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# Industry 4.0 And Turkish National Innovation System: Challenges And Prospects

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# INDUSTRY 4.0 and TURKISH NATIONAL INNOVATION SYSTEM: CHALLENGES and PROSPECTS

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**Abstract:** *This study discusses the structure of Turkish National Innovation System (NIS) and challenges faced in the last decade in the context of the digital transformation. As a developing country and a member of G-20, how these challenges of Turkish NIS are mitigated and further be dealt with. It comprises lessons and provides cases for various similar NISs. In order to evaluate and provide policy recommendations for accelerating the transformation of Turkish economy, it benefits from systems approach as a basic academic framework. It is found that Turkey faces four key structural challenges calling for urgent response for their targets of 2023 (hundredth year of the Republic), namely productivity, growth, employment and investment. Implementing a relatively simple rule compatible with the peculiarities of the system and focusing on the diversity of policy mix, the study proposes ways to mitigate these structural challenges towards digital transformation.*

**Keywords:** INDUSTRY 4.0, DIGITAL TRANSFORMATION, NATIONAL INNOVATION SYSTEMS, STI POLICY, STRUCTURAL CHALLENGES, TURKEY.

## 1. Introduction

The unavoidable introduction of technological changes in the life of modern *homo sapiens* not only alters the humanity itself yet transforms societies and socio-economic structure in a drastic manner. The recent discussions on the so-called industry 4.0 or digital transformation seems to have such a capacity. Its main peculiarity is on the production, consumption and marketing of the goods and services. However, what is deep inside is the restructuring of human-human and human-machine interactions in a wider context. In this paper, we aim to provide a brief examination on policy impacts of the possible reorganization in the context of an emerging economy.

In fact, digital transformation strategy should be rooted at micro level firm strategy. However, the governments must consider the wider impacts at meso and even at macro levels. The policies and specific public strategies have to enhance the applicability of micro strategies especially in emerging countries like Turkey. As noted by OECD (2005) with a special appendix, one of the major shortcomings of developing countries in terms of innovative activities is the existence of problems in the *innovation landscape* especially weak innovation systems as compared to developed world.

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Another connected issue is the capacity and capability of qualified personnel needed for the digital transformation. As evident from the data<sup>3</sup>, the emerging economies have also problems with the education systems. These problems necessitate strategic public intervention for the realization of digital transformation, otherwise the results for some of the developing countries may be detrimental and traumatic.

Turkish economy ranks 17<sup>th</sup> in the 2016 list of world economies with \$ 857,749 m value of total Gross Domestic Product at current prices (World Bank, 2017)<sup>4</sup>. The country has a population of 79.814m<sup>5</sup>(TURKSTAT, 2017) by the end of 2016. 68% of the population of Turkey is between 15-64 years of age and 36% is younger than age 30<sup>6</sup>. The annual average growth rate of GDP was approximately 4.7% for the last three years, however a tremendous fall is observed in 2016 with a growth rate of 2.88%. R&D intensity in Turkey is %1.06 in 2015<sup>7</sup> (TURKSTAT,2017). The total number of FTE personnel were 122,288 in 2015 which is 54.5%<sup>8</sup> of the total R&D personnel. Among FTE personnel, 54.4% were employed by the business enterprises, 10.1% by the government sector and 35.5% were employed by the higher education sector<sup>9</sup>. At the 23<sup>rd</sup> meeting of BTYK convened in 27 December 2011, the National Innovation System and National R&D targets for 2023 were determined. There is a clear shift from horizontal focus to sectoral focus in Turkish R&D and innovation policies. In Turkey, following the adoption of the National Science, Technology, and Innovation Strategy 2011-2016 by the Supreme Council for Science and Technology (SCST), there has been a paradigm shift towards a target and mission-oriented approach.

The academic literature on the policy approach of the digital transformation is almost non-existent in Turkey to the best of our knowledge. The national literature on policy is mainly concerned with the impacts of information society and associated discussions rather stacked on the implications of ICT revolution. The most comprehensive study (TÜSİAD, 2016) is financed by an NGO, namely TÜSİAD (Turkish Industry and Business Association) and written by BG (Boston Consulting Group).<sup>10</sup> This study concludes that *“There is, therefore, a need for a platform where every aspect of the Industry 4.0 approach can be addressed and both the strategic and operational needs and applications can be discussed in depth with the participation of all of the actors responsible for*

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<sup>3</sup> See <http://datatopics.worldbank.org/education/> for an extensive dataset.

<sup>4</sup> <http://databank.worldbank.org/data/download/GDP.pdf>

Published in April 2015, €1=\$1.1186 (Central Bank of Turkey's cross rate, 30.05.2015)

<sup>5</sup> <http://www.tuik.gov.tr/PreHaberBultenleri.do?id=24638>

<sup>6</sup> <http://www.tuik.gov.tr/PreHaberBultenleri.do?id=24638>

<sup>7</sup> [http://www.tuik.gov.tr/PrelstatistikTablo.do?istab\\_id=1620](http://www.tuik.gov.tr/PrelstatistikTablo.do?istab_id=1620)

<sup>8</sup> Calculated from the table reached from [http://www.tuik.gov.tr/PrelstatistikTablo.do?istab\\_id=1620](http://www.tuik.gov.tr/PrelstatistikTablo.do?istab_id=1620)

<sup>9</sup> Calculated from the table reached from [http://www.tuik.gov.tr/PrelstatistikTablo.do?istab\\_id=1620](http://www.tuik.gov.tr/PrelstatistikTablo.do?istab_id=1620)

<sup>10</sup> [http://tusiad.org/tr/yayinlar/raporlar/item/download/7848\\_180faab86b5ec60d04ec929643ce6e45](http://tusiad.org/tr/yayinlar/raporlar/item/download/7848_180faab86b5ec60d04ec929643ce6e45)

*transforming our industrial sectors.*”(TÜSİAD, 2016:13). Another significant attempt is a platform<sup>11</sup> established at METU (Middle East technical University) recently commenced to study the impacts of digital transformation. Another body concentrated on digital transformation is Sabancı University that organized a workshop digital transformation in industry. The produced workshop report gives evidence about the need for a well-defined policy in Turkey especially for SMEs who calls for a road map and a tool kit for Industry 4.0 (Sabancı University, 2017). The same workshop also asks for the implementation of a training strategy together with the support of the whole manufacturing industry ecosystem to sustain the competitiveness of the industry. TÜBİTAK (Scientific and Technological Research Council of Turkey) also prepared a road map on smart manufacturing systems upon the decision taken by BTYK in its 2016 meeting.

This paper aims to contribute to the limited national literature as well as to bring about emerging country perspective to the international literature on a widely-discussed issue yet weak academic knowledge is present. The next section will summarize the basic characteristics of Turkish NIS. Third section will briefly outline the basic premises of digital transformation. The fourth one will link these discussion on a policy context for Turkish case.

## **2. Turkish NIS in Perspective**

This section will summarize the main actors in Turkish NIS. Moreover, it also discusses the research and innovation funding and performers. The last decade has witnessed a shift from horizontal focus to sectoral focus in Turkish R&D and innovation policies. Moreover, following the adoption of the National Science, Technology, and Innovation Strategy 2011-2016 by the Supreme Council for Science and Technology (SCST), there has been a paradigm shift towards a target and mission-oriented approach. In fact, the implementation of such an approach has close links and likelihood to feed up digital transformation in the next decades.

### **2.1 Actors and Their Functions in Turkish NIS**

The Turkish R&I system is centralized and led by the Supreme Council of Science and Technology (BTYK), the legally formalized body chaired by the prime minister. There are also 26 Regional Development Agencies (RDAs) which are affiliated to the Ministry of Development (MoD) to encourage R&D and innovation on a regional scale. There are different political and operational bodies affiliated to different Ministries which organize and develop R&I policies. These institutions are interrelated through different mechanisms. Science, Industry and Technology Ministry (MoSIT) is responsible for the coordination of STI policies. The science, technology and innovation-related duties of the MoSIT

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<sup>11</sup> [http://www.biltir.metu.edu.tr/Flyer\\_draft\\_2017\\_English.pdf](http://www.biltir.metu.edu.tr/Flyer_draft_2017_English.pdf)

are defined as the development, implementation and coordination of the S&T and innovation policies, and the promotion of the R&D and innovation projects, activities and investments.

At the political level, the Supreme Council of Science and Technology (BTYK) is the highest-ranking STI policy making body. It includes 20 permanent members chaired by the prime minister and other stakeholders. The BTYK determines, directs and co-ordinates research and innovation policies. The BTYK meetings take place twice a year with a pre-determined agenda. In total, over one hundred different actors from the governmental bodies, higher education and business enterprise sectors are represented in the meetings. The BTYK reports evaluate the ended or ongoing projects and present a roadmap to achieve predetermined targets of the BTYK or other governmental bodies. The Scientific and Technological Research Council of Turkey (TUBITAK), affiliated to MoSIT, acts as the secretariat of the BTYK.

The Ministry of Development (MoD) and the Higher Planning Council (YPK) are two other important actors in the design and implementation of science, technology and innovation policies. MoD provides R&D tax allowances and other related incentives. The Higher Planning Council (YPK), chaired by the prime minister, is the highest-level body for the preparation and implementation of the national development plans, which also covers S&T policy actions for Turkey. MoD is the secretary to the YPK. 26 Regional Development Agencies (RDAs) which are affiliated to MoD are established to encourage R&D and innovation on a regional scale.

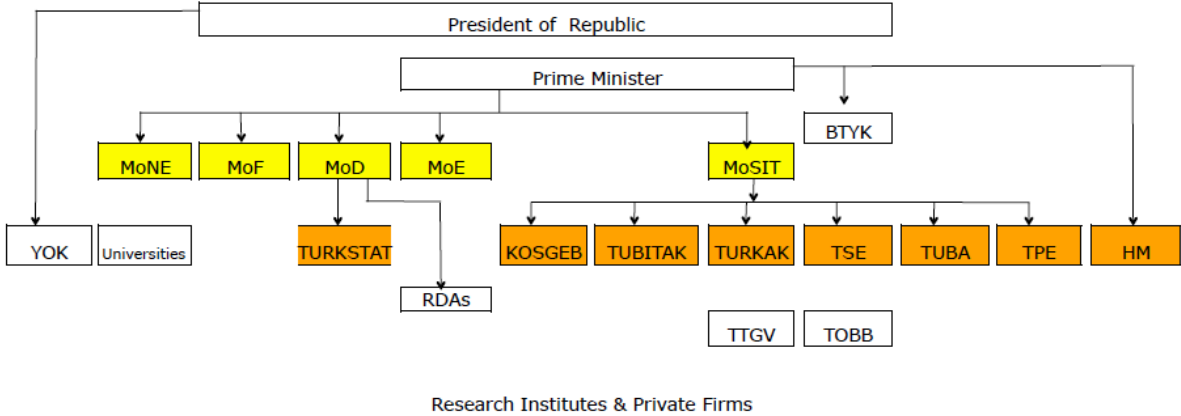
The Ministry of National Education (MoNE) and the Higher Education Council (YOK) design and implement the education policies, and integrate them with the research policies. Turkish Academy of Sciences (TUBA) determines and recommends scientific priority areas and proposes legislation to the government on issues related to scientists and researchers.

At the operational level, the leading actor in the implementation system is TUBITAK. TUBITAK takes the role in facilitating of experimentation and learning, knowledge development, knowledge diffusion, guidance of search and selection, market formation and development of mobilization of resources. TUBITAK provides grants for R&D, innovation, HRST, R&D and innovation networks and science and society. These grants aim to facilitate experiments and learning as well as development and mobilization of resources.

The Small and Medium-Sized Enterprises Development Organisation (KOSGEB) and the Technology Development Foundation of Turkey (TTGV) are other main bodies implementing industrial R&D support measures. Turkish Patent Institute (TPE) carries out the procedures related to industrial and intellectual property rights. Turkish Accreditation Agency (TURKAK) deals with the accreditation of organisations and laboratories. Turkish Statistical Institute (TURKSTAT) is the body responsible for

providing statistical information related to R&D, innovation and industry, among others. Scientific advice to the government is primarily provided by TUBITAK and TUBA. Both organisations are affiliated to MoSIT. The detailed structure of STI system with their systemic functions is given in Figure 1.

**Figure 1: Turkish NIS**



- |        |  |           |   |
|--------|--|-----------|---|
| BTYK:  | Supreme Council of Science and Technology    | TUBITAK:  | Scientific and Technological Research Council of Turkey |
| MoF:   | Ministry of Finance                          | KOSGEB:   | SME Development and Support Organisation                |
| MoSIT: | Ministry of Science, Industry and Technology | HM:       | Undersecretariat of Treasury                            |
| MoNE:  | Ministry of National Education               | YOK:      | Higher Education Council                                |
| MoD:   | Ministry of Development                      | TUBA:     | Turkish Academy of Sciences                             |
| MoE:   | Ministry of Economy                          | TSE:      | Turkish Standards Institute                             |
|        |  | TURKSTAT: | Turkish Statistical Institute                           |
|        |  | RDAs:     | Regional Development Agencies                           |
|        |  | TTGV:     | Technology Development Foundation of Turkey             |
|        |  | TURKAK:   | Turkish Accreditation Agency                            |
|        |  | TPE:      | Turkish Patent Institute                                |
|        |  | TOBB:     | Union of Chambers and Commodity Exchange of Turkey      |

**2.2 Research and Innovation Funding and Performers**

Although the proportion of R&D funded by business sector is significant, government continues to be the leading supporter of the Research and Innovation. The Scientific and Technological Research Council of Turkey (TUBITAK) is the leading agency for management, funding and conduct of research in Turkey. Moreover, since 2003 Turkey is associated to EU research framework programmes. Under the last program hold between 2007-2013, about 50 projects submitted approximately by 1000 participants from Turkey received almost €200m in EU funding<sup>12</sup>. Business enterprises sector is the leading sector with both its share in total R&D expenditure and among the R&D financiers.

As indicated in 2014 SBA Factbook<sup>13</sup>, Turkish economy is dominated by SMEs. SMEs provide over 75% of jobs, accounts for 99.9% of all businesses and produce 53% of the domestic value added. In 2013, 108,930 new businesses were registered, but they are generally in wholesale and retail trade sectors. In 2013 and early 2014, Turkey implemented eight new policy measures addressing four of the ten

<sup>12</sup> [http://europa.eu/rapid/press-release\\_IP-14-631\\_en.htm](http://europa.eu/rapid/press-release_IP-14-631_en.htm)  
<sup>13</sup> [http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2014/turkey\\_en.pdf](http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2014/turkey_en.pdf)

Small Business Act principles on promoting entrepreneurship, improving access to finance and strengthening skills and innovation. Although the budget allocated to R&I is increasing in Turkey, there is still no systematic mechanism aimed at evaluating the programs implemented, ex-ante, intermediary or ex-post. There are impact evaluation studies carried by academicians, researchers and public organizations and they are very limited in number. There have been some recent developments on impact evaluation. The Division of Impact Evaluation in MoSIT was established in June, 2014<sup>14</sup> with the goal of analyzing and increasing the efficiency of support programs. The main missions are collection of data and information required for the implementation of the impact analysis, for the organization of different kinds of meetings to increase capability of analysts and reporting activities. Ongoing impact assessment exercises concern Industrial Thesis Support Programme (SAN-TEZ), Techno-entrepreneurship Support Programme, R&D Centers established according to Law No 5746 on Supporting Research and Development Activities and Technology Development Zones established according to Law No 4691.

The higher education system in Turkey is a centralized one. All HEI's are tied to Council of Higher Education (YOK) in accordance with the Higher Education Law (No. 2547). HEI's can be classified as Universities (State and Non-Profit Foundations), Institutes of High Technology, Post-Secondary Vocational Schools<sup>15</sup>. By October 2017, there is a total of 184 HEIs in Turkey (YOK,2015). Universities have six main units: Faculties are conducting higher education, scholarly research and publication. Graduate schools are concerned with graduate education, scholarly research and applications. Post-secondary School are concerned with providing instruction for a specific profession. Conservatories are institutions to train artists for music and the performing arts. Post-secondary Vocational Schools aim at training people in specific professions. Research and Application Centers are carrying out research and applied studies to meet the applied study needs of various areas. State higher education institutions are funded by the government budget, based on a detailed itemizing of their expenditures, essentially prepared after consultations based on the previous year's allocations. Non-Profit Foundation (private) Universities are funded by their foundations and students.

The main research performer in the public sector is Marmara Research Centre of TUBITAK together with 10 research centers/institutes of TUBITAK. It provides contractual research, testing, training, consultancy, analysis and certification services in its research centers, and operates a technopark. TUBITAK's institutes are the most active research organisations conducting research in their fields of specialisation. Some ministries like Ministry of Agriculture have their own research centers. For nuclear

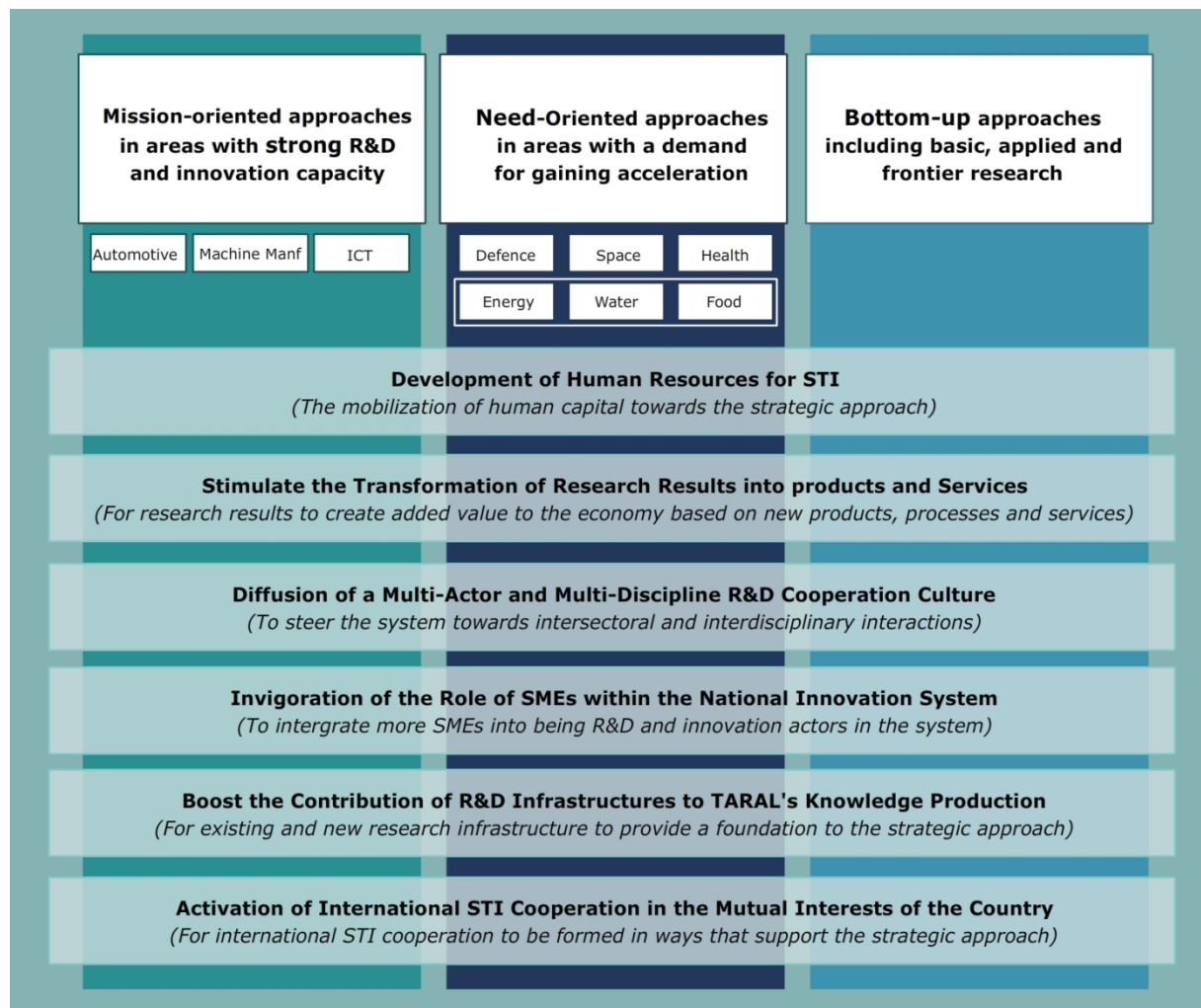
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<sup>14</sup> will be discussed in more details in part 2.2.1

<sup>15</sup> After July 2016, attempt of coup d'etat, military and police academies are closed. Before that date, "Other Higher Education Institute (Military and Police Academies) were also included in the datasets. This may generate a confusion for the studies before and after coup d'etat attempt.

research activities, the Turkish Atomic Energy Authority is the main body both for strategy preparation and carrying out research activities. There are also R&D centers operating under universities and various ministries, such as the ministries of Energy and Natural Resources, and Food, Agriculture and Livestock. Apart from public research agencies, there are private sector R&D centers founded according to law numbered 5746 which concerns the support of research and development activities. The National Science, Technology and Innovation Strategy (2011-2016) document, called as NSTIS (UBTYS) 2011-2016, is still valid as the most important element of the national R&I strategy. UBTYS 2011-2016 is preceded by Vision 2023 though some changes were amended. The vision of the strategy is defined as **"to contribute to new knowledge and develop innovative technologies to improve the quality of life by transforming the former into products, processes, and services for the benefit of the country and humanity."**<sup>16</sup>.

**Figure 2: Strategic Framework of UBTYS 2011-2016**



The strategy outlines mission-oriented approaches in areas with strong RDI capacity, need-oriented

<sup>16</sup> <http://tubitak.gov.tr/en/about-us/policies/content-national-sti-strategy-2011-2016>



approaches in areas with a demand for gaining acceleration, and bottom-up approaches including basic, applied and frontier research are identified. The strategic framework of National Science, Technology and Innovation Strategy (2011-2016) is comprised of three vertical axes and six horizontal axes, as shown in Figure 2. At the 25th meeting of BTYK, which was held on 15<sup>th</sup> January, 2013, health sector included within national prioritized areas. The action plan of the strategy is implemented by the decisions of BTYK in an integrated manner.

In addition to UBTYS 2011-2016, various strategy documents are prepared<sup>17</sup>:

**- Science and Technology Human Resources Strategy and Action Plan 2011-2016: The main targets of the strategy**, under the principles of good governance, **include** increasing the number of the R&D personnel and improving their sectoral and occupational distribution. This target involves policies aimed at directing young people toward R&D-intensive sectors, improving their career perspectives and income streams, devising programs to train people in the field of science and technology in accordance with the needs of the industry, increasing employment of technicians and at diffusing science and technology culture in the society.

**- It was decided at the 21<sup>st</sup> meeting of the BTYK in June 2010 that R&D and innovation strategy documents would be prepared for three different domains (energy, water and food) under the supervision of TUBITAK, with the participation of experts from universities, public sector and industry. Strategy documents including the action plans had been prepared for each domain by December 2011. They are presented briefly below.**

**- National Energy R&D and Innovation Strategy:** The vision of the strategy is to establish global competitiveness through the production of knowledge and innovative outputs using resources efficiently and productively and considering quality of environment and life. The strategy further defines four strategic targets, namely mission-oriented prioritized R&D projects, capacity improvement, commercialization and collaboration.

**- National Water R&D and Innovation Strategy:** The vision of the strategy is to improve unique technologies and policies for the protection of water resources, productive and sustainable use of water resources, and the protection of access rights of all livelihoods to water. It also describes four strategic targets as the improvement of database infrastructure, mission-oriented prioritized R&D projects, capacity improvement, and socioeconomic and hydrologic research.

**- National Food R&D and Innovation Strategy:** The vision of the strategy is to produce high value added, innovative and branding food products with environmental-friendly technologies. The strategy further develops six strategic targets, production of raw materials, industrial R&D and

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<sup>17</sup> <http://tubitak.gov.tr/en/about-us/policies/content-national-sti-strategy-2011-2016>

innovation activities, local capabilities and innovative products, food consumption and health, mission-oriented prioritized R&D projects, and sustainability and environment-friendly technologies.

In all of these documents, a systematic strategy development activity is achieved through the help of experts in line with national and international developments. However, it is not possible to note that these activities are preceded by any ex-ante policy appraisal. Moreover, the strategies include the elements of smart specialization at some extent though not completely. The elements of smart specialization are<sup>18</sup>: (i) analysis of the regional context and potential for innovation (ii) set up of a sound and inclusive governance structure (iii) production of a shared vision about the future of the region (iv) selection of a limited number of priorities for regional development (v) establishment of suitable policy mixes, and (vi) integration of monitoring and evaluation mechanisms. In Turkey, some regional development agencies did carry out an analysis of the regional context and of the potential for innovation in a strategic framework and a limited number of priorities were selected. However, it is difficult to claim that the rest of the elements are taken into account. It can be perceived that all of these strategies are implemented and supported by policy tools such as regional mapping, compliance with the regional priorities, and regional support mechanisms through regional development agencies. The strategies have some cross-sections with EU priorities outlined by the Commission<sup>19</sup> in fields such as smart growth (targets pertaining R&D intensity and R&D environment) to the yet a complete harmony is difficult to be observed especially on inclusive growth and economic governance.

In July, 10<sup>th</sup> 2015, the Law No 6550 on Supporting Research Infrastructures<sup>20</sup> was published in the Official Gazette and in August, 28<sup>th</sup> 2015 its implementing regulation<sup>21</sup> was published also therein. The new legislation has major implications as to the status, administration, management, funding, hiring policies, monitoring, evaluation and support provided to RIs. In a nutshell, this new law aims to contribute to the sustainability of RIs and to their more efficient functioning in Turkey. The problems encountered by RIs in state universities concern mainly<sup>22</sup> (i) the duration of the funding provided by the Ministry of Development: this support is provided for a given time span and terminated thereafter, leading the RIs to search alternative sources of funding (ii) the low attractiveness of the RIs for researchers given the difficulty of having a tenure track when working as a researcher in RIs and low wages offered compared to job opportunities available in the private sector for high skilled researchers, and (iii) the difficulty of collaborating with the industry (or other entities) on a project

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<sup>18</sup> [http://ec.europa.eu/regional\\_policy/sources/docgener/presenta/smart\\_specialisation/smart\\_ris3\\_2012.pdf](http://ec.europa.eu/regional_policy/sources/docgener/presenta/smart_specialisation/smart_ris3_2012.pdf)

<sup>19</sup> [http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/priorities/index\\_en.htm](http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/priorities/index_en.htm)

<sup>20</sup> <http://www.resmigazete.gov.tr/eskiler/2014/07/20140710-3.htm>

<sup>21</sup> <http://www.resmigazete.gov.tr/eskiler/2015/08/20150828M3-11.htm>

<sup>22</sup> <http://stps.metu.edu.tr/sites/stps.metu.edu.tr/files/ARMER-RAPORU-13ekim-enson.pdf>

basis as a source of funding given the public status of RIs in state universities and especially the system of revolving funds (an important part of revenues generated are transferred to the university and allocated to other expenses, and not to the RI generating them). All these endanger the sustainability of RIs and commercialization of their technologies.

The aforementioned new law is an attempt to remedy to these shortcomings on several fronts by enabling RIs to have a legal personality, by ensuring better management, by allowing employment of highly qualified and flexible work force, by leading to sustainable funding of their research activities and finally by promoting collaboration activities with external actors. Some of the significant measures of the new law aim at:

- *Better management:* besides the board of management which will be formed of the representatives of business sector, universities and public institutions there will be an advisory council and a director – a professional manager whose remuneration is based on performance criteria.
- *Funding of research activities:* RIs will continue to benefit from public funding conditional on the monitoring and the evaluation of their research activities. They will also be entitled to tax incentives. However, they are also expected to generate their own revenues through projects submitted to national or international entities and carry out expenditures based on these funds
- *Hiring policy:* RIs will be able to hire researchers on the basis of the labor law (hence not constrained by the legislation regulating state universities), pay them a competitive salary and employ them on a flexible basis (part time). Foreign researchers will be hired as well.
- *Legal personality:* RIs will have their own legal personality. As an entity, they can hire academicians coming from universities for a given time span (several years) on a contractual basis and hence pay them on a more competitive basis. The academician must leave the university and become a staff of the RI. At the end of the contract he/she can return to the university under certain conditions.
- *Collaboration:* RIs can be established jointly by universities and the business sector. They can be located in areas belonging to technology development zones, organized industrial zones, industrial districts, or to private initiatives. RIs can also create companies or become partners in existing ones. One major requirement is that they provide uninterrupted (24h/24h) service to all potential users without discrimination.

These are radical changes as far as the functioning of RIs in state universities in Turkey are concerned. Their objective is to loosen above aforementioned restrictions which impact negatively on the sustainability of research activities in these entities. Possessing a legal personality and being able to attract high-qualified researchers have the potentiality to boost their performance and make them



more sustainable at the same time. However, intrusion of business sector-related people at different levels of management, loosening of links with universities and generation of revenues through project-based activities or even through commercial activities are all developments that are sources of worry for the academic community: they fear that it might exert adverse effects on the nature of research activities conducted by RIs. Indeed, an increased involvement of business in the management and in the activities of RIs might end up with applied research and experimental development taking over fundamental research activities. This might jeopardize frontier research activities in Turkey given that university RIs (thematic or central research laboratories) are the main actors conducting this type of activity. In addition, it remains to be seen whether the important monitoring and evaluation exercises on which the sustainability of public funding depends are within the abilities of civil servants in Turkey. Indeed, such an exercise requires establishment of a number of performance criteria for RIs, their weighting, collection of data on these performance indicators, monitoring of performance of RIs based on these indicators and in certain cases establishment of control groups or counterfactuals in order to carry out an impact assessment analysis – a number of activities for which the number of civil servants and/or time devoted by them to such activities might be insufficient, nor might they have the training necessary to conduct such exercises.

In conclusion, two points can be highlighted as a potential source of problems as far as RIs are concerned: (i) There is no national roadmap in accordance with ERA priority 2 (optimal transnational co-operation and competition to establish a common research agenda, improve interoperability of national programs, and build effective pan-European research infrastructures) and (ii) the weak transnational character of RIs operating in Turkey.

All of the abovementioned efforts should also contribute to the process of harmonization with the *acquis communautaire on research and innovation (Accession Chapter 25)*. Although Turkey is actively reforming, there is insufficient information to establish if Turkey acts sufficiently in line with the EU *acquis* and notably with the ERA priorities. Turkey, as a country associated to the EU research and Innovation Programme 'Horizon 2020', has been invited to prepare a National Roadmap in line with ERA. There is at this stage no commitment (or indication that they will do so) and in the absence thereof, it is difficult to say if the reforms are in compliance ERA. Turkey has from the very beginning followed the actions in ERA and establish already in 2015 its own ERA framework. "Turkish Research Area" (TARAL) launched by BTYK (Supreme Council of Science and Technology) inspired by ERA. With respect to innovation, Turkey has taken several measures identified in the Innovation Union flagship but more substantial reform is expected, as Turkey intends to do, in particular to stimulate cooperation between Academia and Industry and develop new technologies and products. Although the importance attached to innovation is to be welcomed, this should be balanced with reform on

research, and the universities and infrastructures and human capital building both quantitatively and qualitatively, again in line with the key ERA priorities, in order to cover the whole chain from the lab to the market.

### **3. An Empirical and Policy-Oriented Snapshot on Digital Transformation**

This section will focus on the possible repercussions of digital transformation at various levels, namely micro, meso and macro levels, in a policy context. METU-Digital Transformation/Industry 4.0 Platform notes that<sup>23</sup>

*The world has recently witnessed the new concept of "Digital Transformation" which is also known as "4th Industrial Revolution" and "Industry 4.0". Digital Transformation aims to support human capabilities through cyber-physical systems, smart factories, communication among machines and humans, and data-driven decision support systems. Digital transformation requires human capital development by providing collaborative learning networks to build multi-disciplinary communities of practice.*

The new product lifecycles are not only related with the personalized customer demand and extends the existing issues of product development, order, production and distribution of a product to final customer but also its recycling as well with the connected services. However, such a systematic relation will, indeed, needs the establishment of real-time availability of all information concerning each phase of manufacturing, marketing and even recycling. This means the dynamic accessibility to the data that necessitates interconnection data-generating agents such as persons, firms, items, and various systems. Therefore, such an interconnection ends up with a value-creating networks that generates a dynamic optimization in terms of use of resources, cost, and accessibility.

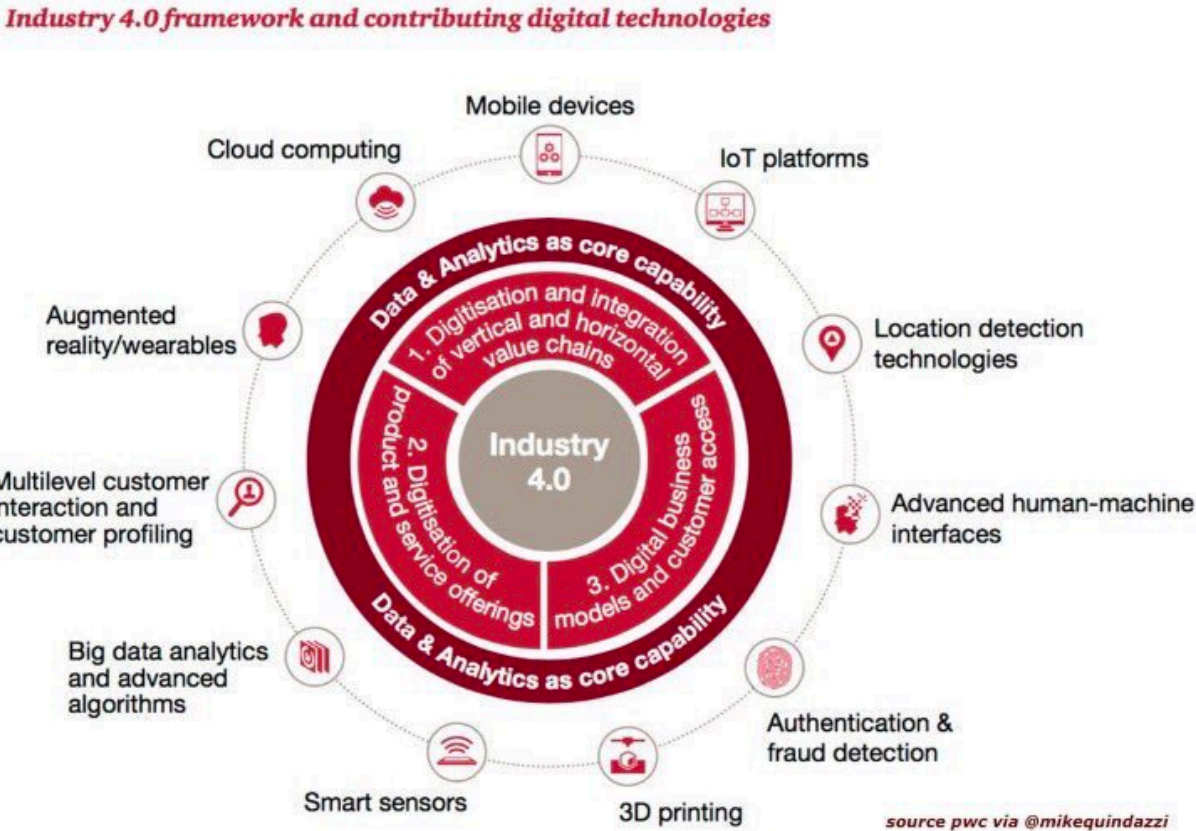
First of all, the transformation aims to provide the digitization and integration of vertical and horizontal *supply* and value chains. In the context of emerging economies not only value but also supply chains are still relevant for the policy concerns since most of these countries has not already enjoyed the full advantage of the so-called ICT Revolution. The transformation vertically digitizes and interconnects the nodes inside the organization in all phases of manufacturing, sales, service and distribution. All data are collected from and distributed to nodes throughout the organization at a real-time basis. Connections are realized through cyber physical systems. Artificial intelligence and augmented reality applications are employed where needed. Outside the organization, horizontal integration takes place to efficiently reach to suppliers, customers and all agents of the value chain. The same data processing methods are used in horizontal integration as in the case of vertical integration. In these processes, smart products have information about their assembling phases. The model uses various digital

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<sup>23</sup> [http://www.biltir.metu.edu.tr/Flyer\\_draft\\_2017\\_English.pdf](http://www.biltir.metu.edu.tr/Flyer_draft_2017_English.pdf)

technologies as depicted in Figure 3. The employed digital model and data-generating processes are used to service suppliers, customers and all agents in the value chain. In either type of integration, human is considered as the key determinant of creating value added. Combined with the well-designed business models run by humans, the system is expected to produce efficient results. Therefore, it brings a new interaction of digital model with the business model which complements each other instead of being a basic substitute of humans with machines.

**Figure 3: Contributing Digital Technologies to Digital Transformation**



Source: PWC, 2016.

In fact, the system will bring about efficiency both in input side and output side. However, it will be misleading to treat the system functioning in such a linear manner. The social behavior which is not totally predictable with the existing data is still on the scene. Thus, the system will not be able to consider non-linearities with a stochastic modelling yet it optimizes the activities though not always ends up with the first-best solutions. The digital transformation is claimed to ensure the efficiency of invested capital, labor, materials, energy and time by 30-50% while decreasing the consumption of other resources by 20-25% (McKinsey, 2015). In turn, increasing the efficiency and competitiveness of organizations both in the private and public sector. The most important value added is in the domain of user-focused approach utilized throughout the system such as customized innovative products,



decreasing the impact of time constraints on orders, etc. However, to enjoy the full benefits of the system both in the production and consumption side, the product and service providing organizations should have a strategic approach to employ the digital transformation starting with a road map, then to strategy. It also necessitates a sustainable monitoring approach that can be applied rather easily with the existence of the big data and its applications to process this data. The ultimate mega aim is to construct a digital ecosystem on a global scene with a mission of increasing the wealth of humanity.

#### **4. Linking Turkish NIS and the Digital Transformation**

At the 29<sup>th</sup> meeting of BYTK in February 2016, three significant decisions are taken towards transition of Turkish industry for increasing international competitiveness in technology production:

- Developing an implementation and monitoring model for smart manufacturing in coordination with all stakeholders
- Increasing goal-oriented R&D efforts in critical and pioneering technology areas (cyber-physical systems, AI/sensor/robotics, IoT, big data, cyber security, cloud techs, etc.)
- Designing support mechanisms for manufacturing infrastructures to develop critical and pioneering technologies.

In accordance with these decisions, TÜBİTAK first carried out a survey with the stakeholders, then a prioritization study was carried out through an expert workshop, followed by a focused group meeting. According to results of the survey on 1,000 firms, only 22% reported that they have a detailed knowledge on smart manufacturing systems (TÜBİTAK, 2017). The highest awareness is observed in electronics, software and materials sectors. Among the surveyed firms, 50% have a strategy to integrate smart manufacturing systems in their production processes (TÜBİTAK, 2017). Regarding the level of digital maturity, the Turkish industry is between the 2nd and 3rd industrial revolution and the most mature sectors are the materials sector (rubbers & plastics), computers, electronics and optical devices as well as the automotive and white goods sector. Three technologies that will provide the most added value according to Turkish firms, are automation & control systems, advanced robotic systems as well as additive manufacturing. The expectation is that these technologies will find their ways mostly in the machinery & equipment sector, the computers, electronics and optical devices sector as well as the automotive and white goods sector. In the prioritization phase, 3 technology groups, 8 critical technologies, 10 strategical targets and 29 products were determined.

The technology groups, strategic targets and underlying technologies are as follows:

1. Digitalization, with a focus on big data & cloud computing, virtualization and cyber security. The following targets are being defined:

- Secure, private cloud service platform: develop secure, private, intelligent and scalable cloud service platforms for end devices, algorithms and applications.
  - Big data analytics: collect, process, correlate, analyse, report and use in decision support systems. Cyber security solutions: develop cyber security solutions Industry 4.0 applications.
  - Modelling and simulation: development of modelling and simulation technologies
2. Connectivity, with a focus on the Internet of Things (IoT) and sensor technologies. The following targets are being defined:
- Industrial IoT platform: Establishment of digital platform of industrial IoT with interoperability, increased security and reliability, and development of software and hardware for industrial endpoint equipment.
  - M2X software and equipment: development of data storage technologies suitable for data emerging with reliable and innovative M2X (Machine-Machine, Human-Machine, Machine-Infrastructure) software and / or hardware that will increase the quality and productivity during the product life cycle.
  - Innovative sensors: development of industrial, physical, chemical, biological, optical, micro-nano sensors; intelligent actors; industrial, wireless, digital sensor networks; artificial vision, image processing, innovative sensor applications and heavy conditions resistant sensors.
3. Future factories, with a focus on additive manufacturing, advanced robotic systems and automation & control systems.
- Robotic, automation, equipment, software and management systems: developing intelligent production robots, equipment and software / management systems that can compete in the international markets in terms of technology and cost, also accessible by SMEs.

- Supplementary manufacturing materials, equipment and software: development of raw materials, production equipment and necessary software and automation systems used in additive manufacturing.
- Intelligent factory systems: development of intelligent factory systems and components and middleware software technologies.

TÜBİTAK's national call for research proposals topics for 2016 and 2017 already reflect a focus on advanced manufacturing technologies as well as the Internet of Things. Specific focus is on:

- Additive Manufacturing:

- Multilayer additive manufacturing
- Rapid prototyping and 3D printing technologies
- CAD/CAM, simulation & modelling software
- Robotics and mechatronics
- Flexible manufacturing

- Internet of Things

- Sensors and sensing systems
- Virtualization
- M2M communication
- Cloud computing

According to TÜSİAD (2016), the expected impact of the digital transformation on Turkish economy are as follows:

- **Productivity gains of 4 to 7 percent** on an annual basis.
- Despite the predicted low skilled job loss, **5 percent absolute increase in employment** is expected.
- **Higher-skilled labor force** structure is expected to prepare a **stronger know-how base** for Turkey.
- Additional total manufacturing based growth of up to 3 percent per year, meaning **1 percent growth effect on Turkish GDP**. Turkish producers are required **to invest about 3 to 5 billion Euro per year** over the next ten years.



The same study exhibits some stylized facts on the digital transformation in terms of levers and sectors as shown by Figure 4 (TÜSİAD, 2016). According to this figure, four sectors have a considerable strength in digital transformation, namely automotive, machinery, white appliances and chemicals. It can be treated as a first attempt to measure readiness of Turkish industry for the digital transformation. Turkey has various strengths towards this transformation. First of all, Turkey has a long tradition of manufacturing expertise and exhibits a significant progress with the development of key industries and growing trade and investment. Second, the last decade has witnessed a rapid export growth which in turn accelerates the articulation of Turkish industry with the global counterparts. The well-developed and relatively large domestic market provides opportunities to process market information and feedback for the production. Finally, rising public incentives targeting to increase private sector RDI, export share of hi-tech sectors, to strengthen research commercialization and entrepreneurship. In the next section, we will discuss the major structural challenges of Turkish NIS with respect to the digital transformation.

**Figure 4: The Levers and Sectors for the Digital Transformation in Turkish Industry**

Industry 4.0 lever	Company	Examples
<b>1</b> Integrated, automated and optimized production flow	White appliances	<b>Integrated quality management</b> <i>Tracks products within the manufacturing process and correlates failure data from testing after front-end-production to reduce waste and improve processing</i>
	Machinery	<b>Integrated design data</b> <i>Utilizes vertical data integration from design to the end-of-line of its semi-automated manufacturing process for optimization of operations</i>
	White appliances	<b>Horizontal data integration</b> <i>Enabled its suppliers to view selected ERP data to tie them closer to an integrated production process in its factory Cerkezkoy</i>
<b>2</b> Virtual product design	Automotive	<b>Virtual factory and product design</b> <i>Offers a joint solution to integrate factory and product design to optimize manufacturing through factory simulation based on the actual manufacturing needs</i>
<b>3</b> Flexible manufacturing	White appliances	<b>Flexible manufacturing robots</b> <i>Implemented a manufacturing line which communicates with RFID-based smart products and adjusts tools and manufacturing tasks to product type</i>
<b>4</b> Automated logistics	Automotive	<b>Laser-guided automated guided vehicle (AGV)</b> <i>Operates a laser-guided AGV logistics system, where the host computer controls inventory and schedules, controls deliveries and routes the AGVs</i>
<b>5</b> Learning and self-optimizing	Chemicals	<b>Self-optimizing process flow</b> <i>Works on an IT algorithm to optimize the quality of the end products process through recognition of disturbances in the basic materials mix</i>

Source: TÜSİAD, 2016.

## 5. Structural Challenges of the National R&I System

According to the European Innovation Scoreboard 2017 Turkey is a **Moderate Innovator**<sup>24</sup>. Innovation performance has been improving at a slow but steady rate between 2008 and 2014, and for 2015 and 2016 a sharp increase can be observed. Turkey is catching up to the EU; its relative performance has improved from 38% in 2008 to 39% in 2014 and then jumped to 51% in 2015 and approximately 60% in 2016 turning the country from a Modest into a Moderate Innovator. Therefore, its performance relative to the EU has increased strongly. The performance improvement is the result of an almost twelvefold increase in Non-R&D innovation expenditures and a more than fourfold increase in Sales share of new product innovations.<sup>25</sup> However, in terms of linkages and entrepreneurship indicators (SMEs innovating in-house, innovative SMEs collaborating with others, public-private co-publications), negative changes have been observed.

There are recent attempts in Turkey in order to cope with the challenge of academia-business cooperation and mobility. In this regard, Ministry of Science, Industry and Technology introduced Government-University-Industry Cooperation Strategy and Action Plan for the years 2015 to 2018. Sample realized actions in the Government-University- Industry Cooperation Strategy Plan for the benefit of open labour market for researchers in HEIs. First, barriers to flexibility in personnel affairs of academic staff are removed for the benefit of Industry-Academy Cooperation. Academic personnel are now enabled to be employed in the R&D and design centers of private sector as full-time or half-time employee. Academicians can work in industry for a temporary period while keeping his/her academic staff statute. They can make use of this opportunity up to 1 year as full time employees after each six-year period with the permission of university governing board. Second, circulating capital of the university is redesigned for the benefit of academic staff who is engaged in university-industry cooperation. There is a net %85 gain of the revenue from the industry academy cooperation activities for academic staff without any deduction or income tax exemption. Third, a new mechanism of encouragement allowances for academic staff is designed; which is also in line with the third mission of HEIs. National or international registered patents, projects financed by private sector, industrial thesis projects are among the criteria for the calculation of the final score for the encouragement allowance of each academic staff. Fourth, there has been an amendment in the application criteria for associate professorship so as to include patents, start-ups and previous experience as a coordinator/researcher in research projects.

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<sup>24</sup> European Innovation Scoreboard 2017

[https://www.rvo.nl/sites/default/files/2017/06/European\\_Innovation\\_Scoreboard\\_2017.pdf](https://www.rvo.nl/sites/default/files/2017/06/European_Innovation_Scoreboard_2017.pdf)

<sup>25</sup> [https://www.rvo.nl/sites/default/files/2017/06/European\\_Innovation\\_Scoreboard\\_2017.pdf](https://www.rvo.nl/sites/default/files/2017/06/European_Innovation_Scoreboard_2017.pdf)

Another remarkable shift is the move from research to innovation. In addition, research and innovation is increasingly seen as a driver for competitiveness and growth and jobs in many sectors and to stimulate investment in general. It still requires a comprehensive strategy on how to achieve this target. The government considers an ecosystem approach centered on the business sector and entrepreneurs crucial for a well-functioning innovation system. Support for entrepreneurship and SMEs is therefore one of the priorities of the Supreme Council for Science and Technology (SCST). Several decrees and policy initiatives have recently been put in place, such as the International Incubation Centre in 2015 and the Acquisition of Foreign High-Tech Companies and R&D Centers of International Enterprises, both in 2014. MoSIT started the Technological Products Promotion and Marketing Programme in 2013 and the Technological Products Investment Support Programme in 2014. Both target firms that have previously received public/international R&D and innovation support.

The Incubation Centre and Accelerator Support Programme also addresses the challenge of increasing international cooperation as it intends to support Turkish companies on international markets e.g. by facilitating global market penetration of products or providing special support to start-ups, and using knowledge capacity of Turkish researchers living abroad. In 2016, the SME Development Organisation (KOSGEB) granted USD 4 million PPP (TRY 5.2 million) for the establishment of incubation centres in the United States only. Moreover, the Investment Support and Promotion Agency (ISPAT) is in the process of developing a new investment support and promotion scheme to attract foreign R&D investments. Researchers are also encouraged to conduct research abroad via several fellowships or grant programmes. The Academy of Sciences (TÜBA) has implemented a new award programme to foster international mobility of researchers in 2015. In addition, in order to facilitate technology transfer from abroad, the Directive on Support for Market Research and Penetration was amended in 2015.

With respect to innovation, Turkey has taken several measures identified in the Innovation Union flagship and there is still room for improvement, as Turkey intends to do, in particular to stimulate cooperation between Academia and Industry and develop new technologies and products.

All efforts mentioned above should also contribute to the process of harmonization with the *acquis communautaire on research and innovation (Accession Chapter 25)*. Turkey is actively reforming, there is commitment to act sufficiently in line with the EU *acquis* and notably with the ERA priorities. Turkey, as a country associated to the EU research and Innovation Programme 'Horizon 2020', has been invited to prepare a National Roadmap in line with ERA. There is commitment of TUBITAK and leading universities to launch actions for compliance to ERA priorities. Turkey has from the very beginning



followed the actions in ERA and establish already in 2015 its own ERA framework. "Turkish Research Area" (TARAL) launched by BTYK (Supreme Council of Science and Technology) inspired by ERA.

Based on the discussion above, the following challenges have been identified for Turkey:

- *Promoting research commercialisation from universities*: This can take place in various forms, such as university start-ups and spin-offs, mobility of researchers and students, contract research projects, joint research projects, innovative public procurement, licensing, consulting, trainings, formal and informal networks, competitiveness clusters etc. This is also underlined by the Global Competitiveness Index in which Turkey has a relatively weak performance. The relatively limited correlation between specialisation in science and specialisation in technologies suggests that the knowledge transfer towards industry through technologies is limited in Turkey.<sup>26</sup> The decisions of the 23<sup>rd</sup> meeting of BTYK and the National Science, Technology and Innovation Strategy 2011-2016 focus on this challenge. The Entrepreneurial and Innovative University Index has been established. Universities included in this index are eligible to apply for support to establish technology transfer offices. In 2013, 10 such offices have been supported. Another 10 are received the support in 2014 and 5 more in 2015. The enrichment of the policy mix with a variety of measures (financial, non-financial, etc.) will help to address this challenge.
- *Increasing the number of innovative high-growth start-ups*: This is an important challenge facing the innovation and economic performance of the country. The underdeveloped venture capital and business angels markets, as well as the limited number and variety of policy measures for start-up creation, are crucial impediments for the establishment and development of innovative businesses in Turkey. It is also a barrier for encouraging educated and qualified human resources to see entrepreneurship as a career option. Insufficient early stage funding is also an obstacle for the development of venture capital industry as it helps to generate a large flow for venture capital investments. The BTYK decisions of December 2011 recognise this challenge and aim to address through new policy measures. Furthermore, the Undersecretariat of Treasury carries out studies for improving the framework conditions for angel investments, and the 'Entrepreneurship Council' established in January 2012 aims to increase number of innovative and technology-based start-ups<sup>27</sup>.
- *Increasing R&D and innovation capabilities of the private sector (in particular, micro, small and medium enterprises (MSMEs))*: The low levels of absorptive capacity of the business sector, particularly that of MSMEs, is a barrier to increase R&D and innovation performance. MSMEs

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<sup>26</sup>[http://www.ewi-vlaanderen.be/sites/default/files/science\\_research\\_and\\_innovations\\_performance\\_of\\_the\\_eu.pdf](http://www.ewi-vlaanderen.be/sites/default/files/science_research_and_innovations_performance_of_the_eu.pdf)

<sup>27</sup> <http://www.sanayi.gov.tr/NewsDetails.aspx?newsID=2292&lng=tr>

constitute 99.9% of the total enterprises and 78% of employment in Turkey, according to KOSGEB. Micro enterprises constitute the majority of MSMEs. They are mainly active in traditional, middle to low-tech sectors, such as garments (14%), furniture (14%), metal products (14%), wood products (10%) and food (8%) (KOSGEB 2011)<sup>28</sup>. There exist policy measures for increasing R&D and innovation investment of the private sector and SMEs, and the National Science, Technology and Innovation Strategy 2011-2016 highlights the role of SMEs. It is important to design and implement specific measures (such as support for R&D/innovation vouchers and knowledge intensive service activities, etc.) for enhancing the learning capabilities, absorptive capacity, and R&D and innovation capabilities of MSMEs and other private sector companies.

- *Focusing on strategic approach on access to finance:* According to the Global Competitiveness Report 2015-2016<sup>29</sup> of the World Economic Forum, `venture capital availability` has one of the worst ranking indicators (93<sup>rd</sup>) in Turkey. The underdeveloped venture capital and business angels markets, as well as the limited number and variety of policy measures for start-up creation, seem to be significant barriers for the establishment and development of innovative businesses in Turkey. The impact of existing strategies should be evaluated and the policy mix should evolve based upon these evaluations. The frequent changes in entrepreneurship supports may have the potential to destabilize the ecosystem.
- *Increasing availability and quality of research personnel:* As evident by indicators, Turkey has a very low share in knowledge-intensive activities, partly explained by the importance of employment in the agriculture, construction and tourism sectors<sup>30</sup>. This has long been recognised as one of the challenges of the Turkish research and innovation system by the government and specific interventions have helped improvements in trends. Current strategies and action plans indicate ongoing commitment in this area. Further efforts and diversified measures are needed to develop human resources in a way that the absorptive capacity of companies is enhanced, and the quantity and quality of researchers are increased. The BTYK decisions of December 2011 and August 2012 support the steps to be taken to tackle this challenge.

A summary of these challenges is presented in Table 1:

**Table 1: Structural Challenges of National R&I System**

Challenge	Main Conclusion
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<sup>28</sup> <http://www.kosgeb.gov.tr/Pages/UI/Baskanligimiz.aspx?ref=23>

<sup>29</sup> [http://www3.weforum.org/docs/gcr/2015-2016/Global\\_Competitiveness\\_Report\\_2015-2016.pdf](http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf)

<sup>30</sup> [http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/iuc\\_progress\\_report\\_2014.pdf#view=fit&pagemode=none](http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/iuc_progress_report_2014.pdf#view=fit&pagemode=none)

Promoting research commercialisation from universities	The enrichment of the policy mix with a variety of measures (financial, non-financial, etc.) will help to address this challenge
Increasing the number of innovative high-growth start-ups	The underdeveloped venture capital and business angels markets, as well as the limited number and variety of policy measures for start-up creation, are crucial barriers.
Increasing R&D and innovation capabilities of the private sector	The low levels of absorptive capacity of the business sector, particularly which of MSMEs, is a barrier to increase R&D and innovation performance.
Focusing on strategic approach on access to finance	The impact of existing strategies should be evaluated and the policy mix should evolve based upon these evaluations.
Increasing availability and quality of research personnel	Further efforts and diversified measures are needed to develop human resources in a way that the absorptive capacity of companies is enhanced, and the quantity and quality of researchers are increased.

**6. Concluding Remarks**

In Turkey, there exist various instruments to tackle structural challenges towards the digital transformation summarized in Table 1. The most significant shortcoming of all these measures being the inexistence of evaluation studies on these support programmes. Although the establishment of evaluation office at MoSIT is a step forward, another concern is an urgent need to develop an evaluation culture and establish an effective mechanism for systematic evaluation of the public R&D funding system, policies and policy measures on the basis of internationally recognised criteria. Therefore, without an attempt of systematic impact assessment and evaluation studies, it is not possible to evaluate the consequences of the current funding system. Turkey is a support schemes’

heaven in some sense yet it has not been evaluated whether these schemes result in optimal outcomes or if sub-optimal ones are obtained. Therefore, how to deal with the difficulties are not clear. For instance, although various interfaces like technology parks, incubators, TTO's etc. were created to speed up the innovative activities of firms and to enhance university-industry interactions, there is no real strategy pertaining to knowledge transfer among university and industry. There is an urgent need to create favourable conditions to foster a growing and robust venture capital market, especially for early stage investments. Moreover, the rules and procedures and streamline processes for starting up, running and terminating a business should be improved for the effectiveness of entrepreneurship incentives. The rules for starting up and running a business are not simple nor designed from an SME perspective. Heavy bureaucracy in applications and red tape are still observed. Although the legal framework seems to be transparent and up-to-date, clientelism is a fact at some instances<sup>31</sup>. Another measure to be introduced is the development of efficient standard-setting system supporting innovative products and services.

In sum, Turkey is a heaven for policy documents, strategies and mechanisms yet it suffers a lot in terms of implementation. Besides the structural challenges mentioned above, there is a need for higher skilled labor force but the frequent changes in national education system seems to be a barrier for such an attempt. Another risk the premature deindustrialization especially connected with SMEs. The low export share of hi-tech products and also seem to be a barrier for an accelerating transformation. All these structural challenges can be mitigated with a holistic approach with the contribution of all stakeholders in the ecosystem including public sector, large corporations and SMEs and knowledge generators. All the stakeholders in the ecosystem need to prepare road maps in accordance with their business models for the digital transformation by explicitly specifying the required policy tools at different levels, namely micro, meso and macro levels. These business models should consider the resolutions for the problems involved in horizontal and vertical supply and value chains. On the other hand, public sector should outline an action plan especially for the infrastructural problems such as skill requirements, ICT infrastructure, SMEs capabilities, etc. Otherwise, the digital transformation process becomes a threat on the road towards the deindustrialization of the country rather than being an opportunity.

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<sup>31</sup> Ocakli, F., 2016, Political entrepreneurs, clientelism, and civil society: supply-side politics in Turkey, *Democratization*, 23, 723-746.

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