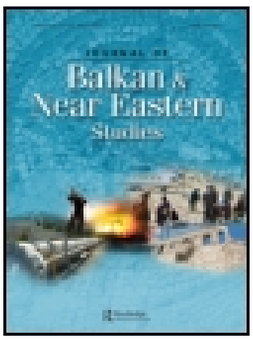

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Interdependence between Gross Capital Formation, Public Expenditure on R&D and Innovation in Turkey

Elma Satrovic [a,b], Adnan Muslija [c], Sadeq J. Abul [d], Dragan Gligoric [e] and Tamanna Dalwai [f]

[a]Faculty of Economics and Administrative Sciences, Çağ University, Turkey; [b]Department of Economic Studies, University of Novi Pazar, Serbia; [c]Faculty of Administration, University of Sarajevo, Bosnia and Herzegovina; [d]Independent Economic Advisor, Kuwait; [e]Faculty of Economics, University of Banja Luka, Bosnia and Herzegovina; [f]Department of Business and Accounting, Muscat College, Sultanate of Oman

ABSTRACT

This paper outlines the roles of gross domestic spending on research and development (R&D) and gross capital formation in the innovation process and detects their contribution to this improvement. The analysis is conducted for Turkey for the period 1990-2017 using annual time-series data. Our findings suggest a bidirectional causal link between all variables of interest and prove that R&D can be a significant driving force for the Turkish innovation process. Most of the research and development activities in Turkey have been performed by universities. Herein, it is of key importance for the Turkish government to increase public expenditure, especially on education, since human capital plays an important role in building innovation capacity.

Introduction

The role of innovation in economic growth has attracted research interest over the last few decades, since it plays a vital role in productivity generation. Innovation decreases poverty while increasing wages and the employment level. Moreover, firms tend to increase their capability to adopt new, better technologies thanks to innovation and consequently generate the productivity of labour. As a consequence, there is much theoretical[1] as well as empirical evidence[2] to date. Ramadani, Gërguri, Rexhepi and Abduli suggest that the relationship between innovation, economic growth and development has been well studied but not well understood.[3] Most of these studies collected data from developed countries, whereas empirical evidence on developing countries is lacking.

Nowadays, in the highly competitive world, innovation has been recognized as one of the most important determinants of economic growth.[4] Consequently, the importance of science and technology has increased, especially in developed countries, including Turkey. With regards to Turkey, Akat and Yazgan outline that it has recorded

CONTACT Elma Satrovic elmasatrovic@cag.edu.tr

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tremendously improved macroeconomic performance in recent decades, particularly regarding real GDP, the employment level and total consumption. Despite the fact that Turkey has recorded exponential growth, Akat and Yazgan stress the need to take into account the strong dependence on external financing.[5] It is important to note that all actors in Turkey (Justice and Development Party—AKP; opposition parties and organizations of civil society) recognize the importance of research and development and innovation for economic growth. Moreover, Karaoğuz suggests that Nihat Zeybekçi, the Turkish Minister of the Economy, advocates an important role for innovation to increase the competitiveness of Turkey and achieve a better trade position at the global level.[6] In this article, the Turkish development strategies in the twenty-first century focused on technology-based production and innovation will be debated. According to the Organisation for Economic Co-operation and Development (OECD), a country needs to offer certain core conditions that facilitate innovation and encourage economic growth, which include: dynamic competition and contestable markets; a well-built, sustainable research and development infrastructure; a continuous emphasis on education at different levels; an impetus for information and communications development; and well-established standards and effective implementation regarding intellectual property protection.[7]

The economic performance has significantly improved, but Turkey's current status can be observed more clearly if we compare this performance with the OECD member states. The OECD suggests that the main sectors of the Turkish economy are under pressure from competitors who have a lower cost labour force.[8] This is true for the majority of the sectors, i.e. agriculture, clothing, transportation equipment, textiles, etc. Concurring with the above, it was necessary to find other sources of competitiveness. Increased in productivity, R&D and innovation are recognized as a good way of maintaining competitiveness and increasing the attractiveness of the Turkish economic sector to foreign investors. R&D is also recognized as one of the key factors of production, since a functional system of innovation can 'pull Turkey out of the middle-income trap'.[9] A comprehensive approach, discussed by many authors, suggests that the Turkish economy is fragile in broad terms.[10] Thus, the future prosperity of the economy is strongly dependent on R&D and innovation.

According to the report for 2008, the OECD has recognized Turkey as a country that imports technology.[11] The concerning fact is the statistics that show that the majority of the patent applications were registered by foreign agents or included foreign co-investors, whereas the domestic firms were found to register only 10% of the total patents. Moreover, Turkey had less than one triadic patent per million population in 2008. Nowadays, the statistics appear more promising compared with the past one or two decades, since the investment in science and technology increased intensively in the period 1998–2009. Consequently, a rise has been recorded for all sectors.[12] Special attention has been paid to stimulating the development of science and technology in the business enterprise sector. To be more specific, it is important to emphasize that the gross domestic spending on R&D as a share of GDP increased from 0.37% in 1998 to 0.85% in 2009.[13]

Even though the public expenditure on research and development has increased in Turkey, it is still far behind the OECD and EU27 average. Further evidence that corroborates this statistic is reflected by the Global Innovation Index for health care,

which ranks Turkey 49th out of 129 countries. The index awarded a score 39.65—nearly half that of Switzerland, which is ranked top.[14] Research and development plays a crucial role in innovation, which is recognized as the engine of growth. Innovation must be implemented by society as a whole. A complex, non-linear relationship is recognized in R&D and innovation whereby advancements in technology cannot occur unless systematic work is undertaken in this regard.[15] The role of the government is to provide the public expenditure that will tend not only to improve the business climate and attract foreign investors but also increase the productivity of the inputs. Several steps have already been taken. For instance, the number of full-time equivalent (FTE) R&D personnel increased from 58,000 in 1998 to 74,000 in 2009. Moreover, the number of publications and patents increased in Turkey during the period of interest. The number of patent applications by non-residents also increased while the number of patent applications registered by residents increased ten-fold in the ten-year period. Figure 1 shows the significant increase in patent applications by residents in Turkey.

Recent decades have been characterized by the development of technology. The development of new technology, especially information technology (IT), has happened very quickly. Investment in this technology is recognized as an important infrastructure for managing knowledge.[16] Even though technological innovation is expected to have a positive impact on business performance, the empirical evidence on this link remains inconsistent. However, Aghion, Howitt and Romer indicate that technological innovation plays an important role in the growth process.[17]

Better technology and an innovative capacity, combined with improved productivity, play an important role in competitiveness and so, consequently, economic growth.[18] For this reason, many authors have explored the determinants of innovation.[19] Berger and Diez suggest that investment brings in new technology, knowledge spillover and new marketing skills that improve the performance of the host firms.[20] Thus, the role of the government is crucial. It is necessary to create a favourable business climate to attract

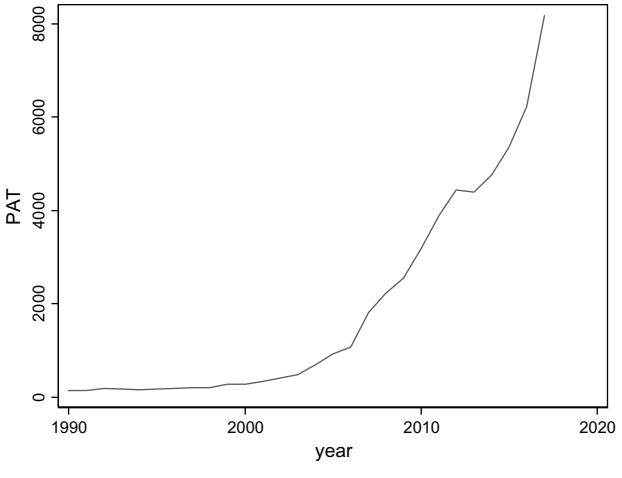

Figure 1. Patent applications in Turkey (residents).
Sources:World Bank, World Development Indicators https://data.worldbank.org/country/turkey?view=chart (accessed 20 May 2019); OECD, OECD stat. <https://stats.oecd.org/> (accessed 20 May 2019).

foreign investors and also to direct the funds towards research and development to develop the innovation process. In addition, it is necessary to mention that capital directed towards innovation has a public-goods property and thereby creates a positive externality which demands a greater role by the government.[21]

Figures 2 and 3 indicate that both the gross domestic spending on R&D (percentage GDP) and gross capital formation (percentage GDP) increase in the period of interest. A

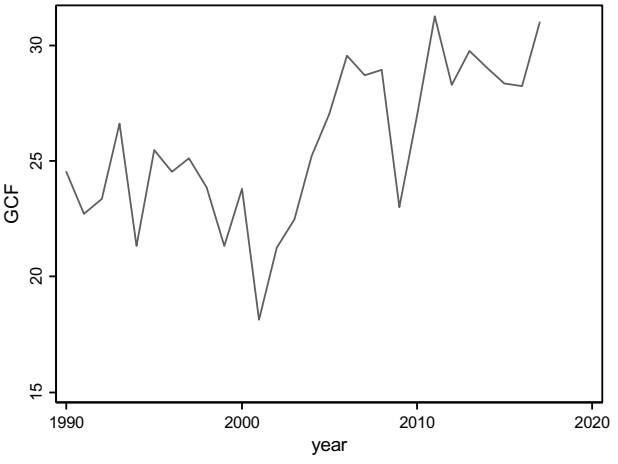

Figure 2. Gross capital formation in Turkey.
Sources: World Bank, World Development Indicators https://data.worldbank.org/country/turkey?view=chart (accessed 20 May 2019); OECD, OECD stat. <https://stats.oecd.org/> (accessed 20 May 2019).

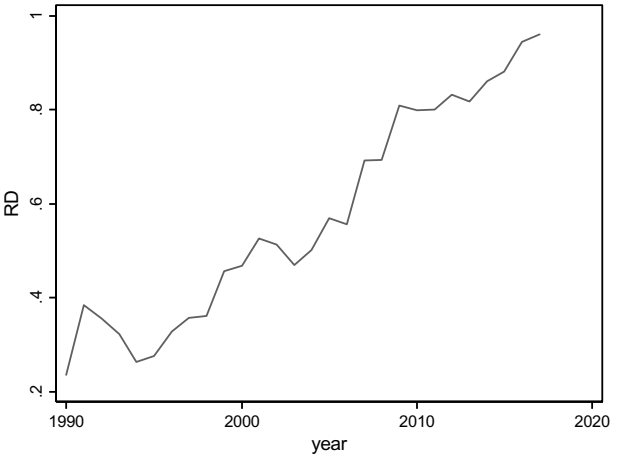

Figure 3. Gross domestic spending on R&D.
Sources: World Bank, World Development Indicators https://data.worldbank.org/country/turkey?view=chart (accessed 20 May 2019); OECD, OECD stat. <https://stats.oecd.org/> (accessed 20 May 2019).

group of researchers have found mixed evidence on the relationship between innovation and per capita economic growth for 19 EEA countries.[22] The hypothesis that demand leads the innovation–growth nexus finds support, as per capital economic growth contributes to innovation, whereas the hypothesis that supply leads the innovation–growth nexus is supported by innovation determining per capita economic growth.

In terms of Turkey, the link between innovation and economic growth has been explored frequently. However, the empirical evidence on the link between innovation and gross domestic spending on R&D is lacking, which provided the to for this paper. Hence, we contribute to the emerging literature examining the contextual influences on innovation by focusing on the case of Turkey and exploring the potential role of gross capital formation. Our findings can be of great importance for policy-makers, taking into account the launch of the Turkish Research Area (TARAL).

Following the introductory remarks, this paper presents a detailed literature survey of the studies by analysing the relationship of interest. The empirical results section presents in detail the findings of this research together with the discussion. Finally, we provide some policy implications.

Background to the relationship between innovation, gross capital formation and public expenditure

Innovation's multiple effects on the economy are visible in terms of economic growth, global competitiveness, financial systems, quality of life, and trade openness.[23] Where firms are considered important innovative actors,[24] the government is seen as stimulating their ability to absorb, improve and create new technologies.[25] The government provides an infrastructure and an institutional platform for exchange to enhance firms' capabilities. Government, enterprises and scholars have long emphasized the role of scientific R&D in economic growth.[26] R&D activities generate knowledge and technology that increases productivity at three levels—firm, industry and national, so the chain effect of productivity will lead to increased returns on investment which reflect higher income levels and thereby higher economic growth.[27] The Marshallian Macroeconomic Model was implemented in the US to examine the returns on federal spending for basic research, applied research and development research.[28] The findings suggested that federal spending on applied research generated a larger return in comparison to applied or development research.

Qi, Hap and Shi investigated the link between public expenditure and innovation. They collected data for Inner Mongolia (an autonomous region in China). The empirical evidence of this paper suggests that not only does public spending drive innovation activity but it can also play a significant role in the promotion of public expenditure, suggesting a bidirectional link between the sample variables.[29] Moreover, increases in R&D expenditure are expected to play a key role in the improvement of competitiveness. These findings are strongly supported by Lichtenberg and Lach.[30] A group of researchers on behalf of Maradana advocate that an increase in R&D contributes to applied research which, in turn, increases the number of inventions, thus enhancing innovation[31] so, from a linear perspective in an innovation process, localized R&D lies at the core of the technological process which eventually leads to economic growth.

Another study, by Goel, Payne and Ram, focused on the relationship between R&D outlays at a disintegrated level and economic performance. The findings suggested that federal R&D had a higher role in growth than non-federal R&D.[32] However, Balci advocates that, based on Turkey's experience, an increase in expenditure on the inputs of innovation would not necessarily translate into improvements in innovation.[33] Over the last 15 years, Turkey has emphasized the importance of innovation and R&D. There was a 74% increase in Turkey's research intensity indicators from 2006 to 2007.[34] Despite this increase, there are inefficiencies in the Turkish R&D support system which are chaotic in nature.

Wang et al. collected annual panel data on 110 world economies for the period 1995–2015 to test whether or not the ideology of the government may have had an impact on the innovation process. They utilized the Generalized Method of Moments (GMM) framework. This paper suggests that the specific circumstances of each country should be taken into account when analysing the link of interest. However, the general conclusion states that technological innovation is assigned to promote innovation in technology whereas rightists promote the development of new, better technology.[35] These findings are supported by Aidt et al. and Smith et al., who report that, when the ruling party changes—i.e. when the right-wing wins the election—the investment in wealth significantly rises which leads to sustained growth that is driven by better innovation performance.[36]

Afonso et al. emphasize that innovation is considered a key determinant of economic growth, especially in developing countries. However, the innovation process is not easy and requires collaboration between all economic parties in society. Moreover, the authors suggest that the innovation process requires significant public expenditure on the development of human capital (i.e. education) as well as on research and development.[37] In this light, it is important to emphasize that an increase in public expenditure, directed towards education and the greater productivity of inputs, is recognized as essential for boosting innovation activity, especially in the long run. These findings are supported by Alawamleh et al. in the case of Jordan. The authors suggest that investment in human capital and innovation are the two concepts that are of key importance for growth.[38] Research on the relationship between innovation and economic growth for the European Economic Area (EEA) suggested the existence of both unidirectional and bidirectional causality between the two.[39] Therefore, it recommended that policy strategies should promote innovation in order to increase the per capita economic growth.

Just like public expenditure, gross capital formation can play a significant role in the technological progress of the economy. Lau et al. indicate that investment plays an extensive role in knowledge spillover and helps local firms to take more action in terms of innovation.[40] Moreover, Song et al. suggest that the positive externalities associated with gross capital formation tend to increase the innovation capacity of the host economy in the case of China.[41] Similar evidence is provided by Perri and Peruffo.[42]

Loukil has examined the relationship between investment and innovation in the case of developing countries. The panel data were collected for the period 1980–2009. The empirical evidence suggests a linear link between these variables of interest. The most important findings suggest that governments need not only support investment, but also direct the necessary funds to prepare firms to use the positive externalities that the gross

capital formation generates.[43] A justification of these findings is provided by Sjoholm, who uses the case of Indonesia, and Cheung and Lin, who use the case of China.[44] Zawalińska, Tranand and Płoszaj investigated the benefits of two research-related policies: government expenditure policy and tax relief policy. The findings suggest that the public funds allocated to the purchase of R&D services has a direct effect whereas tax relief provides an indirect stimulation to R&D through lower prices. The net effect of both policies shows an increase in R&D capital stock that translates into an improvement in productivity for the whole economy.[45]

Lin and Lin investigated the potential link between investment, trade openness and innovation in the case of Taiwan. The findings of this paper imply that investment and trade openness tend to have a significant positive impact on the innovation activity of Taiwan. Consequently, the empirical evidence identifies that investment is the most important determinant of innovation.[46] Evidence of the positive impact of investment on innovation is also provided by Erdal and Gocer who employ panel data econometrics for the case of Asian developing countries for the period 1996–2013. The authors suggest the necessity of supporting gross capital formation, especially for countries that lack capital and have old technology, since it may play a key role in the accumulation of capital as well as sustained growth.[47]

In terms of Turkey, there is a lack of empirical evidence on the link between gross domestic spending on R&D, investment and innovation. Atiyas and Bakis conducted an empirical analysis and concluded that foreign firms in Turkey are more dedicated to the innovation process compared to domestic ones.[48] In the light of innovation, there are numerous reports outlying significant issues in regard to the evaluation mechanism. Evaluation studies are very limited and are conducted by academics, researchers or public institutions.[49] To conclude this section, it is worth summarizing the research study conducted by Karaoğuz.[50] The aim of his study was to examine the political dynamics, if any, in the Turkish R&D policy during the AKP period. Although the literature suggests that the R&D policy should be above politics, Karaoğuz suggests that this is not the case in Turkey. The political parties agree that innovation cannot be disputed under any conditions since it plays a key role in the dignity and independence of the nation as well as in the modernization process. The main conclusion suggests that deliberation policy alternatives were hindered due to the weak capacity of the institutions.

Research materials and methods

The aim of this paper was to explore the causal link between the three variables of interest. For this purpose, we collected time-series data for the period 1990–2017. The country of interest was Turkey. World Bank and OECD datasets were used to collect the data on all of the variables of interest. Maradana et al. stress the need to be very careful when selecting the proxy for innovation.[51] Accordingly, PAT—patent applications, residents were adopted as a reliable proxy for innovation. Wang suggests that PAT is a definite measure of innovation.[52] Patents have the advantage of not being exposed to personal views, as in the case of surveys, and they reflect the quality of innovation as they are examined by experts.[53]

It was also necessary to select an appropriate proxy for public expenditure on research and development. Using RD—gross domestic spending on R&D (% of GDP)—as a proxy for public expenditure on R&D is justified by Ildirar et al.[54] Finally, GCF—gross capital formation (% of GDP)—is suggested by Oyedokun.[55] To provide empirical evidence regarding this area, we employed the econometrics of time-series data or, in other words, we adopted the Toda and Yamamoto approach. Under the null hypothesis, there is no causal relationship between these three variables of interest. However, the alternative hypothesis suggests that gross domestic spending on R&D and gross capital formation may have a causal link with innovation.

Empirical analysis of gross capital formation and its relationship with public expenditure on R&D and innovation

The empirical findings of this research start by providing the main measures of the summary statistics (Table 1). In terms of the proxy variable of innovation, the minimum number of patent applications by residents is recorded for the year 1990. This variable has displayed an increasing trend, with the maximum number being reported in the last observed year. These values can be easily justified if we take into account the fact that the Turkish Patent and Trademark Office has prepared the Industrial Property Code no 6769 (IP code) which was accepted by Parliament and entered into force on 10 January 2017.[56]

In the early 1990s, Turkey aimed to join the Customs Union, and official negotiations were conducted with the European Union. In this light, industrial property law needed to be in accordance with the EU legislation. For this purpose, decree laws were implemented in 1995 and were related to industrial property rights, trademarks and patents. The main motivation was to harmonize Turkish IP law with agreements at the international level. The IP Code managed to resolve some of the main issues in Turkish IP law; however, there still exist certain drawbacks considering patent law. Stiglitz suggests that intellectual property was intended to boost innovation. The author also suggests that society's innovation system consists of many elements, including the intellectual property regime with the particular aim of supporting innovators to innovate.[57] Intellectual property rights include various parts of the intellectual property system; some of those are patents and copyrights. Stiglitz shows various ways to finance research; for instance, through research labs supported by government or universities.[58]

Public expenditure is approximated by gross domestic spending on R&D. Hence, in light of the results, RD has a minimum in 1990 , while the maximum value is recorded for

Table 1. Description of the data.

stats	PAT	RD	GCF
Mean	1894	0.573	25.71
sd	2268	0.230	3.35
Max	8175	0.961	31.27
Min	138	0.236	18.14
Skewness	1.194	0.220	−0.208
Kurtosis	3.384	1.665	2.255
Meas. unit	Total	% of GDP	% of GDP

Source: Authors calculation based on World Bank, World Development Indicators https://data.worldbank.org/country/turkey?view=chart (accessed 20 May 2019); OECD, OECD stat. <https://stats.oecd.org/> (accessed 20 May 2019).

2017, revealing that Turkey has made significant efforts to engage in research and development, showing a positive trend over the sampled period. The last variable of interest is GCF. Gross capital formation as a percentage of GDP reached the maximum value in 2011 while the minimum value was recorded for 2001. All of the variables report significant dynamics within the period of analysis, which is also confirmed by the standard deviations.

So far, innovation has been recognized as driving growth. However, measuring innovation is highly complex. Over the sampled period, Turkey recorded significant growth, with a particular objective to promote and support innovation. Turkey supports innovation and records a significant increase in growth; is there a relationship between the two? This is a relationship with high compatibility, but there is still the question of how to measure the impact of innovation and which of the impacts of innovation (direct or indirect) contribute to the growth process. Burhan et al. stress that it is inherently impossible to measure innovation, so it is challenging to find an appropriate proxy. The authors also suggest that patents are among the most commonly used proxies for innovation.[59,74,75] Some of the empirical studies indicate that patents do not provide a perfect proxy for innovation, although a fairly good one.[60] Although there exists a general consensus that a patent system is a fairly good proxy for innovation activity (at least in part of), several authors argue in favour of the explanatory power of patents. This proxy for innovation has faced much criticism and one should be very careful about using it in empirical studies.

With regard to criticism, Smith suggests that patents are a proxy for invention rather than innovation, and do not include all innovations, i.e. not all innovations are patented and innovations are far beyond the patents.[61] Moreover, our study analyses the case of an emerging market economy (Turkey), thus there is a need to take into account the fact that the application of patents could be weaker in emerging compared to developed countries. To deal with these issues, patents' quality adjustments have received significant attention in the last decade. To summarize, the patent is not the optimal proxy for innovation, since it cannot cover all innovations. However, Smith suggests that total factor productivity can be only measured by means of innovations, showing the necessity to explore the disadvantages of patents as a proxy for innovation.[62]

As a matter of fact, there are other proxies for innovation. For instance, innovation has been represented by means of the quality of patents in the last decade . One of the methods is also the citation of patents that tries to differentiate between the relevance of the innovations. The last two decades have witnessed a dramatic increase in the use of patent citation data as a proxy for innovation. It is also important to note some of the limitations associated with this method. For instance, the quality of citations is questionable. To address this issue, Ejermo sought to develop an index that will take into account the quality of the citation.[63]

Despite the limitations of patents, they are still a common proxy for innovation and offer several advantages. The most important advantage is that they are easy to measure, so the data can be easily accessed. Moreover, the number of patents can be easily compared at the global level, to show the differences between developed and developing countries. Due to the data availability, patents are the only feasible proxy for innovation and their usage represents the limitation of this study.

In terms of research and development, Turkey lags far behind the OECD average. Effort is lacking in terms of research and development expenditure, scientific articles, the number of researchers as well as the number of patents.[64] This is quite surprising considering the high number of graduates in the science and engineering fields. However, most research and development in Turkey is performed by universities. The statistics indicate that Turkey performs well compared to other countries. It is worth noting that the Turkish business sector significantly supports research and development. However, the government is still the leading supporter. The Scientific and Technological Research Council of Turkey (TUBITAK) is the leading institution that manages, funds and conducts research in Turkey.

As a matter of fact, the Supreme Council of Science and Technology (Bilim ve Teknoloji Yüksek Kurulu—BTYK) adopted the National Science, Technology and Innovation Strategy (2011–2016) in December 2010. The particular aims of this strategy were to develop human resources in the field of science; to improve technology and innovation; to encourage the transformation of research results into commercial products and services; to promote the culture of multi-partner and multi-disciplinary R&D and innovation cooperation; to encourage small and medium-sized enterprises (SME) to become stronger actors in the innovation system; and to promote international collaboration. The support from SMEs is of critical importance, considering the fact that the economy of Turkey is dominated by SMEs. These were found to provide more than 75% of jobs in 2014.[65]

Within the scope of the National Science, Technology and Innovation Strategy (2011–2016), automotive, machinery and manufacturing technologies, information and communication technologies, and the energy, water, food, security and space sectors were identified as focal areas. While the national income is targeted to become 2 trillion USD in Turkey in 2023, R&D expenditure is aimed to increase to 60 billion USD. To reach these objectives, a number of important steps have been taken, such as investment incentives. However, weak points are still connected with the protection of intellectual property rights or R&D capacity. This implicates that although the IP Code managed to resolve some of the main issues within Turkish IP law, there are still some drawbacks considering patent law. Moreover, to increase Turkish competitiveness at the national level, the human resources need to be significantly improved. This requires both a well-established institutional infrastructure and support.[66] Foremost, macroeconomic stability is necessary; a well-designed incentive system as well as the protection of property rights.

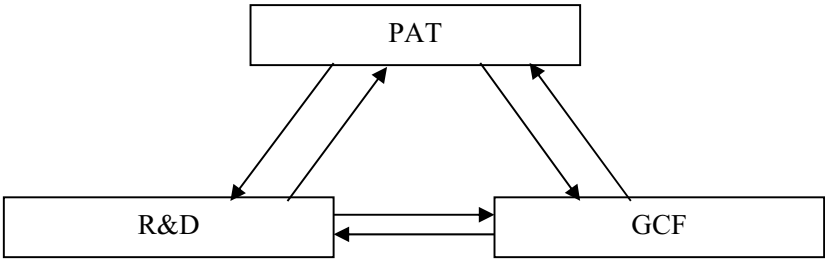

Figure 4. Causality direction.

Furthermore, we have tested the causal links between the three time-series by employing the Granger causality test. The findings of the Granger causality test (Figure 4) imply that both public expenditure on research and development and gross capital formation were found to Granger cause innovation in the case of Turkey (1% significance level). Moreover, both innovation and gross capital formation were found to Granger cause gross domestic spending on R&D at a 5% level of significance. Finally, innovation is found to Granger cause gross capital formation at a 5% level of significance, whereas gross domestic spending on R&D Granger causes gross capital formation at a 5% significance level.

To conclude this part of the paper, it is important to note that the findings presented in tabular form outline the bidirectional causal link between the proxy for innovation and gross domestic spending on R&D, implying that the role of the government is necessary to stimulate the innovation process that will lead to increased productivity and, consequently, increased employment and reduced poverty. These findings are consistent with the prior literature that suggests that government support contribute to better innovation performance in Turkey and Poland.[67] However, the gross domestic spending on R&D can be the positive externality of innovation, especially in developing countries. Similarly, the positive effects of R&D tax credits were noted on innovation.[68] Alternatively, in Norway and Italy no impact on innovation was shown to be due to R&D.[69] R&D is an important source of innovation in developing countries. Following this example, governments may direct more funds towards this purpose. In addition, a bidirectional link is found between gross capital formation and innovation as well as between gross domestic spending on R&D and gross capital formation.

Discussion and conclusion

The data collected and analysed in this paper suggest that the growth process in Turkey is not strongly linked to the economic structural development. In the period 1990–2017, Turkey faced a significant transformation, from agriculture-dominated to an economy with a particular focus on industry. As opposed to developed countries, the Turkish national innovation system (NIS) has faced many issues in the last few decades and is still categorized as fragmented.[70] The discrepancy between the Turkish national innovation system and economic structural development has significantly jeopardized the competitive potential of the Turkish economy. As a consequence, the national innovation system is still weak and fragmented with a small percentage of research and development expenditure on GDP. However, Turkey is an interesting economy to investigate and debate, since it has recorded an exponential increase in the manufacturing sector.

This research investigated the potential causal relationship between innovation, public expenditure and gross capital formation in Turkey. The case of Turkey was selected since this economy has recorded significant macroeconomic progress in the last few decades. Moreover, in 2004, Turkey conceptualized the Turkish Research Area (TARAL) to improve innovation activity in the business and public sectors. Both of these sectors, together with non-profit organizations, are expected to work together to boost innovation and R&D activity in Turkey. To analyse this link, we collected time-series on an annual basis for the period 1990–2017 and utilized the Toda and Yamamoto approach.

Gross domestic spending on R&D and gross capital formation are reported to Granger cause innovation in the case of Turkey. Moreover, both innovation and gross capital formation were found to Granger cause gross domestic spending on R&D. Innovation is found to Granger cause gross capital formation whereas gross domestic spending on R&D Granger causes gross capital formation. The findings imply a bidirectional causal link between innovation and gross domestic spending on R&D. A bidirectional link is found between gross capital formation and innovation as well as between gross domestic spending on R&D and gross capital formation.

The results of this paper imply that the role of public expenditure is necessary to stimulate the innovation process that will lead to increased productivity, and consequently increase employment and reduce poverty. However, gross domestic spending on R&D can be the positive externality of innovation, especially in developing countries. R&D is an important source of innovation in developing countries. Following this example, governments may direct more funds towards this purpose. These findings are in line with Qi et al. and Shah.[71] A bidirectional link between innovation and gross domestic spending on R&D and innovation and gross capital formation suggests that the creation of new knowledge is not the only determinant of innovation but that this is also determined by the institutions and economic environment. This is why the role of the government is of key importance. These findings are also supported by Grilliches and Furman et al.[72] An example of a similar finding is extended for China, where innovation is emphasized as the top priority for national development.[73] The government's approach to innovation included actions such as increased allocations in the research target areas, government intervention in domestic companies, innovation-friendly policies and the promotion of technological national sufficiency.

Gross capital formation drives the innovation process since multinational corporations provide funds, better technology and training for domestic sources, leading to positive externalities. Moreover, knowledge spillover is likely to occur. Foreign competition may motivate domestic firms to search for new sources of competitiveness, i.e. to boost innovation. To provide the necessary support, governments need to invest in local education as well as research institutions that will supply the labour force actively included in the innovation process and will also find a way to cope with the international competition. However, these effects can be lower than expected; hence the empirical evidence on the matter to date provides inconclusive results regarding the link between innovation, gross domestic spending on R&D and gross capital formation.

The findings of this research are used to provide several policy recommendations. First, the necessary funds to develop the skills of the labour force in the host country (Turkey) should be provided in order to enable them to understand and use the new technology. Moreover, the language barriers should be removed by providing intensive language courses. It is of crucial importance to increase the gross domestic expenditure on R&D as well as the number of personnel specialized in R&D, since investment in R&D is necessary to stimulate sustainable growth. In fact, the growth stimulated by innovation is in line with Schumpeterian ideas. Finally, it is necessary to develop strategies that will strength the Turkish capacity for research, and promote cooperation with other countries as well as with the business enterprise sector. It is of key importance to attract funds that will be directed towards research and development. However, significant progress has been recorded in the case of Turkey. Apart from this, Turkey is still far behind the EU

average or the OECD in terms of gross domestic expenditure on R&D, so there exists huge potential for further development.

As a matter of fact, Stiglitz indicates that the innovation systems nowadays occur within the universities and research labs supported by the government. These lay down the foundation for the basic research.[74] Although monetary return is not the major motivating factor, innovation still needs to be financed. Therefore, an important question becomes not only how to motivate innovation but also how to finance it. To conclude this research, we will therefore discuss the promotion of academic and industrial research. In this regard, there were many programmes launched by TUBITAK ARDEB (Research Support Programme Directorate of TUBITAK)[75] since 2013, with a particular aim to promote academic research[76] and boost collaboration between private organizations, R&D centres, and public organizations enrolled in research and development, infrastructures etc. In addition to the support of academia, TUBITAK provides significant support for the research and development conducted by industry.

Regarding recommendations for future research, it would be interesting to analyse the impact of energy due to its important role in the production process.[77] Research could also take into account the R&D outlays at a disaggregate level and how these contribute to gross capital formation. Moreover, the introduction of human capital can provide a significant insight for decision makers. Finally, the role of trade openness may be interesting. Since the time-span covers the years of the financial crisis, the potential structural breaks should be taken into consideration.

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Disclosure statement

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Notes on contributors

Elma Satrovic holds a PhD in Management from the University of Sarajevo, Bosnia and Herzegovina. She also obtained her MA in Management from the same institution. She teaches

the basic economic principles of micro and macroeconomics and statistics. Her main research interests are: applied macroeconomics, quantitative economics, economic growth, financial development, tourism and energy. Elma is proficient in both panel and time-series econometrics.

Adnan Muslija received his PhD from the Faculty of Administration, University of Sarajevo, Bosnia and Herzegovina in 2020. He completed his Master's degree in Economics in 2011 from the Faculty of Business Economics, Pan-European University Aperion in Banja Luka, Bosnia and Herzegovina. His research interests are: foreign direct investments, good governance, tourism, innovation and economic growth.

Sadeq J. Abul gained a PhD from Durham University, UK in 2003. He has 37 years of experience in the banking sector in Kuwait. He spent 26 years working at the Central Bank of Kuwait, and also worked in the Department of Economic Research and the Governor's Office. From 2006-2017, he worked at Kuwait International Bank as a General Manager. In 2017, he retired and currently works as an independent economic advisor. His research interests include stock market efficiency, volatility, behavioural finance, the real estate market, and emerging markets.

Dragan Gligoric has been Assistant Professor at the Faculty of Economics, University of Banja Luka since 2007, in the field of International Economics. He defended his PhD thesis, 'Impact of Hard Peg Exchange Rate Regimes on Current Account Balance', in 2016. His areas of interest are exchange rates, foreign direct investments, innovation and internationalization, economics integration and applied econometrics. He has an excellent knowledge of statistical programs: Stata, EViews—time series analysis, panel analysis, and cross-sectional data analysis.

Tamanna Dalwai is Assistant Professor in the Department of Business and Accounting, Muscat College, Oman, affiliated to the University of Stirling, UK. She received her PhD in Accounting from Universiti Teknologi Malaysia and MBA (Finance and Accounting) from California State University, Hayward. She is an Associate Fellow of the Higher Education Academy, UK. She is an avid researcher in the fields of intellectual capital, capital structure, accounting education, corporate governance, corporate social responsibility, financial theories, international accounting standards, cost of capital, quality assurance and Islamic finance.

ORCID

Elma Satrovic http://orcid.org/0000-0002-8000-5543
Adnan Muslija http://orcid.org/0000-0002-8176-6600
Sadeq J. Abul http://orcid.org/0000-0002-6571-320X
Dragan Gligoric http://orcid.org/0000-0002-7171-8699
Tamanna Dalwai http://orcid.org/0000-0001-5754-5384