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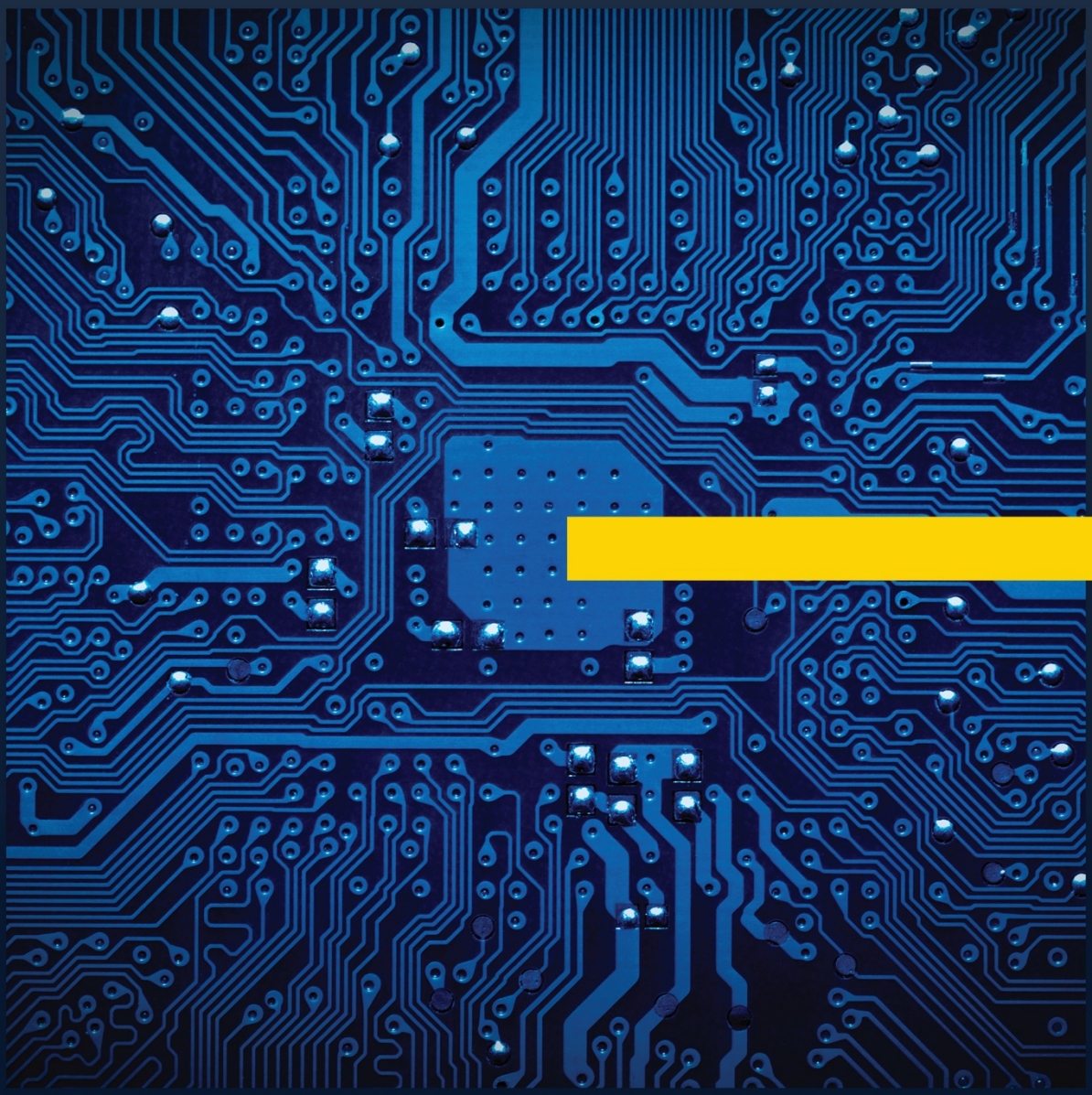

PATH FOR UKRAINE'S ECONOMIC GROWTH: TECHNOLOGY UPGRADING

WORLD BANK GROUP

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October 2019

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ABBREVIATIONS AND ACRONYMS

EBRD	European Bank for Reconstruction and Development
ECI	Economic Complexity Index
EU	European Union
FDI	Foreign Direct Investment
GCR	Global Competitiveness Report
GDP	Gross Domestic Product
GVC	Global Value Chains
HHI	Herfindahl-Hirschman Index
IAOP	International Association of Outsourcing Professionals
ICT	Information and Communication Technology
IP	Intellectual Property
ISO	International Standards Organization
IT	Information Technology
ITU	Index of Technology Upgrading
NRBS	Natural Resources-based Sector
SMEs	Small and Medium Enterprises
R&D	Research and Development
RTD	Research, Technology, and Development
S&E	Science and Engineering
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USPTO	United States Patent Trademark Office
WEF	World Economic Forum

ACKNOWLEDGEMENTS

This report was prepared by Slavo Radosevic (Professor, University College London - UCL), Randolph Bruno (Associate Professor, UCL), Christopher Hayter (Assistant Professor, Arizona State University), and Anwar Aridi (Private Sector Specialist, World Bank) with excellent research assistance from Kiril Osaulenko (Consultant).

The team was led by Anwar Aridi (Private Sector Specialist – Task Team Leader), the editor of the report, with support from Iryna Kuzmina (Consultant).

The report benefited from the generous feedback provided by Ernesto Lopez-Cordova (Lead Economist), Paulo Correa (Lead Economist), and Austin Kilroy (Senior Economist). William Shaw provided useful editorial review.

This report was made possible by the financial support of the Swedish Government.

EXECUTIVE SUMMARY

OBJECTIVE

Despite its enormous potential, the Ukrainian economy has declined for much of the past three decades. Per capita income fell by 28 percent from 1990 to 2018, and productivity remains below 1990 levels. Poor economic performance was in part due to severe economic shocks, but also reflects structural difficulties faced by companies and institutions forced to adapt to competitive global markets.

The purpose of this report is to examine Ukraine's economic decline and development through the lens of technology upgrading. The technology upgrading framework assumes that economic growth is a function of technology capability, whereby upgrading occurs through technological, industrial, and organizational change. Technology upgrading contrasts with approaches that frame the issue as R&D-based growth based on the *linear model of innovation*[1]. Within this perspective the poor performance of the Ukrainian economy reflects its limited capability to generate, as well as absorb, new technology. The report applies the **technology upgrading framework** to analyze the Ukrainian economy. The framework is comprised of three interrelated components:

- **Technology Intensity:** evaluates the depth of industrial capabilities by examining five aspects of the economy, including production, management, R&D, and technology capabilities, as well as innovation activities.
- **Structural Features:** signals the extent to which capabilities are present across different structural features of the economy; i.e. the breadth of technology upgrading. Structural features include four sub-components, which are economic complexity, infrastructure, knowledge diversification, and firm structure.
- **Interactions with the Global Economy:** measures the extent to which an economy is involved in knowledge and technology exchange in the global economy in support of technology upgrading.

The report also features **a case study on Ukraine's booming ICT sector**. ICT was chosen because it is Ukraine's fastest-growing sector and showcases the country's potential, while simultaneously demonstrating which factors and capabilities can constrain its future growth.

[1] The early model (from the 1980s) postulates that innovation starts with basic research, followed by applied research and development, and results with production of commercial products/services and diffusion.

KEY INSIGHTS

With some exceptions, Ukraine fairs poorly in terms of technology upgrading. Ukraine ranks last among comparison countries in a composite index of technology upgrading, with especially low performance in terms of production, management, and R&D capabilities. Ukraine scores somewhat better in terms of structural features, though it still ranks poorly due to weak organizational capabilities. Ukraine-based corporations do not possess the size and scale to compete internationally even when compared to similar economies. Ukraine scores less poorly in terms of interactions with the global economy due to increasing inflows of FDI and the emergence of the ICT industry. However, despite its proximity to the EU market, Ukraine could be much better integrated into international and European supply chains, which could be a primary source of new technological and managerial knowledge.

While Ukraine has developed a vibrant ICT industry, significant challenges exist for its long-term success. The ICT industry developed due to Ukraine's stock of talented human capital, a low self-employment tax, growing international demand for software services, an active knowledge diaspora, and low barriers to entry. The majority of firms in the ICT industry are small and focus on low-value added segments of the market. However, there is a significant segment of firms that have advanced technical and managerial capabilities and that are developing new products and services. Nevertheless, the lack of managerial talent, policies that disincentivize capability-building, and low domestic demand for services mean that the ICT industry and other industries that could benefit from digitization are not realizing their upgrading potential.

KEY RECOMMENDATIONS

To address the challenges described in the report, three main areas for policy action are recommended. These include: (1) the development of firms' managerial capabilities and adoption of productivity-enhancing technologies, (2) better integration into global value chains, and (3) supply and retention of a digital-ready workforce. The report also offers cross-cutting recommendations for improving Ukraine's business environment and the complementarities needed for firms' growth and upgrading. These recommendations are drafted in recognition of the low institutional capacity of the Ukrainian government bodies dealing with firm innovation, as well as the country's unique policy context.

- **Address constraints related to the business environment.** Industrial upgrading is limited in Ukraine by its weak business environment, including an overly-flexible labor market, corruption and weak intellectual property. Efforts to improve the business environment

could include industry-specific reforms and a gradual reform in the FOP tax[2] system, based on an analysis of the sectoral impact and aiming at reducing distortions. These reforms and analysis could involve industry stakeholders and associations to outline specific roadmaps.

- **Build managerial and technical capabilities.** Capabilities can be built incrementally through a piloting approach that leverages productivity-improving technologies. These could include vouchers or cost-sharing arrangements to incentivize firms to upgrade managerial capabilities and adopt process improvement techniques, international production and managerial standards, and new technologies that support increased productivity, including ICT solutions. Further, the mismatch between public R&D funding and the needs of industry could be addressed through a pilot program to restructure public R&D institutions to be more demand-driven and support innovative activity within industry.
- **Facilitate domestic and international industry linkages.** Ukrainian firms suffer from poor adoption and implementation of international quality standards. To address this challenge, a pilot program can help Ukrainian SMEs integrate into global supply chains through twinning projects with foreign companies. Foreign companies could realize improvements in productivity and quality while gaining greater understanding of Ukrainian markets.
- **Invest in digital-ready human capital.** The growing need for ICT engineers and the rapid out-migration of industry talent underlines the need for investment in and expansion of digital-ready human capital. Ukraine could implement education reforms and introduce training programs at universities and technical schools to enhance the supply of trained and tech-savvy ICT workers. University-Industry Advisory Boards could also be established to guide these programs and help develop modules emphasizing advanced skills that would help the industry move into high-value added services and product development.

[2] FOP or Personal Entrepreneurs Systems enables natural persons to conduct business (services, trading) without incorporation of a separate legal entity. This form of business is simple to register and can offer good tax savings through the Simplified Tax regime. In Ukraine, this is also widespread alternative to employment as amount of tax accrued on income of Private Entrepreneurs is much lower than the amount of taxes accrued on salaries of employees.

1. INTRODUCTION

Despite its enormous potential, the Ukrainian economy has declined for much of the past three decades. Per capita income fell from $11,910 in 1990 to $8,573 in 2018, although data on GDP may exaggerate the extent of the fall in welfare (since relative prices have changed dramatically). Ukraine has fallen further behind Central European peers, which are Poland, Belarus and Romania (Figure 1). Labor productivity has improved somewhat since 2010, but nonetheless remains below 1990 levels while peer countries have realized significant gains (Figure 2)—and the growth in total factor productivity has remained largely negative since 1991. This dismal history in part reflects severe economic shocks, including the economic disruptions during the transition to a market economy, the impact of the Global Financial Crisis in 2008, and the conflict in eastern Ukraine in the past five years. At the same time, limited productivity gains also can be attributed to the structural difficulties faced by Ukrainian industry, as manufacturing's share of output has dropped sharply and goods exports have become focused on primary, rather than higher value added, goods. While the agricultural sector remains strong and the share of services in GDP has almost doubled since 1990, declines in manufacturing are now limiting further growth of the services sector.

The poor performance of manufacturing reflects the economy's limited capabilities to absorb and generate new technology. Some positive trends are based on technological upgrading, in particular the rapid and sustained growth of the ICT sector and the emerging exports of machinery and equipment products. Nevertheless, exports are dominated by commodities like agriculture, iron and steel. The emergence of the ICT sector is important given the need for Ukrainian industries to enhance productivity growth through digitization, as well as digitization opportunities in other countries associated with Industry 4.0. However, the failure to upgrade industries and harness the emerging ICT sector would mean continued economic decline.

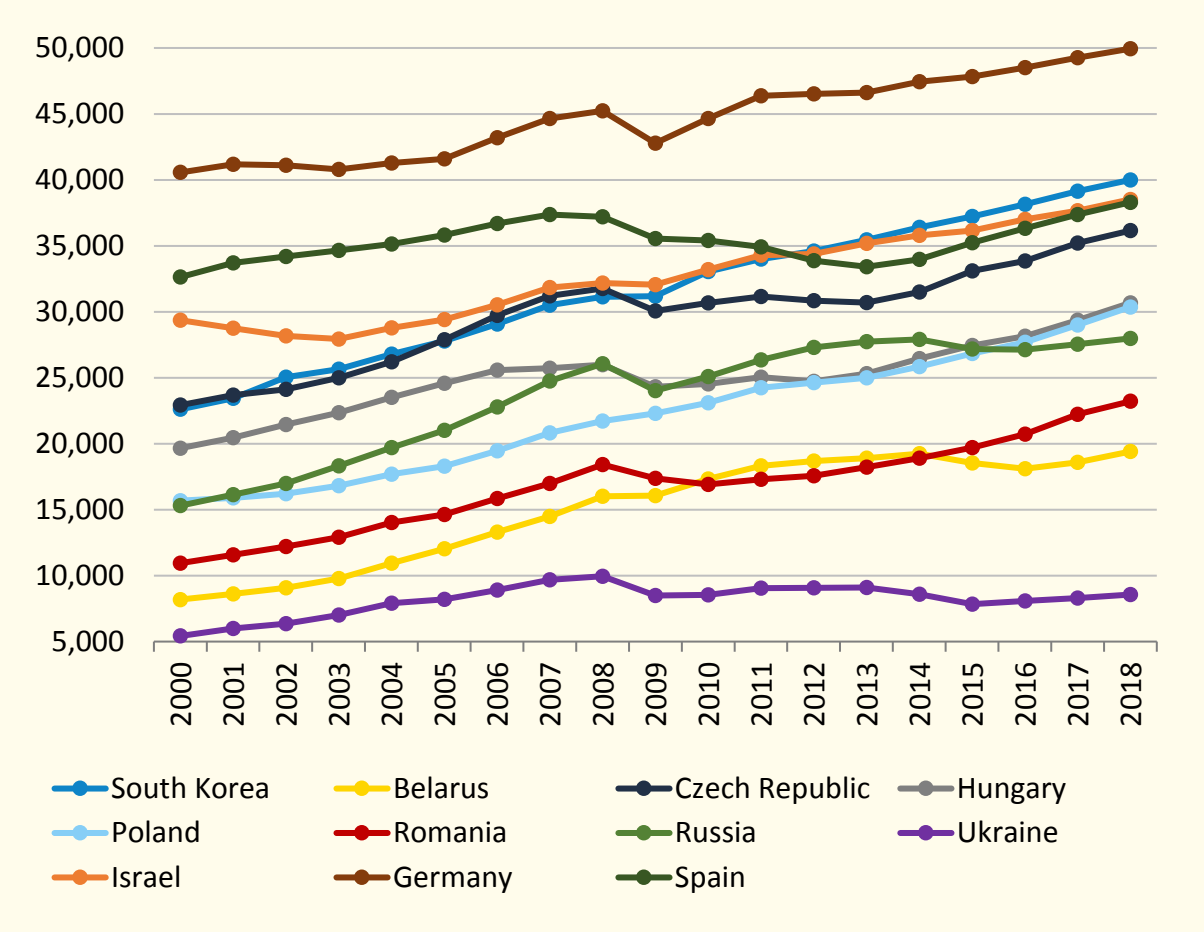
This study adopts a technology upgrading framework to analyze the decline in Ukraine's economy. The report complements four other World Bank studies focused on technology-based growth, including innovation and entrepreneurship ecosystem dynamics; intellectual property rights (IPR) and technology transfer regulation; public expenditures related to science, technology, and innovation; and a best practice review of fiscal incentives for science, technology, and innovation[3]. A focus on technological capabilities is appropriate for Ukraine's

[3] The four World Bank reports are available here:

- Cheney, David; Zolotarev, Andrey P.; Wyne, Jamil; Aridi, Anwar. 2017. Ukraine - Innovation and entrepreneurship ecosystem diagnostic (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/126971509628933853/Ukraine-Innovation-and-entrepreneurship-ecosystem-diagnostic
- Cirera, Xavier; Frias, Jaime Andres Uribe; Zolotarev, Andrey P.; Aridi, Anwar. 2017. Ukraine - Science, technology, and innovation public expenditure analysis (English). Washington, D.C. : World Bank Group.

status as a lower-middle income country and contrasts with approaches, such as those within the European Union (EU), that prioritize research and development (R&D) related targets.

Figure 1. Trends in GDP per Capita (in 2017 US$)



Source: The Conference Board Total Economy Database.

In middle-income countries, innovation most often occurs in "downstream" activities related to production capabilities, including technology and standards adoption, cost and quality-oriented process improvements, and improved management practices.[4] For

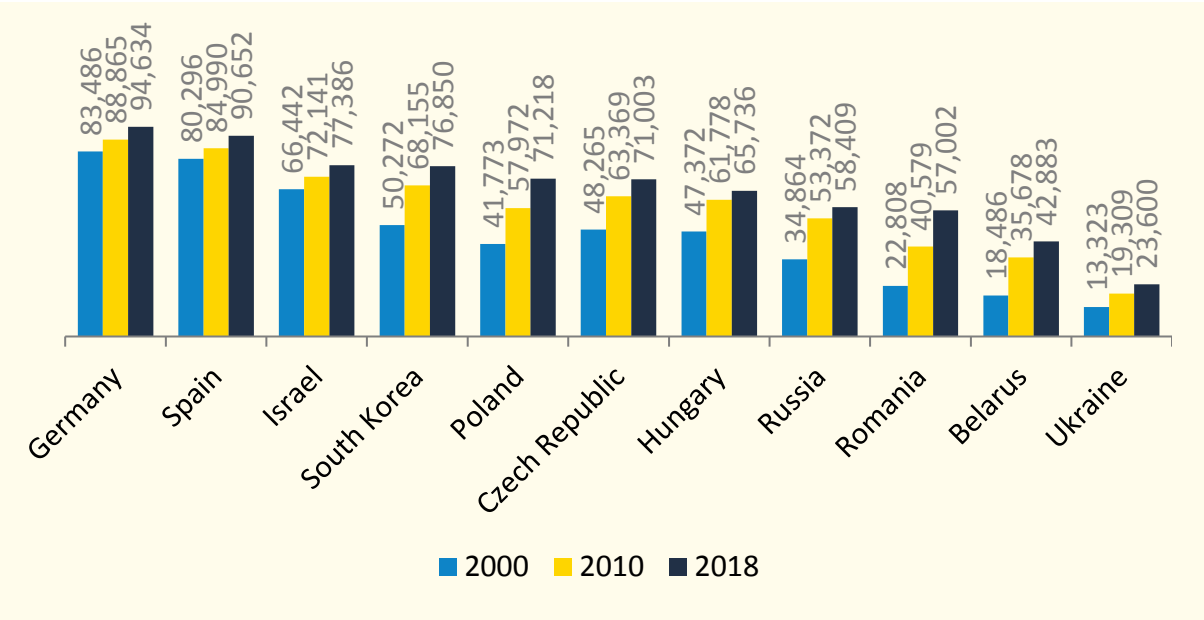
http://documents.worldbank.org/curated/en/314581509695378056/Ukraine-Science-technology-and-innovation-public-expenditure-analysis

- Guceri, Irem; Zolotarev, Andrey P.; Aridi, Anwar. 2017. Ukraine - Fiscal incentives for science, technology and innovation activities: good practice review report (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/928361509629258438/Ukraine-Fiscal-incentives-for-science-technology-and-innovation-activities-good-practice-review-report
- Stanković, Mirjana; Aridi, Anwar. 2017. Ukraine - Intellectual property and technology transfer regulatory review (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/133701509628796923/Ukraine-Intellectual-property-and-technology-transfer-regulatory-review

[4] Radosevic 2017.

example, Korea and Taiwan—which were poor, underdeveloped countries forty years ago—achieved rapid rates of economic growth by focusing on industrial upgrading, accumulating advanced industrial capabilities over time. Given its proximity to Western Europe and manufacturing and educational legacies, this study assumes that industrial upgrading similarly offers Ukraine a promising path for rapid economic development.

Figure 2. Labor Productivity: Output per Employed Person (in 2017 US$)



Source: The Conference Board Total Economy Database.

The technology upgrading framework assumes that economic growth is a function of technology capability, whereby upgrading occurs through technological, industrial, and organizational change. This framework, based on analytical work by Slavo Radosevic and Esin Yoruk,[5] conceptualizes technology upgrading as a three-dimensional process (Figure 3) that includes technology intensity, breadth of technology upgrading (structural features), and interactions with the global economy. Illustrated in Figure 3, technology upgrading is an outcome of the interaction between the intensity of technology-related activities (dimension I), structural factors that affect the breadth of upgrading (dimension II), and the way an economy interacts with the other two factors (dimension III). Each dimension can be evaluated using specific indicators illustrated in Table 1.[6] Further, the interaction of the dimensions and their respective indicators enable the creation of a composite index of technology upgrading, thus providing a holistic understanding of Ukraine's economic performance and enabling comparisons with peer and aspirational countries (See Annex 1 for a more detailed discussion on the framework).

[5] For further explanation, see Radosevic and Yoruk (2016, 2018).
[6] See Radosevic and Yoruk (2016, 2018) for a discussion of the selection of the specific indicators.

Section 2 uses this framework to explain why the Ukrainian economy continues to decline, especially in comparison to other countries in Central and Eastern Europe, such as the Czech Republic and Hungary, as well as aspirational benchmark countries, such as South Korea, Israel, and Germany. Section 3 discusses the rapid growth of Ukraine's booming ICT sector and its role in technology upgrading. Based on a comprehensive review of academic research and qualitative interviews with ICT entrepreneurs and managers, investors, and industry analysts, the study finds that significant but not yet exploited opportunities exist to connect ICT capabilities to needed industrial upgrading within other sectors (e.g., agriculture, engineering, heavy manufacturing), and to upgrade the management and technical capabilities of the ICT sector itself. Finally, Section 4 provides policy recommendations, linked to specific challenges identified within the report, for technology upgrading in Ukraine.

Figure 3. Dimensions of Technology Upgrading

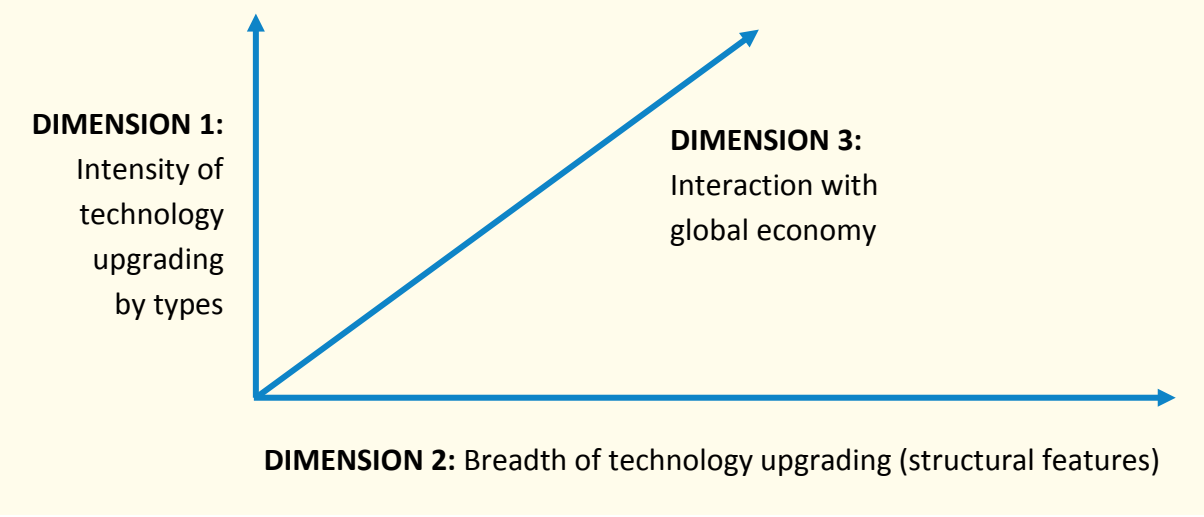


Table 1. Technology Upgrading Framework

Category	Sub-category
Technology Intensity	**Index A**
	Production capabilities
	Management capabilities
	R&D capabilities
	Technology capabilities
	Innovation capabilities

Category	Sub-category
Structural Features (Breadth)	**Index B**
	Economic complexity
	Infrastructure
	Knowledge diversification
	Firm structure
Interactions with the Global Economy	**Index C**
	Connections to Global Value Chains (GVCs)

Note: For the list of indicators that measure each of the categories, see Annex 1.

2. TECHNOLOGY UPGRADING ANALYSIS

This section discusses Ukraine's performance according to the technology upgrading framework, which is based on three components: technology intensity, breadth of technology upgrading (structural features), and interactions with the global economy.

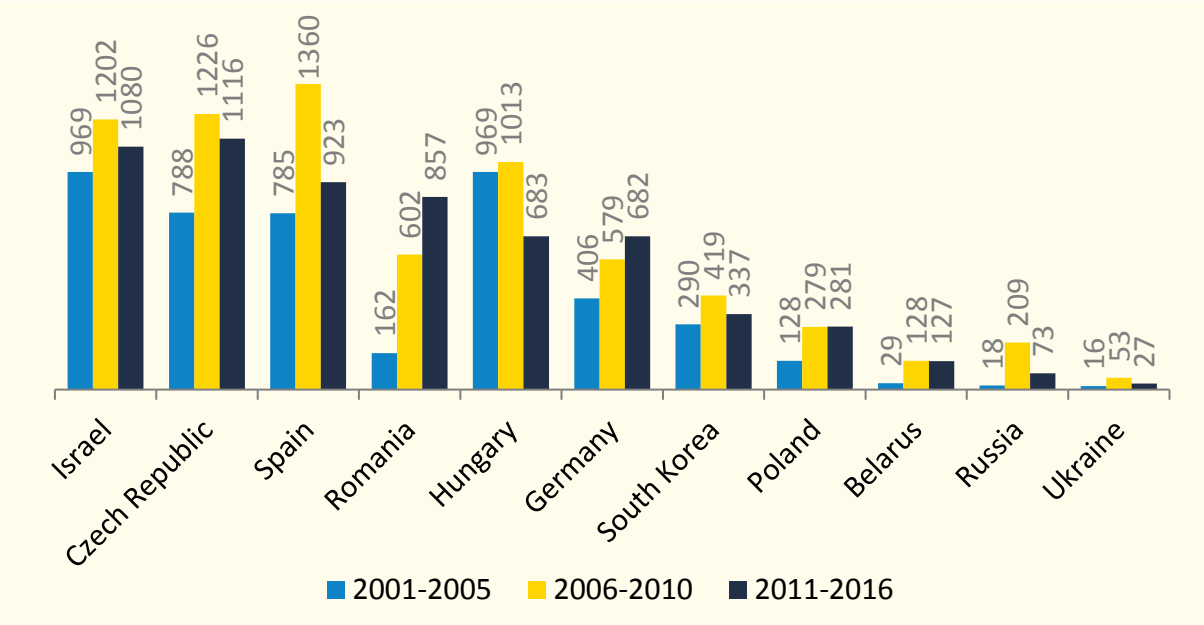
2.1. TECHNOLOGY INTENSITY

The technology intensity component of the industrial upgrading framework is comprised of five sub-categories, which are production, management, R&D, and technology capabilities, as well as innovation activities. An in-depth understanding of how Ukraine scores within each of these categories supports the study's overall finding that poor technology upgrading capabilities are an important driver of the decline in the Ukrainian economy.

2.1.1. PRODUCTION CAPABILITIES

The production capabilities sub-category measures the quality of activities related to production. The indicators used include the extent of adoption of the International Standards Organization (ISO) 9001 guidelines, reliance on trademarks and industrial design counts, and the use of on-the-job training.

Figure 4. Number of ISO 9001 Certificates (per million inhabitants) (Average rate per period, 2001–2015)



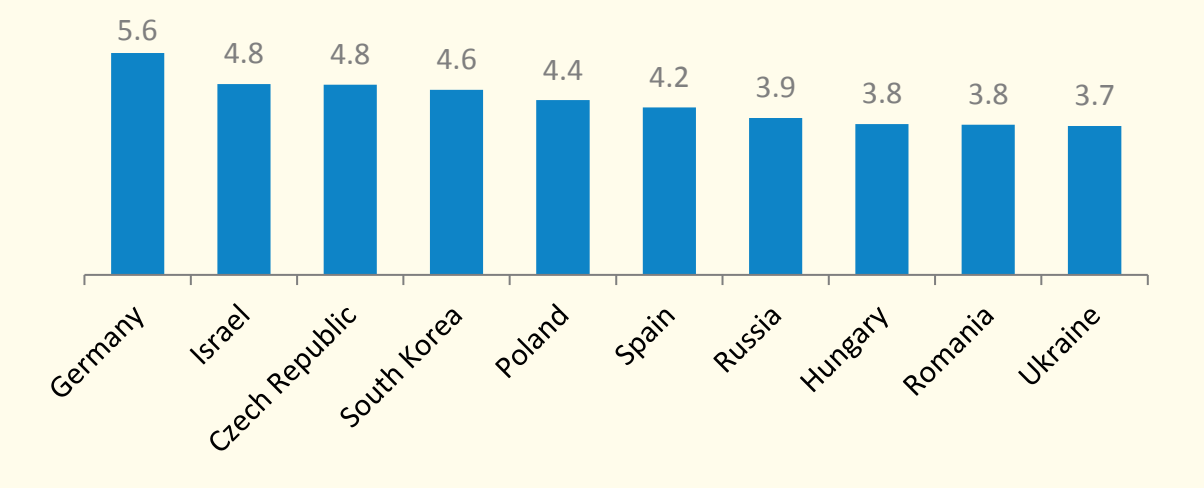
Source: Authors, based on ISO Database.

Ukraine has a relatively low rate of ISO 9001 adoption, with only 27 certificates per million residents (in 2011-2016) (Figure 4). ISO 9001 certification demonstrates a company's capability to consistently provide products and services that meet customer and regulatory requirements. ISO certificate adoption per capita is thus one indicator of the quality of production, including services. Ukraine lags not only behind its Central European peers but also behind Belarus and Russia, both economies that are traditionally more dependent on internal markets compared to Ukraine.

A low rating in adoption of quality increasing activities is commensurate with the low priority given to on the job training (Figure 5). Ukraine scores slightly lower than some of its Central European peers, such as Romania and Hungary, and far lower than aspirational countries.

On the other hand, the use of trademarks and industrial design counts has increased, which reflects increasing competition (primarily through product differentiation) in consumer goods and services in the local market, rather than in more demanding international markets (see Annex 3 figures 1 and 2).

Figure 5. Composite Assessment of On-the-job Training (Average 2007–2017)



Source: World Economic Forum (WEF) Global Competitiveness Report (GCR) Database.

2.1.2. MANAGEMENT CAPABILITIES

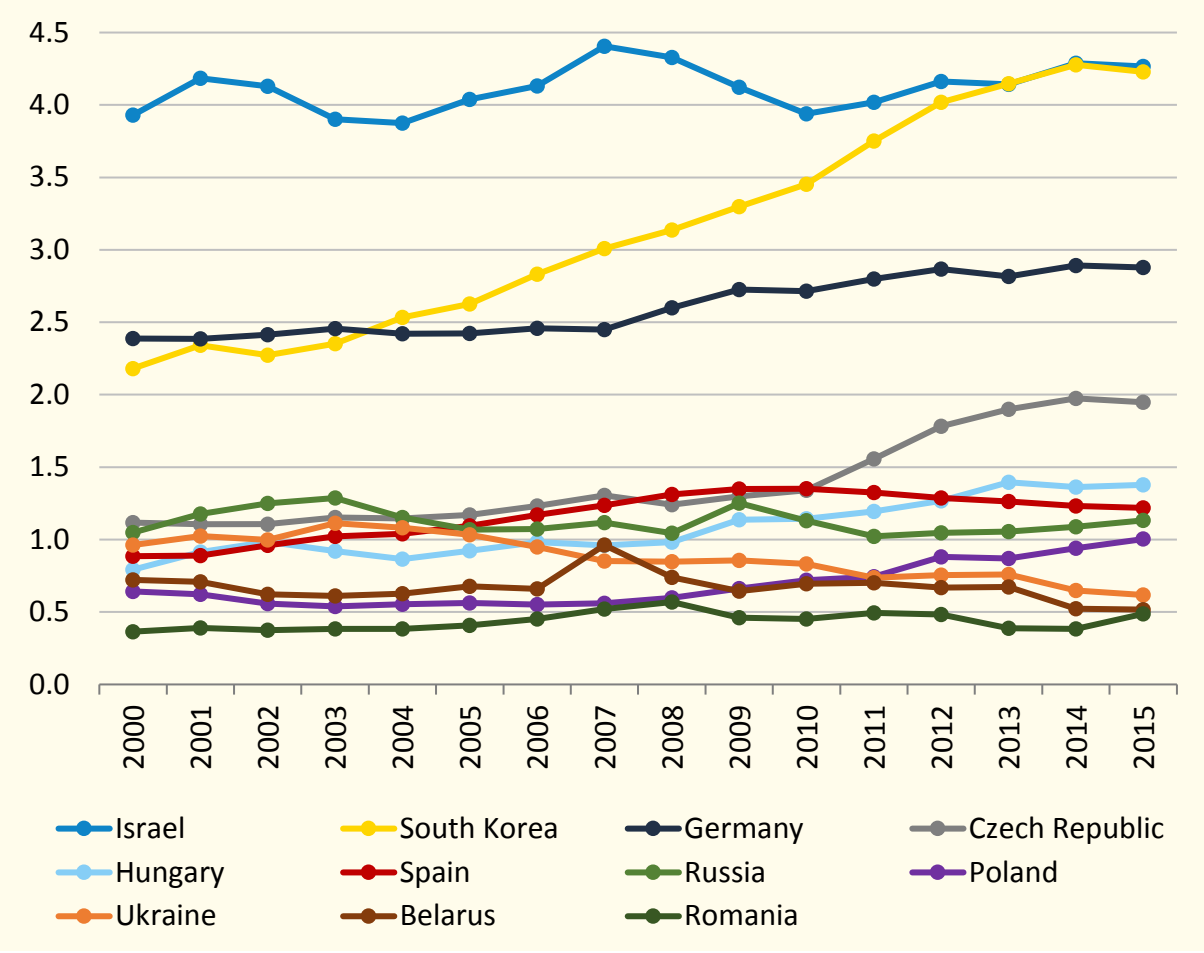
Ukrainian enterprises possess relatively weak management capabilities. Management capabilities are critical to the performance and growth of businesses and other organizations, and thus their aggregate contribution to the Ukrainian economy. The only available data, from a 2009 European Bank for Reconstruction and Development (EBRD)/World Bank survey of

firm-level management practices[7], finds that significant management-related challenges exist in Ukraine in areas such as the extent to which management shares enterprise performance data with employees, local enterprise autonomy, computer and high-speed internet utilization, and innovative behavior. More positive findings are that Ukrainian firms make use of production targets and reward a high percentage of employees for successful firm-level performance.

2.1.3. R&D CAPABILITIES

While R&D spending is not prioritized in the technology upgrading framework, it is nonetheless an important consideration for economic performance.

Figure 6. R&D Expenditures as a Percentage of GDP

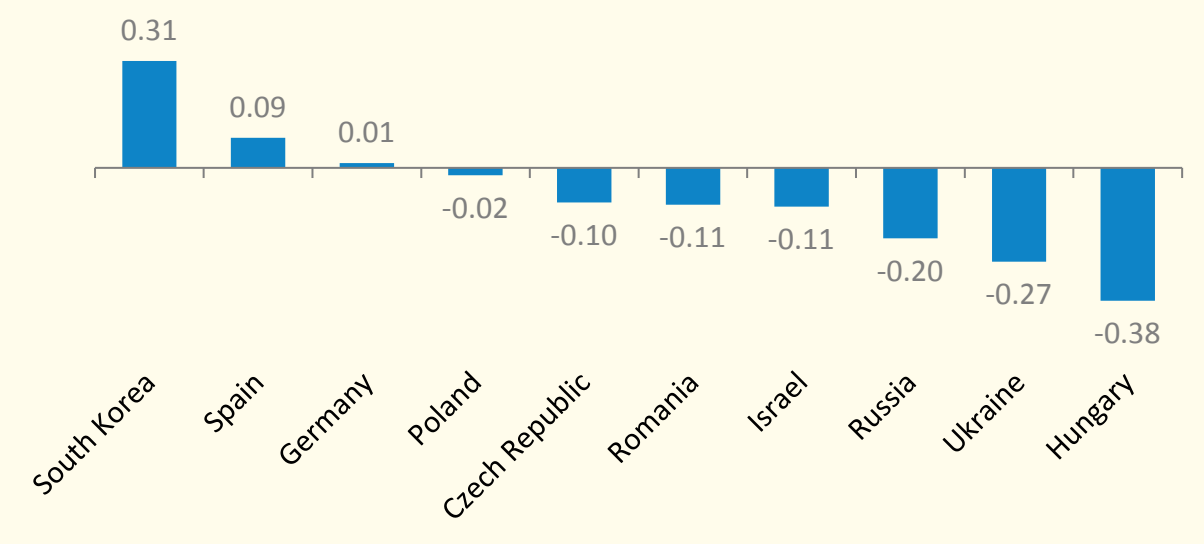


Source: World Bank Development Indicators

[7] The survey includes questions such as the extent to which managers use performance data, production targets, and employee incentives, as well as utilization of R&D and introduction of new products (the latter two aspects are discussed in the sections below). Link to the sources: https://www.ebrd.com/what-we-do/economic-research-and-data/data/moi.html

Ukraine has seen a steady and significant decline in its R&D capabilities. R&D expenditures fell from 1.0 percent of GDP in 2000 to 0.6 percent of GDP in 2015 (Figure 6). Ukraine spends less, relative to GDP, than all comparators in Figure 6 except Romania and Belarus, and spends far less than South Korea and Israel, which spend more than 4 percent of GDP on R&D. The number of researchers per million inhabitants plummeted from 2,156 in 1997 to 1,826 in 2000 and then to 1,259 in 2015 (see Annex 3, Figure A3). Similarly, the share of technical personnel in R&D employment has declined from 12 percent in 2006 to 9.8 percent in 2015[8]. The overall erosion of R&D system is also reflected in relative decline of S&T articles per million people (see Annex 3, figure A4). Ukraine also ranks at or near the bottom in comparisons of the quality of research institutions[9].

Figure 7. Net Demand for RTD Servicesa (Average 2007–2018)



Source: Authors based on GCR Database 2019.
Note: a. Net demand is difference in assessment between demand and supply for RTD. Demand for RTD is average of the following indicators: the extent of staff training, on-the-job training, degree of customer orientation, buyer sophistication, and firm-level technology absorption. Supply of RTD is average of the following indicators: quality of the education system, quality of math and science education, availability of research and training services, quality of scientific research institutions, and availability of scientists and engineers.

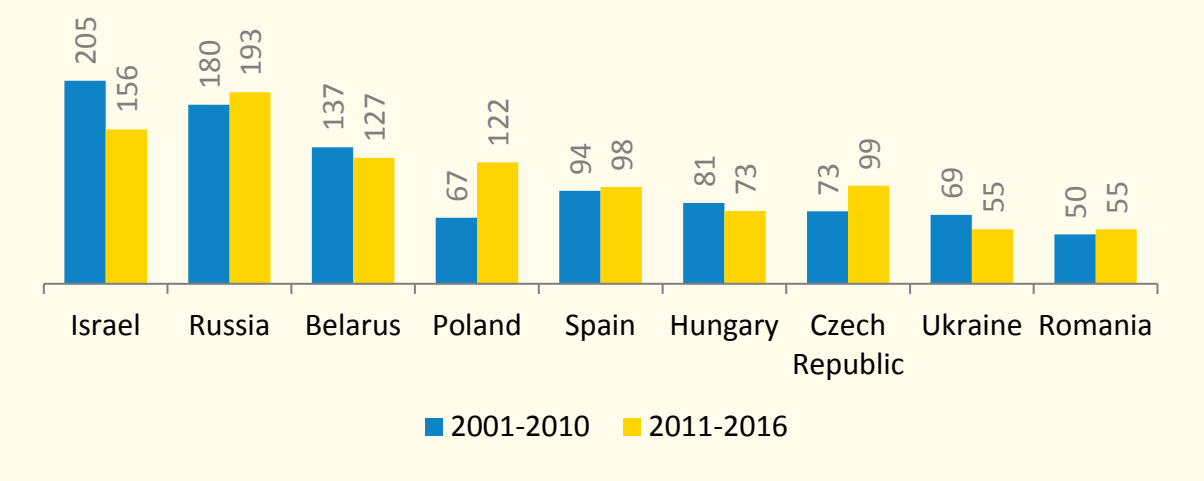
2.1.4. TECHNOLOGICAL CAPABILITIES

Technological capabilities to generate new knowledge behind or at the technology frontier are reflected in domestic and international patenting, respectively.

[8] Source: UNESCO UIS database
[9] Source: WEF GCR database

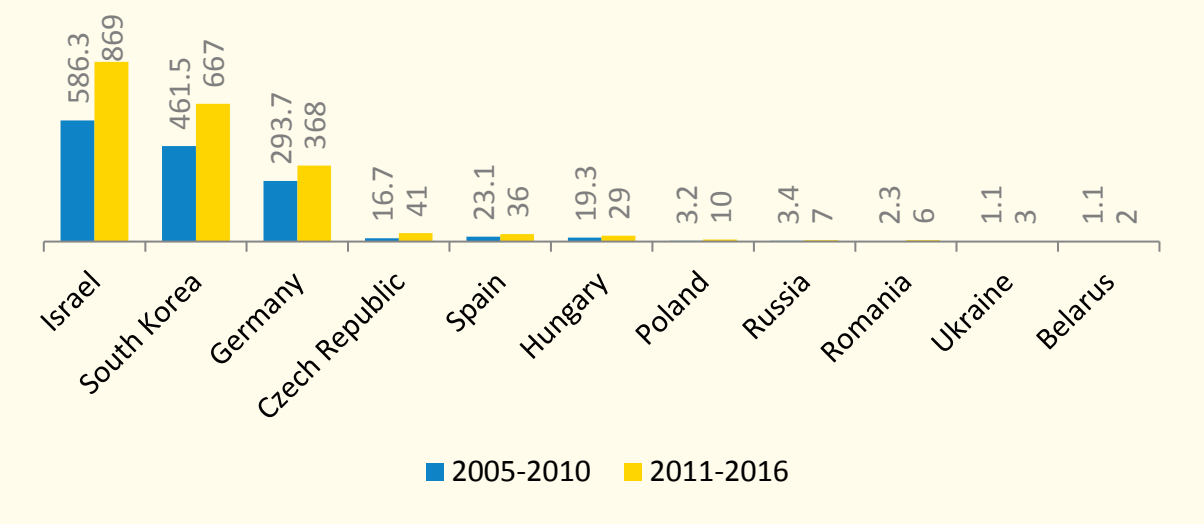
Ukraine has one of the lowest patenting rates among peer and aspiration countries.[10] Ukraine is next to last among comparators in terms of residents' domestic patents per capita (Figure 7), and its patenting rate has declined steadily since 1992. International per capita patent applications to the U.S. Patent Trademark Office (Figure 8) have increased, but remain very low. In other words, Ukraine's capacity to generate innovations that are below the technology frontier has declined substantially, while its capacity to generate knowledge at the technology frontier is marginal.

Figure 8. Average Number of Resident Patents (per million inhabitants)



Source: WIPO Statistics Database.

Figure 9. Patent Applications to the USPTO (per million inhabitants)



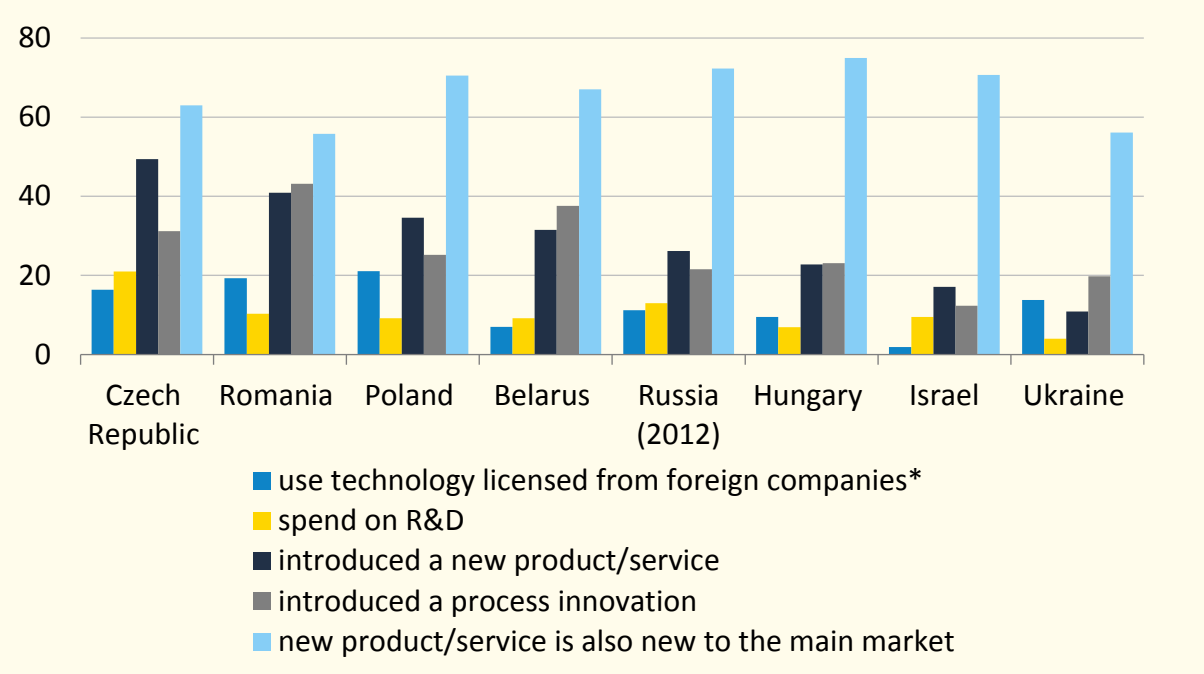
Source: WIPO Statistics Database.

[10] The technology capability aspects of the technology upgrading framework are meant to provide an understanding of a country's ability to generate technology through an examination of patenting activity.

2.1.5. INNOVATION CAPABILITIES

Ukraine's performance in firm-level innovation capabilities is mediocre.[11] The country ranks in the middle of the comparison group in terms of the percentage of companies that introduce a process innovation and license technology from foreign firms (Figure 9). However, Ukraine ranks last in terms of the percentage of companies that conduct R&D and introduce a new product or service (WBES, 2013).

Figure 10. Innovation-related Activities among Firms (2013)



Source: 2013 World Bank Enterprise Survey.

An increasing number of Ukrainian firms are re-engaging in innovative activities, although the share of firms involved in innovation only recently reached the level seen in 2002 (see Annex 3 figure A5). Moreover, the overall frequency of these activities is still marginal, which is consistent with the low level of the index of technology upgrading (see below). Innovation activities are confined to a small share of firms, which explains the weak link between aggregate trends in innovation and productivity.

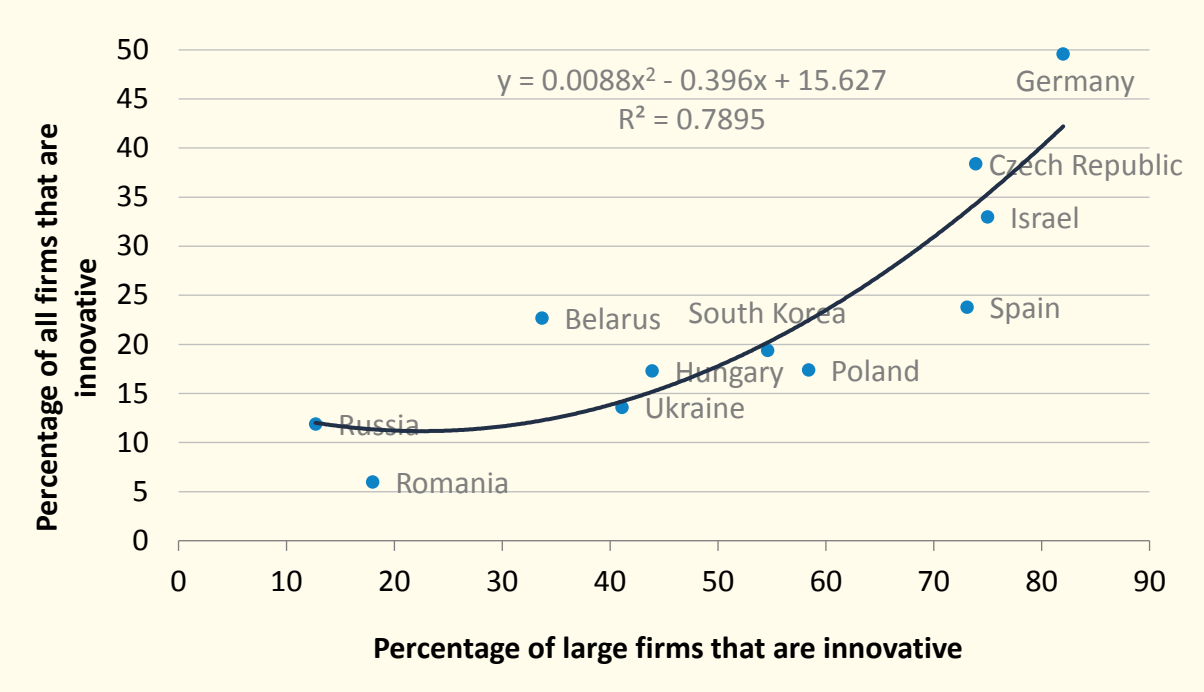
The share of large firms engaged in innovative activities is lower than in aspirational peers. The share of large firm innovators is typically higher than that of small firm innovators, and large firms typically conduct a significant proportion of innovative activities in the most advanced sectors and economies (Evangelista et al, 1997).[12] While the share of innovators is

[11] Innovation capabilities include the extent to which enterprises are engaged in innovative activities, number of product and process innovators, innovation expenses, and the sources of innovation spending.
[12] Evangelista et al. 1997.

higher among large firms than among small firms in Ukraine, the share of large firm innovators is half of the corresponding share in aspirational peers (Figure 10). This suggests that large firms are not drivers of the economy's innovation activities to the same extent as in more successful economies.

Finally, innovative activities are concentrated in the three largest urban areas. The top three innovative regions in Ukraine, which are Kiev, Harkiv, and Zaporozhie, account for 48 percent of innovation expenditures and 56 percent of innovative activity (Kislenko, 2018). Equipment purchases can comprise up to 85 percent of annual innovation-related activities, so the relative concentration of innovative activity reflects the high capital-intensity of these regions.

Figure 11. Percentage of All Firms and Large Firms Engaged in Innovative Activities (2014)



Source: Authors, based on UNESCO Innovation Statistics 2019.

2.2. STRUCTURAL FEATURES OF TECHNOLOGY UPGRADING

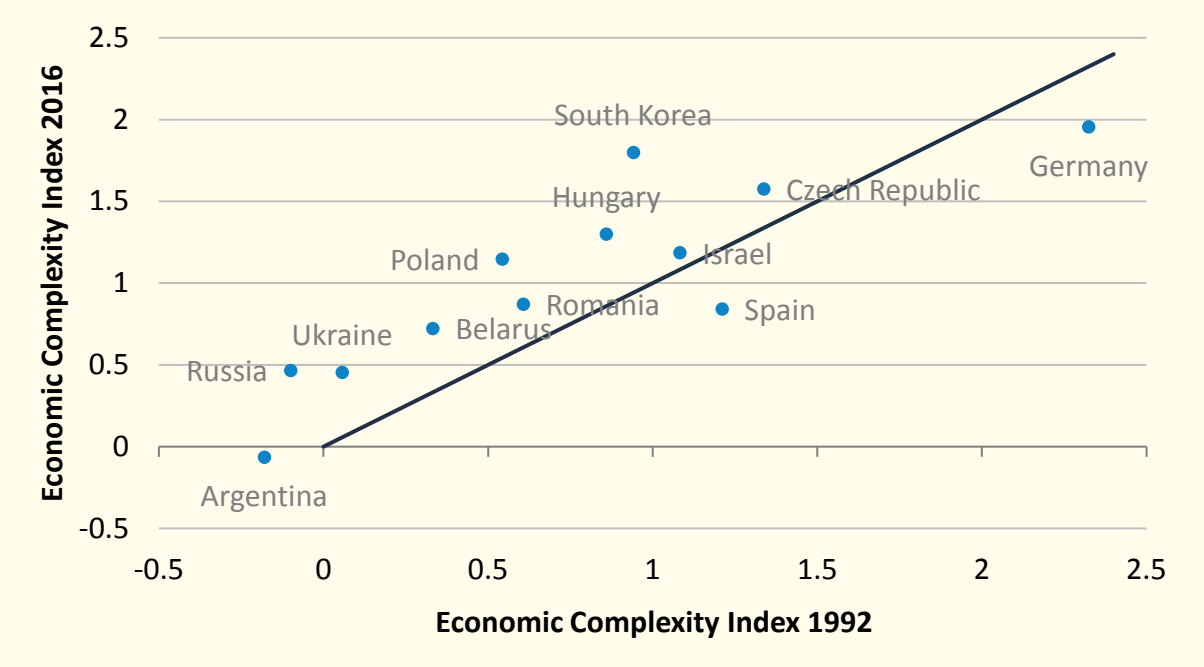
While upgrading intensity reflects the depth of capabilities, **structural features signal the extent to which capabilities are visible through different structural features of the economy**. Structural features are comprised of four sub-categories, which are economic complexity,

infrastructure, knowledge diversification, and firm structure, the latter three reflecting the breadth of technology upgrading. In Ukraine, technology upgrading breadth relies upon legacy capabilities developed during the former Soviet times, especially in terms of science and engineering education. However, as described below, structural aspects of the Ukrainian economy are also deteriorating.

2.2.1. ECONOMIC COMPLEXITY

Ukraine scores relatively low on measures of economic complexity.[13] Though Ukraine has achieved modest gains in the economic complexity index (ECI) over time (Figure 11), these gains were realized predominantly between 1992 and 1999. As of 2016, Ukraine's ECI was equivalent to Russia's and well below that of Belarus, Romania, Poland, and Hungary. Low economic complexity reflects export concentration in simple, resource-based products.

Figure 12. Economic Complexity Index: A Comparative Perspective 1992–2016



Source: Authors, based on https://atlas.media.mit.edu/en/.
Note: Year range from 1992 to 2016. Czech Republic starts from 1993.

Ukraine continues to benefit from the Soviet-era legacy of a strong educational system. Ukraine scores high in its business community's subjective assessment of math and science education, higher than Israel, the Czech Republic, and Poland, and with scores similar to

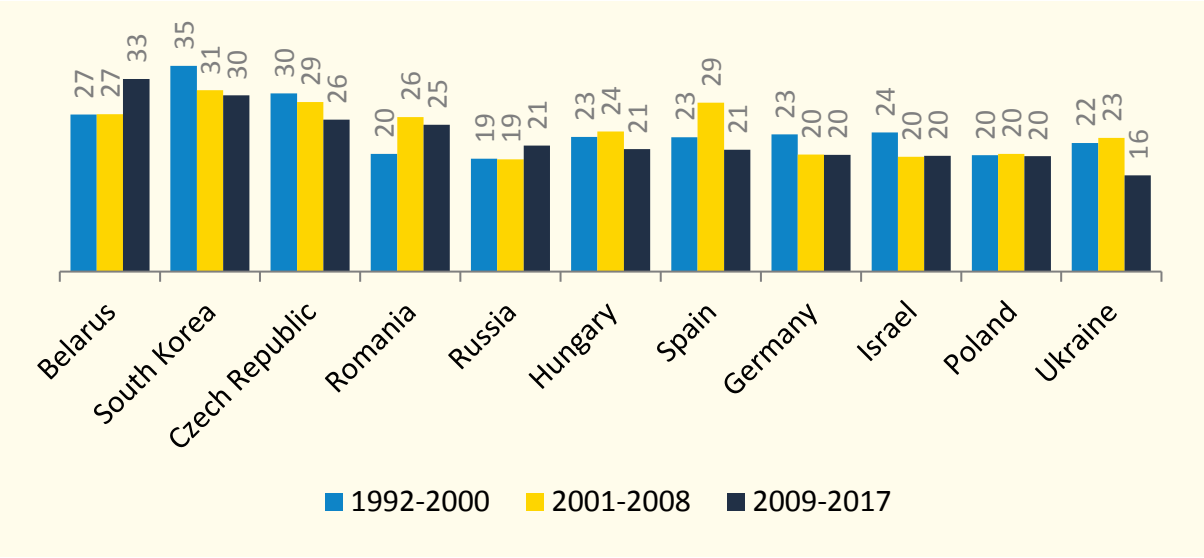
[13] Economic complexity is measured through the Economic Complexity Index (ECI), which provides insights into the extent to which a country or region possesses knowledge-intensive capabilities important for export-oriented productivity (Felipe et al. 2012).

Germany[14]. In addition, Ukraine enjoyed high levels of overall educational attainment in the 1990s, and these levels continued to rise from 2000 to 2010 (see Annex Figure A6). However, this rise in educational attainment was modest, and by 2010 Ukraine had been surpassed by all other comparison countries except for Spain and Romania. These trends may improve in the future, as gross enrollment rates in tertiary education increased from 48.8% in 2000 to 83.4% in 2014[15]. Further, Ukraine ranks relatively low in terms of the availability of scientists and engineers and related services (see Annex 3 Figure A7), which means that many students do not progress into higher levels of postsecondary education in math and science.

2.2.2. INFRASTRUCTURE

Ukraine's public and private infrastructure investments are low and declining. Public and private physical investment rates, where infrastructure typically plays an important role, declined to an average of 16 percent of GDP between 2009 and 2017, placing Ukraine at the bottom of peer and aspirational economies (Figure 12). In 2010-18 period, on average two thirds of investment went to agriculture, industry, construction and trade[16]. Investment in 'information and communication' activities were on average only 4.7% of total physical investment in this period. Low investment in ICT infrastructure is indicated by the low take-up of broadband internet services. Ukraine has the lowest level of broadband subscribers per 100 people and achieved the smallest increase in new subscriptions (except for Israel) of all comparison countries included in the study (Figure 13).

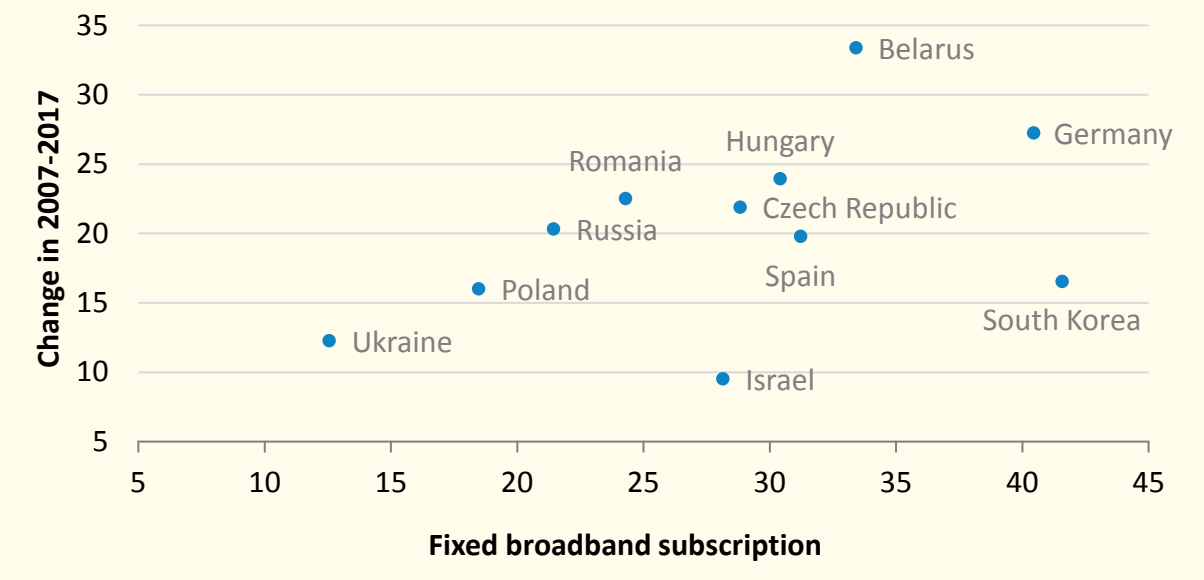
Figure 13. Physical Investment as a Percentage of GDP



Source: World Bank Development Indicators Database.

[14] Source: WEF GCR Database
[15] Source: Word Bank Development Indicators
[16] Source: Ukrstat https://ukrstat.org/en/operativ/menu/menu_e/ioz.htm

Figure 14. Broadband Subscription Rates (per 100 individuals)



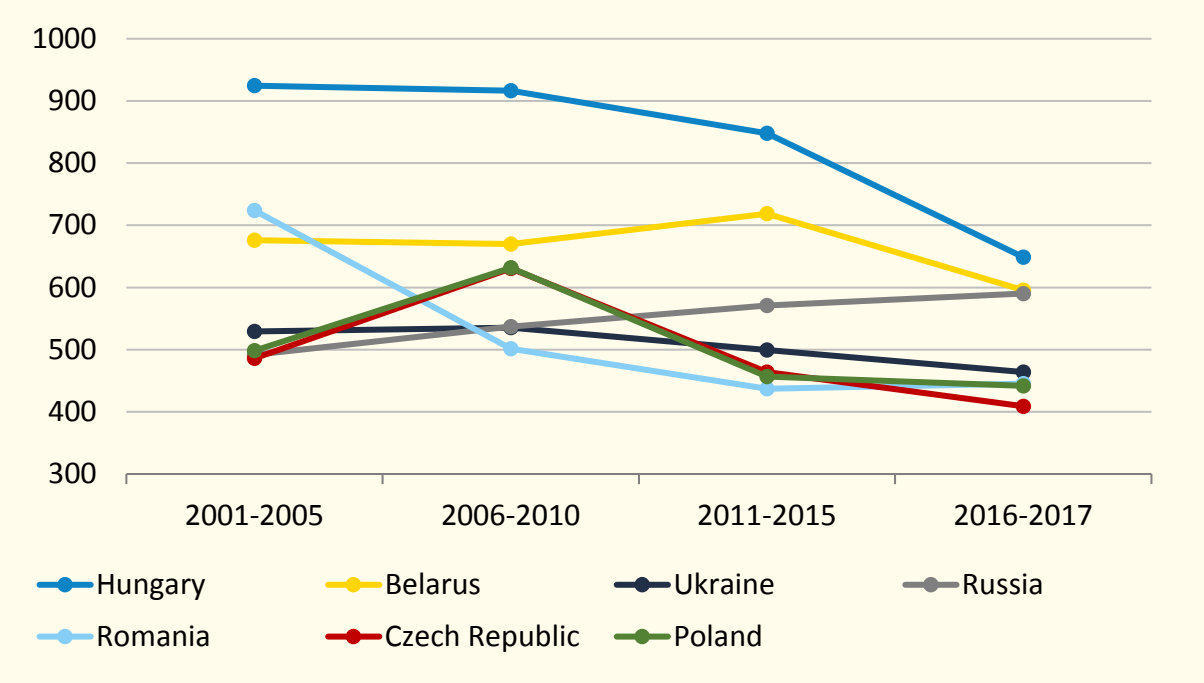
Source: Based on World Bank Development Indicators.

2.2.3. KNOWLEDGE DIVERSIFICATION

Ukraine's knowledge base is gradually diversifying, an indication of middle-income country growth. The share of patents in different patent classes can be used as a proxy for the diversification of knowledge (the higher the concentration of patenting, the more narrowly specialized is the economy).[17] Usually, growth in a developing country is characterized by a diversification of the country's knowledge base, which would be indicated by an increasing number of patent classes.[18] Ukraine possessed a relatively concentrated knowledge base as a result of specific areas of scientific and technological focus during the Soviet Union era (Figure 14).[19] From 2002, however, Ukraine began to diversify its knowledge base (as proxied by the Herfindahl-Hirschman Index of its patents), a trend that continue gradually to 2016-17. This initial strong shift was induced by the change from a closed to an open economy, and the embrace of new technology areas. A similar, gradual knowledge diversification is indicated by data on patenting at the technological frontier (Annex 3 Figure A8 shows US patents, but European patents show quite similar trends). Both indicators demonstrate that Ukraine is experiencing gradual knowledge diversification.

[17] The Herfindahl-Hirschman Index (HHI) is a commonly accepted measure of market concentration which is here used to measure concentration of share of different patent classes. It is calculated by squaring the share of each patent class and then summing the resulting numbers.
[18] Keun 2019.
[19] The main shift towards more diversified knowledge base took place in the 1992-1995 period and significantly slowed down afterwards.

Figure 15. Technology Diversification Demonstrated through Domestic Patenting (Hirschman-Herfindhal Concentration Index)



Source: Authors, based on WIPO database.

The level of sophistication of buyers of Ukrainian products is at a low level and is similar to that of the buyers of goods from other Central European countries[20]. Low buyer sophistication hinders innovation activities even when there are technological opportunities and research, technology and development (RTD) capacities. Among all countries, including Germany, Israel and Korea, buyer sophistication fell during the period of observation (see Annex 3, Figure A9), the likely result of the global financial crisis of 2008. Buyer sophistication in Ukraine is well below that of aspirational peers, which is in keeping with earlier observations about the low levels of economic complexity, especially the declining share of manufactures in goods exports. Low buyer sophistication is also compatible with the large demand gap for RTD services (Figure 6, above).

Ukraine is the lowest ranked among peers in terms of access to new technologies (Annex 3 Figure A10). Following other countries in Central Europe, Ukrainian firms have gradually improved their access to technology, which is an important precondition for technology upgrading. However, in relative terms Ukrainian firms are still behind their Central European peers, suggesting informational, financial or regulatory barriers that impede the acquisition of new technologies.

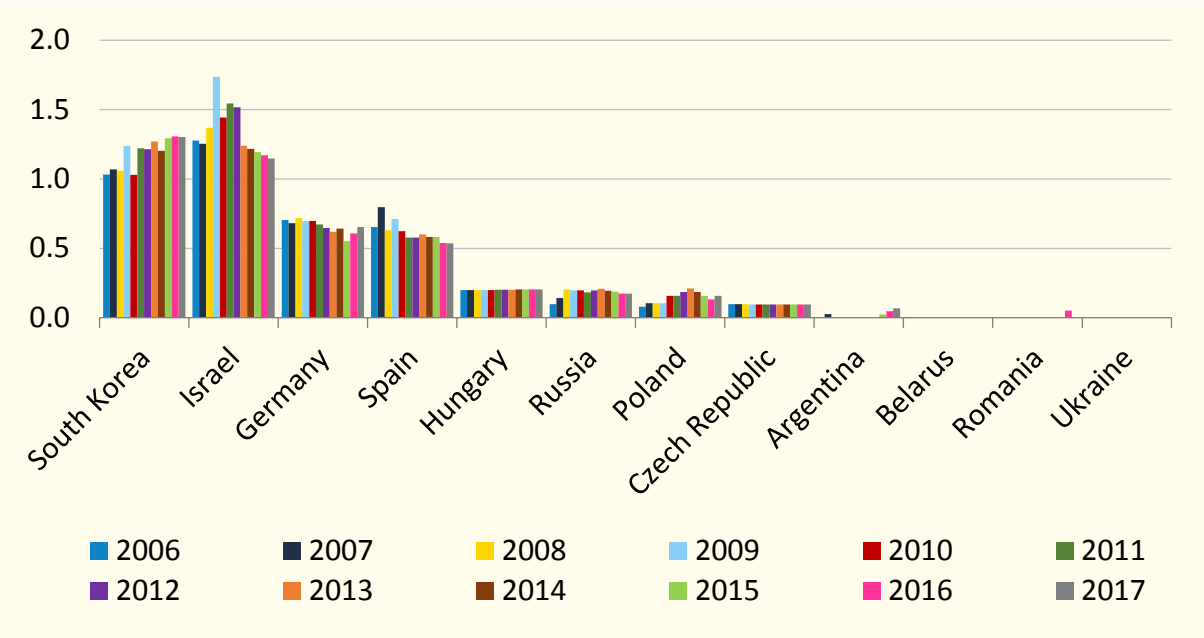
[20]Buyer sophistication is measured as a response on question 'In your country, how do buyers make purchasing decisions? [1 = based solely on the lowest price; 7 = based on a sophisticated analysis of performance attributes] source: World Economic Forum Global Competitiveness Reports database

2.2.4. FIRM STRUCTURE

Ukraine lacks large, dynamic firms. Dynamic economies possess a mix of firms of different sizes and organizational capabilities. For middle-income countries, large firms are particularly important to enable scale and thus global competition (Lee et al., 2013). Similar to Belarus, no Ukrainian company is included in the Forbes2000 list of the largest 2000 enterprises in the world **(**Figure 15).[21] In comparison, Poland and Israel, despite their smaller populations, have generated a disproportionally large number of multinational companies that perform well in global markets. Six Polish and ten Israeli firms were included in the Forbes2000 list in 2017. These findings are consistent with earlier observations relating to the low level of organizational capabilities among Ukrainian firms.

Ukrainian enterprises have a relatively low capability to absorb technology, especially compared to aspirational countries (see Annex 3 Figure A11). Further, firms in most countries have experienced some decline in capacity to absorb technology (except for Russia) despite improved availability of new technologies. This probably indicates difficulties in developing organizational capabilities for the absorption of new technologies. New business models and new types of organisational capabilities are required for IT-based competition. This will further complicate acquisition of organizational capabilities for Ukrainian firms. Ukraine scores lowest in terms of the utilization of professional management (its scores are below all its Central European peers), which further hinders acquisition of organizational capabilities (see Annex Figure A12).

Figure 16. Number of Firms in Forbes2000 List (per million inhabitants) (2006–2017)



Source: Forbes2000 database.

[21] Link to the list: https://www.forbes.com/global2000/

2.3. INTERACTIONS WITH THE GLOBAL ECONOMY

Involvement in knowledge exchange channels, particularly those related to global value chains, is critical for technology upgrading. The global interaction component of the technology upgrading framework measures the extent to which an economy is involved in knowledge and technology exchange. The indicators include export composition and mix, FDI flows, and intellectual property revenues and expenses. High levels of these indicators do not necessarily indicate knowledge acquisition and absorption, as that depends on the extent to which knowledge exchanges support technology upgrading.[22] For example, Ukraine continues to expand its economic relationship with the EU but has yet to embrace and implement quality standards that might yield broader economic benefits. Further, in some cases exposure to foreign technology may substitute for, rather than enhance, local technology activities.

Except for rapidly growing ICT service exports, **Ukraine's export mix is increasingly comprised of lower value-added (non-manufactured) goods**. A country's export mix can provide some insight into sector-specific industrial capabilities. In 1995, for example, Ukraine's exports were composed of transportation equipment (23 percent) and ICT services (5.6 percent), along with iron-related products (flat-rolled iron, semi-finished products of iron etc), fertilizers (nitrous fertilizers and ammonia) and raw materials like iron ores, petroleum, and coal. In 2016, ICT services constituted 12 percent of exports and agricultural products (e.g. corn, sunflower seed oil, wheat, and meslin[23]) had increased from 13 to 43 percent of exports. The rising shares of ICT and agriculture has come at the expense of manufactured goods and non-ICT services, which fell from 70 percent of exports in 1997 to 46 percent in 2017. Transportation equipment, fertilizers, chemicals, and input materials such as semi-finished iron had particularly large declines in export shares.

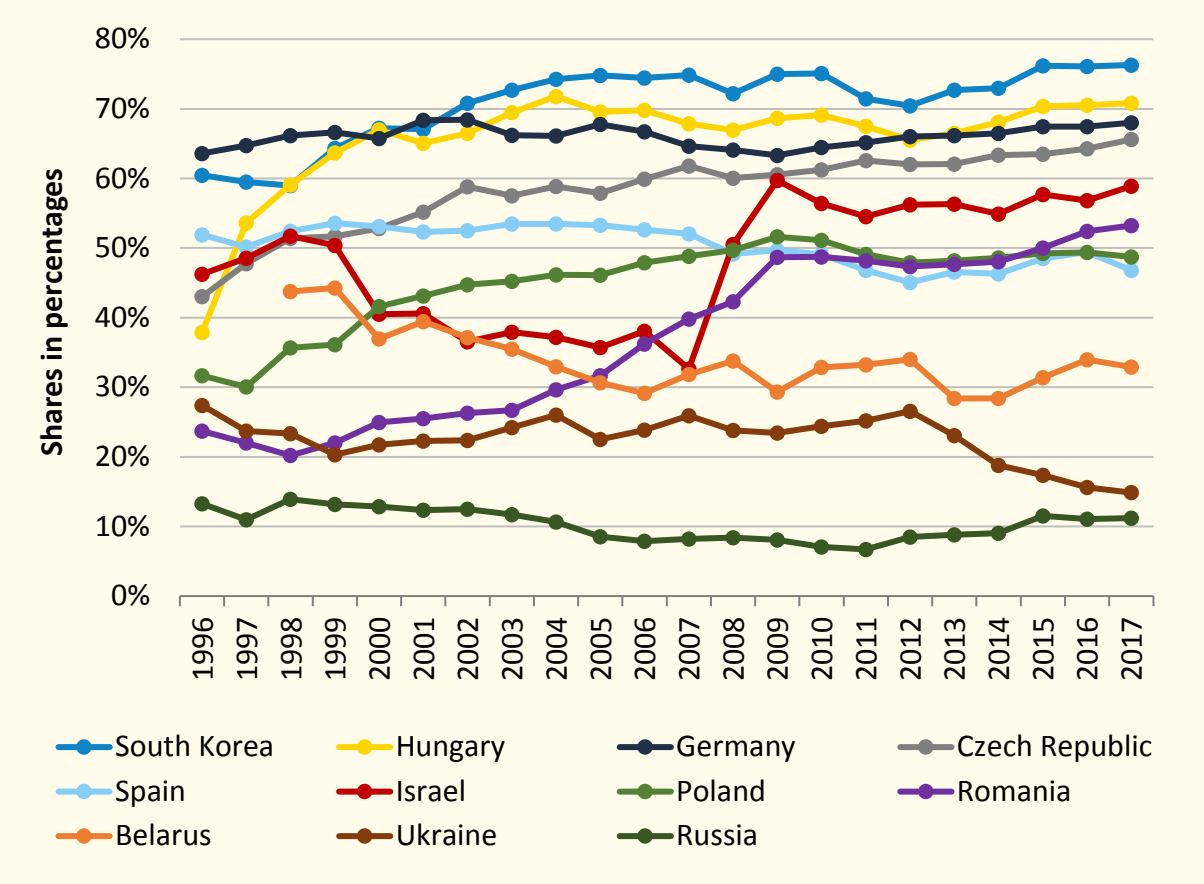
The complexity of Ukrainian exports has declined, particularly after 2012 (Figure 16)**.** A comparative framework was constructed to understand the extent to which the changing export mix is comprised of complex, high-value added industries. Among manufactured goods, Ukraine saw rapid export growth in the electrical machinery sector but flat or declining trends in most other manufactured goods, especially chemicals and road vehicles. By contrast, agricultural exports have increased significantly.

Inflows of foreign direct investment (FDI) to Ukraine have increased. FDI can provide needed foreign investment capital for upgrading facilities, equipment, and labor. FDI inflows as a percentage of GDP rose steadily from 1992-2000 to 2011-17, to a higher level than in all peer and aspirational countries except for Hungary (see Annex 3 Figure A13). While increasing FDI may be viewed as a positive trend, further study is required to understand if FDI is flowing

[22] Radosevic 1999.
[23] A mixture of wheat and rye that is sown and harvested together is known as meslin.

to export industries or is dedicated to production for the local market. Export-oriented FDI would be the quickest and the most effective way to achieve an improvement in Ukrainian firms' low level of participation in global supply chains.

Figure 17. Share of Exports Comprised of Complex Industries



Source: Authors based on UNCOM Trade Database.
Note: This analysis uses a category of complex industries instead of high tech, which is a narrow category often linked to assembly economies and can give a very distorted picture of the real domestic value added. Complex industries include SITC Rev. 3 categories 5, 71–79, 87 and 88 SITC Rev.3 sectors: 5 - Chemicals and related products, n.e.s.; 71 to 75 Machinery - power generating machines, special industrial machinery, metalworking machinery, general industrial machinery, n.e.s, office machines; 76 - telecommunications equipment; 78-79 - transport equipment (road vehicles, other transport equipment); and 87-88 electrical and optical (scientific equipment, n.e.s., photo apparatus n.e.s., clocks).

Though improving slightly over time, FDI outflows from Ukraine remain low. FDI outflows reflect the capability of domestic corporations to build scale and compete internationally. Ukraine, along with Romania and Belarus, had the lowest level of FDI outflows as a percentage of GDP among peer countries (see Annex 3 Figure A14). These results support previous findings that show weak organizational capabilities among domestic firms.

Finally, **Ukraine's payments for the use of foreign intellectual property (as a percent of GDP) are considerable and comparable to its peers, but sales of its own IP are miniscule**. Both the sale and purchase of intellectual property (IP) provide another perspective on the extent to which Ukraine interacts with global markets. Licensing fees paid indicate the use of foreign knowledge. Ukraine paid an average of 0.45 percent of its GDP to license foreign IP, though, in real terms, the $500 million it spends annually places Ukraine just above Belarus and below Romania. In contrast, Ukraine received 0.06 percent of its GDP or, on average, $69 million per year of foreign licensing fees for its IP in 2000-2017 period[24]. This imbalance of licensing fees shows, like Ukraine's export mix and economic complexity, that the country possesses a low level of industrial upgrading capabilities.

2.4. SUMMARY ANALYSIS

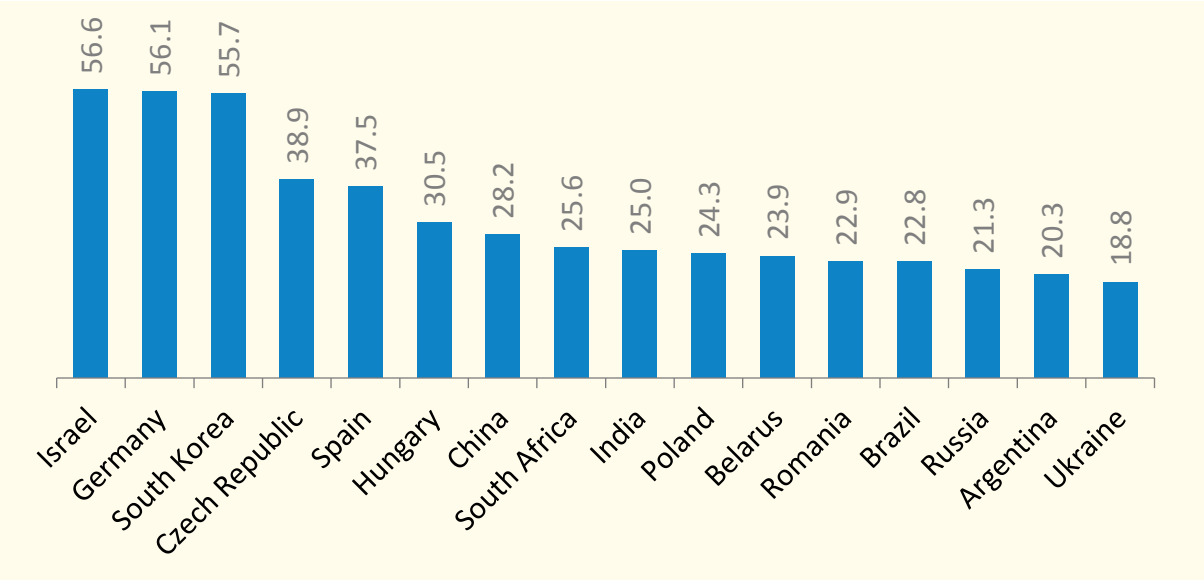
With the exception of its science and engineering education, growing ICT industry, and agricultural production, Ukraine fairs poorly from a technology upgrading perspective. Ukraine's score of 18.8 on a composite index of technology upgrading puts it last among comparison countries in the study (Figure 32). Ukraine is ranked lowest among all comparison countries in intensity of technology upgrading (Figure 33), particularly due to poor performance in production, management, and R&D capabilities. Ukraine and all its regional peers lag much less in relation to aspirational peers (Germany, Korea, Israel) in terms of breadth of technology upgrading. However, Ukraine still scores poorly (though not as low as Argentina), largely due to firms' weak organizational capabilities, including the lack of large corporations that have the scale to compete internationally. Finally, Ukraine scores best in terms of interactions with the global economy, scoring higher than five comparison countries primarily due to inflows of FDI and the emergence of the ICT industry. Nevertheless, many opportunities remain to enhance Ukraine's increasing interconnectivity to global markets, especially the EU, to further industry upgrading efforts. However, countries such as India, Brazil, and Russia have much larger internal markets than the Ukraine does, which tends to reduce the extent of global interactions. Countries that are more similar to Ukraine in terms of their size and location in Central Europe have similar or better scores on the index of interactions with the global economy.

The gap is sizeable and significant in relation to aspirational and geographical peers and much less significant in relation to the BRICS and the legacy peers. Figure 34 summarizes the relative position of Ukraine in relation to different groups of peers. On the index of technology exchange, Ukraine is ahead of its legacy peers and on infrastructure ahead of the BRICS average. Its lag in relation to all four groups of peers is the most significant with respect to organizational and production capabilities. In conclusion, the most significant issues that

[24] Source: World Bank Development Indicators

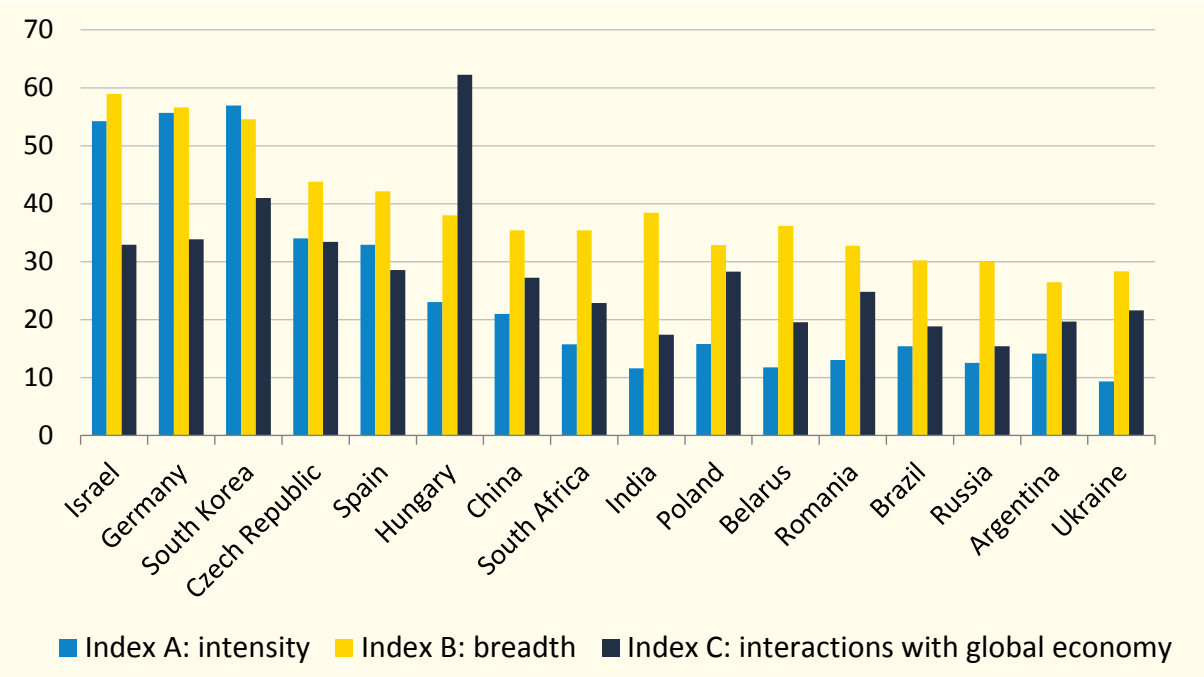
hinder technology upgrading of Ukraine are located **in downstream activities related to management capabilities, corporate governance, training, and quality**.

Figure 18. Composite Index of Technological Upgrading



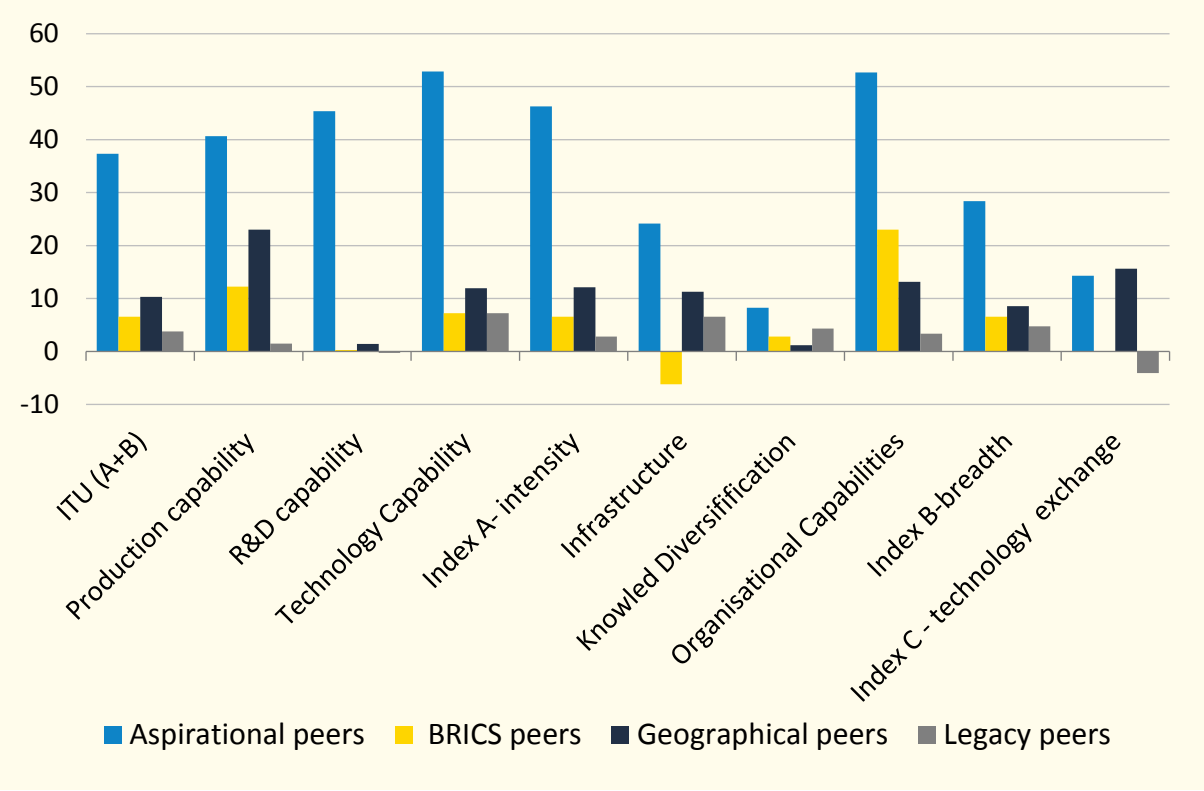
Source: Authors.
Note: For methodology of construction of ITU, see Annex 1.

Figure 19. Three Indexes of Technology Upgrading: Intensity, Breadth, and Interactions with Global Economy



Source: Authors.

Figure 20. Distance of Ukraine in relation to its peers on index of technology upgrading (A+B) and its components, and on index of technology exchange (C)



Source: Author's calculations. Note: Peers are averages of respective countries; Positive values denotes the lag of Ukraine in relation to peer group; negative values denote that Ukraine is ahead of respective peer group. Distances are calculated as differences between the averages of the respective peer group and Ukraine on different indexes and sub-indexes. Note: Aspirational peers (Germany, Israel, Korea); BRICS peers (China, Brazil, India, South Africa); Geographical peers (Czech Republic, Hungary, Poland, Romania); Legacy peers (Russia, Belarus)

2.5. FROM GENERIC TO SECTOR-SPECIFIC PERSPECTIVE

Thus far, the exploration of Ukraine's technology upgrading issues has been primarily confined to global insights by using non-sector specific data. However, technology upgrading is not only about macro and micro processes, but also about what happens at the sector and organizational (mezzo) level. Unfortunately, innovation policy has usually favored R&D intensive sectors, ignoring non-research related sources of growth, such as amassing production capabilities.

Ukraine's export structure is driven by the low share of complex industries (Figure 16) and, most predominantly, by two sectors (1) *Natural resources-based sectors (NRBS*) such as agriculture (corn, wheat, seed oils, soybeans, barley) and raw materials and low processed

commodities (iron, ferroalloys, iron ore, iron pipes) which amount to the bulk of Ukrainian exports, and (2) *ICT services.* It is also important to highlight that the following industries comprise a relatively low share of Ukraine's exports: (3) *Labor intensive industries* (suits, shirts, footwear, leather, garments), and (4) *Machinery and equipment* (locomotive parts, vehicle parts). Each of these four sectors would require a sector-specific analysis which would explore their specific paths and sector-specific obstacles to technology upgrading (Box 1 provides a brief description of these sectors).

The following section will explore the emergence of the ICT industry and the dynamics associated with its status as an 'exclave'. By doing so, the report highlights the growth potential of the industry, while focusing on its potential role in technological upgrading of Ukraine.

Box 1. Key Ukrainian industries with potential for growth through technology upgrading

Natural resources-based sectors (NRBS) account for a significant proportion of export growth and thus are essential for maintaining current account balance. If properly developed, NRBIs could provide prosperity for the country (and companies). While NRBS are often considered low-tech with limited technological opportunities, significant opportunities exist to focus on higher value-added segments of NRBS, and thus improve their overall economic impact.

Labor intensive industries represent currently a small share of Ukrainian exports, despite considerable differences in labor costs between Ukraine and nearby EU markets. Little is known about sector-specific challenges experienced by these industries (clothing, leather, footwear), though they face significant competition from China and other Asian countries. Further, the FOP tax regime of employment (more on this below) exacerbates problems among these industries. The sector has developed subcontracting links with EU firms through outward processing traffic trade or tolling arrangements, thus offering opportunities for upgrading and future growth.

Sector of machinery and equipment (SITC7) or capital goods is of high relevance for the Ukraine economy. This sector, especially export of machinery and engineering products, was among the most important during the Soviet period and survived in the transition period mainly due to exports to CIS countries, but now only accounts for a small proportion of exports. The health of the sector declined markedly after the changing geopolitics of 2014, which reduced the opportunity to export to Russia. However, this sector is vital for technology upgrading as it represents technological capabilities that possess significant spillover effects. Limited insights are available into current challenges and opportunities for shifting activities towards export and technology upgrading.

ICT services/software industry has been growing in the recent period thanks to available human capital and low barriers to entry into global markets. In that respect, this sector can be considered a 'rising star' although its continuous growth is not guaranteed and potential benefits to the local economy have not yet been realized fully. In addition to opportunities for upgrading, the ICT industry is not well-linked with other industries and sectors within Ukraine, embodying what the literature calls an 'exclave' whereby companies make use of Ukrainian talent but locate other functions abroad. Further, experience linking ICT to value-added segments within the industries discussed above, among others, would enable companies to capture part of the growing global market for 'servicification' of manufacturing associated with Industry 4.0.

3. CASE IN POINT: UKRAINE'S ICT SECTOR AND THE PROMISE OF DIGITAL TRANSFORMATION

The ICT sector has experienced rapid rates of growth thanks to the availability of human capital and low barriers to entry into global markets. International trends, such as the search for cost savings after the 2008 financial crash and recent and growing 'servicification' of manufacturing[25], have also contributed to the rapid expansion of the industry. Countries with a vibrant ICT sector can enjoy two types of economic benefits: those associated with the sector's direct contribution to employment and incomes and, perhaps more importantly, economy-wide gains in productivity associated with the diffusion of ICT throughout the economy.[26] However, while Ukraine's ICT sector is considered a 'rising star', its continuous growth is not guaranteed and its effects on the local economy have thus far been very modest. This section explores these trends by examining the emergence of the ICT industry in Ukraine, the extent to which the growth of ICT services exports has increased the use of ICT domestically and the factors that help explain this, and barriers to future industry upgrading and ICT diffusion.

3.1. INDUSTRY EMERGENCE: PLANTING THE SEEDS

The ICT sector has rapidly become a critical driver of economic activity within Ukraine. The ICT sector is dominated by the export of ICT services, largely business-to-business outsourcing to developed countries, especially the United States.[27] In 2017, the sector generated 3.5 billion dollars of exports, accounting for more than 3 percent of GDP and 10 percent of foreign direct investment flowing into Ukraine. The fastest growing segment is computer services, which increased from $42 million in 2005 to $1.5 billion out of $2 billion of ICT-related export activity in 2014. By 2019, ICT had become a more-than-$4 billion industry. By 2014, Ukraine ranked 12th in the world in the export of computer services (Figure 25).

Most of this activity is generated by the more than 1,000 ICT outsourcing companies located in the Ukraine. Five of these are on the International Association of Outsourcing Professionals (IAOP) "Top 100 Outsourcing Leaders" list, with 13 more companies listed in IAOP's "rising

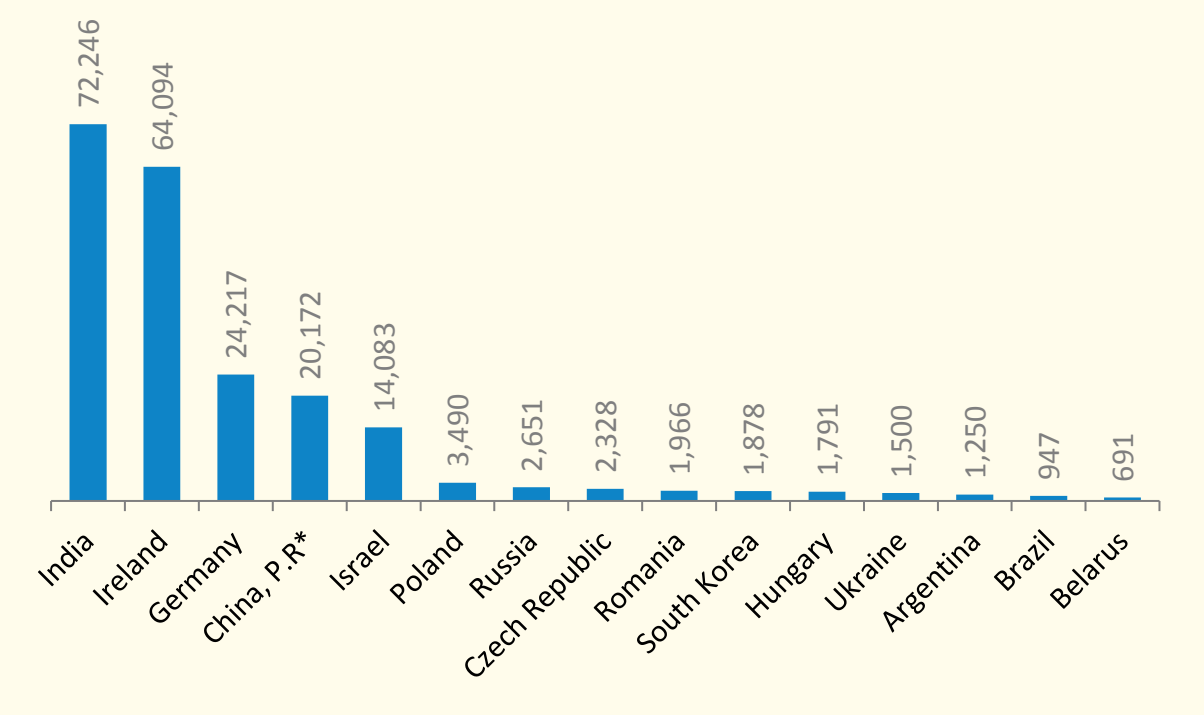
[25] For more on this see Hallward-Driemeier, Mary; Nayyar, Gaurav. 2017. Trouble in the Making? : The Future of Manufacturing-Led Development. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/27946 License: CC BY 3.0 IGO

[26] See, for example, Jorgenson (2001). For an international perspective, see Jorgenson (2004).

[27] National Investment Council of Ukraine 2018.

leader" list.[28] The sector employed more than 125,000 software engineers in 2017, a number projected to grow to more than 200,000 by 2020.[29] ICT services companies are located throughout the country, especially in Kiev, Lviv, Kharkov, Odessa, and Dnipro.

Figure 21. Export of Computer Services (US$, millions) (2014)



Source: Authors, based on IMF Database Trade in services.
Note: *Also includes telecom and information services.

The rapid growth of the Ukrainian ICT sector is attributed to the confluence of several domestic and global factors. Domestically, Ukraine's strong science and engineering education system provided the foundation for a talented ICT workforce. Similar to the experience of other major outsourcing players such as India and Ireland[30], Ukraine's skilled diaspora has also played a key role in the emergence and global growth of the industry. Outsourcing firms such as EPAM (see Box 2) and Luxoft[31] were established in the United States and Switzerland, respectively, by expatriates who sought to link talented Ukrainian software engineers to outsourcing opportunities in Western Europe and the U.S. These early outsourcing firms and others demonstrated to global clients the quality and cost benefits of outsourcing from Ukraine, on which other firms have built.

[28] These companies include Ciklum, EPAM, Infopulse, Luxoft, and Softserve on the Top 100 Leaders list with AMC Bridge, Artezio, ELEKS, Innovecs, Intellias, Itera, Miratech, N-iX, Program Ace, Sofengi, Softjourn, Sigma, and Team International Services on the "Rising Star" list.
[29] National Investment Council of Ukraine 2018.
[30] For literature on the role of skilled diaspora in the establishment of outsourcing businesses, see Saxenian (2007).
[31] See https://www.epam.com/ and https://www.luxoft.com/.

Box 2. EPAM: Global Product and Service Developer

EPAM is one of a very few global leaders in ICT outsourcing originating from Eastern Europe; the company has been listed on the New York Stock exchange since 2012. EPAM grew from less than 200 people in 2000 to more than 28,000 employees in 2019, 6,000 of whom work in Ukraine (3,000 in Kiev). The company focuses on the media/publishing, oil and energy, financial services and retailing industries.

EPAM was established in 1993 in New Jersey and was co-founded in Minsk by two Belarusian immigrants. Initially, the company focused on niche developments for large MNCs like SAP, later moving into e-commerce development for Toyota, ABB, USB, Barclays, and other multinationals. EPAM then focused on building market share and brand recognition in the US market, working with Oracle and Thomson Reuters. In 2004, EPAM acquired a Hungarian company and began to expand into European markets. As part of this expansion EPAM came to the Ukraine around 2006, supported by acquisitions in Russia, India, Canada and the US.

In the process, the company has moved away from a pure outsourcing model to a business model focusing on technology consulting, product development, and end-to-end solutions. This shift came from finding talented ICT professionals around the world in places like Ukraine and developing organizational and management capabilities to effectively establish, manage, scale, and complete large-scale projects for clients, leading to high customer satisfaction and strong business growth. The company also works with local education institutions, such as the Ukrainian Catholic University, to design and deliver vocational training to individuals interested in working in the ICT sector.

Ukraine's ICT sector growth accelerated in 2010 after the 2008 global financial crash motivated large corporations in the US and Western Europe to look for financial savings. The opportunity to eliminate in-house "IT departments" and rising costs in traditional outsourcing destinations such as India and Ireland inspired these corporations to look for cheaper service alternatives in Central and Eastern Europe, including Ukraine. Entrepreneurial-minded ICT engineers in Ukraine responded to mounting demand for computer services by establishing small outsourcing startups. Entrepreneurial entry into international outsourcing markets requires neither large capital investments nor large internal markets. ICT engineers only need a laptop, a good internet connection, and a working knowledge of English to participate.

The so-called FOP tax system[32], which established a 5 percent income tax rate for independent contractors, made an important contribution to the establishment and growth of large ICT firms. A freelance workforce supported by the FOP tax system is particularly attractive in the Ukrainian outsourcing services industry, where task complexity, such as substituting for firms' ICT staff, is relatively low. The use of freelancers also means that companies can benefit from a high degree of operational flexibility, while keeping overhead rates relatively low. This "Uberisation" model—that is, where a workforce operates in a freelance regime similar to that of Uber drivers—has spread beyond the ICT sector into professional services occupations. A recent ILO study (2018) showed that 44 percent of the Ukrainian workforce is employed as freelancers, the highest percentage in Europe.

The pervasive Uberisation of industrial relations in Ukraine has its advantages, but also significant disadvantages. While ICT workers pay only a 5 percent tax on incomes (marginal income tax rates for full-time workers in other industries approach 40 percent), they forego some or sometimes all regular social benefits.[33] Further, while the FOP system has provided companies with the flexibility to form *ad hoc* product teams and dismantle them quickly, it also has discouraged the development of long-term management and organizational capabilities (discussed below) critical to the continual upgrading of the industry.

3.2. ALTERNATIVE FUTURES FOR THE ICT INDUSTRY: OVERCOMING THE CAPABILITIES CHALLENGE

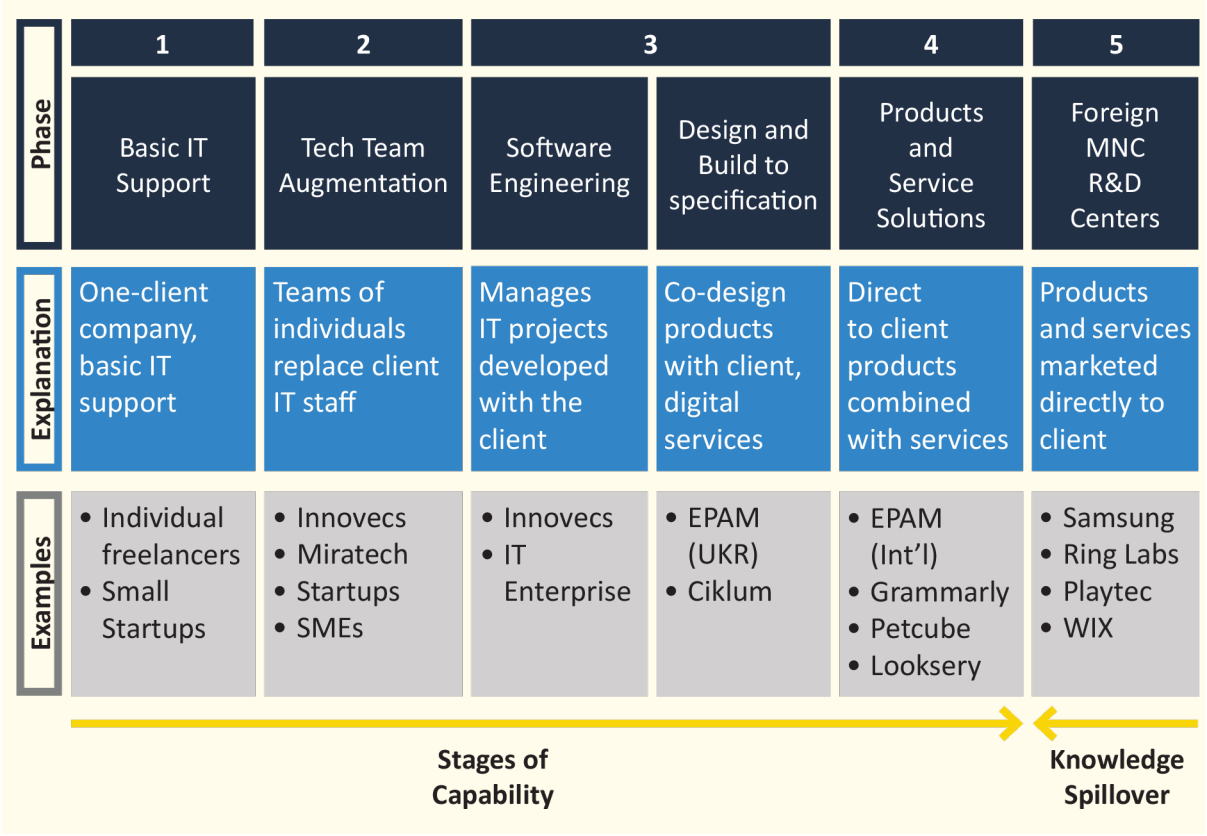
While most ICT firms in the Ukraine have five employees or less, those that expand tend to reach specific developmental milestones, illustrated in Figure 26 (this analysis is based on interviews designed to understand the factors driving the growth of ICT companies in Ukraine)**.** With some exceptions, most ICT companies in the Ukraine begin as outsourcing service companies. In Phase 1, small startups comprised of a few individuals provide basic ICT support to one client with on-site staff or remotely. In Phase 2, small startups or SMEs replace the entire ICT staff of client companies and undertake low-level ICT service functions. According to interviewees, a majority of Ukrainian ICT firms fall within phase 1 or 2. Phase 3 companies focus on implementing and managing more complex ICT projects on behalf of customers and providing end-to-end solutions to their business customers. These ICT companies are much larger, provide a wide range of ICT services, and may market products directly to consumers. Companies in Phase 4 are the least common in Ukraine. A Phase 4

[32] FOP or Personal Entrepreneurs Systems enables natural persons to conduct business (services, trading) without incorporation of a separate legal entity. This form of business is simple to register and can offer good tax savings through the Simplified Tax regime. In Ukraine, this is also widespread alternative to employment as amount of tax accrued on income of Private Entrepreneurs is much lower than the amount of taxes accrued on salaries of employees.

[33] Some ICT outsourcing firms still offer some benefits such as insurance and paid holidays.

company may or may not develop out of a Phase 3 company, but nonetheless provides a wide variety of services and sells products directly to consumers. Finally, Phase 5 represents captive R&D centers of large multinational corporations with strong ICT profiles[34], which do not develop out of an earlier phase but have accumulated specific capabilities that are similar to companies in Phase 4.

Figure 22. Stages of Capability Upgrading within the ICT Industry



Source: Authors.
Note: Column 4 'Direct to client' label describes situation where products and services are directly sold to client avoiding intermediaries or being part of subcontracting chain

Similar to industrial development in other sectors, **the development of ICT companies in Ukraine does not follow an automatic, linear process, but instead requires the internal development of management capabilities and organizational systems.** Such systems do not emerge from mere involvement in the outsourcing business.[35] In fact, the relative ease of entry and ability to quickly earn revenues means that companies focus primarily on projects whereby individual programmers work on tasks designed by a foreign client, what industry

[34] Several multinationals have established so called "R&D centers" in Ukraine in an attempt to access technical talent without jeopardizing IP.
[35] Radosevic and Yoruk 2016, 2018.

representatives term “working in caves.” Programmers “working in caves” generally do not have a holistic understanding of the overall software product into which their component is being integrated, much less the overall operations of the business. While this arrangement may be the result of the efforts of outsourcing companies to limit their risk of being displaced by sub-contractors, this phenomenon nonetheless limits the contribution that outsourcing firms can make to their partners’ businesses and hampers their own development.

Companies that progress to advanced developmental milestones must transition from relatively arms-length relationships with clients to partnerships in which companies co-develop solutions through shared technical capabilities and insights (Boxes 3 and 4). The ability to make this transition depends on the accumulation or availability of management and organizational capabilities. According to interviewees, only a small percentage of ICT companies in Ukraine possess these capabilities. Unfortunately, there is little short-term incentive for firms in Phases 1 or 2 to upgrade their organizational capabilities that might help them evolve to Phases 3 or 4.

Box 3. Innovecs: Outsourcing Company

Innovecs is a 600-employee company established in 2012 and incorporated in the US. Innovecs is among the top 5000 US ICT services companies. The company focuses on exporting ICT services to Israel (40 percent market share), the US (40 percent), and the European Union (20 percent). Innovecs derives 60 percent of its revenues from basic “commodity” outsourcing and 40 percent from professional services. Profit margins are rapidly declining in the outsourcing line, where companies compete primarily on cost. Therefore, Innovecs is developing its professional services. A shift to professional services as well as developing products and solutions requires robust management capabilities. The company is thus attempting to recruit experienced foreign managers to Innovecs, especially those with family connections in Ukraine.

Box 4. Luxoft: A Successful Transition from Outsourcing Company to Software Developer

Luxoft is a publicly-traded multi-national custom software development company with nearly 13,000 employees and 41 offices in 22 countries. While the company is incorporated in Switzerland, Ukraine is its largest hub with 4,000 employees. The company was initially established in Russia and later expanded to Ukraine and Poland. Luxoft's clients consist primarily of large multinational corporations, such as Boeing, Ford Motor Co., and Deutsche Bank.

Luxoft has successfully transitioned from an outsourcing company to software developer and provider of end-to-end solutions. This transition is reflected in the adoption of umbrella contracts in lieu of short-term, deliverable-specific contracts to support the co-development of products with their clients. They are especially well-recognized for their work in automotive ICT especially through their partnership with Mercedes-Benz with whom they developed custom dashboard software.

Luxoft overcame some of the drawbacks of working in Ukraine by developing the management and organizational capabilities required to be flexible and maintain high quality standards. For example, though 95 percent of the company's Ukrainian workforce are individual freelancers working under the FOP system, Luxoft provides continuous vocational training, generous benefits, and overall good labor relations to improve recruitment and increase retention, not to mention ensure continuity in client projects. The company also has joint programs with Ukrainian universities and has established corporate development programs. Finally, the company has developed a culture of collaboration and cross-unit teamwork that enables it to draw from the deep experience and technical talent of its staff.

Product or service ICT companies that operate as brand companies are in the most sustainable segment in Phase 4 of the capability building framework. This is the most profitable segment, but also the one with the most significant barriers to entry. Thus only a few companies in Ukraine belong to this category, which are Grammarly, MacPaw, Terrasoft, Snapchat and Petcube. Many are incorporated abroad, and several of them are foreign-owned. Among the most prominent examples of successful companies in Phase 4 are Ring (Box 5) and EPAM (Box 2).

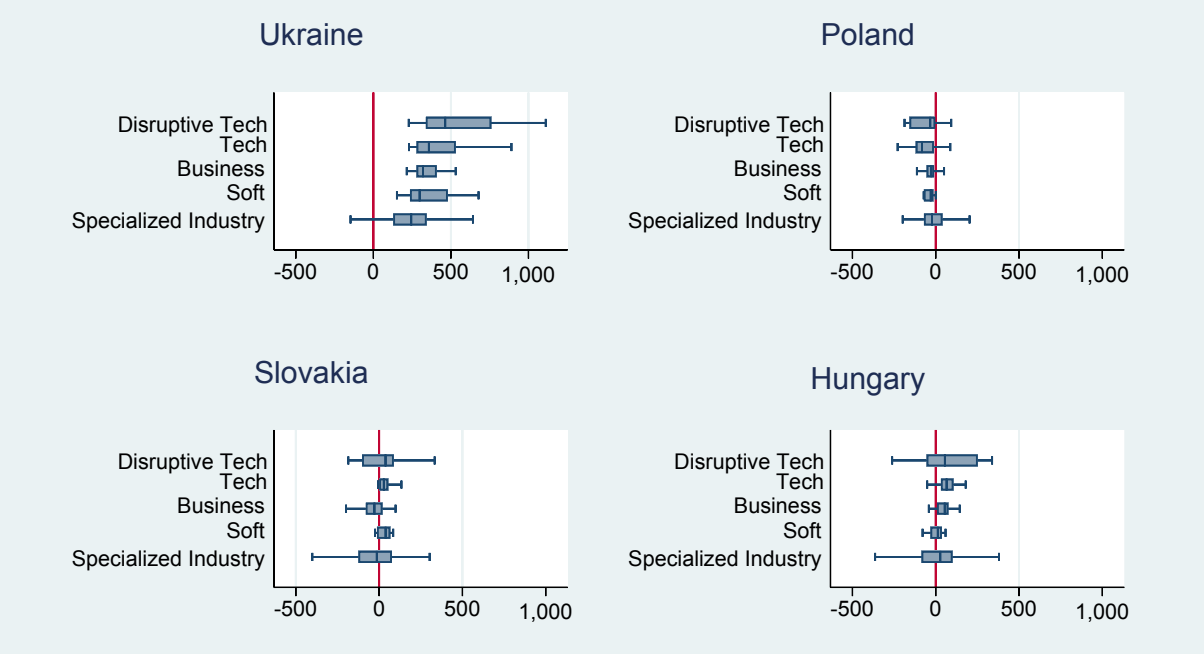
Box 5. Ring or Ukraine as Development Location for Unicorns

Ring was established in Santa Monica, California in 2013 by Jamie Siminoff and was bought out in 2018 by Amazon for more than $1 billion USD. After receiving venture capital funding, the company located much of its software development work to Ukraine. The company grew from approximately 10 to 800 employees in two and a half years. Currently, all stages of product development (design, prototyping, testing, engineering and quality assurance system) are done in Ukraine. The company was able to rapidly expand due to the excellent talent that exists in Ukraine, including the emergent technical capabilities in software as well as radio technology developed during the days of the Soviet Union.

Ring illustrates the potential of Ukraine as an excellent location for rapid upscaling. This is

one of the few cases that goes against the dominant trend where an idea is developed in Central and Eastern Europe but upscaled in developed markets such as the US or EU. Ring also illustrates the potential of global entrepreneurship and development activities that span the several countries (Ukraine, US, and Taiwan) where Ring units are manufactured. However, the most important ingredient to Ring's success has been the management capabilities of the Ukrainian team, in combination with the talent of Ukrainian engineers working within the FOP system.

Figure 23. Net out-migration by skill category (per 10,000 LinkedIn members)



Source: Cited in Ukraine's Country Private Sector Diagnostic (CPSD). Staff calculation using World Bank Group-LinkedIn Digital Data for Development.[36]

Ukrainian ICT firms that wish to upgrade their organizational capabilities face a lack of managerial talent in the ICT sector. Rapid sector growth has increased the demand for talented human capital. Ukraine has simultaneously experienced a dramatic 'brain drain' to EU countries of individuals with expertise in emerging technology areas such as artificial intelligence, cloud computing, cyber-security, computer graphics, and game development, especially relative to other Central European countries (See Figure 27). The shrinking ICT labor supply has resulted in rapidly growing wages which, over time, will mean that most Ukrainian firms will no longer able to compete only on price and will eventually need to consider ways to upgrade their managerial and organizational capabilities, especially in project management

[36] Country Private Sector Diagnostic (forthcoming). Ukraine at a Crossroads: Building the Foundations of the New Economy. World Bank

and software engineering. However, the ICT sector in Ukraine faces challenges that are similar to other sectors in the economy: the country has low capacity to undertake upgrading.

On the positive side, there are many efforts among real estate developers in Ukraine to encourage the physical clustering of ICT firms and other start-ups. The idea is that physical clustering of ICT firms may lead to benefits beyond the need for office space, including networking, common human capital pools, and new opportunities to partner. This reflects recognition of the specific requirements of this market segment, as well as the low capacity of the public sector to promote clustering among start-up companies. Prominent examples of this new trend are Platform (Box 6), UnitCity (Box 7), I-Hub in Kyiv and the Lviv IT Park. Private equity capital is involved in some of these ventures. It is estimated that in Kiev alone there are 12-15 of such co-working spaces of different sizes and missions.

These ICT co-working spaces operate as a community of like-minded individuals and companies, often co-located with ICT training and educational facilities. However, these spaces usually do not yet offer sector-specific shared services. While all the elements of the shared co-working spaces are important, experiences around the world (Saxenian, 2007) show that the most important ingredient for sector success will be the extent of knowledge exchanges through informal communications and networking. At this point, it is too early to see to what extent this will happen.

Box 6. Platform: The Coolest Place in Town

Established in 2015, "Platform" provides shared co-working spaces to 270 small companies and 439 individual members in central Kiev focused on developing new products (as opposed to outsourcing). While the majority of companies work in the ICT sector, other companies focus on marketing, retail development, and other sectors.

Companies and individuals purchase space from Platform and, in return, receive internet access, are able to network with other occupants, and have free access to social events, including lectures on topics relevant to these companies. Platform does not provide other human resources or business services. Interviewees spoke of Platform as one of the "coolest" places in Kiev given its community of dynamic startups focused on product development. Platform is at 100 percent occupancy.

Box 7. UnitCity: Co-working Space with a Vision

"UnitCity" is a new development in Kiev that provides space and two accelerators for more than 90 startups. UnitCity is located on the site of a Soviet-era motorcycle factor and is

one-third completed. The remaining development plans include apartments, shopping areas, parks, and other recreational facilities.

The two accelerators in UnitCity work with companies to improve their ability to develop technology solutions. One example is **RadarTec,** a 10-person accelerator that seeks to encourage and support entrepreneurial ventures to help solve challenges within Ukraine's agri-business sector, ranging from the use of drones, to human resource management and to seeds. The accelerator has already helped establish more than 200 start-ups around the country.

UnitCity also offers online, 1.5-year training courses in ICT based on a franchise with the French École 42 MOOC provider[37], emphasizing project-based and peer-to-peer learning. The self-paced, online training is provided for free in exchange for a three-year commitment to work in startups established within UnitCity. The school currently has 900 students enrolled in the program.

3.3. BACKWARD LINKAGES AND PRODUCTIVITY GROWTH: THE MISSING LINK

The economic development literature shows that productivity growth is correlated with the diffusion of ICT within the economy.[38] Similarly, micro-level studies show that effective ICT implementation enables organizations to realize higher levels of efficiency, resulting in higher output, labor cost savings, and higher product and service quality.[39] Thus, the emergence of a domestic ICT sector is ideally linked to the diffusion and adoption of digital solutions within other sectors of the economy, otherwise known as "backward linkages." Backward linkages are especially important within the manufacturing and services sectors, accelerating country-level productivity growth.[40] In one area of comparison, the share of enterprises using computers, Ukraine is falling behind: 69% percent of enterprises in Ukraine use computers compared to the EU28 average of 98%. These data help confirm study findings (discussed below) that the growing ICT sector is largely disconnected from the other sectors of the economy.

Backward linkages can enhance industrial productivity and reinforce the competitiveness and adaptability of the ICT sector. For example, the development of the ICT industry in China

[37] https://qz.com/1054412/a-french-billionaires-free-teacher-less-university-is-designing-thousands-of-future-proof-employees/.
[38] See, for example, Jorgenson (2001). For an international perspective, see Jorgenson (2004).
[39] See, for example, Lehr and Lichtenberg (1999).
[40] Arora and Gambardella 2005a.

was linked to ICT infrastructure modernization efforts in the banking, telecommunications, consumer electronics, and retail sectors. Linkages with digitization efforts in the Brazilian public sector similarly help explain the emergence of a vibrant ICT sector, while linkages formed between ICT software firms and domestic hardware firms helped develop the organizational and managerial capabilities of both.[41] In these examples, ICT firms experienced high demand from domestic firms, and in the process they developed specialized capabilities for working with these sectors. These capabilities, in turn, could be used to export services to the same sectors in other countries. The local companies received ICT solutions tailored to their local needs and in the process become more productive. All sectors benefited from an expanding pool of ICT-related human capital and inter-sector linkages that boosted national productivity and enhanced the overall competitiveness of domestic firms. [42] By contrast, ICT clusters that emerged in India, especially Bangalore, were comprised of companies without linkages to other sectors in the Indian economy.[43] Such industrial "silos" are themselves important to employment but do not impact economies to the same extent as when ICT is linked with other sectors.

Our review of the literature and qualitative assessment based on consultations with industry leaders, associations, investors and entrepreneurs concludes that the Ukrainian ICT sector has emerged primarily as an export-focused "silo" with few economic ties to domestic industries. This situation is described in the literature as an 'exclave' - a sector disconnected from a country's economic context. An 'exclave' is not only isolated from other sectors, it is also externally oriented in terms of organization, investment, and incorporation.[44] The ICT sector's position as an exclave is analogous to firm-level observations (described in the previous section) that most outsourcing companies are organized into project-based "caves".

In Ukraine, areas with the most significant potential for ICT application are agriculture, transport (pipelines, railroads), aviation, the financial sector, and healthcare. However, the readiness and level of demand for ICT-based restructuring differ sharply among these sectors. Also, there are significant differences in the financial capacity of industries to finance ICT projects; financial capacity is solid in agriculture, but specific demands are just now being articulated for ICT-related opportunities to improve productivity. Today, organisations like Agrohub[45] are attempting to broker this divide between large agro-holding companies and innovative entrepreneurs in the ICT sector.

Domestic market-oriented ICT companies, so-called *localizers*, do exist in Ukraine. These companies serve local markets, promoting *de facto* backward linkages within former state-owned enterprises in aerospace and energy and government departments (the companies

[41] Arora and Gambardella 2005b; Breznitz 2007.
[42] Arora and Gambardella 2005b
[43] Chaminade and Vang 2008.
[44] Radosevic and Wade 2014.
[45] https://agrohub.org.

formerly serviced Russia and other CIS members). While ICT localizers possess intimate knowledge of domestic enterprises within different sectors and produce complete solutions, they do not possess connections with outsourcing companies, nor do they enjoy the same level of resources or capabilities as their export-oriented counterparts. Thus, there is a disconnect between the capabilities of these firms and what is needed in the ICT sector.

Several additional factors are inhibiting backward linkages in Ukraine. First, industrial engineering capabilities have declined. During the days of Soviet Union, design and construction bureaus possessed a working knowledge of enterprise operations and understood related opportunities to improve productivity. This knowledge, which is critical for the effective application of ICT in legacy industries (e.g., aerospace, steel production, etc.), unfortunately no longer exists; the design bureaus have disappeared and no industrial engineering intermediaries have emerged to take their place within Ukraine. Second, ICT is increasingly embedded in hardware. Thus, when Ukrainian companies buy foreign equipment the software is already embedded within, which limits the potential for establishing backward linkages to local companies through co-developing and implementing disembodied software.[46] Finally, local clients often seek ready-made ICT solutions or hire temporary employees to design ICT solutions. Neither approach encourages the co-development of value-added joint products important for upgrading in the software sector. Interestingly, Phase 4 companies are already working with foreign clients to co-develop solutions for Smart Cities and Industry 4.0 applications (discussed below). Thus, the ICT capability exists in Ukraine to establish backward linkages, but the aforementioned elements have prevented this from occurring.

The underdevelopment of backward linkages within the Ukrainian ICT sector highlights two interrelated economic opportunities. First, the Ukrainian ICT sector is well positioned to take advantage of the emerging Industry 4.0[47] wave in Europe and the global demand for digital skills. Industry 4.0 is an emerging industrial trend whereby physical manufacturing systems are interconnected through cloud-based machine learning applications that enable flexible production and a high degree of product customization. The Ukrainian ICT sector could realize substantial economic benefits from the Industry 4.0 wave if local companies and solution providers develop the capacity to implement digital solutions and products that service specific industries, especially the manufacturing sector which is increasingly being transformed through servicification. Primary areas where I4.0 solutions could impact adopters include operational improvement, the disruption of existing value chains and business models, and the demand for digital skills. The Ukrainian ICT sector, given its scale

[46] While embedded systems have some advantages in costs, maintenance, reliability, and so on, they are also inhibiting further improvements in technology.

[47] The term "Industry 4.0" originated with the German government as part of a national high-tech initiative launched in 2011. There is no single agreed upon definition of Industry 4.0. The concept is sometimes used interchangeably with the term "The Fourth Industrial Revolution" which is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. (Schwab 2016).

and readiness, is well positioned to be the supplier of digital solutions and products to European and global manufacturers and MNEs as they embark on the digitization trend.

The second opportunity lies within the Ukraine market and the digitization needs of its enterprises and sectors. Ukraine's industrial production capabilities have not been improving, especially in former state-owned enterprises. ICT services and solutions have the potential to open new opportunities for optimizing production and business processes. The application of digital solutions could be piloted in resource-based industries where exports have been growing, such as agriculture. Ukraine has around 20 large agro-holdings, which are strong financially but still lagging in terms of adoption of digital solutions compared to their European and international peers. Partnering of ICT and agro-companies could be one of the key priorities for both industries.[48] Further, productivity improvements would likely be realized through digitization even in traditional industries such as textiles and apparel. Finally, digitization of government services and institutions, if effectively implemented, is likely to improve service delivery, transparency, efficiency and create a much-needed demand pull for local digital service providers. Neighboring Estonia's experience of digitization of government services could provide inspiration and useful lessons.

In sum, while a vibrant ICT industry is rapidly emerging in Ukraine, constituent firms are primarily focused on relatively low-value-added outsourcing within the ICT global value chain. This reflects the overall low capacity for technology upgrading in the wider economy. Firms operating in high-value-added markets have developed management and organizational capabilities that enable them to break down long-standing project-based caves and co-develop end-to-end solutions with clients or develop new products to sell directly to consumers. Perhaps a more significant challenge for Ukraine is, however, the disconnect—that is, lack of backward linkages—between outsourcing-focused ICT firms and firms within other sectors such as aerospace, agriculture, and heavy machinery. The absence of backward linkages means that firms within other sectors do not have the ability to compete globally and, perhaps worse, may continue to decline. Backward linkages would thus improve firm-level success while accelerating country-level productivity and improving overall economic and social development. The next section provides several recommendations for improving technology upgrading within the Ukrainian ICT sector.

3.4. SUMMARY OF THE ICT INDUSTRY CASE

- The ICT industry is the fastest growing in Ukraine and a critical contributor to the economy.

[48] As an example, Agrohub (https://agrohub.org) is a local initiative which aims to catalyze the relationships between agro companies and innovative entrepreneurs, startups, training centers, experts, and international companies.

- The industry has flourished due to Ukraine's stock of talented human capital, a low self-employment tax, growing international demand for software services including the 'servicification' of manufacturing, knowledge diaspora, and low barriers to entry.
- Most firms in the ICT industry are small and specialize in relatively low-value added software services. Firms that have developed the technical and managerial capabilities needed to develop new products and scale their companies are the most profitable and resilient.
- The FOP tax system was critical to the emergence of the ICT industry, yet could also disincentivize firms from building managerial capabilities important for scaling and upgrading.
- The lack of managerial talent in Ukraine also constrains the development of the industry.
- Low domestic industrial demand for ICT services, the lack of industrial engineering capabilities, and poor inter-industry connectivity means that both the ICT industry and other industries are not realizing their economic potential.

4. RECOMMENDED AREAS FOR POLICY ACTIONS

This section provides recommendations for how Ukrainian industry, non-profits, government, and donors can begin to address the challenges of technology upgrading discussed in this report.

4.1. BACKGROUND TO RECOMMENDATIONS AND THEIR IMPLEMENTATION PRINCIPLES

This report details three main impediments to technology upgrading in Ukraine. First, managerial capabilities are weak, R&D expenditures are low and declining compared to GDP, and the availability of researchers is falling. Second, despite its size, proximity to the EU market and its industrial networks, the Ukraine economy is not strongly integrated into international supply chains as the primary source of new technological knowledge. Third, the ICT services sector has achieved significant success in the last ten years, but its further contribution will reach limits unless there are backward linkages to the sector that would contribute to the diversification of the economy.

Given these three diagnostic insights, three areas of for innovation policy actions are emphasized:

- Enhancing *technology upgrading* by promoting activities and organizations that can improve *managerial capabilities, and through the adoption of productivity-enhancing technologies.*
- Enhancing the *integration of Ukraine into global value chains/FDI and their links to domestic firms*
- Building *a digital-ready workforce*

Any policy discussion needs to recognize the government's low institutional (policy) capacity. Ukraine faces pervasive market (coordination) and government failures in which conventional top-down policy logic is likely to fail. This has been repeatedly demonstrated by the recent history of innovation policy of the country (EC, 2017[49]; WB, 2017[50], Yegorov,

[49] EC (2017) Peer Review of the Ukrainian Research and Innovation System, Horizon 2020 Policy Support Facility
https://rio.jrc.ec.europa.eu/en/policy-support-facility/peer-review-ukrainian-research-and-innovation-system
[50] Cheney, David; Zolotarev, Andrey P.; Wyne, Jamil; Aridi, Anwar. 2017. Ukraine - Innovation and entrepreneurship ecosystem diagnostic. Washington, D.C. : World Bank Group.

2013[51]). Hence, the report envisages the need for a *new approach in innovation policy*.

Several implementation principles are articulated to highlight the unique policy context of Ukraine and thus improve the likelihood of successful implementation of these recommendations. These include:

- The Ukrainian government currently lacks the capacity to lead implementation efforts for industrial upgrading. Thus, other *non-profit, industry, and donor-supported groups could take responsibility* for spearheading the efforts suggested below.
- The government's role in contributing and facilitating collective action around different innovation issues remains essential. However, *its involvement in implementation of different policies should match its policy implementation capacities*.
- Policy is about facilitation and moderation of self-organization activities undertaken or proposed not only by government but also by *non-state organizations*.
- The industrial upgrading policy is also about *upscaling* the existing or emerging bottom-up initiatives.
- *Small-scale pilots* that focus on improving policy aspects are likely to yield significant benefits. Small pilots can be developed to specific regional and industrial contexts and can be adapted for other contexts. Successful pilots can be reconfigured for the purpose of scaling up, while unsuccessful pilots can be canceled.
- Industrial upgrading efforts will likely be most effective when *implemented at the regional level*. A *subnational* approach can emphasize contextual differences and specific needs, especially those related to upgrading local industries.
- Decisions about specific policy instruments are more successful when based on a careful assessment of institutional capacities for their design, implementation, monitoring and evaluation. Thus, *selectivity* is key; only those actions where there is a good match between policy intention and policy implementation capacity should be promoted.

Table 2 summarizes the challenges and proposed solutions that seek to address the three areas above.

http://documents.worldbank.org/curated/en/126971509628933853/Ukraine-Innovation-and-entrepreneurship-ecosystem-diagnostic

[51] Yegorov, I. (2013): Erawatch Country Reports 2012: Ukraine. ERAWATCH Network – Centre for S&T Potential and Science History Studies of the National Academy of Sciences Ukraine.

Table 2. Matrix of recommendations to Improve Industrial Upgrading in Ukraine

Operating Business Environment	**Business environment constraints**	Improve the business environment by addressing issues, such as labor market, intellectual property rights, and FDI policy and promotion, that impact industrial upgrading
	FOP Tax Consequences	Gradually increase the FOP tax rate informed by sector-specific studies on the impact of the increase
Managerial and Production Capabilities	**Low Managerial capabilities**	Implement a voucher or cost-sharing grant pilot program to incentivize firms to undertake projects to upgrade their managerial capabilities and leverage productivity-enhancing technologies.
	Unresponsive R&D Institutions	Reform public R&D institutions to be 'demand driven' and support innovative activity within industry
Global Value Chains	**Lack of Connectivity to GVCs**	Support the integration of Ukrainian SMEs into global value chains by assisting their adherence to international standards
Human Capital	**Shrinking ICT Labor Supply**	Expand and upskill the ICT workforce pipeline through joint technical school/university-industry educational programs guided by University-Industry Advisory Boards

Note: For the list of indicators that measure each of the categories, see Annex 1.

4.2. ADDRESS CONSTRAINTS RELATED TO THE BUSINESS ENVIRONMENT

4.2.1. IMPROVE THE BUSINESS ENVIRONMENT

Problem: Several aspects of the business environment in Ukraine can be improved to support industry performance, including within ICT. Specific challenges include an overly flexible labor market, high levels of corruption[52], a weak intellectual property rights framework[53],

[52] According to Transparency International Corruption Perceptions Index Ukraine is ranked 120 out of 180 economies. Source: https://www.transparency.org/country/UKR

[53] Based on Ginarte and Park index of patent rights data for 2015, Ukraine's index was 3.88. This is significantly lower compared to seven CEE economies (Bulgaria, Czechia, Hungary, Lithuania, Poland, Romania and

underperforming FDI policy and promotion, excessively and poorly designed regulations, frequently changing governments and policies[54], and unrealized potential benefits from local linkages. These challenges create a drag on business and stand in the way of industrial upgrading.

Approach: While the Ukrainian government has attempted to implement governance-related reforms, placing greater emphasis on improving the operating business environment would help to promote technology upgrading. Further, industry could play an active role to improve the country's business environment. For ICT, the industry association (IT Ukraine) is considered one of the best-organized associations in Ukraine and has played an active role to promote partnerships with educational institutions and engage in policy issues such as streamlining the foreign worker permit process. However, it has yet to establish a long-term policy strategy that would provide a critical voice to improving the overall business environment.

Required Action: Industry associations, such as IT Ukraine, could outline sector-specific policy strategies for improving the business environment in Ukraine. The envision innovation agency/office[55], in cooperation with the Donor community, could also play a catalytic role in translating the strategies and facilitating industry collaboration in areas of common interest.

4.2.2. GRADUAL FOP RATE INCREASE AND POTENTIAL SECTOR DIFFERENTIATION

Problem: The FOP system has been critical to the development of the ICT sector. However, the classification also has had unintended consequences in reducing labor supply in traditional industries (because tax rates are much higher in comparison to freelancers), such as textiles, apparel, and other industries that require scale to be efficient. Further, within the ICT sector, the FOP system might have contributed to the weak development of long-term management and organizational capabilities.

Slovakia) whose score was 4.14. The index is the unweighted sum of five separate scores for: coverage (inventions that are patentable); membership in international treaties; duration of protection; enforcement mechanisms; and restrictions (for example, compulsory licensing in the event that a patented invention is not sufficiently exploited). This index was designed to provide an indicator of the strength of patent protection, not the quality of patent systems. Source: Walter G. Park (2008) International patent protection: 1960–2005, *Research Policy*, 37: 761–766. Data for 2015 are received from personal correspondence of authors with Dr Park.

[54] Cheney et al. (2017).

[55] The Ukrainian government had outlined several plans for establishing an enterprise innovation and industry-focused support office or agency which never materialized on full scale. There are currently few bodies that claim ownership of the innovation and industrial agenda but with little financial or human resource capabilities to achieve the stated objectives.

Approach: FOP tax rates could increase gradually for the ICT sector and increase more rapidly for other sectors. According to ICT industry experts, it seems that a doubling to 10 percent is still considered acceptable. Opportunities to differentiate the tax system by sector could be explored, so as to not to discourage entry and investment in traditional industries where FOP has created unfair competition between businesses operating in FOP and the standard regime. Taxation, competition and technology upgrading effects should be considered in this effort.

Required actions: Commission a study by credible international consultancy organization to explore the issue and propose model of FOP tax reform with special reference to its sector specific implications

4.3. ENHANCE TECHNOLOGY UPGRADING THROUGH BUILDING MANAGERIAL CAPABILITIES

4.3.1. UPGRADE MANAGERIAL AND PRODUCTION CAPABILITIES THAT CAN LEVERAGE PRODUCTIVITY-IMPROVING TECHNOLOGIES

Problem: Low production and managerial capabilities

Ukraine is the lowest ranked on the index of production capability among comparison economies. This reflects poor management practices, as well as a lack of attention to quality and productivity improvements. World-class quality is the crucial precondition for participating in global or regional value chains. Ukrainian exporters are already constrained by poor quality, and face significant difficulties in complying with quality standards (product features, health and safety) in export markets. While the ICT industry fares better in terms of international standards, interviews with industry leaders suggest that a lack of managerial capabilities is a critical constraint on moving from outsourcing to implementing and managing complex ICT projects and end-to-end solutions (see Figure 26). Thus, both managerial capabilities and quality standards are nationwide issues, which could be addressed initially in specific sectors where there is a critical mass of awareness that managerial capabilities and quality are critical preconditions for exporting. For example, such sectoral pilots could be initiated in food processing, software, or machinery sectors or in any sector where stakeholders have recognized quality as not only their individual, but a collective, challenge.

Approach: A voucher and/or cost-sharing grant programs could be piloted to incentivize firms to undertake projects to upgrade their managerial and production capabilities and leverage productivity-enhancing technologies. Vouchers could be used for activities that would improve managerial and production (manufacturing and service) capabilities, such as twinning arrangements with foreign industry associations, internships or temporary work

practices in foreign companies to enhance managerial skills among individuals working in that industry. Vouchers also could be used to fund the integration of technologies into business operations to enhance productivity and improve operations. This in turn could increase demand for ICT services provided by domestic software companies, especially if they develop the capabilities need for working with other sectors.[56]

Required actions: A pilot voucher program would encourage industry to undertake projects to upgrade managerial capabilities and adopt process improvement techniques, international production and managerial standards, and new technologies that support increased productivity, including ICT solutions. While a voucher system would be valuable in the short-term, long-term effectiveness can be improved by working with commercial providers of productivity services or, as discussed below, the conversion of some applied R&D-performing institutions into public-private service providers that work on a subnational level.

4.3.2. UNDERTAKE PILOT PROGRAM FOR RESTRUCTURING PUBLIC R&D INSTITUTIONS

Opportunity: R&D mismatch and low innovation activity, yet promising industry experiences working in partnership with universities

The gradual erosion of the R&D system of Ukraine continues, with R&D organizations changing their activity profile under challenging conditions of limited public funding and a "survival mode of operation". This process has become dysfunctional, as it has created a big gap between demand needs and supply capacities. There is a potentially significant untapped demand by SMEs for technical services, testing services and problem-solving skills, which cannot be addressed by R&D organizations oriented mainly towards the public sector.

Approach: Reform R&D institutions to be 'demand driven' and support innovative activity within industry

The aim is to facilitate "active and gradual restructuring" of public R&D institutions. This would involve voluntary activities supported and facilitated by internationally-funded public program for supporting the restructuring of the public R&D system. The objective is to develop a new profile of R&D institutes, restructure them towards technology extension services or technology institutes, or reorient them towards upstream R&D publicly-funded programs.

This is an *activist* approach, in the sense that government through its relevant agencies facilitates the restructuring of R&D institutes on an individual basis. It is *gradual*, as it is based

[56] For example, Agrohub, an industry led initiative, attempts to create connections between agriculture companies and innovative entrepreneurs, startups, training centers, experts and international communities in the implementation of ICT in agriculture. The challenge is how to extend this model to facilitate the implementation of ICT in other sectors like industrial engineering, clothing, heavy engineering or automobiles.

on bottom-up initiatives of R&D institutes, includes their financial participation and requires the involvement of other stakeholders. Unlike the immediate privatization option, this approach recognizes that R&D institutes are not ordinary commercial enterprises as they operate in between public and private knowledge bases. Their funding mode should reflect their hybrid, ie. public – private, function.

The active and gradual approach assumes that the most appropriate organizational and ownership profile of R&D institutes cannot be decided in advance. It *has to be discovered* in the process of active restructuring which involves all stakeholders and is also *voluntary and sector specific*. The final owners/operators will differ in each case and may be public institutions, private firms, or different mixed forms depending on the specificity of resources and the private/public knowledge profiles of the R&D institutes.

Required actions: A model for restructuring the public R&D system and its implementation is to be outlined, under a dedicated project to be developed by the Ukrainian government (or its relevant innovation institutions) in cooperation with the donor community.

4.4. FACILITATE THE INTEGRATION OF UKRAINE INTO GLOBAL VALUE CHAINS AND DEEPEN THEIR LINKS TO DOMESTIC FIRMS

4.4.1. PROGRAM OF SUPPLY CHAIN INTEGRATION OF UKRAINIAN SMES THROUGH REACHING STANDARDS REQUIRED BY INTERNATIONAL BRAND MANUFACTURERS OR SERVICE PROVIDERS

Opportunity: Low adoption and implementation of international quality standards and related low participation in global value chains.

Approach: The aim of this program is to increase the share of Ukrainian suppliers in the supplier networks of foreign medium-sized and large enterprises, improve cooperation between foreign firms and local suppliers in the field of productivity improvements, and promote the growth of SMEs. This can be accomplished through twinning projects between SMEs and foreign companies to develop networks of local suppliers. The tool to promote these strategic partnerships would be cooperation in productivity and quality enhancing projects in selected sectors/technology areas.

Required Actions: In the first phase of the program, the medium-and large-sized companies would select local SMEs that choose to become their suppliers, identify the aims of the project, and cooperate in product and process innovation tasks. The partners would develop

a medium-term business plan, explaining how the project's results would be exploited by the suppliers and the foreign partner. The foreign partners would monitor the progress of innovation activities of the selected partners, who would cooperate with each other. The foreign partner also would commit to audit the participating SMEs upon the completion of the project, and in case of a successful audit, to issue a supplier certificate.

Such a program could be funded by a consortium of international organizations and managed by the local contractor organization with the involvement of interested Ukrainian regions.

4.5. INVEST IN DIGITAL-READY HUMAN CAPITAL

4.5.1. EXPAND AND UPSKILL THE ICT WORKFORCE PIPELINE

Opportunity: There is an increasing need for well-trained ICT engineers and technicians that possess sophisticated programing and managerial skills. Further, Ukraine is experiencing significant out-migration of talented individuals, especially with expertise in areas such as artificial intelligence, cloud computing, cybersecurity, and machine learning, therefore increasing the urgency of improving the ICT workforce pipeline.

Approach: Build and expand education and training at universities and technical schools focused on producing more and better-trained ICT workers.

Required Actions: The program would focus on joint technical school/university-industry educational programs, whereby industry provides inputs through advisory groups and rotates in personnel to administer training. These could be 2+1 years training programs, in which the first two years are administered by academic staff and focus on the academic side of programming, while the final year is administered by industry personnel on loan from companies but using a common curriculum. These efforts could also include the establishment of University Industry Advisory Boards that would include ICT industry representatives who could provide input and advice on the content of these training programs to ensure relevance and respond to the enterprises' needs. Further special modules could be developed that emphasize skills and capabilities needed to help the ICT industry venture into high-value added services and product development. In this context, the government of Ukraine also established in 2019 an IT Creative fund focused on ICT skill development that could be leveraged to help support these initiatives.

ANNEX 1. METHODOLOGY

MEASURING TECHNOLOGY UPGRADING

ITU is composed of two categories: Index A - intensity/type of technology upgrading and Index B - breadth of technology upgrading.

ITU = IndexA + IndexB

The first category is composed of three components: production capability, technology capability and R&D and knowledge intensity based on fifteen indicators. The second category is composed of two components: human capital and physical infrastructure and structural change based on sixteen indicators. The weights for each category and their components and the list of quantitative indicators for each sub-index are presented in tables below. All indexes and sub-indexes are estimated based on the standardization of quantitative indicators followed by aggregation of components with equal weights given to each component, which can be written as:

$$I_c = \sum_{j=1}^{J} \sum_{m=1}^{M} w_{jm} \left\{ (X_{jmc} - X_{jm}^{min}) \mid (X_{jm}^{max} - X_{jm}^{min}) \right\}$$

where c indicates country, w is the weight, j and m are indicator and component subscripts and min and max denote the minimum and maximum values of each indicator across countries.

Table 3. Technology Upgrading Framework

Component (Sub-index)	Quantitative Indicators	Component Weight
Index A: Intensity and types of technology upgrading (Weight: 1/2)		
1. Production capability	1. ISO9001 Certificates pmi 2. Trademark Application, residents pmi 3. On the job training	1/6

Component (Sub-index)	Quantitative Indicators	Component Weight
2. Technology capability	4. Patents resident applications to national office pmi 5. Patent applications to USPTO pmi 6. Patent applications to EPO pmi 7. Resident's industrial design count pmi	1/6
3. R&D capability	8. Business enterprise sector R&D expenditure (as % of GDP) 9. R&D expenditure (% of GDP) 10. Researchers in R&D pmi 11. Technicians in R&D pmi 12. Scientific and technical journal articles pmi 13. Science citations pmi 14. Quality of scientific research institutions 15. University - industry collaboration in R&D	1/6
Index B: Breadth of technology upgrading: structural features (Weight: 1/2)		
4. Infrastructure: human capital and physical	16. Average years of schooling 25+ 17. Quality of maths and science education 18. Availability of research and training services 19. Availability of scientists and engineers 20. Fixed broadband Internet subscribers (per 100 people) 21. Gross Fixed Investment as % of GDP	1/6
5. Structural change	22. HHI for total national patent applications 23. HHI for patent applications to EPO 24. HHI for patent applications to USPTO 25. Buyer sophistication 26. Change in buyer sophistication (%) 27. Availability of state-of-the-art technologies 28. Change in availability of latest technologies (%)	1/6
6. Firm organizational capabilities	29. Number of firms in Forbes 2000 pmi 30. Firm level technology absorption 31. Reliance on professional management	1/6

Component (Sub-index)	Quantitative Indicators	Component Weight
Index C: Interactions with the Global Economy		
7. Technology and knowledge exchange	32. Technology balance of payments (receipts) as % of GDP 33. Technology balance of payments (payments) as % of GDP 34. Share of exports in complex industries in total exports (SITCRev3 5 71-79 87 88) (2002-16 average) 35. Foreign direct investment, net outflows (% of GDP) 36. Foreign direct investment, net inflows (% of GDP)	

Source: Authors, based on adaptation of Radosevic and Yoruk (2017).
Note: pmi (per million inhabitants)

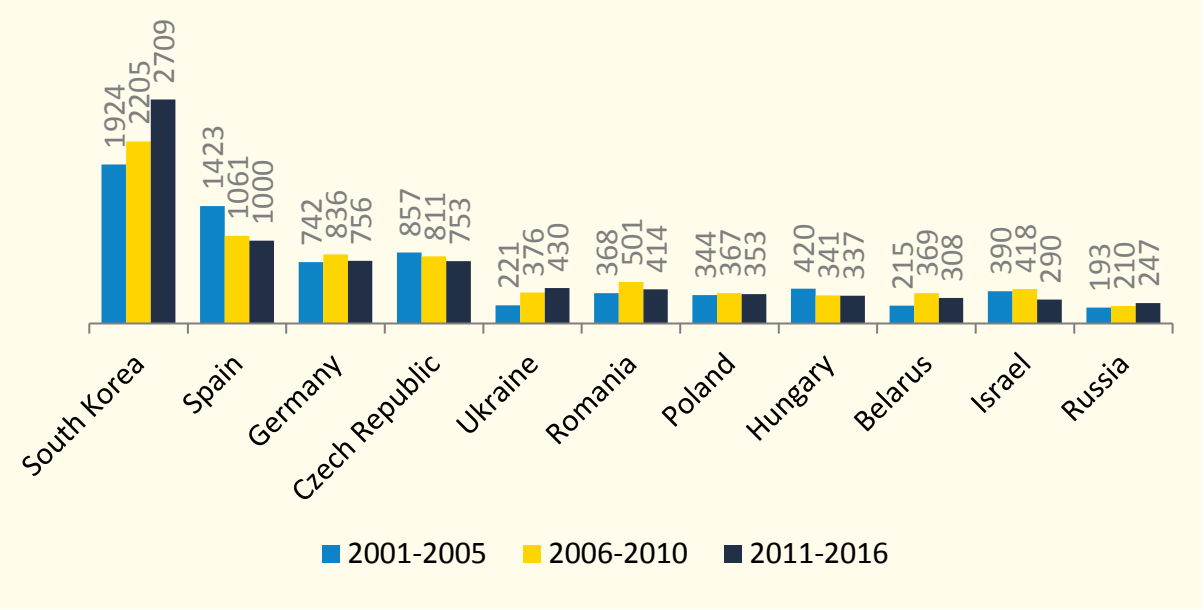
ANNEX 2. QUALITATIVE INTERVIEWS

The team conducted about 15 interviews with the following IT firms, organizations and individual experts in and outside of Ukraine.

- EPAM
- Innovecs
- IT Enterprise
- IT Ukraine Association
- Luxoft
- Platforma
- Ring Ukraine
- Ukrainian Association of Light Industry
- Unit City
- EU FORBIZ
- Small and Medium Enterprises Development Office (SMEDO)
- Marina Vyshegorodskikh, Ciklum
- Mark Kapij, Darwin's Grove (US)
- Johnny Ghibril, B-Yond (US)
- Martin Kenney, University of California Davis

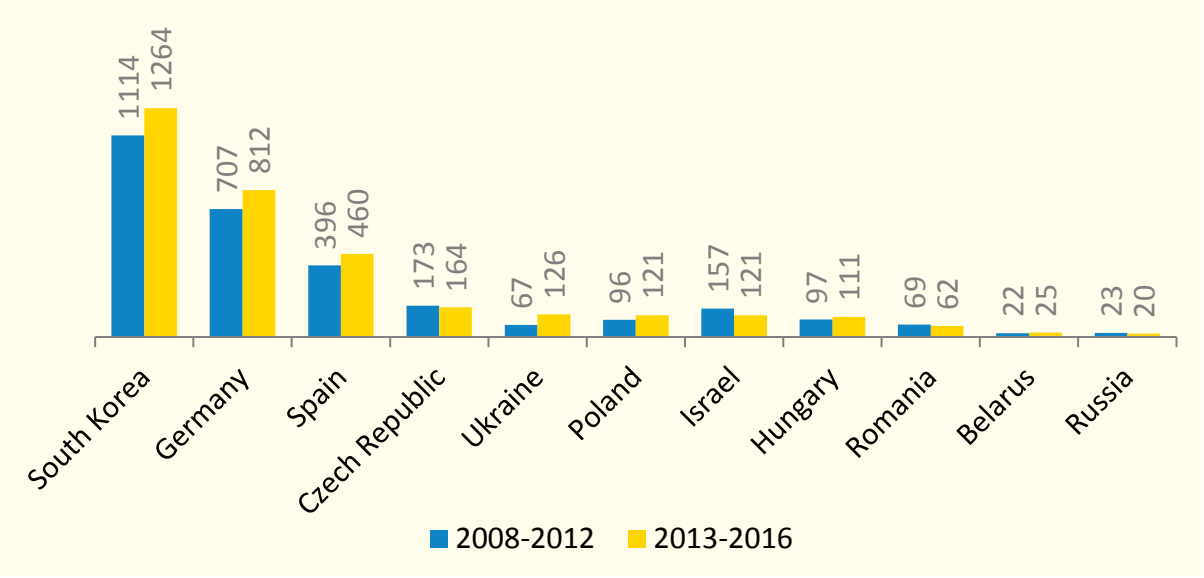
ANNEX 3. STATISTICAL ADDENDUM

Figure 24. Trademark Applications by Residents per Million Population (Average rate per period, 1994–2016)



Source: WIPO Statistics Database.

Figure 25. Resident Industrial Design Count (per million inhabitants)

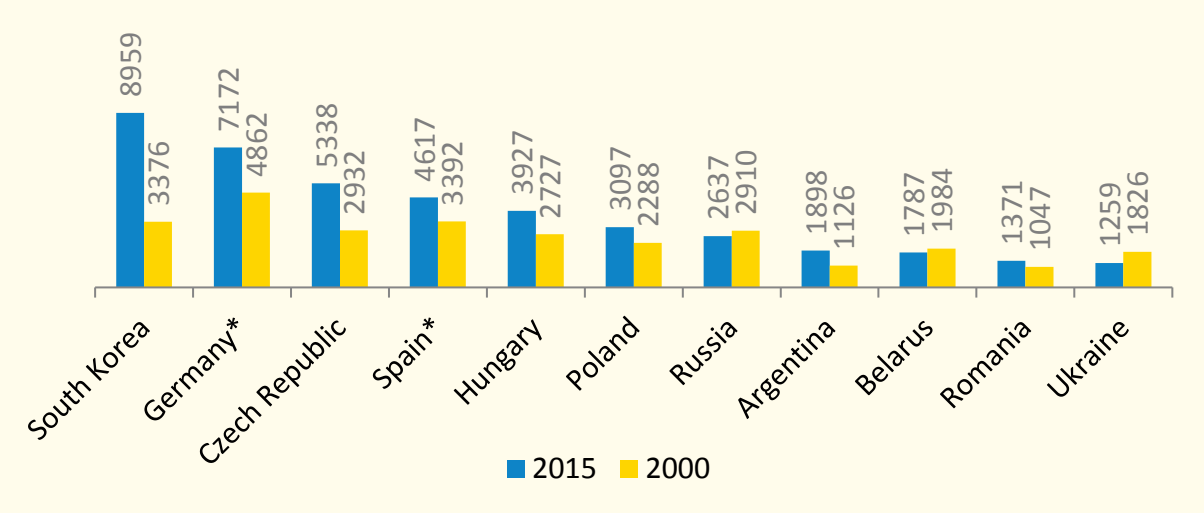


Source: WIPO Statistics Database.
Note: Trademarks offer intellectual property protection for a company's brand identity, which enables companies to differentiate their products and compete within domestic and international markets.[57] By 2016, Ukraine had reached the level of its Central European peers (except Czech Republic) and was above

[57] Schautschick and Greenhalgh 2016.

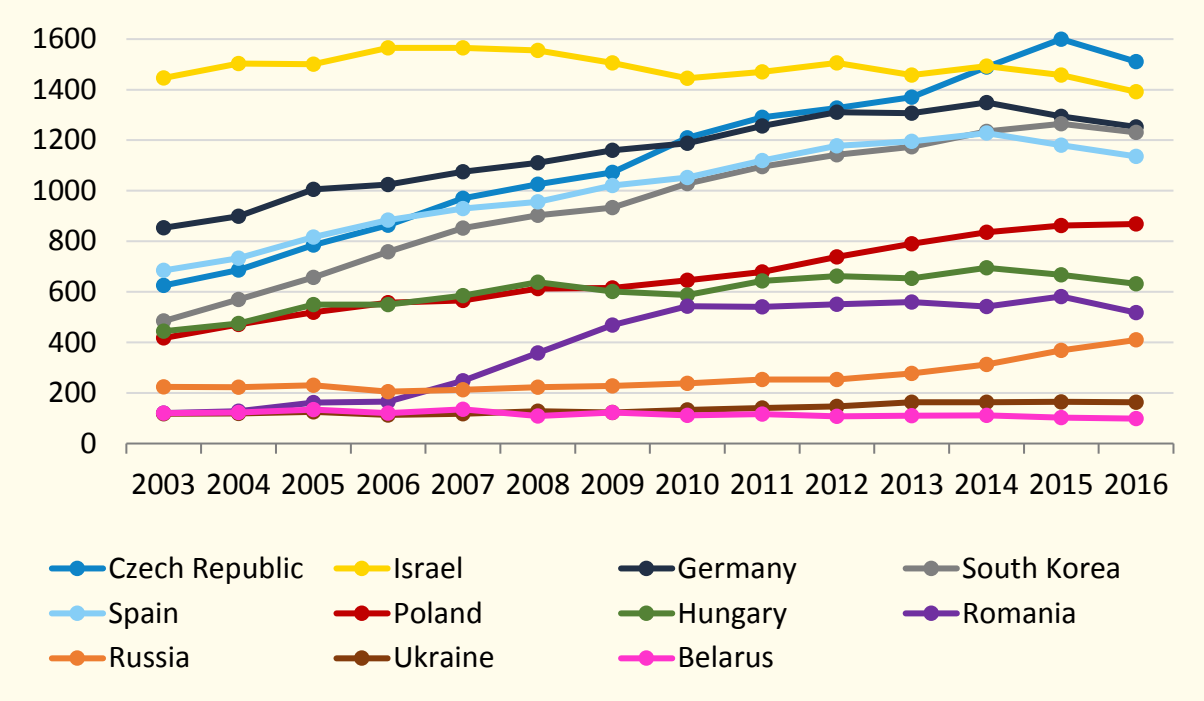
the levels of Israel and Russia Industrial designs are legal rights that can protect the overall appearance of a product or a part of a product. Industrial design counts per capita increased from 2008-12 to 2013-16, to higher levels than in most countries in Central Europe, as well as in Israel (figure 6). However, these indicators may not indicate a significant increase in technological capabilities, as, for example, would a rise in patents. Also, trademarks are registered on average for a 10-year period, and their increase in Ukraine reflects the relative novelty of this marketing innovation rather than a sharp rise in the creation of intellectual property.

Figure 26. Number of Researchers (per million inhabitants)



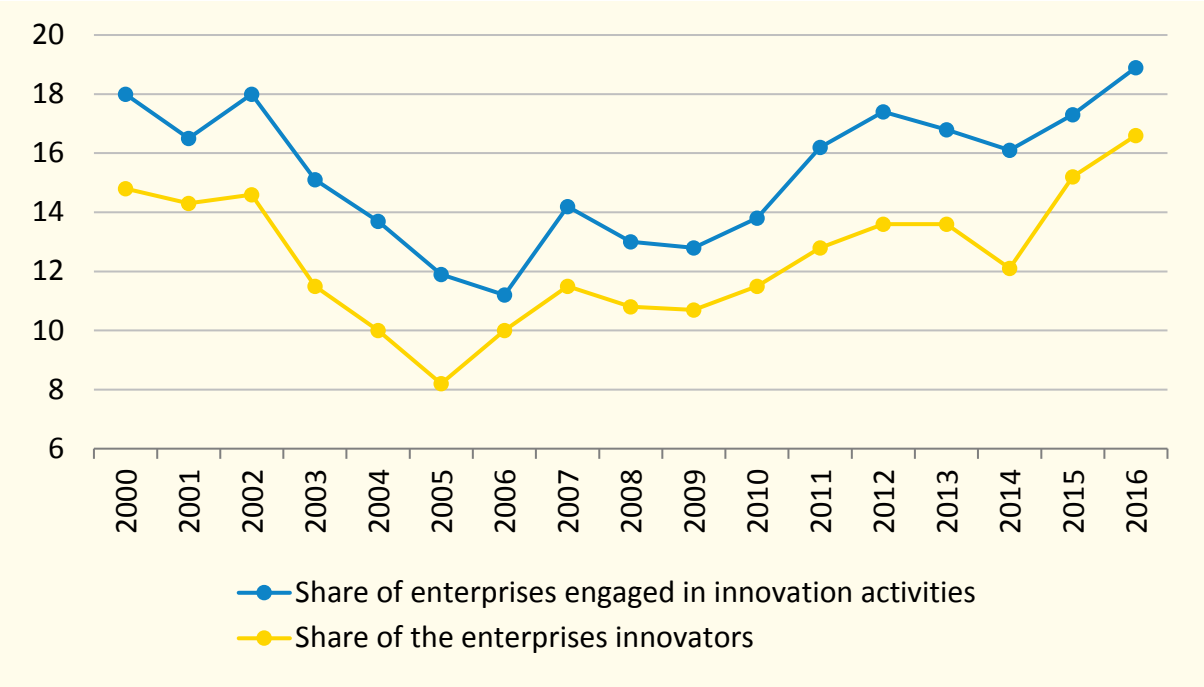
Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Innovation Statistics Database.

Figure 27. Number of Scientific and Technical Journal Articles (per million inhabitants)



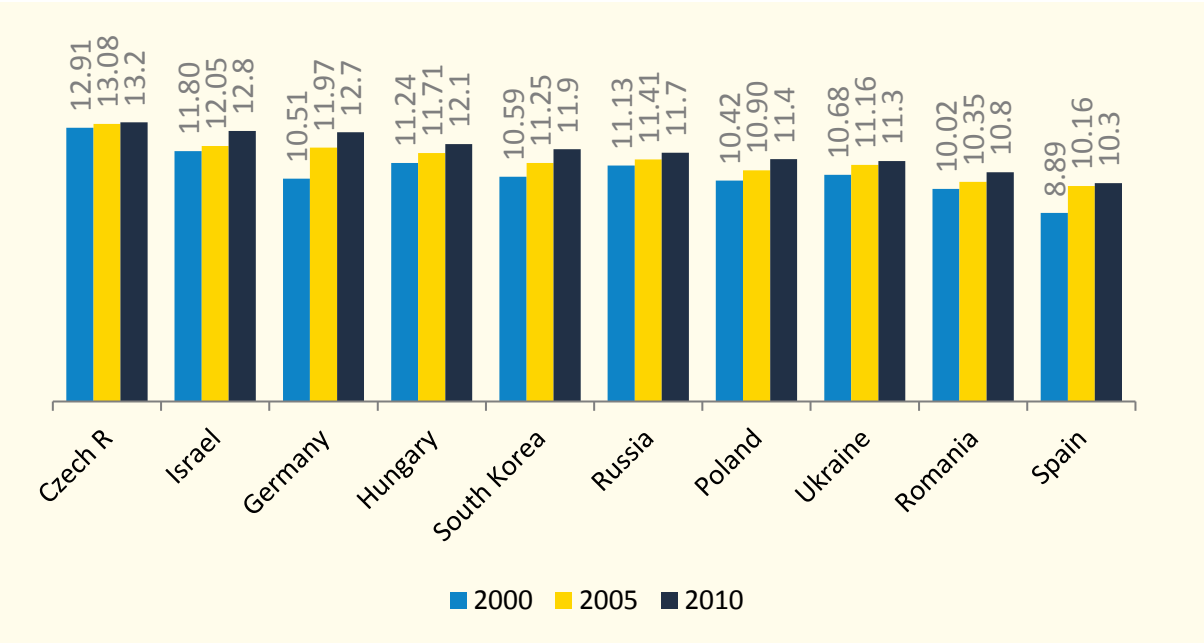
Source: World Bank Development indicators based on NSF Science and Engineering (S&E) Indicators.

Figure 28. Share of Enterprises and Enterprise Innovators Engaged in Innovation-related Activities (2000–2016)



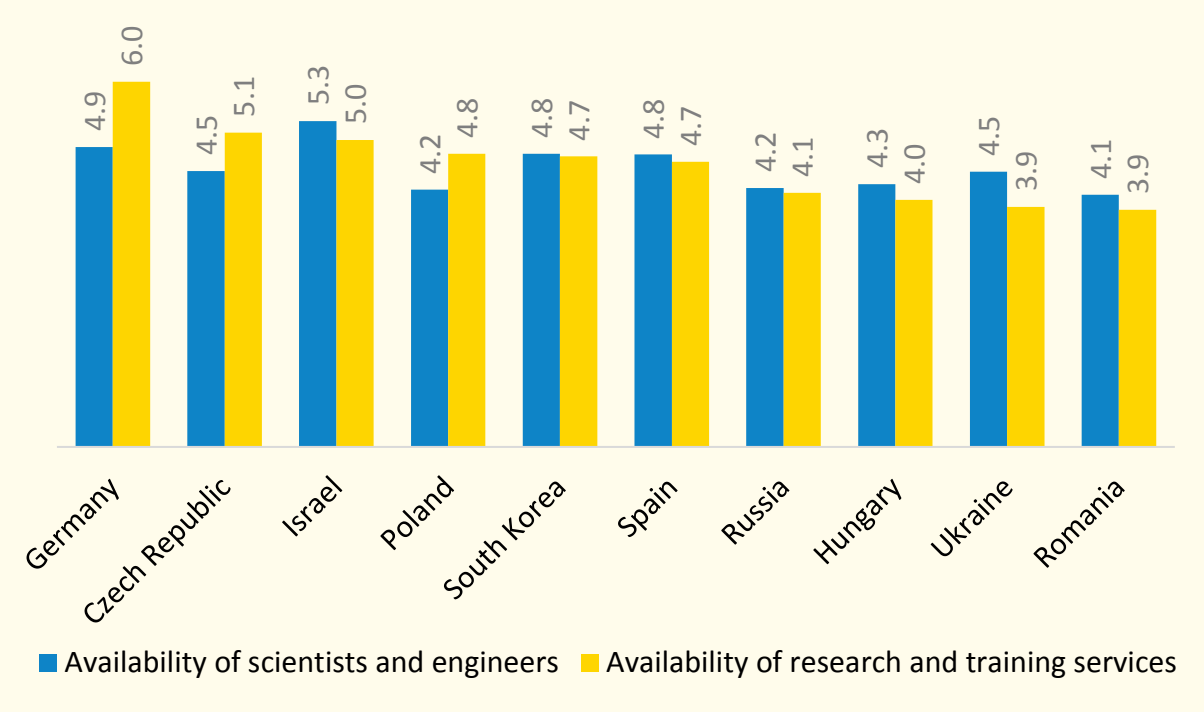
Source: Innovation Activity of Manufacturing firms in Ukraine 2017, Ukraine National Statistical Office.

Figure 29. Average Years of Educational Attainment (1990–2010)



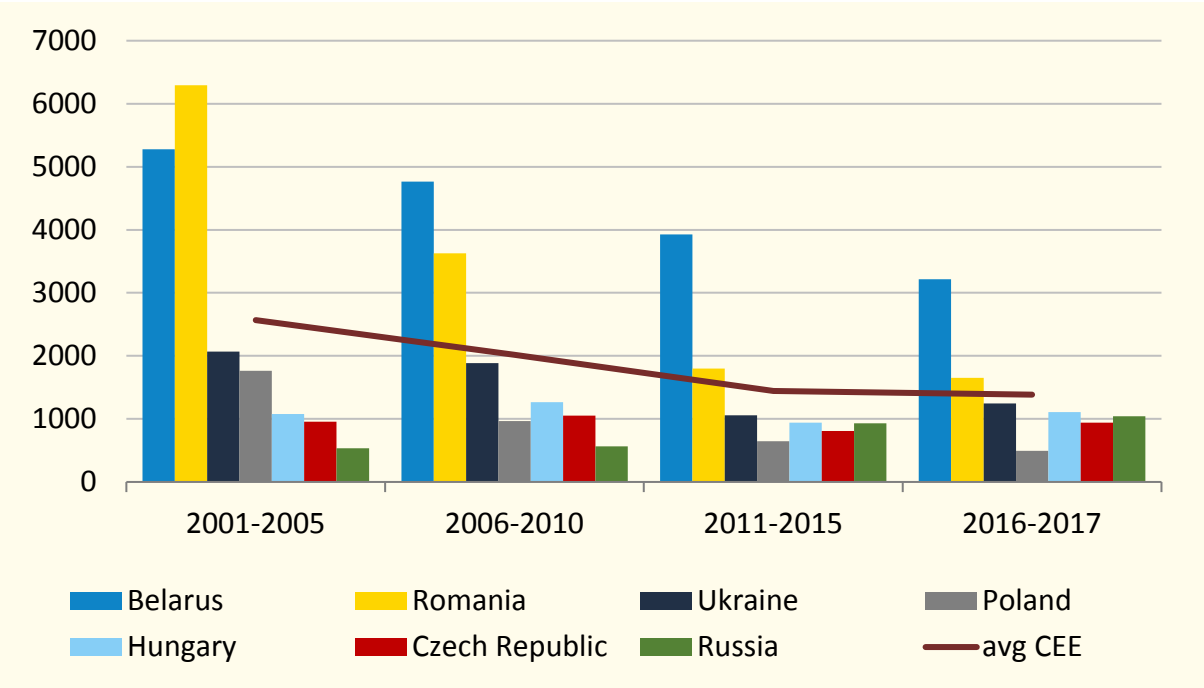
Source: Educational Attainment for Total Population, 1950–2010. Barro R. and J. W. Lee. Database v. 2.2, June 2018.

Figure 30. Availability of Scientists and Engineers and Related Research and Training Services (Average 2007–2017)



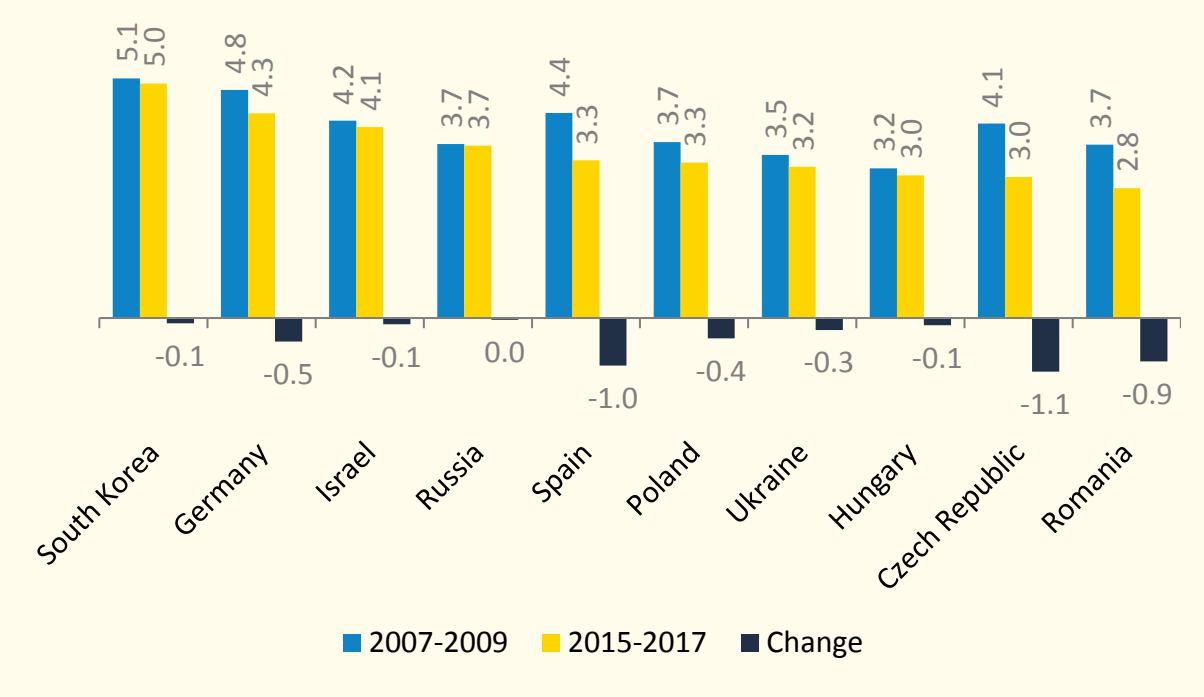
Source: Authors, based on WEF GCR Database 2019.
Note: From 1 to 7, where 7 is best.

Figure 31. Technology Diversification Demonstrated through Patenting in the United States (Hirschman - Herfhindhal Concentration Index)



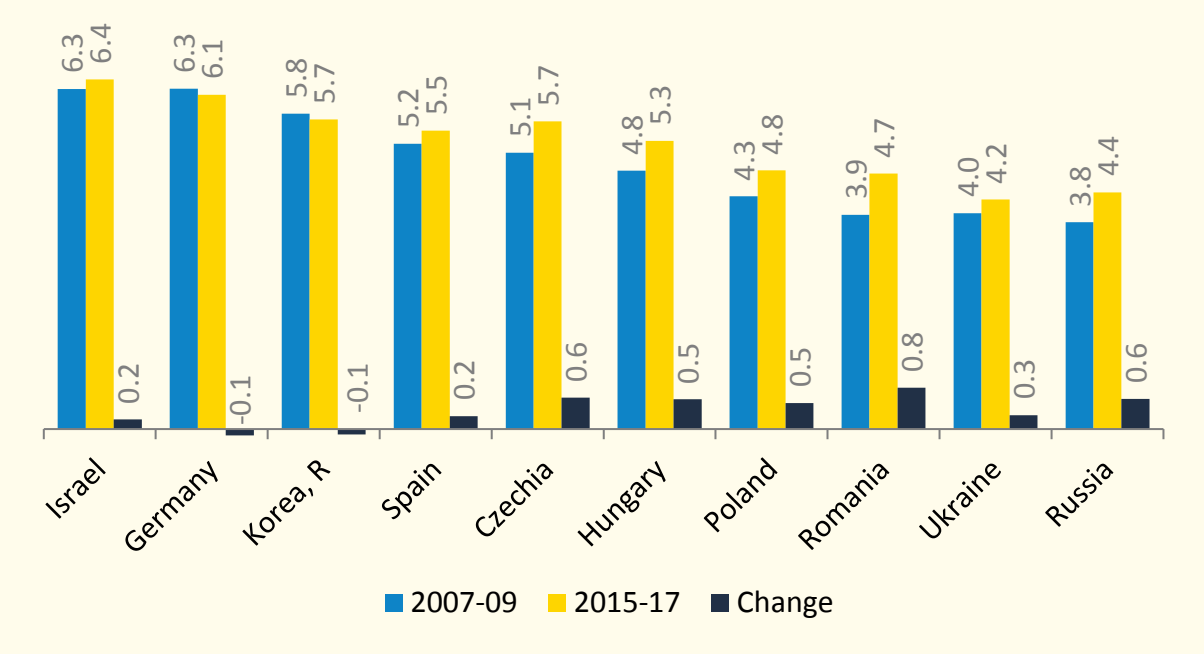
Source: Authors, based on WIPO database.

Figure 32. Changes in Buyer Sophistication Levels (2007–2017)



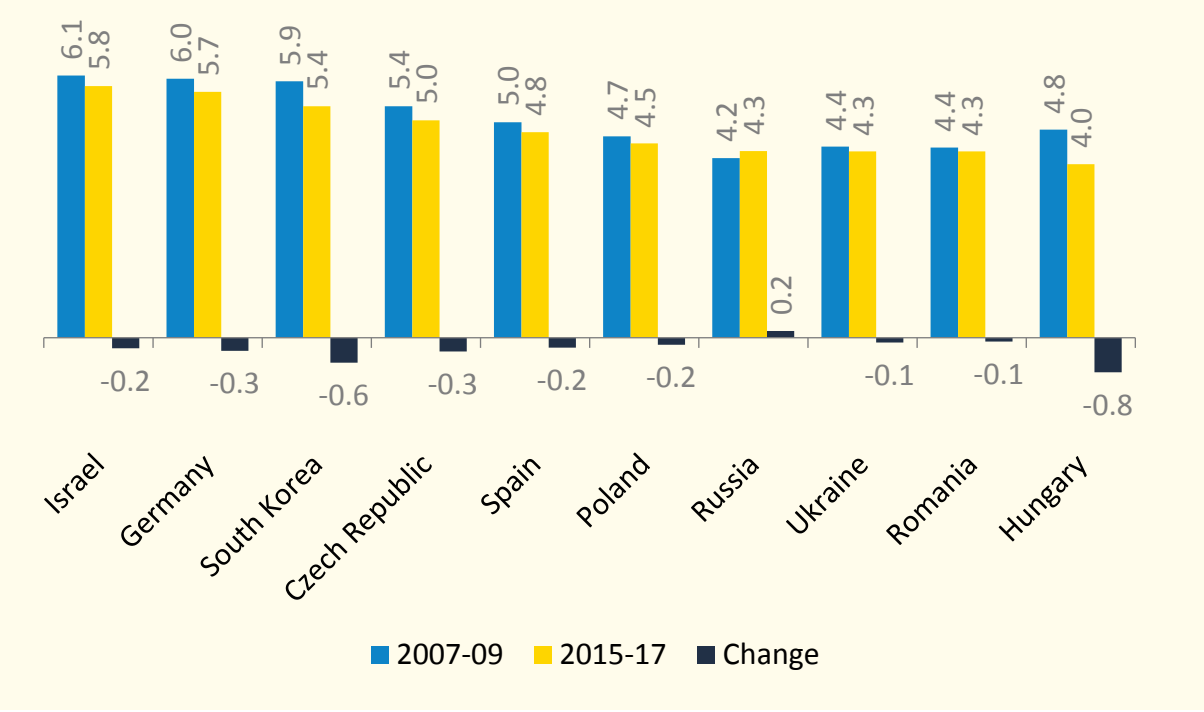
Source: WEF GCR Database.
Note: Response to the survey question "In your country, on what basis do buyers make purchasing decisions?" [1 = based solely on the lowest price; 7 = based on sophisticated performance attributes]

Figure 33. Availability of New Technology (2007–2017)



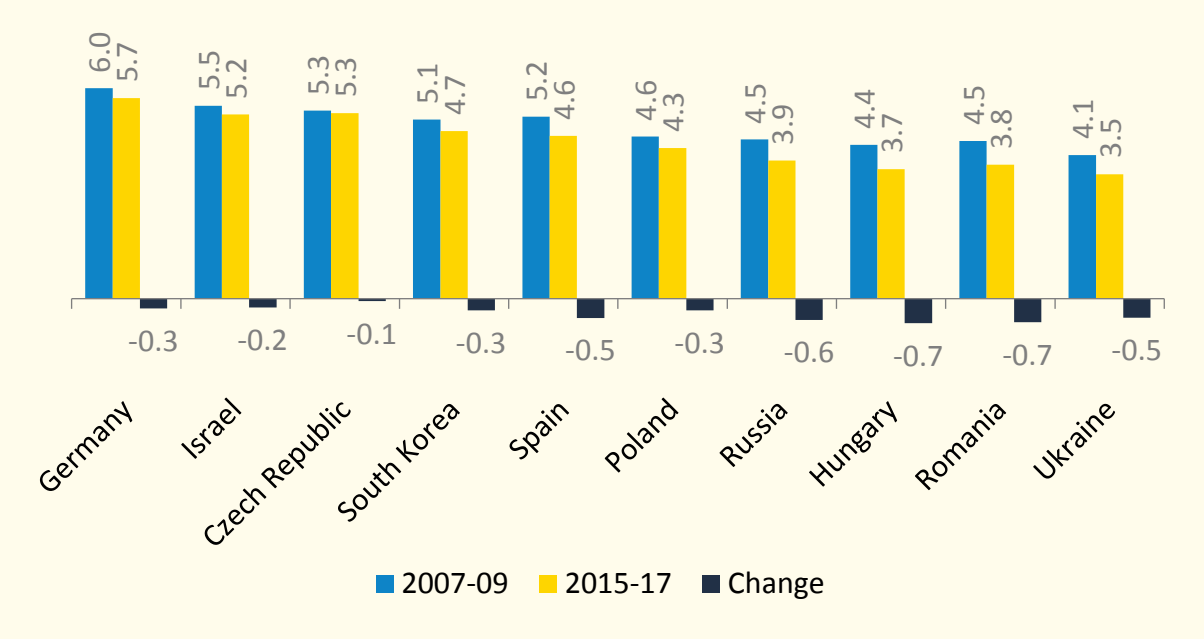
Source: WEF GCR Database.
Note: Response to the survey question: In your country, to what extent are the latest technologies available? [1 = not at all; 7 = to a great extent]

Figure 34. Capacity of Firms to Absorb Technology



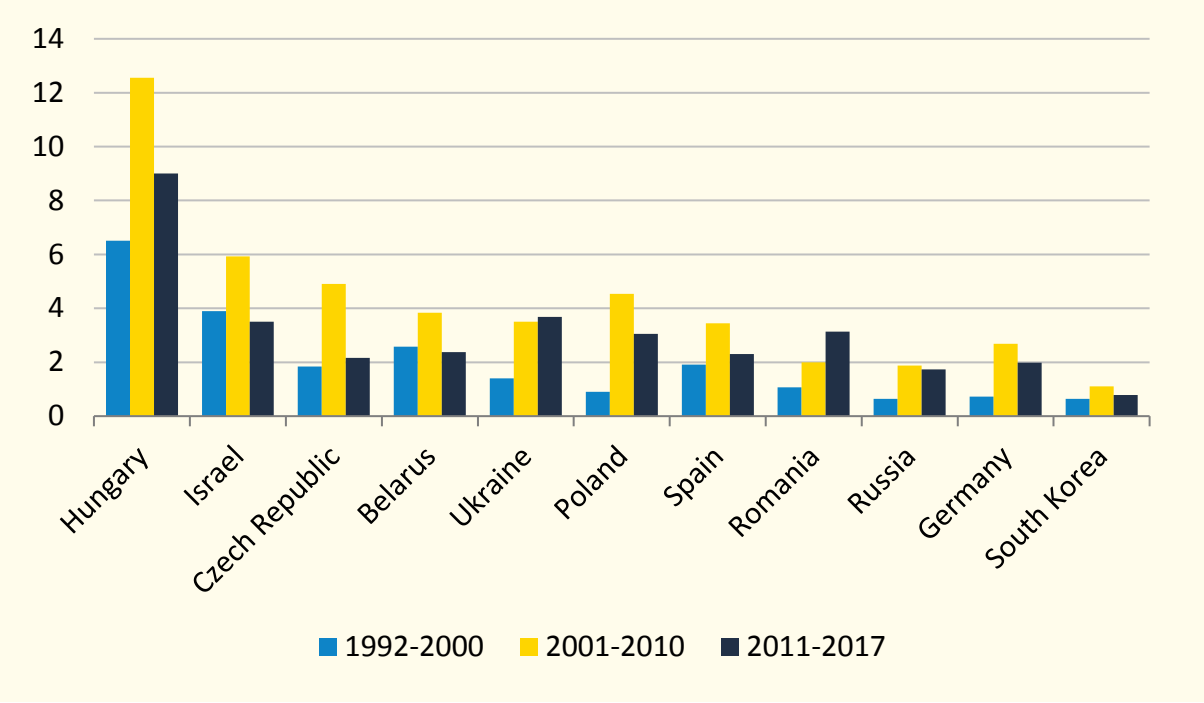
Source: WEF GCR Database.
Note: Response to the survey question: In your country, to what extent do businesses adopt the latest technologies? [1 = not at all; 7 = to a great extent]

Figure 35. Reliance on Professional Management



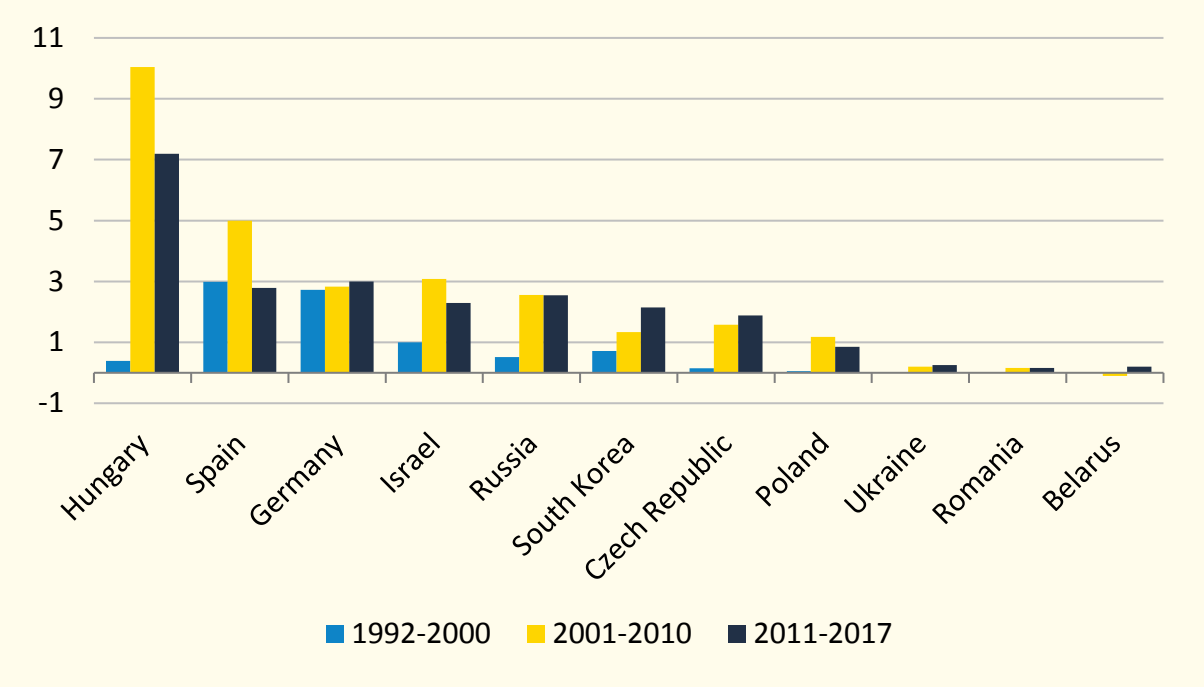
Source: WEF GCR Database.
Note: Response to the survey question: In your country, who holds senior management positions in companies? [1 = usually relatives or friends without regard to merit; 7 = mostly professional managers chosen for merit and qualifications]

Figure 36. Net Inflows of FDI as a Percentage of GDP (1992–2017)



Source: World Bank Development Indicators Database.

Figure 37. Net Outflows of FDI as a Percentage of GDP (1992–2017)[58]



Source: World Bank Development Indicators Database.

[58] Hungarian data reflect a mixture of investment flows, repatriation of profits and transfer pricing driven flows.

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