Chapter 12
Evolution of Technology Transfer in Belarus: Two Parallel Dimensions in a Post-Soviet Country

Radzivon Marozau, Natalja Apanasovich, and Maribel Guerrero

12.1 Introduction

Effective knowledge transfer and exchange between the scientific and industrial sectors is considered as an important way to speed up innovation worldwide (Perkmann and Walsh 2007; Harryson et al. 2008; Radas and Božić 2009). Since there is a strong correlation between the level of income and national commitments to innovation even in transition (Krammer 2009), the transformation of knowledge and technology into valuable economic activity has become a high priority in many policy agendas in post-soviet countries. At the same time, even innovation-driven economies face difficulties in transforming great R&D results into the technological development of industries and their competitiveness in the global market (Debackere and Veugelers 2005; Dosi et al. 2006; Audretsch et al. 2012; Guerrero et al. 2020).

Post-soviet transition economies inherited to a different extent a modernized version of the linear model of the technological upgrade based on the extramural R&D

R. Marozau (✉)
BEROC Economic Research Center, Minsk, Republic of Belarus
e-mail: marozau@beroc.by

N. Apanasovich
BEROC Economic Research Center, Minsk, Republic of Belarus

School of Business of BSU, Minsk, Republic of Belarus

M. Guerrero
Facultad de Economía y Negocios, Universidad del Desarrollo, Santiago, Chile

Northumbria Centre for Innovation, Regional Transformation and Entrepreneurship (iNCITE), Newcastle Business School, Northumbria University, Newcastle upon Tyne, UK

Centre for Innovation Research (CIRCLE), Lund University, Lund, Sweden
e-mail: maribel.guerrero@northumbria.ac.uk

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(Radosevic 1996). In the early 1990s, re-organization of the Science and Technology (S&T) system was not among the government officials' priorities, while two obvious diametrically opposed ways were to adjust the soviet model gradually or to raze it to the ground and to adopt good western practices and best-of-breed tools. Regardless of the chosen way, the links needed to be re-established but within a narrower boundary of independent countries.

The Republic of Belarus, arguably, appeared the most sluggish in its movement towards the market economy and western-like institutions. The country was unique among its peers because of or despite this institutional choice because it has preserved the organizational capabilities of ex-soviet large industrial enterprises that were pillars of socioeconomic development in certain periods. In this regard, public funding of extramural R&D for such enterprises became a cornerstone of the Belarusian S&T and innovation system that enabled technology upgrading and stimulated the Total Factor Productivity (Radosevic 2017). Mesmerized by certain success, Belarusian policymakers overestimated the role of R&D in innovation systems and economic development. This caused the incline towards the allocation of resources and commercialization of research output, while such areas as promoting the science-business-education links, as well management, marketing and engineering practices remained underdeveloped or neglected (Marozau and Guerrero 2016). Moreover, multinational enterprises have not become the major actors in technology transfer and business R&D, unlike in other Central Eastern European economies (Lengyel and Cadil 2009).

Whether by accident or on purpose, the state policy has contributed to the parallel development of two paths: the 'traditional' soviet-style economy and the 'new' entrepreneurship-driven economy. This segregation has permeated different policy spheres including the S&T and innovation system, where this gap might be more evidential, engendering crucial challenges for policymakers and main actors. In this regard, the purpose of this chapter is to demonstrate how the state policy shaped paths of knowledge and technology transfer activities of different types of actors. In general, comparable and relevant data on knowledge transfer is scarce in Belarus. The official surveys on R&D are filled by an organization that reflects such activities in accounting. For taxation purposes, private enterprises tend not to report about R&D activities, recording them as current expenditures and not contributing to intangible assets. Having no stimuli and avoiding additional reporting issues, many innovative enterprises stay beyond the survey's scope. According to Belarusian classification, the survey on innovation covers only medium- and large-sized enterprises (>100 employees) in certain sectors. These circumstances may substantially distort the official statistics and consequently mislead policymakers. In this regard, to triangulate our findings, we capitalized on primary data at the enterprise level gathered by the National Statistical Committee, by the World Bank within the framework of Business Environment and Enterprise Performance Surveys (BEEPS) and by the Association of Advanced Instrument Manufacturers.

We provide evidence of how a general policy towards socio-economic development rather than certain policy measures has generated two parallel dimensions of the knowledge and technology transfer related to the 'traditional' and 'new'

economies. Our main arguments are that state policy in knowledge generation and transfer appeared timely and opportune that enabled the preservation of industrial potential and output until the 2010s. At the same time, policy attempts to integrate foreign best practices of innovation-based development have not resulted due to the irrelevance of institutions in Belarus as a country gradually transitioning to the market economy. In this regard, the main pressing policy challenge is to reconcile the 'traditional' industrial and 'new' entrepreneurship-driven economies.

The remainder of the chapter is structured as follows: In Sect. 12.2, we provide a brief overview of the soviet science and technology sphere that became a template for Belarusian authorities and describes the knowledge and technology transfer processes triggered by the dissolution of the Soviet Union. Section 12.3 discusses the evolution of the state policy related to the technology transfer in Belarus, while Section 12.4 illustrates how the 'traditional' and 'new' economies co-exist. Section 12.5 provides main implications and a general conclusion.

12.2 Antecedents

12.2.1 Soviet Science and Technology System

It is widely documented and acknowledged that the Soviet Union had a well-developed science and technology-fueled system with a high level of expenditures and many qualified engineers and researchers, especially in natural sciences (Martinsons and Valdemars 1992; Egorov and Carayannis 1999). At the same time, judging by traditional indicators, such as patents and research papers in international journals, does not reflect the Soviet science achievements because of its main focus on the military and 'the Iron Curtain' between the Western world and the USSR. The arms race with the U.S. preconditioned the advances in military weapons development and the aerospace sector that had a multiplier effect on many related research fields (Martinsons and Valdemars 1992). In these conditions, research institutes and enterprises located on Belarus' territory developed and manufactured 'brains' (automated control systems, computers) and 'eyes'(radiolocation, optics, electronics) for the Soviet weapon and aerospace sector. As for civilian manufacturing, it did not require any breakthrough in science and technologies because it was characterized by rather a catching-up development based in many cases on copying or re-invention. This, however, enabled to develop of engineering potential, particularly in Belarus that was often regarded as the 'assembly line' of the Soviet Union due to the relatively high concentration of manufacturing enterprises represented among others by BelAZ currently taking 27%[1] of the world market of haul

[1] For further details, visit http://www.gki.gov.by/upload/new%20structure/info%20for%20investors/oao_more/600038906.doc

trucks over 90 tons; Minsk Tractor Plant that manufactured about 10% of wheel tractors in the world.[2]

The hierarchical and centralized organization of the whole economy led to two remarkable and apparent peculiarities of the soviet science and technology system. First, the dominating linear model of innovation with exaggerated overestimation of the role of R&D and the lack of interaction among actors and users impeded quick technological advance, especially in the civilian sector (Hanson and Pavitt 1987). One of the reasons for that was the centralized economy with a stovepipe pattern and dysfunctionalities stemmed from actors' location in different hierarchy branches (Egorov and Carayannis 1999). Second, the general perception of technology as a commodity that could be transferred to and implemented at any enterprise in a certain industry, in the same way, diminished the importance of doing-using-interacting processes (Jensen et al. 2007) in new product development. Weak bottom-up and horizontal links made research organizations and researchers unresponsive to the industry needs. As a result, the R&D, manufacturing processes and customer needs appeared separated from each other (Radosevic 2011), while all channels of the knowledge and technology transfer and the end product distribution were planned and pre-defined by the state. The extramural nature of R&D and a passive role of enterprises that were not a business but production units in the complex enterprise "Soviet economy" (Radosevic 1996), were propagated to post-soviet economies and created a daunting challenge to policymakers. As a result, the civilian R&D sector entered the transitional process of the 1990s, being mostly uncompetitive in the market economy's context compared to foreign knowledge and technology producers. At the same time, the end of the Cold War gave rise to the flow of military and dual-use technologies that were quite advanced to the market through different channels.

12.2.2 Post-soviet Science and Technology System

The disintegration of the Soviet Union in 1991 was marked by the serious decline in output in all the former soviet countries due to disruption of existed production chains and new market reality in general. From the very beginning of the transition period, Belarusian authorities adhered to the gradual movement towards the market economy, retaining substantial control over the economy and restricting the privatization of large enterprises (Palacin and Radosevic 2011). This was mirrored in Radosevic's (1996) approaches as 'gradualism without therapy' to dealing with the S&T sphere that continued being financed and coordinated by the state and having the Academy of Sciences as a key actor without any substantial restructuring. It was based on the assumption that the Belarusian R&D sector, whose only customers were large laggard soviet enterprises, was not capable of adapting to these drastic

[2] For further details, visit https://neg.by/novosti/otkrytj/traktor-s-dalnim-pricelom

changes, and the industrial sector was not able to compete in market conditions (Djarova 2011). Moreover, the S&T system's re-organization was not among the government officials' priorities who concentrated on economic stabilization and development of market institutions while redirecting the soviet S&T potential and human capital to marketable civilian R&D was suspended in many countries, including Belarus (Egorov and Carayannis 1999). To a large extent, this preconditioned the replication of soviet-style knowledge and technology transfer mechanisms. Thus, the Belarusian S&T system adopted the organizational model and its drawbacks of the Soviet civilian R&D sector, not the military one. One of the inherited instruments to bring knowledge and technologies from research organizations to the industry were also inherited from the Soviet Union – State science and technology programs (SSTPs). This instrument has remained the most important channel to transfer and commercialize knowledge and technologies from state research organizations to the public sector. However, the volume of public expenditures – the dominant source of R&D funding – was not comparable to budgets allocated in the Soviet Union. Without compensating market institutions, these cuts switched research organizations into 'survival mode' (Grudzinskii 2005) and forced them to study how to commercialize 'free-for-the-taking' knowledge and technologies. Simultaneously, many high-skilled scientists and engineers left research organizations and universities seeking job opportunities in Western countries or for another occupation (low-skilled jobs or entrepreneurial activities) (Pobol 2011).

As a response to these trends, two phenomena in R&D institutes were observed: (1) diversification of the activities in terms of products, services, and markets; (2) spontaneous privatization and (3) related to this phenomenon of quasi-spin-offs (Radosevic 1996). While diversifying their activities, many research institutes and research departments at universities were forced to expand into services (testing, quality control, measurement and standardizing) and production activities (Radosevic 1998), thereby commercializing the stock of knowledge and technologies. And since that time and public funds, they have been more oriented towards short-term fundraising than towards a strategic development of strong relationships within the innovation system (Marozau and Guerrero 2016). This approach resembled the Chinese path of universities' and research organizations' transformation that assumed that this would allow gaining experience and learning and cultivating the entrepreneurial culture and raising capital to develop research capacity for future high-tech entrepreneurial activities (Zhou and Peng 2008). But in the case of post-soviet economies, this was not a general policy but an issue of survival. The necessity of researchers and engineers to survive, combined with the poor property rights protection, engendered many spin-outs or spontaneous privatization when employees used the stock of knowledge and technology created at Soviet research organizations and commercialize it on an individual basis (Radosevic 1996). Arguably, this process became the most important channel of knowledge and technology transfer to the Belarusian private sector, giving rise to the development of new technology-based innovative enterprises – so-called "Belarusian Hidden Champions" (Marozau et al. 2021).

Many research organizations and universities span off small commercial organizations to commercialize knowledge and technologies to preserve the R&D potential of a parental organization. However, as Radosevic (1996) pointedly noted, these were rather quasi spin-offs that could be only a 'packaging' for knowledge- and technology-based products, or more often, services. A quasi-spin-off person might be employed full-time at a parental organization and use its equipment to manufacture spin-off products or deliver services. In the chaos of the 1990s, some quasi spin-offs managed to pump out substantial human and physical resources and intellectual property from the public sector to the private one. Some research organizations and universities, for example, Belarusian State University, continued spinning off new wholly-owned new ventures till the 2000s. Such spin-offs usually had a certain degree of autonomy in decision making and strategy implementing and separate bank accounts and property rights (Marozau et al. 2019). However, with the development of the market of R&D services as well international cooperation, spin-offs from public organizations started losing their competitiveness due to mismanagement as well as the lack of flexibility of start-ups and bureaucracy inherent in state-controlled organizations. As a result, no role models of Belarusian public organizations' spin-offs competitive in international markets can be identified. They became 'suitcases without a handle', causing additional disturbances to many parent organizations and, consequently, the number of such spin-offs is steadily decreasing.

12.3 The Belarusian Technology Transfer Framework

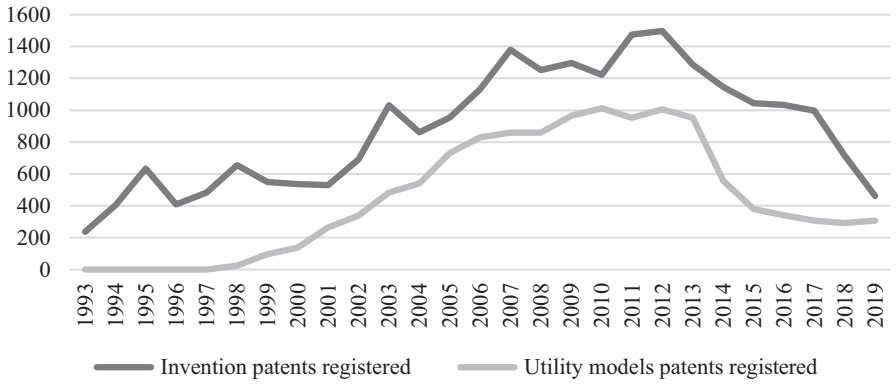
In the Republic of Belarus, the departure point of challenges related to the technology and technology transfer to the industry is arguably the establishment of the Committee on Science and Technology under the Council of Ministers in 1993. In this year, the government adopted the approach of implementing State science and technology programs and State programs for scientific research that existed in the Soviet past. After some re-subordination and re-organization of governing bodies, in 2004, it received its current name, "State Committee for Science and Technology" (SCST) that is the same as the main state body responsible for the S&T policy in the Soviet Union. This succession was not occasional, but it reflected the policymakers' adherence to the soviet approaches to coordinating science and technology. In the 1990s, there were hot debates in Russia whether to stipulate 'privatization' of the R&D results or keep them public ownership. Belarusian authorities were contemplating the discussion in the neighboring country, while processes of transfer and commercialization of publicly funded knowledge were regulated by the Civil Code of the Republic of Belarus. However, the creation of the Union State of Russia and Belarus in 1999 raised a question on harmonizing the legislation in many spheres, particularly in science and technology. As a result, Belarus followed Russia's path in 2003 and assigned to the state the intellectual property rights arisen from state-funded research, i.e. SSTPs and State programs for scientific research. The

implementation of these programs conserved the Soviet linear model of innovation with extramural R&D activities while introducing some new practices.

12.3.1 Science and Technology Instruments

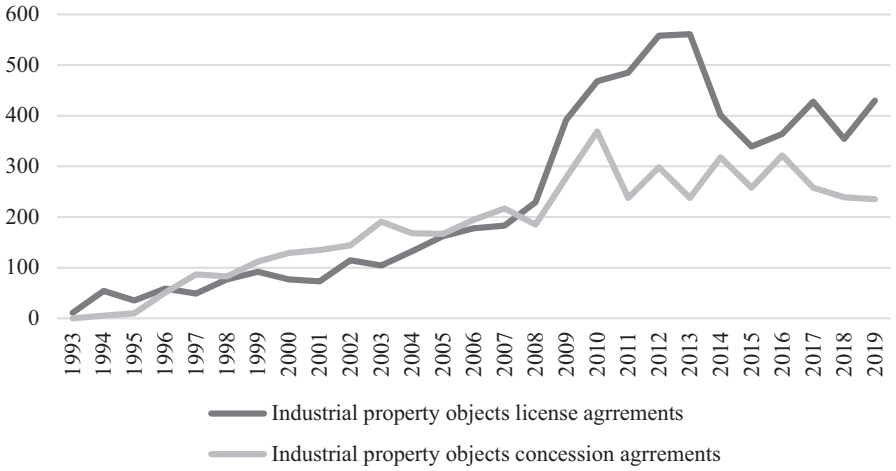
State science and technology programs are formulated by SCST based on Priority areas of scientific and technical activities invigorated by President's edicts for 5 years; while no general clear-cut industrial policy has been developed SSTPs yet consist of subprograms that in turn consist of tasks (projects) that have three main actors: (a) a state customer – a governing body (including the National Academy of Sciences) that by default is an owner of R&D results; (b) executors – mostly state research organizations that conduct R&D; and (c) a manufacturer – state-controlled enterprises that produce R&D-based goods or services. The development and implementation of SSTPs leave very little room for newcomers, especially from the private sectors, and for new initiatives even in the R&D directions that SSTPs prescribe (Dobrinsky and Stahlecker 2017). However, officially, a single task is an executor initiative that develops an application for funding based on its expertise and proposes certain research to a manufacturer. In many cases, such tandems are decided ex-ante, have long-lasting relationships and trust because both bear responsibility for innovative output. If a manufacturer can fund the implementation and manufacturing stage (at least 50% of the whole task budget), a joint bid is sent to a state customer for expertise and approval and, later on, to SCST that compiles subprograms and programs from approved tasks. Possibly, manufacturers can initiate tasks, while state customers' role is always passive. The main and evident drawbacks of the implementation of this instrument of knowledge and technology transfer are the lack of cutting-edge innovations as output due to the legislative absence of right for risk; the cliquishness of all actors that are not conducive to new horizontal and vertical links necessary for innovation system development (Lundvall 1999); and traditionally, low involvement of the private sector resulting from two previous limitations as well as of bureaucratic issues and excessive state control. In these circumstances, the formal transfer of knowledge and technology has been substantially limited – in many cases, state-controlled organizations refrain from collaborating with the private sector, being afraid of accused of corruption.

However, in the low demand for R&D combined with lack of intramural R&D capabilities and financial resources at state-controlled enterprises for technological upgrade, SSTP played the decisive role in preserving the R&D and engineering potential in the Belarusian public sector. In this context, the state compensated for the incipient actions of market actors (Radosevic 2011). For most state research organizations, the funding received within the SSTP remains the main source allowing them to survive and compels them to initiate new R&D activities. It should be acknowledged that while implementing the S&T policy in Belarus, the emphasis has been made on strengthening control over the progress of state-funded R&D activities rather than on creating a competitive environment favorable for the



Source: Authors

Fig. 12.1 Number of patents registered in Belarusian. (Source: Authors)



Source: Author

Fig. 12.2 Number of license agreements concluded. (Source: Author)

innovative organic development of industries and the country. In 2006 (Decree of Council of Ministers #1103), 2009 (Edict of President #432), 2013 (Edict of President #59), 2018 (Edict of President #240) gradually elaborated and liberalized transfer of R&D results obtained from state-funded activities but mostly among state customer, executors and manufacturers. Concurrently, the legislation enforced these organizations, enterprises and universities to commercialize the results of R&D activities, except fundamental research, within 3 years. To commercialize 'un-commercialize' R&D results created for budget money, when a state customer, executor, or manufacturer failed to transform them into products or services, the State register of rights for scientific and technological activities results was created in 2013. The extent of the problem with mandatory commercialization can be illustrated with the number of entries in this register – 2.700 as of June 30, 2019.

12.3.2 Intellectual Property Market

The market of intellectual property started developing in parallel to the market economy in the early 1990s. This process was moderated with the demand growth for R&D results and incremental changes in the state policy (Figs. 12.1 and 12.2).

One may observe that steady growth of the number of registered patents and license agreements abrupted in 2014. This might be attributed to two separate policy measures: the considerable increase of the patent registration fees and enactment of the Edict of the President #59 in 2013. Thus, in 2014, the patent registration fee grew on average by 1000% and reached 500 USD[3] Evidentially, this increase hit individuals and organizations that registered patents for their own sake without commercialization intention. Before this change, national patent registration was treated as a valuable scientific output. As for the Edict of President #59, it stipulated mandatory commercialization of IPRs arisen from state-funded research by their owner. This circumstance was a stimulus not to register IPR not to bear responsibility for commercial output.

Since the early 2000s, replicating the Western path of the industry-science links (Debackere and Veugelers 2005) and innovation ecosystem development, Belarusian authorities were concerned about creating the infrastructure for knowledge and technology transfer (Lenchuk 2006). Thus, to organize a communication platform and regulate the process of technology transfer and facilitate cooperation between researchers, entrepreneurs and investors, the Republican Center for Technology Transfer (RCTT) was established in 2003 with support from UNIDO. However, this agency could not ensure financial sustainability earning on its core functions as a technology transfer intermediary without state support. The gap between the supply and demand sides of the knowledge and technology market was not closed or narrowed. State research organizations seamlessly cooperated and transferred knowledge and technologies to state-owned enterprises within SSTPs, while 'the rest' of the research output, in most cases, did not fit the market. Consequently, RCTT was incorporated in the Center of System Analysis and Strategic Research of the National Academy of Sciences.

Similarly, technology transfer centers and offices have not become drivers of the knowledge transfer but due to inherent bureaucracy, while focusing mainly on documenting and administering the intellectual property and creating additional knowledge filters (Marozau et al. 2016; Marozau and Guerrero 2016; Belitski et al. 2019). Technological parks appeared 'renting agencies' (Radosevic 1996), providing favorable tax regimes rather than entrepreneurship and innovation ecosystems connecting technologies with business experts, entrepreneurs, venture capitalists. These examples demonstrate that transferring organizational models into a different institutional context of transition economies have not provided similar outputs and, in some cases, deviated from original missions (Radosevic 1996).

In general, most of the substantial changes in legislation related to knowledge and technology transfer were related to regulating intellectual property rights stemming from state-funded research relevant to the state-owned organization or fiscal stimuli for manufacturers of innovative products that appeared quite attractive to

[3] For further details, visit: http://www.belmarket.by/slishkom-dorogie-patenty

private enterprises. These fiscal stimuli were provided to residents of Free economic zones (exemption/reduction of profit tax, exemption from import tax), the Hi-Tech Park (exemption from income tax, import VAT), technological parks (50% reduction of income tax), manufacturers of innovative products defined by the council of Ministers (exemption from income tax). Another noteworthy policy measure that affected the public sector and was mostly disregarded by the innovative private sector was the Resolution of the Ministry of Finance #75 on the accounting of S&T activities that allowed accounting recognition and amortization R&D results in the form of intangible assets. Before this resolution, all R&D expenditures were treated as current ones increasing production costs. This was considerable support for loss-making and low-margin state-controlled enterprises competing on prices in the former Soviet Union market. To innovative private enterprises operating on the global market and relying on know-hows rather than patents (Inzelt and Apanasovich 2017) this legal action did not matter. They continued conducting R&D activities without reporting the creation of intangible assets and thereby decreasing income tax and avoiding bureaucracy and additional statistical reporting on science and technologies. About 60 legislative acts and norms regulate knowledge transfer and commercialization, intellectual property and respective infrastructure.

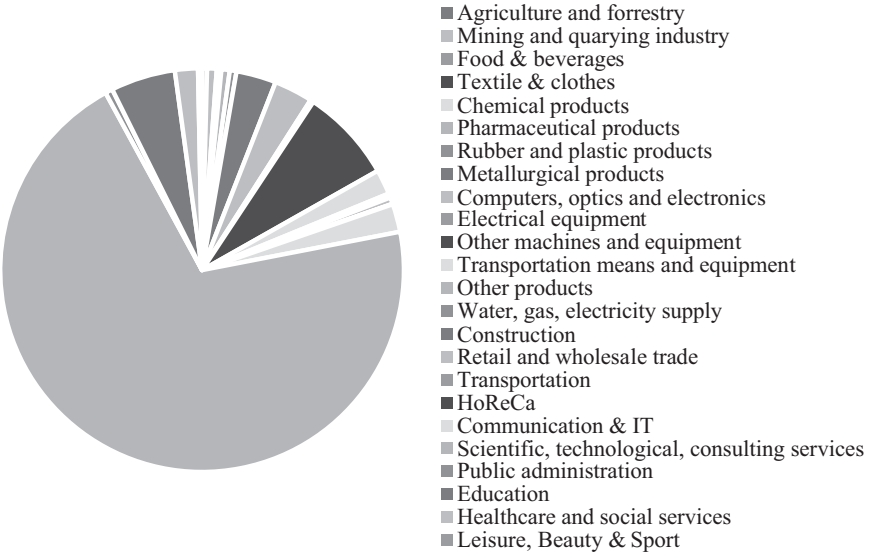
12.4 Co-existence of Two Parallel Economies in the Twenty-First Century

The Belarusian authorities' implicit institutional policy has been distinguishing between 'two economies' having different functions. The traditional part of the economy represented by state-owned enterprises ensures employment and gross output, while private enterprises dominate the new part is expected to provide dynamism and be a long-term driver of economic growth (Kruk 2019). This initially unthought concept permeated among different areas, including the S&T and innovation systems, where this gap might be more evidential, engendering crucial challenges for policymakers and main actors. The situation was also regarded as the dual path of technology upgrading driven by either large state-owned, technology-push enterprises relying on extramural R&D activities or flexible demand-pull, small- and medium-sized private enterprises (Inzelt and Apanasovich 2017).

12.4.1 Technology Transfer in the 'Traditional' Economy

The Republic of Belarus appeared one of the very few post-soviet countries that choose the path of keeping large and medium industrial enterprises under the state's roof. This guaranteed a certain degree of employment and industrial output stability in the 1990s and, most importantly, enabled preserving organizational resources (mostly human and physical ones) and capabilities (reputation, networks, business processes). Till the mid-2000s, such enterprises, enjoying financial and organizational state

support and the vacuum on the market of the Commonwealth of Independent States (CIS), had been drivers of the socio-economic development. It is not surprising that the state policy in the area of S&T as well as budgetary resources was concentrated on supporting a small group of industrial giants. A high level of vertical integration and engineering potential, fueled with R&D results from state research organizations and universities, enabled to produce and upgrade quite complex but standardized products (haul truck, tractors, harvesters) or develop efficient manufacturing processes (oil processing, metallurgy, chemical industry). The National Academy of Sciences of Belarus (NAS) is part and parcel of the state-controlled S&T system still takes the dominant position in the area of knowledge creation that has about 7800 employees involved in R&D activities – about 28 percent of the total number of personnel involved in R&D in Belarus).[4] The NAS's organizational structure includes more than 100 organizations (research institutes and centers, design bureaus and manufacturing enterprises) established to commercialize R&D results. There are many cases of tasks within SSTP when a state customer is NAS, while executors and manufacturers create a subsystem within a state-controlled R&D system. In general, this application-oriented profile substantially contrasts with the antecedents and peers (Mayntz 1998). The extramural nature of R&D makes such enterprises more rigid and clunky, while they face strong competition in their target markets of the CIS countries. Figure 12.3 demonstrates that the dominating role in knowledge production is played by organizations whose main



Source: Author

Fig. 12.3 Share of intramural R&D expenditures by main sector of activity, as a percentage of total intramural R&D expenditures 2019. (Source: Authors)

[4] Analytical report on situation and development perspectives of science and technologies in the Republic of Belarus. Access mode: http://belisa.org.by/ru/print/?brief=analytical_publ Access date: 25.05.2020.

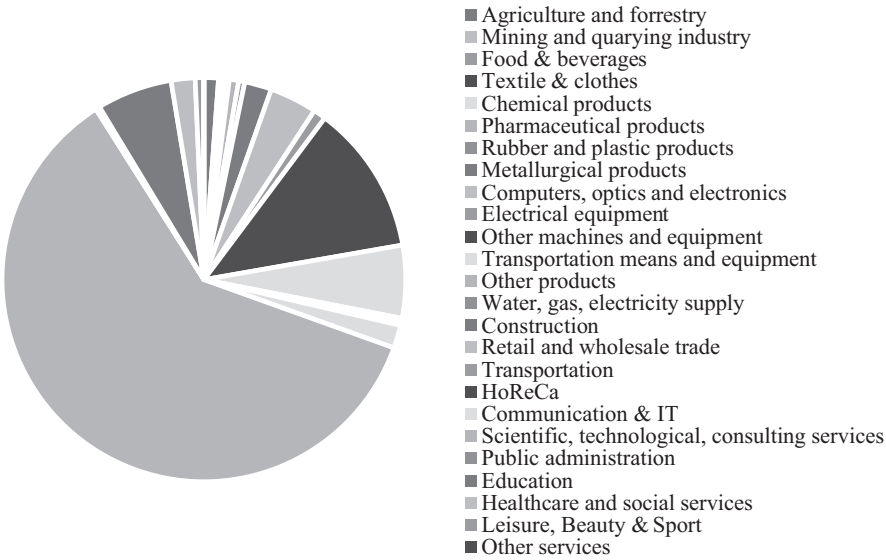
sectors are 'Scientific, technological, consulting services' and 'Education'.[5] Such extramural organizations account for ¾ of total intramural R&D expenditures, of which 52 percent are financed from the state budget and non-budgetary funds (Belstat 2020).

A very similar situation is observed when considering the number of personnel involved in R&D – 2/3 are employed in 'Scientific, technological, consulting services' and 'Education' (Fig. 12.4). Meanwhile, innovative activities of Belarusian industrial enterprises are largely driven by installation and effective use of new equipment (Palacin and Radosevic 2011). In 2019, 67.5 percent of total expenditures on technological innovations were related to acquisition and installation of equipment and only 11.1% - to R&D activities. Moreover, notwithstanding the positioning of the Belarusian innovation performance as R&D-driven, 'learning-by-doing' and 'learning-by-using' were more important predictors of the innovation output (Apanasovich et al. 2016). This is another argument questioning the legitimacy of the created heavy-weight extramural and state-funded R&D system. In general, a formalistic approach to implementation of the corporate governance complemented with vague stimuli and conflicting performance indicators set by the state (Ivy 2013) at both state-owned enterprises and research organizations creates an unfavorable environment for radical technological and organizational innovations as well as involvement in global value chains (Apanasovich et al. 2016). Being vertically integrated and driven by maintenance of the employment level and output indicators, large industrial enterprises have no need and motivation to establish links and collaboration with non-affiliated SMEs. Evidentially, this deteriorates the clustering potential of regions and monotowns (Arias et al. 2014). In these locked-in settings, the impact of the state or universities' innovation support infrastructure (technological parks, centers for technology transfers) is with some exceptions quite limited. As for privately established infrastructure such as accelerators, venture funds, business angels communities, technology incubators, they look extraneous for the 'traditional' economy.

In contrast to developed Western countries, universities in post-soviet economies such as Belarus do not have the pretension to be key actors in cutting-edge knowledge and technologies. They remain mostly teaching institutions satisfying a high domestic demand for higher education (Kwiek 2012; Marozau and Guerrero 2016), while R&D activities are concentrated in incorporated centers and institutes at universities that operate in the same conditions and regulatory framework as other state research organizations. Consequently, they have similar focus, structure and target customers. The share of budget funding in intramural R&D expenditures in the higher education sector is even higher (65%) than at research organizations (51.1%) (Belstat 2020) that makes their R&D capabilities more dependent on public money.

Notwithstanding weak entrepreneurial and innovation capabilities and the unreadiness of the institutional environment (Marozau et al. 2019; Guerrero and

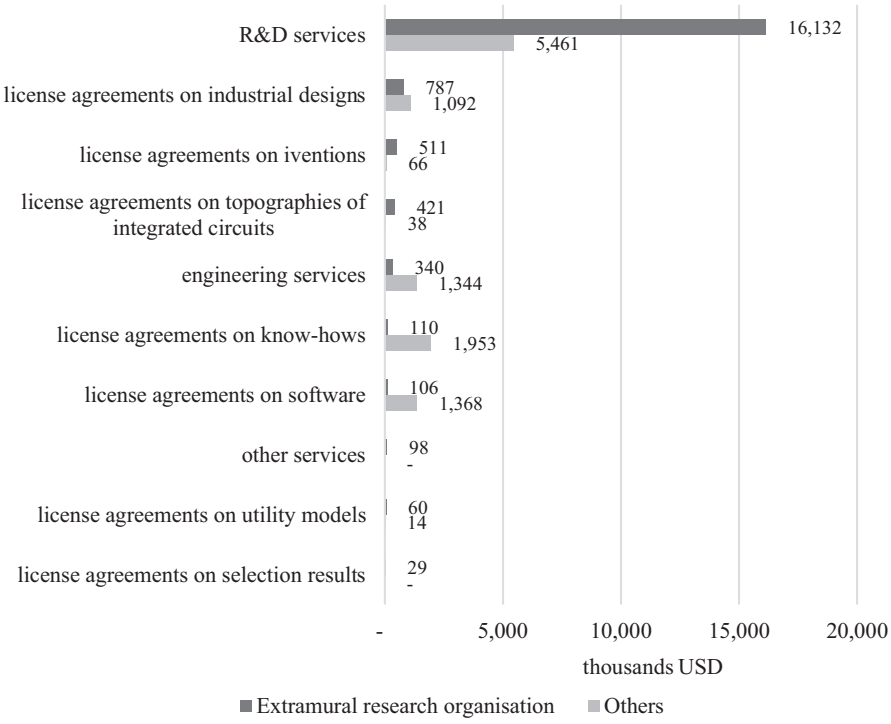
[5] When deciding on the dominating R&D system (extramural vs. enterprise-based), we argue that in case of Belarus it is reasonable to consider these distributions by sectors rather than looking on broad sectors (public, business enterprise, education) because of quite complicated structure of organizational forms and subordination.



Source: Author

Fig. 12.4 Employees involved in R&D expenditures by main sector of activity as a percentage of total employees involved in R&D, 2019. (Source: Authors)

Urbano 2012, 2019), policymakers in Belarus tried to replicate the success of Western Universities in the development of the entrepreneurial mission. In 2018, the Ministry of Education initiated the Experimental project on implementing the "University 3.0" model aimed at the development of research, innovation, and entrepreneurial infrastructure for the creation of innovative products and commercialization of intellectual activities. An important concern related to this project is whether not-for-a-show measures relevant to the current stance of the universities' resources and capabilities and, most importantly, institutional environments can be adopted (Marozau and Guerrero 2019). We argue that the overestimation of the linear path of innovation inherited from the Soviet time combined with the strong commercialization pressures put on the state-owned sector creates a deleterious mixture. Firstly, this withdraws financial resources and policy efforts from a general institutional environment for innovation development. Secondly, excessive pressure has deformed the structure of R&D activities towards development and services (Fig. 12.5) at the expense of the relative decline of basic and applied research activities (Radosevic 2011). Thirdly, this combination stimulates R&D activities to pick low-hanging-fruits and, consequently, orients towards marginal innovation. These circumstances prevent the building of enterprises' innovation capacity from competing on developed high-margin markets, while the undeveloped CIS market for technological knowledge and innovative products allows to some extent to keep the S&T system as it is. Simultaneously, in this extramural R&D system, state research organizations, especially the National Academy of Sciences, and universities have an untapped innovation potential that could repeat the role played 30 years ago in possible new shock therapy.



Source: Authors

Fig. 12.5 Total revenues by activities, 2012 ($N = 531$). (Source: Authors)

12.4.2 Technology Transfer in the 'New Economy'

Paradoxically, but the 'new economy' and innovative private enterprises in particular, due to the absence of institutional reforms such as privatization and liberalization of economic activities and general chaos of the late 1980s and early 1990s (Daneyko and Golenchenko 2013). Thousands of researchers and engineers faced the choice: to have 2–3 parallel jobs sometimes unrelated to their competencies, to immigrate, or to try to start up a business using relatively 'free-for-the-taking' knowledge and technologies even from the military sector. As a result, thousands of legally independent companies were established in this period based on engineering competencies obtained at large industrial enterprises or R&D results from research institutes and university laboratories. The latter engendered the most intensive and avalanche-like flow of R&D-based knowledge and technologies to the manufacturing sector. During the 1990s, such new enterprises lured away or absorbed hundreds of high-skilled researchers and engineers and therefore acquire the intramural nature of R&D from their establishment. The collaboration with research

organizations and universities were continued rather on an individual basis and appeared marginal.

Evidentially, the stagnant and small domestic market of R&D-based products and services, many of which stemmed from military technologies, appeared only a testbed for Belarusian small innovative firms (Marozau et al. 2021). Since 1998, Belarusian authorities started establishing free economic zones to create a preferential tax and customs regime for export-oriented manufacturing enterprises. Even the CIS market became only a launchpad for further expansion by most competitive knowledge-based enterprises to the global technological market that in many cases were entered with original equipment manufacturing model (OEM-model) or job-lot manufacturing. As a result, the soviet R&D potential was complemented with learning-by-exporting and by interacting within global value chains and preconditioned the success of Belarusian enterprises in the Business to Business (B2B) sector with irradiation, electrooptical, measuring laser equipment. Starting with the low-price strategy, 'no-name' Belarusian enterprises understand their real competitive advantages – their capability to be nimble, flexible, and ready for customization as opposed to foreign industrial giants (Fig. 12.6) (Marozau et al. 2021). In this context, the knowledge and technology transfer contribution from domestic research organizations and universities was marginal since they are considered slippage and lagging behind. SSTP financed from the state budget seemed both risky due to excessive control combined with tough punishment for failure and unreasonably time-consuming. There still is a mutual fear of collaboration and knowledge and technology transfer when it is somehow related to public money since the borders between formal and informal regulations are blurred (Egorov and Carayannis 1999). Also, low awareness and skepticism exist among businesses about state-provided opportunities in science and technology. Technology transfer centers and offices rarely address this challenge (Belitski et al. 2019) due to the lack of market understanding and experience in working with globally competitive private enterprises.

For enterprises that have crossed the formidable developed markets' threshold, the channel of knowledge transfer from foreign end-users (Fig. 12.7) still enables them to generate incremental innovations, increase market shares and take positions among top-5 in certain niches. This required the development of intellectual property rights at international patenting bodies, but the protection of know-hows appeared even greater important and more appropriate to many knowledge-intensive enterprises (Inzelt and Apanasovich 2017). This is arguable, another demarcation line between the public and private sectors. In the public sector cultivating the technology-push model, it is necessary to protect the intellectual property with patents to report on spending budget money and transfer to the industry as intangible assets.

While considering the whole population of manufacturing enterprises (Fig. 12.8), intramural ideas and R&D were also the dominant source of innovative products, followed by redevelopment or replication of competitors' products. The contribution of extramural knowledge and technology producers was inconsiderable.

Moreover, the trend to rely more on intramural R&D instead of acquiring external knowledge can be observed when comparing Belarusian enterprises' responses

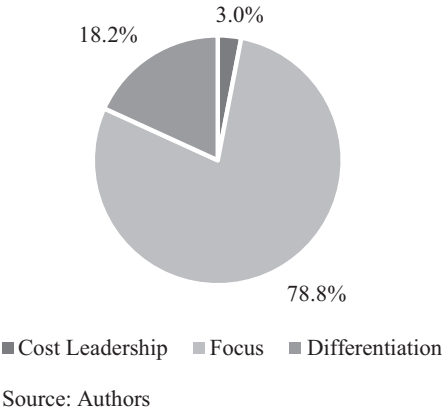


Fig. 12.6 Dominant strategy of private enterprises of the advanced instrument manufacturing and electronics sectors. (Source: Authors)

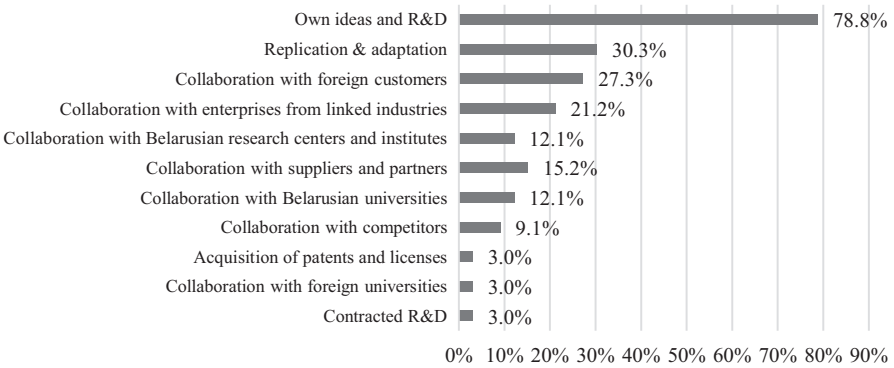
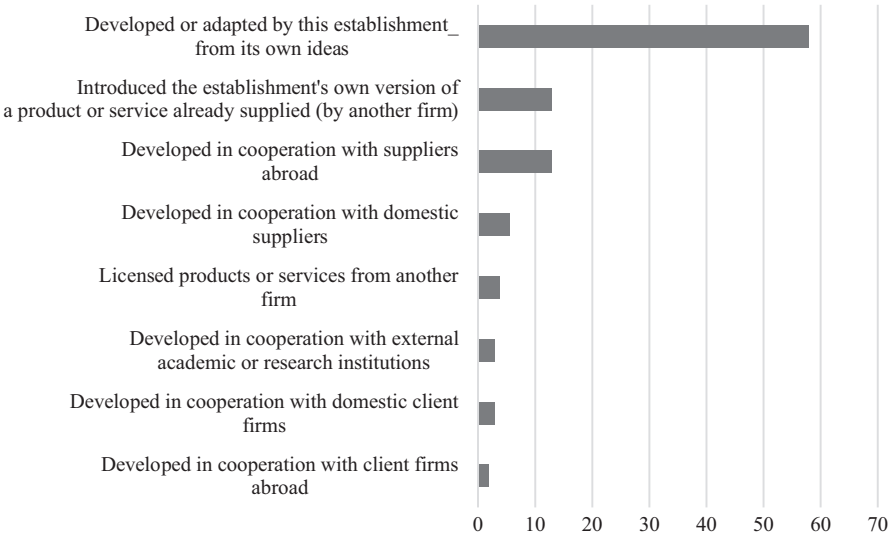


Fig. 12.7 Ways how private enterprises develop innovative products. (Source: Authors)

to the same question with the 5-year differences (Fig. 12.9). In both samples of 2013 and 2018, dominated private enterprises (without state share) – 86.3% and 75.6%, respectively. The basis of the Belarusian BEEPS survey 2018 additionally demonstrates the decisive role of intramural R&D expenditures in the development of new-to-market products or services, while spending on extramural R&D was also found to be related to the innovative output.

Acknowledging the ecosystem's role in the competitiveness of particular entities, innovative private enterprises, including those in the ICT-sector, are becoming key actors of the innovation support infrastructure, establishing or coordinating accelerators, venture funds, sponsored laboratories in universities, fab labs, and mentorship programs. This compensates for the state's passive role and creates prerequisites that do not lose the momentum based on the soviet scientific and technological potential.



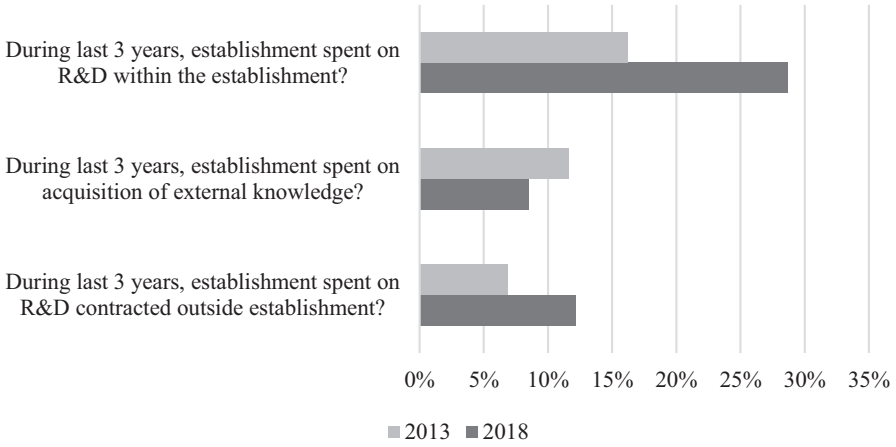
Source: Authors

Fig. 12.8 Ways how manufacturing enterprises develop innovative products, 2012. (Source: Authors)

12.5 Conclusions

The main implication of the present study for policymakers is that the co-existence of two separate technological development paths can last as long as the state has financial resources and willingness to support state-owned enterprises. In the current situation and at least in the short term, this dualism does not significantly extend the development of innovative private businesses due to their inherent distancing from the state S&T system and mostly different market niches. Belarusian knowledge-intensive enterprises are more amenable to fiscal stimuli (custom fees, taxes) than to direct state financing and participation in state programs due to the excessive state control and long bureaucratic processes that do not stimulate any flexibility in the R&D and manufacturing activities. A quite simplified understanding of how R&D activities are designed, transferred to the manufacturing sector and drive technology upgrading is at odds with what private export-oriented enterprises learned from the market. Simultaneously, a potential hotbed for future knowledge-based enterprises could be the state-controlled military industry that is still competitive and effective (Marozau et al. 2021). A certain degree of liberalization of enterprises in this sector, combined with the development of the corporate governance systems are necessary for their expansion and diversification.

However, in pursuit of innovation-driven socioeconomic development, the key long-term policy challenge is to reconcile the ‘traditional’ and ‘new’ economies,



Source: Authors

Fig. 12.9 Expenditures on R&D, 2013–2018. (Source: Authors)

particularly in the area of knowledge and technology generation and transfer. In the hardest and fastest scenario, Belarusian authorities could 'repeat' the financial shock of the early 1990s, enforcing research organizations and individual researchers to act more entrepreneurially. The first step in this direction could be the abolishment of widely used practices when most of a budget of state research organizations consist of budgetary funding within the framework of SPSRs or SSTPs. The new wave of potential academic entrepreneurs would find a substantially more developed entrepreneurship- and innovation support ecosystem than it was in the 1990s, including access to financing, training in business management, support infrastructure. However, markets have become more globalized and highly competitive. In general, the development of spin-offs and spin-outs may promote stronger links between the 'new' industry and science and bridge the gap between the extramural R&D sector and the market (Parhankangas and Arenius 2003; Steffensen et al. 2000; Treibich et al. 2013). In a soft scenario, risk-acceptation and flexibility of agenda-setting and implementation in state-funded programs and projects combined with securing equal access to funding for private enterprises would at least help to start building trust between representatives of the 'traditional' and 'new' economies. As a possible measure to raise awareness of businesses on capabilities of research organizations, universities and individual scientists could be providing abundant documented but uncommercialized R&D results (about 2.700 as of June 30, 2019) to enterprises for a nominal fee. With a promotion campaign of the measure and its outcomes, this will probably increase the interest in further collaboration with researchers or organizations. Taking into account many failures in commercializing state-funded R&D activities, policymakers should consider abandoning excessive commercialization pressures. Since the 1990s, such a policy approach to the S&T sphere, on the one hand, has taken a toll on fundamental research and scientific excellence and, on the other hand, has supported the

competitiveness of traditional enterprises and sectors. For the current stance, it looks inappropriate due to substantial changes in domestic and international markets. In the future, the allocation of R&D-related rights and profits results should be clear-cut and irrevocably assigned to executors or co-financing enterprises whose relationships should be regulated by the Civil Code. Moreover, special state-funded programs or reconfigured SPSRs should support individual researchers and engineers from state-owned organizations and universities by assigning them intellectual property rights.

The incompleteness of market reforms (slow-footed privatization, underdeveloped stock-market, massive financial support to inefficient state-owned enterprises and even whole sectors) remains the main impediment on the declared way towards an innovation-based economy (Lenchuk 2006). Simultaneously, arbitrary state intervention is not aimed at establishing mechanisms of transferring both financial and knowledge flow from the 'traditional' economy to the 'new' one but rather aimed at preserving the 'traditional' enterprises with marginal upgrades. In this context, policy attempts to integrate foreign best practices of innovation-based development have not resulted in similar outcomes since they have appeared irrelevant to formal and informal institutions in Belarus as a country gradually transitioning to the market economy. Since the process of knowledge and technology transfer depends on the entrepreneurial behavior of scientists and engineers (Guerrero and Urbano 2014; Belitski et al. 2019) as well as the entrepreneurial orientation of research organizations and universities (Lockett et al. 2003; Bozeman et al. 2013; Guerrero et al. 2015), the vibrant entrepreneurial sector and general entrepreneurial culture should be developed in the first instance (McMillan and Woodruff 2002; Guerrero et al. 2008; Krammer 2009; Urbano and Guerrero 2013). In Belarus, cultural and social norms such as lack of trust, fear of failure, paternalism at the individual, organizational and state levels are still barriers to entrepreneurship development (Akulava et al. 2020). Therefore, recent advances in creating a favorable normative and regulatory environment have not given rise to an upsurge of technology-based entrepreneurial activity (Guerrero et al. 2020). In this regard, we argue that till the Global financial crisis, the state policy in the area of knowledge generation and transfer appeared timely and opportune that enabled to preserve the industrial potential and output and consequently to secure socio-economic development. However, substantial reconfiguration of markets, value chains and business models and international relations in the recent decade has challenged the Belarusian economy's structure and is steadily inclining it to the 'new' one.

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