FUTURING THE CHANGING WORLD FOR INDUSTRIAL TECHNOLOGIES

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Extended abstract

Keywords: Foresight, impact assessment, knowledge economy, industrial technologies, production systems

Introduction

The paper[1] presents the context, the method and the empirical impact assessment study for futuring industrial technologies within FTA in the knowledge economy. This study has been carried on and published by Laboratory for Emerging Production Paradigms (EPPLab) a Unit of ITIA-CNR that makes research and applies advanced methods and tools in futuring studies for decisional processes in the production systems strategic area and for RTI policy to meet effectiveness in the knowledge-based innovation. The empirical study supports with sound intelligence the implementation of the High level EU strategy to respond to the "*grand challenges*. The European paradigm High Added Value (HAV) in industrial research is emerging in the EU political agenda, linked - in the global economy scale - to the global Competitive Sustainable Development (CSD) paradigm discussed by learned societies at world level. This response needs advancements of the conventional foresight studies from a linear to a complex approach. The method " futuring cycle" plays the role of "support service on ground" to the goal of EU leadership. The four complementary components of the "rolling programme" are Foresight, Roadmapping, Implementation and Monitoring (FRIM). They form the FRIM futuring cycle that has the scope to ensure effectiveness, efficiency and consistency of R&D for 'production systems' emerging response paradigms. This paper reports about the results of the empirical autonomous impact assessment study already carried on at European level within the roadmapping activity in the EU Support Action Leadership project. This study outlines the traceability of the sectors' demand through an innovative futuring analysis of the transectoral technologies expected impact on 25 manufacturing sectors. Therefore it represents a management tool for prioritization for future intervention, planning and coordinating the multi-annual policy proposals programmes. It is a support available to stakeholders, especially Public Administrations, research institutions, associations and industries.

Methodology

The empirical study on the expected impact of transectoral technologies on manufacturing sectors applies the demand-driven approach to relate the 49 RTD macro areas (Offer) with the 147 industrial innovation targets (Demand) - resulting from the surveys of Key Opinion Leaders of 25 manufacturing sectors. This analysis links the Foresight component with the Roadmaps development process. The resulting initial impact assessment matrix provides a twofold view - RTD macro-area level (focusing the technological driver of change) and at sector level (focusing

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[1] Dr. Paci is the main author and wrote all paragraphs. Eng. Chiacchio wrote paragraphs about the operative method, that refers to her doctoral study in Economic and Management Engineering.

the competition driver of change): The matrix shows direct – time horizon - and indirect – traceability - elements. The operative method – applied to the Leadership information base – is composed by three logical steps: Extraction – for sectoral *roadmap targets*; Catching – for sectoral target content and time horizon; Relationship – for the link between Sectors and RTD areas. The initial impact matrix is the aggregate view, with time horizon, that shows the multi-sectoral perspective of the RTD macro-areas and the multi-technological perspective of sectors.

Results and policy impact/implications

This study provides relevant elements for prioritization of RTD areas. The initial impact assessment matrix allows to prioritize the 49 most relevant macro areas for 25 manufacturing sectors and to provide 100 top topics to the EC for FP7 in the Activity 4.3 "New Production". It supports the direct involvement of stakeholders on planning and coordinating future actions in terms of R&D programmes and funded projects.

Conclusions

Time horizon and traceability of industry needs represent strategic elements for future industrial technologies and for horizontal issues. The applied method ensures the value upstream of knowledge through assessment of existing competences and skills, fragmented now in multiple stakeholders. Therefore in the Knowledge economy, a rolling process permits to research and industry stakeholders to operate more effectively and to proceed faster towards the common goal. This paper contributes to the further development of conventional foresight that should move from a linear to a complex approach to respond to the increasingly complex, interdependent and uncertain realms of today's business and policy strategy.

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Paper

1 Summary

The paper[2] presents the context, the method and the empirical study on impact assessment for futuring industrial technologies in the knowledge economy within FTA – carried on and published by Laboratory for Emerging Production Paradigms (EPPLab) a Unit of ITIA-CNR that makes research and applies advanced methods and tools in futuring studies for decisional processes in the production systems strategic area and for RTI policy to meet effectiveness in the knowledge-based innovation. In this new scenario FTA in research and innovation is the emerging relevant process to support multiple stakeholders – researchers and industrialists – including the European Commission. The results support with sound intelligence the implementation programmes of the High level strategy towards year 2020 for the EU responses to global challenges .

This paper is focussed on the results of the empirical autonomous study already carried on at European level within the roadmapping activity in the Leadership project on impact assessment analysis. This is an impact assessment study that integrates FTA and supports the stakeholders, especially public institutions, on planning priorities and coordinating the multi-annual policy proposals programmes identifying the "Time horizon" as the main perspective. The study applies FTA in the context of the FRIM rolling programme.

This objective of the study - that refers and applies the demand-offer methodology shared in the European Leadership context and is based on the Leadership knowledge base – is the expected impact of 49 transectoral technologies on 25 manufacturing sectors. It enables to relate the Foresight component – that describes the needed transectoral RTD macro areas – to the Roadmaps – that define the feasibility level introducing time-horizons for achieving the transectoral enabling technologies with R&D topics to meet the sectoral innovation targets.

The study output adds to this collective effort the traceability information, i.e. the result of showing the multi-sectoral perspective of the RTD macro-areas and the multi-technological perspective of sectors. This result shows for each sector the feasibility of macro areas with call topics that are expected more relevant to meet the industrial innovation demand according to short, medium and long term horizons.

This analyis applies a clustering approach by "innovation time scale" and provides elements relevant to 1) European stakeholders to be aware and immediately react with new high tech solutions to the identified needs, 2) Industries that are innovative and interested to shift from resource-intensive to the knowledge-intensive base and 3) multilevel policy bodies for the objective "Optimizing Research Programmes for ERA" for competitiveness and sustainability.

Leadership project has been the first big support action funded by RTD FP6 NMP Programme to meet the Commission need of new initiatives with results on both high technologies and horizontal policy issues. The latter are rather new both to the Industrial Technologies Directorate in DG RTD as well as to R&I Communities, Research Networks, Institutions and Platforms. They should develop the new capability to generate not only high tech projects but also anticipatory initiatives, understanding this transformation process and self-organizing.

[2] Dr. Paci is the main author and wrote all paragraphs. Eng. Chiacchio wrote paragraphs 3.1 that refers to her doctoral study in Economic and Management Engineering.

In this context, traceability represents a core feasibility element supporting all analysis for future-oriented technologies and issues to assess the value upstream through availability of existing competences and innovation demand,fragmented now in multiple stakeholders, to achieve with sound policies strategic directions.

Therefore, a rolling and demand driven process permits the participation of all performers in foresight, roadmaps, implementation and monitoring initiatives to respond to the need of Sound Intelligence support, as already envisaged by CREST Multilevel Policies Report to contribute to ongoing ERA initiatives such as FORERA - Foresight for the European Research Area.

Keywords: Foresight, impact assessment, knowledge economy, industrial technologies, production systems

2 Introduction

The paper[3] presents the context, the method and the empirical study impact assessment results – carried on by EPPLab of ITIA-CNR - for futuring industrial technologies within FTA in the move ahead of ERA reality in the knowledge economy. Vision development requires cooperative efforts and continuous support to the European Union and Member States policies to achieve Europe to be a Leader Actor in the global policy and markets.

In this new scenario FTA in research and innovation is the relevant process useful in last five years to multiple stakeholders – researchers and industrialists – with support of the European Commission. It supports with sound intelligence the implementation of the High level strategy for the EU responses to global challenges [1].

The importance of response paradigms as core element for change within High level strategy in industrial research is reported in the literature. The response paradigm represents a tool to describe a pattern of conduct that supports actions towards directions. The application of the paradigm needs additional insight analysis of different dimensions of the conduct in relation with the drivers of change. Today the traditional economic and technological factors of change are extended to social and environmental drivers. These drivers in the k-economy are inter-linked with production and manufacturing systems determining the innovation complexity that requires new efforts.

To respond to the "*grand challenges*" in industrial research, the High Added Value (HVA) is the emerging European paradigm bringing forward the European leadership in next generation technologies within industry research cooperation. Looking in the global economy scale, where competition and sustainability are the key perspectives to be harmonized, the HAV EU paradigm is linked to the global Competitive Sustainable Development (CSD) paradigm which is under discussion for interventions at global and national level [2].

These efforts can be synthesised in the concept of Strategic Intelligence (SI) which must be implemented to support HAV K-based innovation of products/services, processes and business models and CSD industrial policies for sustainable growth [3].

Foresight and Roadmapping, Implementation and Monitoring play the role of "support service on ground" to the aim of leadership towards the "common vision" to respond to concrete challenges ahead. These activities make the Futuring cycle components of the "rolling programme".

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3 Dr. Paci is the main author and wrote paragraphs 1, 2, 3, 4, 5. Eng. Chiacchio wrote paragraphs 3.1 within her doctoral study in Economic and Management Engineering.

The concept of the “rolling programme” encompasses the four Futuring activities, which are innovative from the conventional sequential ones and life-cycle oriented. The new Futuring activities, explained below, integrate impact assessment analysis and methods and tools of knowledge management for innovation [4] [5]. These Futuring cycle components have the scope to ensure effectiveness, efficiency and consistency to futuring-oriented technologies of production systems paradigms [6]:

- *Foresight* (F) enables decision making initial and continuous updating about demand driven technologies related to top down knowledge based R&D policies supporting it with early attractiveness and feasibility analysis [7].
- *Roadmapping* (R) moves towards an open process [8] and enables initial and continuous screening and planning of the future work supporting the advanced feasibility of next generation technologies’ development with traceability of industrial expected impacts by time horizons, needed for policy RTD prioritization [9].
- *Implementation* (I) builds consistent objectives for stakeholders interventions and plans priorities to minimizing threats, maximizing opportunities and reducing risks for new HAV products/services, processes and business models. This is supported by the analysis on ground of best practices and pilot projects [10]. This activity enables to develop also horizontal policy issues such as “new education” [11].
- *Monitoring* (M) enables the assessment and evaluation of the innovation process towards new markets based on future-oriented technologies. This activity is related to market knowledge capture and supports costs and especially value benefits analysis of options choice in strategic fields of industrial interests in terms of sustainability [12].

In this approach, the Futuring cycle components - that structure the FRIM cycle - makes a continuous process for the preparation of actions and provides impact assessment analysis for research-based innovation through early estimation of impacts. FRIM cycle recalls the strategic concept of the “unique loop” [13] integrating the industrial economy approach with the K-economy approach. The new approach enables to interlink - as reported in the Figure 1 - the different logical steps and phases – providing information for the preparation of policy actions.

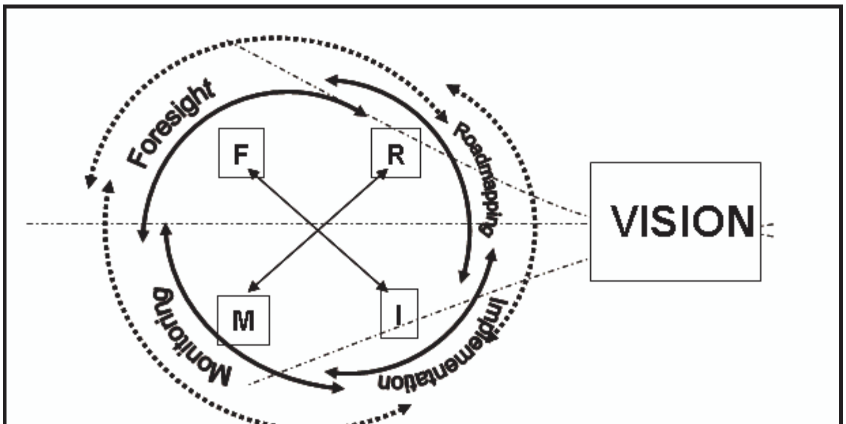

Figure 1: Rolling programme of the Futuring components making the FRIM cycle

The goal of the "rolling programme" for futuring the changing world for industrial technologies, is to track and make the end-to end visibility of the advancements towards turning knowledge into innovation according to the evolution of production systems' paradigms. The development of this process is depicted in the Figure 2.

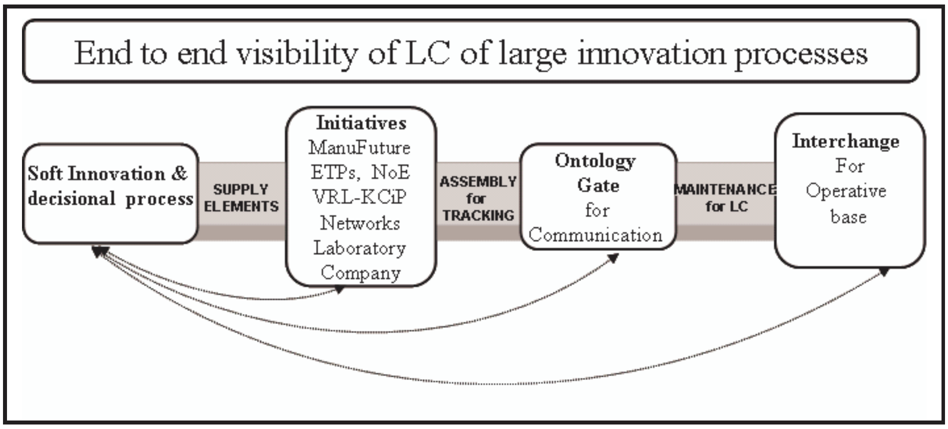

Figure 2: End-to-end futuring process

Among the four FRIM components described above and depicted in Figure 1, this paper is focussed on the results of the empirical study already carried on at European level within the roadmapping activity in the Leadership project [14]. This empirical study is an autonomous report that supports with impact assessment the futuring-oriented technologies described in previous Foresight and Roadmapping initiatives:

1. Foresight manufacturing visions, foresight studies and particularly the Strategic Research Agenda for research based manufacturing with the reference model with the Pillars of the R&D transformation [1].
2. The transectoral Roadmaps for Industrial Technologies that provided the initial screening of transectoral enabling technologies related to the three R&D Pillars - New Business Models, Advanced Industrial Engineering and Emergent technologies - plus the ICT for engineering roadmap. The six transectoral technologies roadmaps provide the policy makers and stakeholders a key tool for planning and coordinating policy actions [15].

In this important collective initiative for European industrial technologies, the empirical study has provided a sound traceability analysis of variables that allows to early estimate the transectoral technologies expected impact on 25 manufacturing sectors. This future-oriented technologies analysis – establishing the link between F and R - is built on the large Leadership project information-base constituted of technology fact sheets, surveys with industry questionnaire, consultation and validation meetings that form the knowledge and project management of the Leadership Support Action.

In the empirical study this large information–base has been processed to become a knowledge-base to meet the objective of the future-oriented technologies impact assessment. To this data collection a clustering approach has been applied. The dimension "Time horizon" has been identified as the main variable for supporting the need of planning and coordinating the multi-annual policy proposals programmes. The empirical study outputs, with its aggregate views per macro-areas and per sector, enable the feasibility assessment for planning and coordination of further policy proposals and work.

In this future-oriented context, the Leadership project has been the first big support action funded by RTD FP6 NMP Programme to develop transectoral technologies roadmaps and implementation plans to support the ManuFuture Initiative and the Commission Industrial Technologies Directorate in DG RTD's programmes to meet the EU strategic R&D policies [16] towards HVA paradigm. European Foresight projects previously funded have been Manvis e Futman [17] [18].

The Leadership project requested high-level coordination with Communities, Research Networks, Institutions and Platforms in industrial research. In the way to the European Research Area (ERA) these new organizations are called to develop the new capability to generate not only high tech projects but also anticipatory initiatives, with early understanding and adaptation to this ongoing transformation process and self-organizing their R&TI activities [19].

3 The methodology

The empirical study for expected future-oriented technologies impact assessment aims to establish spatial-temporal relations to connect Foresight studies and Roadmaps for the development of new transectoral enabling technologies to innovate industrial products, processes and organizations. The future planning focusing on the time horizon for innovation, since the initial assessment of the need of this development, meets the HAV policy objectives for industrial research. The scope is planning and coordinating future actions in terms of R&D programmes, competitive calls and highly promising competitive projects. This requires the impact assessment analysis of priority transectoral R&D areas focussing the time-horizon of the sectors'demand for push and pull transectoral technologies. Therefore, the time-horizon is the critical dimension that represents the time-to-market demand development for k-based innovation, validated across multiple sectors.

The impact assessment futuring analysis - that is reported in this paper and has been applied to the Roadmapping activity of the Leadership SSA Project – provides the likely impacts of the future-oriented transectoral technologies. It accompanies the process of policy actions development and support policy makers, industries, researchers and other stakeholders with time horizon and traceability. The analysis of key technologies supports prioritization in the short, medium and long term to lead to a new k-based manufacturing industry.

The Leadership project followed the "demand-driven" approach that introduces the stable relationship between the research and Innovation by clustering the offer of research themes (O), coming from scientific and technological competencies, and the demand of solutions (D), coming from industries, in the new "science to market" relation [20]. This project provides the knowledge base to carry on the impact assessment FTA analysis. The Leadership information base, which is referred to the 2007-2015 time-span, is constituted by:

- 25 manufacturing sectors with related Sectoral roadmaps produced in the Roadmapping activity;
- 147 industrial targets produced in the Roadmapping activity;
- 49 RTD macro areas grouped in 6 RTD pillars screened in the Foresight activity;
- 491 technology fact sheets produced in the Foresight activity and screened in the Roadmapping activity.

The empirical study, based on Leadership data collection, applies the demand-driven methodology to analyze the RTD macro areas descriptions (O) - related to foresighted technologies resulting from the roadmapping screening of 491 fact sheets - and the 147 industrial innovation targets - resulting from the surveys of Key Opinion Leaders of 25 manufacturing sectors.

The study delivered effective, efficient outputs – synthesized in the report in Initial Impact Assessment Matrix - on expected impact of future transectoral technologies on multiple manufacturing sectors. This FTA - consistent with the FRIM rolling programme - enables to relate the Foresight component – that produced RTD macro areas – with the Roadmaps (R) development process. It analyses the impacts linking the offer of research themes and the industry demand of innovative solutions. This linking between Foresight and Roadmapping activities looks towards the full Futuring cycle for innovation – from Foresight to Monitoring (Figure 3).

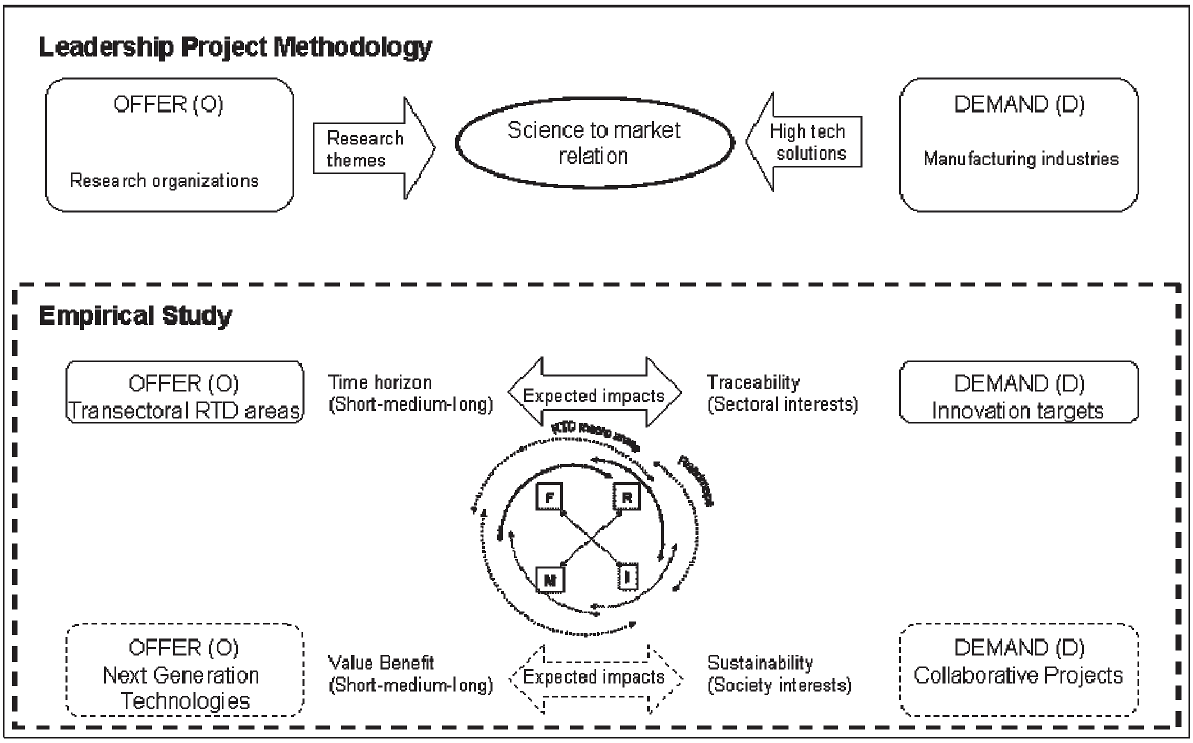

Figure 3: Applied methodology **(EPPLab elaboration from Demand-offer methodology [21])**

The O/D method has been supported with knowledge management techniques - due to the large innovation process that is related to the HAV paradigm - in the European context and has enabled to identify - for each of 25 manufacturing sectors - the screened macro areas relevant to meet the industrial innovation targets within the short (2007-2009), medium (2010-2012) and long (2013-2015) term horizon.

This impact analysis adds essential details to the R&D transectoral macro area with related topics, allowing to assess and trace early industry innovation expectations through :

1. the time- horizon distribution of the demand considering the technological driver of change

2. the sectors' demand of future-oriented technologies considering the competition driver of change.

The impact analysis clustered the information within the two-dimension, Market & Growth and Innovation [14] of the Innovation time scales matrix. These two dimensions aim to the objectives of "Lead markets" and of "HAV paradigm". Both perspectives converge into the perspective of Sustainability (the CSD paradigm).

Therefore, the empirical study reported in this paper provides a twofold view of the initial impact assessment providing direct and indirect elements – summarized in the initial impact assessment matrix - to early understand the expected impact of priority areas focussing the time-horizon and traceability:

- *At macro-area level,* focusing the technological driver of change. The aim is to understand what sectors require each macro area. The relation is: "1 macro area: n sectors".
- *At sector level*, focusing the competition driver of change. The aim is to understand what macro areas are required by each sector. The relation is: "1 sector: n macro areas".

The macro-area view focuses each one of 49 transectoral macro areas - grouped in six clusters that represent six R&D pillars [1]. An example of this view is showed in Figure 4. This FTA allows to:

- *Assess* the initial multi-sectoral impact of each of 49 foresighted transectoral macro-areas - emerging from the R&D pillars roadmap - on sectors' demand.
- *Trace* the "transectoral" feature of the macro areas raising the industrial expectations.
- *Identify* the relevance by distribution of *time horizon* of each macro-areas in relation with the industrial demand by year and in the short (2007-2009), medium (2010-2013) and long (2013-2015) term.
- *Weight* each macro-area by score (the sector demand) and identify the common (≥ 6 sectors' requests) or advanced (< 6 sectors requests) transectoral macro-areas.
- *Prioritize macro areas* according to the score (the sectors demand) and time horizon relevance.
- *Show* the multi-sectoral perspective of macro-areas.

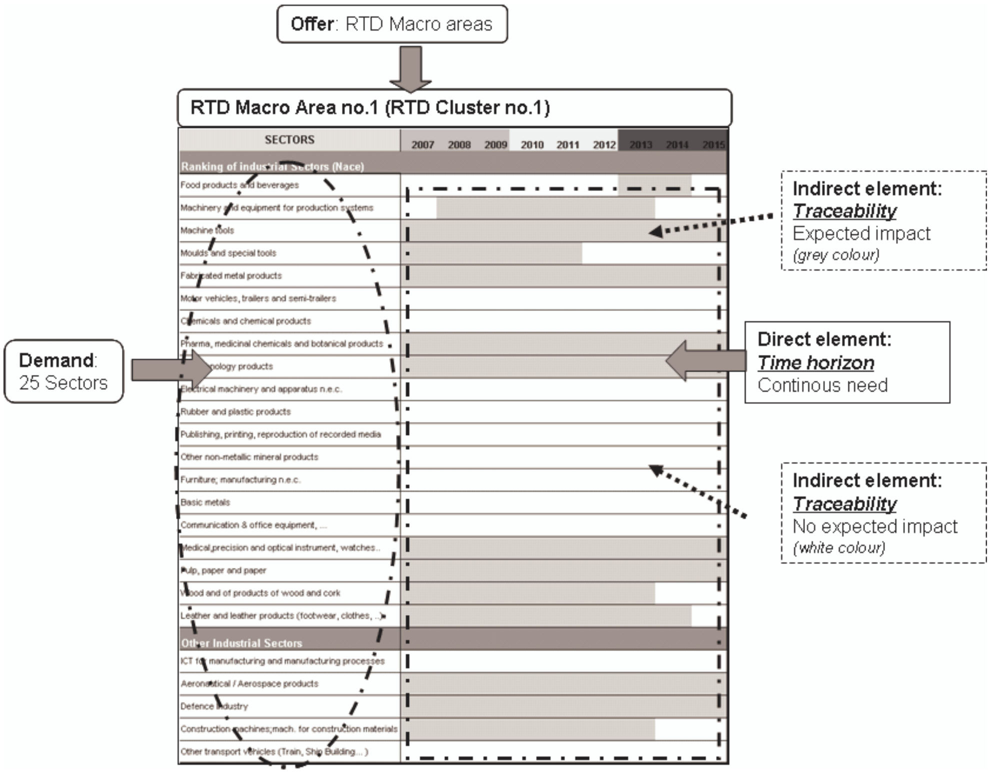

Figure 4: Impact assessment at macro area level (ex. RTI sectors'view)

The RTI sectors' view focuses the likely impacts of futuring RTD themes within each of 25 manufacturing sectors. This expectation is investigated to capture the innovation needs of each sector focusing the competition driver of change. The analysis of 147 industrial targets mapped into the 49 macro-areas aims to understand each sector expectations and to:

- *Assess* the impact characterization of transectoral technologies at sector level.
- *Identify* the distribution of *time horizon* of transectoral macro areas expected within each sector by year and in the short (2007-2009), medium (2010-2013) and long (2013-2015) term.
- *Trace the R&D pillar directions* of the sector' innovation process.
- *Prioritize the transectoral technologies* for the *R&D* innovation process of each sector.
- *Show* the multi-technological perspective of sectors' innovation.

The twofold view impact analysis, reported in the empirical study, benefit from a continuous updating of *Foresight* activity – about demand driven technologies - and *Roadmapping* activity – integrating the screening and planning of the future work with likely innovation impacts by time horizon for prioritization and traceability of available competencies and skills for future implementation plans. *Monitoring* is also a fundamental activity, ensuring effectiveness, efficiency and consistency of the rolling programme, to support policy stakeholders on planning, coordinating and *Implementing* the R&D programmes and policy proposals in multi-annual perspective.

3.1 The operative method

This empirical study refers to the field of production engineering studies[4], looking forward to k-economy in terms of efficiency, effective and consistency of industrial research in the competitiveness and sustainability perspective.

The operative method of this empirical study focuses on three variable aspects of the impact assessment analysis:

- The sectors HVA targets from year 2007 to year 2015, focusing respectively the technological and the competition driver of change.
- The demand distribution by time horizon: short (2007-2009), medium (2010-2012) and long (2013-2015) term.
- The sectors' needs of RTI macro-areas in the multi-sectoral perspective and the sectors' multi-technological perspective.

To this end, a knowledge base, built on the Leadership data collection (491 RTD macro areas - grouped in six R&D pillars' clusters – and 25 sectoral roadmaps), enables to process the analysis of multiple future-oriented enabling technologies essential for innovation achievements in the time-span 2007-2015. The impact analysis flow is described below (Figure 5).

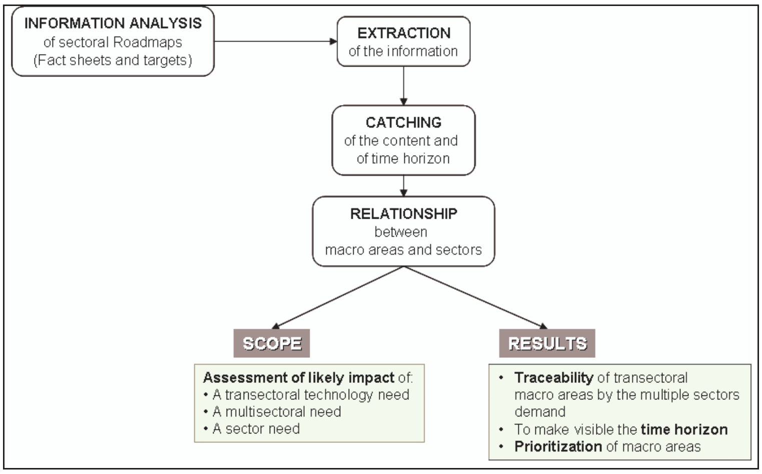

Figure 5: The impact analysis flow

The knowledge base for the impact analysis both at macro-area level and at sector level, is processed through three logical steps:

Extraction (the first step): each sectoral *roadmap* is examined and its *targets* are pointed out. The targets that are reported in the roadmaps explicit the innovation need (technological or not) of the industry. It gives a preliminary overview of R&D directions of sector innovation.

[4] These fields refer to the doctoral studies in Economic and Management Engineering of Eng. Chiacchio.

Catching (the second step): the analysis focuses on each sectoral target with in-depth analysis to catch better its technological content and its time horizon. The technological analysis looks to target content and to the linked technologies that are considered enabler for the target achievement. The target's time horizon analysis look to the year(s) (in the time span 2007-2015) in which the last enabling technologies for the target's achievement are scheduled by roadmappers.

Relationship (the third step): the relation between Sectors and RTI areas is defined. The analysis of sector target – that is carried on in the previous step – allows to connect the Sectors and RTI macro areas by technological content and to attribute the appropriate time horizon to RTI macro area according to the targets' time horizon.

At the end of these steps, a sectoral cross-reference has been built between targets and RTI Areas by time horizon:

- each macro area is linked to one or more sectors with different time horizon by Sectoral targets' analysis (macro-area view)
- each sectors is linked to one or more macro-areas with different time horizon by Sectoral targets' analysis (Sectoral view)

The impact assessment analysis of each macro areas is visible in terms of the manufacturing sectors demand. Results are given in terms of time horizon and traceability:

- The thorough analysis of the industrial targets led to evaluate and distribute *over a proper time-horizon the relevance of transectoral RTD macro areas*, framed within the six pillars' clusters.
- Taking into account the weight of the elementary cross-referencing, *each macro-area is assessed together with its importance* in terms of transectoral aspects *and is prioritized.*
- The *traceability of the technological macro area* is also demonstrated in terms of transectoral demand.

Results are also visible at sector level, scaling down the transectoral approach to industry level:

- The characterization of transectoral macro area at sector level shows the different innovation time scale in which the sector requires RTD macro areas for the R&D innovation.
- The aggregated results at R&D pillars level capture and highlight the R&D pillars' directions of the sector innovation.

The aggregated results of the analysis give the aggregate view, with time horizon, of multi-sectoral perspective of the RTD pillars and related macro-areas and multi-technological perspective of sectors, by the relationship among RTD Areas, Sectors and Time-horizon.

4 Results and policy impact/implications

The empirical study applies FTA introducing a clustering approach by "innovation time scale" to establish the spatial relation between the multiple technologies demand and the industrial innovation targets.

The result that summarize the overall findings of the analysis of the empirical study is the initial impact matrix that provides the aggregate view of the impact analysis at macro-area level, aggregated by RTD pillars, and showing (Figure 6):

- the RTD pillars prioritization (Emerging technologies pillar is the most requested by sector demand)
- the time horizon dimension, according to the short, medium and long term distribution
- the traceability from RTD pillars to RTD macro-areas and to manufacturing sectors.

Offer: RTD pillars — **Demand**: Sectors — **Time horizon**

PILLAR	# of SECTORS	# of SECTORS for TIME HORIZON		
		SHORT	MEDIUM	LONG
NEW BUSINESS MODELS	19/25	16	18	18
ADAPTIVE MANUFACTURING	22/25	19	20	19
NETWORKING IN MANUFACTURING	23/25	21	23	22
DIGITAL, K-BASED ENGINEERING	24/25	23	24	24
EMERGENT TECHNOLOGIES	25/25	24	25	25
ICT MANUFACTURING	19/25	18	19	18

Figure 6: Initial impact matrix

These results support policy makers, industries and researchers on the process of policy actions development, building priorities, providing the time horizon dimension and traceability issues.

Particularly, the Future-oriented technologies analysis allows to prioritize the 49 most relevant macro areas, grouped in six pillar cluster, for 25 manufacturing sectors and provide around 100 top topics to be selected by the European Commission for FP7 multi-annual planning in the Programme 4.3 “New Production”.

These elements relevant to policy makers:

1) European stakeholders to be aware and immediately react with new high tech solutions to the identified needs,

2) Industries that are innovative and interested to shift from resource-intensive to the knowledge-intensive base

3) Policy Bodies at multilevel for the objective “Optimizing Research Programmes for ERA“ for competitiveness and sustainability.

The exploitation of the results permits the direct involvement of industrial stakeholders on planning and coordinating future actions in terms of R&D programmes, competitive calls and high-promising funded projects, building priorities of transectoral technologies and providing topics usable for the definition of RTD areas in Research Programmes at European or national and regional level, as appropriate.

In the k-economy stakeholders are called to develop new capabilities to generate anticipatory initiatives that require impact assessment analysis to understand the entire transformation process. A continuous Futuring cycle with FRIM components in a rolling programme is a necessary backbone to support both competitiveness and sustainability issues, ensuring – with direct stakeholders involvement - effectiveness, efficiency, consistency of actions and commitment of the targeted communities, especially in industrial research and innovation.

The proposed Futuring cycle approach to industrial technologies represents a different type of best practice for future-oriented technologies and multilevel framework conditions for innovation where the science to market relation and time-to-market become essential for strategic sectors. It would be spread on base-research looking to the full life concept of technology.

5 Conclusions

This new approach to Futuring, with related methods and tools, integrates the innovation decision processes of organizations and allows a direct participation of research organizations and industry companies to the rolling programme and related activities. This new Futuring approach allows to operate in an open environment where traceability of industry needs represents a strategic element for future.oriented technologies and for horizontal issues – such as education - that ensure the value upstream through availability of existing competences and of sound directions, fragmented now in multiple stakeholders.

Therefore, a rolling process of each separate components of the Futuring cycle permits the participation of performers in foresight, roadmaps, implementation and monitoring initiatives to respond to the need of “Sound Intelligence support” already envisaged by CREST Multilevel Policies Report, 2007.

In the Knowledge economy, this approach permits to research and industry stakeholders to operate more effectively and to proceed faster toward the common goal.

This paper contributes to the further development of conventional foresight that should move from a linear to a complex approach to respond to the increasingly complex, interdependent and uncertain realms of today’s business and policy strategy in the Knowledge economy [22].

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