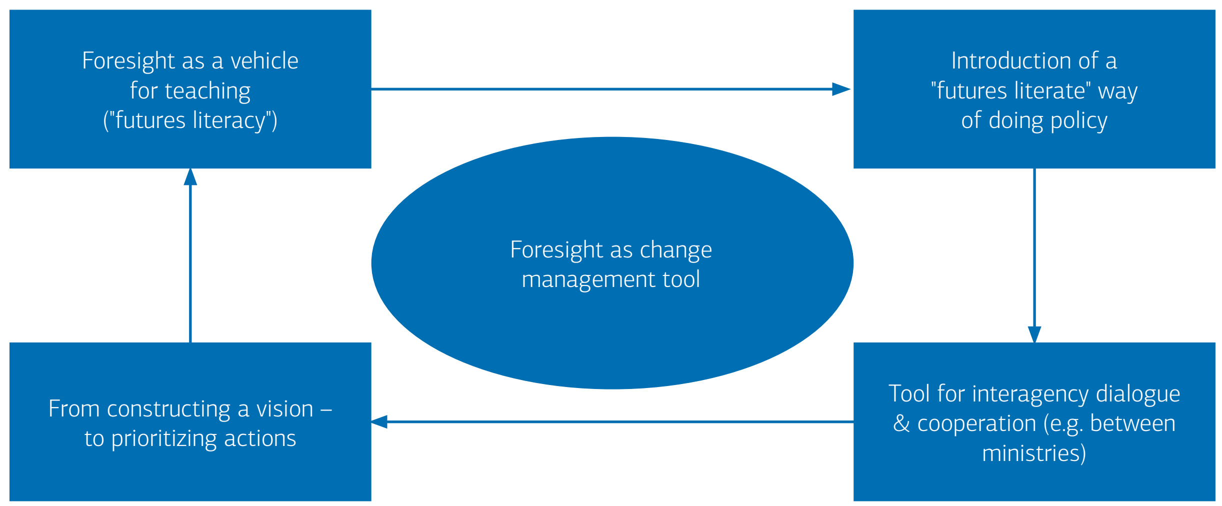
With regards to key results of skills foresight, it was emphasized during the design session that *the process of the foresight sesion is very valuable and fruitful in itself*: capacity-building as part of the result, stakeholder participation in sessions and the steering committee brings shared values, the core of which is the value of communication for the long-term strategic development agenda between policy makers, education and training institutions and the private sector.

It was noted that STF serves as a tool for change management, raising awareness of the problems and gaps in the strategic policy-making (Fig. 1). In this context, the value of dialogue was emphasized, as in response to all relevant actors need opportunities to sit at the same table translating the strategic dialogue into enhanced government-to-government, government-to-business, and government-to-citizen cooperation. Building capacity among stakeholders who do not sufficiently collaborate with each other to 'sit together and develop a vision' was considered an invaluable asset in itself.

3 Skills Technology Foresight framework

The skills technology foresight seeks to identify the future skills gap in the industry and recommend necessary changes in the curriculum

Figure 1: Foresight as change management tool



and formats of technical vocational education and training and higher education system that may help to close the gap. General framework scheme of STF developed during the Workshop is presented in the Figure 2.

3.1 Sequence of analysis

Participants of the workshop agreed that the STF process should be done through the series of sequential steps that can help derive the necessary information:

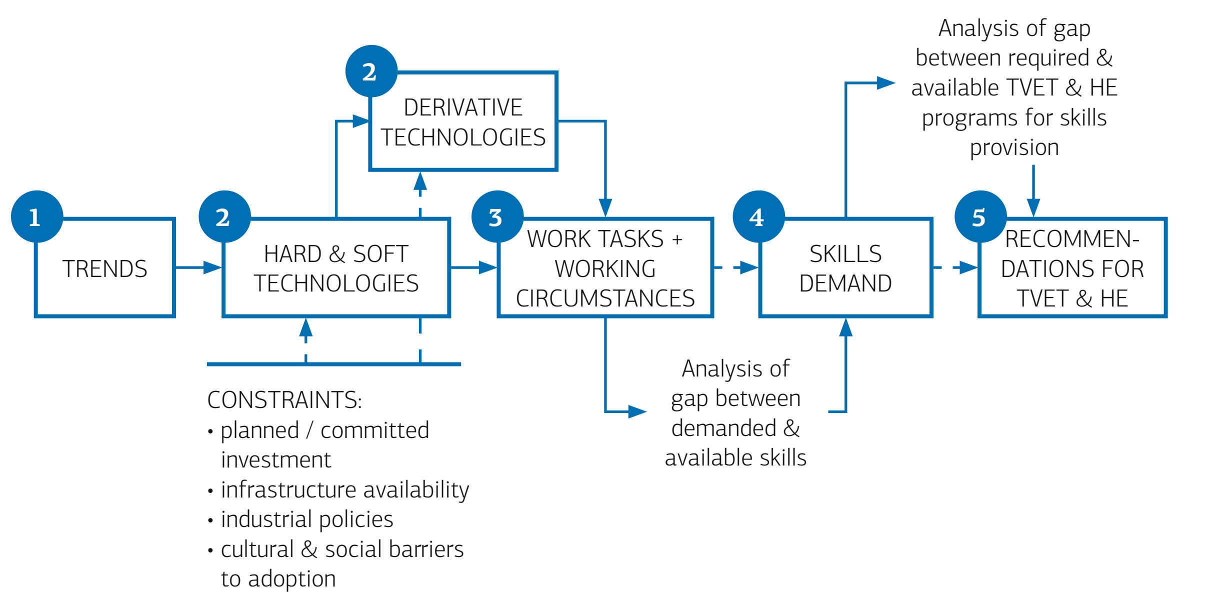
1. TRENDS: The process has to begin with the analysis of needs of consumers and stakeholders that drive the development of the industry / sector. These needs are reflected in trends that shape the industry's future that should include (though should not be limited to) the following types of processes:

- changes in the consumer demand due to changing consumer expectations and preferences (e.g. growing demand for healthy and organic food in the food processing industry);
- changes in domestic and global industrial production standards (e.g. increasing application of environment-friendly operations);
- changes in the industry resource base that may constrain the development of the industry (e.g. increasing average workforce age);
- general changes in the economy that induce new working practices (e.g. intensified application of digital technologies that leads to wide application of remote workforce).

These trends present opportunities for new market niches and threats to existing business models that dominate the industry – that will require response from the industry.

2. TECHNOLOGIES: The industry responds to opportunities and threats by adopting new hard technologies (e.g. the new equipment, or the production process, etc.) and soft technologies (e.g. the new business models, or

Figure 2: General skills technology foresight framework



the management process, etc.). The applicability of these technologies is constrained or enabled by factors such as:

- planned investment of key business players or the government into the technology development or transfer;
- availability of infrastructure that enables the technology: e.g. modern software sector requires both the reliable supply of electricity and sufficiently good telecommunication networks that allow Internet communication;
- industrial policies, e.g. environmental tax liabilities that allow adoption of alternative energy sources;
- cultural and social barriers to adoption: e.g. religious considerations can constrain the use of computers, or highly authoritarian corporate cultures can constrain the application of participatory leadership formats.

Since adoption of technologies is a response to challenges posed by trends, the response time should be taken into the account. This is an important consideration even in case of technology transfer (as technologies have to be identified, licensed, installed and adopted through the industry learning), but even more so in case of technological innovation – the time lapse between research, prototype development, product development, early adoption and mass-scale application can be significant. The technology-driven demand for skills becomes evident (and requires the provision of new education and training) only when new technologies become widespread (e.g. when they are applied by at least 10-20% of industry enterprises).

It should also be noted that adoption of specific technologies in the sector may require the adoption of derivative or complimentary technologies in related sectors (e.g. technologies of suppliers or infrastructure providers). For instance, adoption of tractors and other heavy agricultural equipment requires servicing and fueling stations (i.e. the response from complimentary sectors that enable the application of a technology).

3. WORK TASKS AND CONDITIONS: Based on the list of technologies that industry seeks to apply, it is possible to define the list of necessary work tasks to be performed by employees. Some of these work tasks will be shaped as new occupations (e.g. wider use of domestic robotics will require workers specialized on developing or serving these robots), while the majority of these tasks will be to the existing workforce and will redefine the scope of their responsibility (e.g. the use of genetically modified crops does not necessarily imply new occupations in the agricultural sector, but it may require existing workers to use different procedures that help grow these crops).

Apart from that, some technologies may redefine not only the individual work tasks but working environments. For instance, wider application of computers may enable electronic document turnover which will require all workers to track their operations with the use of digital equipment – and it may also enable some workforce to work remotely. Moreover, in some cases, working environments scenarios can redefine the individual work tasks: e.g. the implementation of cyberphysical production systems in developed industrialized countries can imply working environments that will lead to either simplification or to sophistication of work tasks (depending on the extent to which employees will be required to control and reprogram the self-maintained robotic production lines).

4. SKILLS DEMAND: Based on the changing work tasks and working environments, it is possible to define the skills demand in the sector. The existing skill base in the industry should be compared to the skills that are required, and following types of skills should be identified:

- new skills defined by work tasks that cannot be performed with the existing skill base (e.g. application of neural implants in medical industry requires special training of neurosurgeons and supporting specialists such as nurses);
- obsolete skills: some skills in the sector can be rendered obsolete by the application of new technologies – e.g. wide application of tractors and trucks in rural South-East Asia has made the elephant transportation (and, consequently, el-

ephant breeding) almost non-existent. Worth saying, the phasing out of obsolete technologies occurs gradually, so the time should be taken into consideration while obsolete skills are still necessary because older technologies are still applied;
- skills with changing scope of application: some technologies, either hard or soft ones, may change the scope of application of certain skills, for instance, turning them from specialized into general sectorial skills (e.g. wider application of recycling and reuse practices in the industry may require that every worker in the industry is aware of, and applies, resource-saving practices).

The skills can be identified with particular focus to:

- workers, technical personnel (e.g. engineers), management, and self-employed specialists;
- new occupations (what new types of jobs will emerge in the industry) or existing occupations (change of work tasks and skills required from existing jobs);
- large enterprises or small / medium enterprises (including companies working in the informal sector).

5. RECOMMENDATIONS: Based on the identification of skills demanded, a set of recommendations can be developed for different stakeholders that can influence the provision of these skills. The most important of these is the TVET and HE system. Recommendations can be based on the analysis of gaps between skills required by the sector and educational and training programmes performed by TVET and HE providers. Once the gaps are identified, it is possible to develop the programme of changes required in the curriculum and education format to serve the future skill needs better.

Apart from changes that can be implemented at the TVET and HE system level, some changes may be required from the policy-makers. For instance, sometimes the skills gap cannot be closed by local providers due to lack in the education and training system itself, and the government can help train education providers internationally, or otherwise encourage the international exchange of skills.

It is also possible that stakeholders from within the sector labour market (such as employers or trade unions) contribute to the skill base development. One of the most obvious ways to improve the skill base is on-job training and internship opportunities provided by the sector employers. Leading employers can also collaborate to develop training programmes for the sector. These opportunities should be addressed during the STF session – since employers are the key beneficiaries of efforts to improve the sectorial skill base, they can also actively contribute to this improvement.

3.2 Time horizons

The skills technology foresight considers changes that may happen some time into the industry future. As we discussed above, the industry requires certain time to response to changing consumer and stakeholder needs through adoption of new technologies. Apart from that, the TVET and HE system requires certain time to response to changing skill demand, even if this demand is presented immediately. For instance, taking into account the time required to revise educational programmes, and the education cycle itself, the earliest when new technological specialists can be brought into the industry from the higher education system is between three and five years. This cycle is shorter for workers trained in TVET system (but still would be at least between two and three years). Training for specific skills, however, can be introduced on shorter timespans (e.g. courses can be created even within the annual cycle if the need is pressing).

The discussion of industrial trends (and projects / plans to be implemented by key industry players), technologies that can be adopted by the industry, and changes that can be made in the TVET and HE sector to accommodate the demand for new skills, can be made across three time horizons:

- near-term (typically, between now and 2-3 years from now, but sometimes longer, depending on industry's technology life-cycle) is the horizon where things are more or less defined by processes already in use and projects already being implemented, and where only short-term improvements in technologies and training can be made;
- mid-term (typically, between 3 and 7-8 years from now) is the horizon where most industries define their strategic objectives, where noticeable changes can be made to industrial technology practices, and where TVET and HE system can adopt new education and training programmes to match future skills demand;
- long-term (typically, between 7-8 and 20 years from now) is the horizon where long-term 'vision of the sector' is formed, and where certain technologies can substantially disrupt the existing industry's practices. While this horizon is too far for the TVET and HE system to be taken into consideration for specific education and training programmes, it can be used to identify the 'direction for transformation' (e.g. if the sector expects to actively use the digital technologies or robotics in the long-term, respective training for engineers can be embedded into educational programmes).

Table 1 lists content requirements for these three horizons in more detail.

3.3 Expertise for Skills Technology Foresight

The variety of expertise required to complete each step is described below in the Table 2. These types of expertise can be accessed through various methods such as desk research, interviews, DELPHI inquires, expert panels, etc. It can be recommended, however, that some of these methods employ collective face-to-face work in mixed expert groups: although different types of expertise are required at each step, it is highly advisable that all experts participate in all stages of the foresight to establish collective understanding of results and build a continuous dialogue on themes touched in the foresight.

4 Implementation of the STF methodology

The participants of the design session emphasized that the generic framework in no way assumes the one-size-fits-all approach, and it is a general guideline rather than a fixed standard.

Although the foresight session is the core step of the STF, in order to reach full-scale re-

Table 1: Time horizons of STF and different focuses of analysis

Horizon	Near-term (approx. 2-3 yrs)	Mid-term (approx. next 3-5 yrs)	Long-term (approx. next 7-10 yrs)
Industrial planning focus	Projects and plans that are currently being executed	Strategic objectives set by industry's businesses	Long-term vision of the industry
Technological focus	Short term technology improvements (technologies entering the market through innovation or transfer)	Technologies that allow substantial gains in productivity / competitiveness (currently developed or potentially transferred)	Disruptive technologies (currently researched) that can potentially change industry's technological base
Focus of TVET and HE changes	On-job training, short professional advancement courses, minor changes in TVET programmes	Main potential for improvement through changes in curriculum of HE and TVET programmes	'Direction for transformation': curriculum elements that can sustain in longer term

sults for the skills anticipation using STF methodology there are three major blocks of the process:

- pre-session activities
- foresight session
- post-session activities

4.1 Pre-session activities

The participants of the workshop agreed that pre-session activities is a very important stage for the whole success of the STF implementation, thus special attention should be paid to it. The pre-session activity should be focused on three blocks:

- determination of the key sponsor
- desk research
- identification of experts

4.1.1 Determination of the key sponsor

The first and the most important question which arises before the foresight session is determination of the key sponsor of the project inside the country / region. Serving as initiators of foresight activities, government, industry-level councils or employer unions need to play a key role as the agents of change. It was also noted that commitment to implementation of foresight results may be stronger when driven by private sector; at the same time, the sustainable approach is that foresight needs to be demanded from within the country / region rather than induced from the outside institution.

The key sponsor of the project is responsible for defining the scope of the project, the sector (or sectors) selection, etc. It is also responsible for embedding the foresight activities in agenda (e.g., national development plans 2020/2030 and beyond), showing how foresight fits into a broader framework.

4.1.2 Desk research

The desk research firstly is aimed at describing the context and the prospects of the sector, such as the sectorial size and dynamics, description of key sector players etc. The second focus of the desk research is the horizon scanning for future skills features scanning global technology trends (through country applicability, technology gap, technology development checks – whether global technologies can be applied to the sector).

4.1.3 Identification of expert groups

In order to reach productive discussion special attention should be paid to the participants of the foresight group. Special attention should be paid to the selection of the participants of the foresight group. The ideal list of participants should look as representatives from the following entities:

- representatives of leading employers of the industry
- small innovative businesses (start-ups or the like)
- employers' organizations and trade unions
- education sector representatives
- human resources management and skills experts
- representatives of leading sectorial suppliers and other related industries
- research & development institutions, analytical companies, business strategy consultants
- prospective labour market participants, e.g. students

The recommended group can have 15-30 people with the following tentative composition:

- Industry representatives – 40-50%
- Industry development experts (including representatives of the related industries and suppliers) – 20-30%
- Education experts – 20-30%
- Other participants – 10-20%

4.1.4 Foresight session

Foresight session being the core of the STF methodology is divided into three stages:

- technology foresight aimed at the constructing of the vision of the future of the industry and the professionals working in it or reviewing the existing vision
- skills anticipation based on the technology foresight
- recommendations to the education system, policy makers and labour market stakeholders aiming to close the gaps between skills demand and supply

The design of session should be generally based on the framework described above.

4.1.5 Post-foresight activities

Although it was mentioned above that the process of the foresight session is a significant product itself, in order to implement the results following steps are recognized by the workshop participants as important:

Verification of results

In order to be sure in the quality of the results of the foresight session, the thorough verification of the results is needed. This verification can be made using:

- additional panel studies with industry experts;
- questionnaire surveys based on the foresight session results;
- verification interviews with international experts.

Development of change projects

This step implies not only the creation of the piloting change projects but also their follow up and support from the STF sponsor (or other interested parties revealed during the STF process). Nevertheless this process is beyond the scope of the Skills Technology Foresight methodology.

Dissemination of the results

During the workshop the participants emphasized the significance of the dissemination stage, which is aimed to help the new policies and new approaches adoption by the general public.

Table 2: Expertise required for each step of STF

Step of the STF	Key expertise required	Key experts to provide this expertise
Trend identification	• Knowledge of domestic and global market trends and their implication for business strategies • Ability to spot trends and derive market requirements	• business owners and strategy / planning officers • marketing experts / trend watchers • business consultants • industry regulators
Hard and soft technologies required	• Knowledge of existing and potentially available hard technologies in domestic and global markets • Knowledge of best domestic and global managerial practices • Ability to derive technological requirements from market requirements	• strategy / planning officers • technology and production officers • R&D specialists • international equipment suppliers • business consultants and technology transfer experts
Working tasks / working conditions	• Knowledge of existing workforce structure and specific tasks assigned to various jobs in the industry • Ability to derive workforce requirements from technologies applied	• HR officers • strategy and production officers • trade union representatives • business consultants
Skill demand	• Knowledge of existing skill structure of various jobs in the industry • Ability to derive skill requirements from working tasks assigned	• HR officers • education specialists (TVET and HE) • business consultants
Demand for change of TVET and HE practices	• Knowledge of existing curriculum and formats of education in industry's TVET and HE system • Ability to derive curriculum change requirements from skills required	• HR officers • education specialists (TVET and HE): methodology and planning

5 Conclusion

Technology foresight-based skills anticipation has a high potential as an emerging policy-making tool for improving labour market policy, facilitating driving economic modernization and industrial development, producing quality long-term sectoral planning, promoting informed strategic social policy decisions and tackling emerging social problems at the early stage.

STF is a relatively new interdisciplinary approach at the confluence of technology foresight and skills anticipation studies. The method represents a change management tool, being a vehicle for teaching (futures literacy building) and government-to-government, government-to-business and government-to-citizen cooperation and professional communication.

The requirements suggested form the basis for a skills technology foresight that is created within the framework of the Moscow School of Management SKOLKOVO and the ILO collaboration, and will be further piloted in several developing countries.

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SKOLKOVO Education Development Centre

The SKOLKOVO Education Development Centre (SEDeC), headed by Denis Konanchuk, was founded in May 2011.

Activity Areas:

- studies in the area of university development and upgrading higher education systems;
- developing personnel provision concepts for corporations and industries, creating conditions for effective interaction between the labour market and the professional education systems;
- consulting and training management teams, implementing the strategies of educational institution development in Russia and abroad.

Our goal is to develop new approaches and to propagate new education management practices employed in Russia and abroad.

Research Philosophy:

- practice-oriented approach: expert appraisal and solution of topical problems faced by corporate and government structures;
- public discussions of issues related to changes in the content and technologies of education and their impact on modern society;
- use of the leading international experience in the area of education development and its adjustment to the Russian environment.

The Centre's employees have prepared development programmes for the largest Russian universities (the Ural Federal University named after the first President of Russia B.N. Yeltsin, the Northern (Arctic) Federal University named after M.V. Lomonosov, the Russian International Olympic University), series of strategic sessions and integrated educational programmes have been offered for the leaders and the talent pool of the Russian universities.

Currently, the SKOLKOVO Education Development Centre is implementing the Programme for Preparing University Rectors, in which over 110 leaders of Russian universities from 50 Russian regions are taking part. The programme is being implemented at the request of the RF Ministry of Education and is unprecedented in its scope.

In addition, in partnership with the International Labour Organisation, the Interaction between the Labour Markets and the Professional Education Systems Project is being implemented in Russia and in five developing countries. The project results have been presented at the 2013 G20 Summit.

SKOLKOVO
Moscow School of Management

Established in 2006, the **Moscow School of Management SKOLKOVO** is the largest private business school in Russia. SKOLKOVO trains business leaders to apply their professional skills in dynamically developing markets, training leaders who will set up and run their own businesses and lead the development of the Russian economy. SKOLKOVO offers a range of academic programmes, including Executive MBA, corporate executive education programmes, the SKOLKOVO Startup Academy for young entrepreneurs, and the SKOLKOVO Practicum.

The SKOLKOVO community brings together those who believe that an entrepreneurial approach and proactive attitude are the key to the successful development of the Russian and global economies. This includes representatives of the largest Russian and foreign companies, small and medium businesses, and public authorities.

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