An Empirical Analysis of the Macroeconomic Dynamics of Innovation

Cigdem Borke Tunali

Introduction

Since the beginning of the second half of the twentieth century, it has been generally accepted that innovation plays a key role in economic growth and development, both in developed and developing countries. As a result of this, determining the factors that affect the innovation performance of firms has become a significant issue in recent years.

Although there are quite a few studies that examine how technological development and innovation affect economic growth and the rate of development of countries, the number of studies analysing the relationship between macroeconomic factors and the innovation performance of firms is very low. Hence, the aim of this chapter is to investigate the influence of macroeconomic indicators on the firms' innovation performance in the middle-income European countries that are

C.B. Tunali (✉)
Department of Economics, Faculty of Economics,
Istanbul University, Istanbul, Turkey
e-mail: cbtunali@istanbul.edu.tr

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either members or formal/potential candidates for membership of the European Union (EU).

In the empirical analysis, the real gross domestic product (GDP) growth rate, unemployment rate, deposit interest rate, domestic credit to the private sector and final consumption expenditure are used as macroeconomic factors. Moreover, firm-level characteristics such as spending on research and development (R&D) activities and firm size are added to the models. Since the middle-income countries are examined in the analysis, both introducing new products and services and upgrading an existing product line or service is employed as the dependent variables of the models. This is because middle-income countries are more likely to upgrade their existing product lines or services instead of introducing new products or services than are high-income countries. The results of the empirical analysis indicate that most of the macroeconomic factors under investigation affect the innovation performance of the firms. Hence, policy-makers should take into account macroeconomic factors while designing economic policies that aim to enhance the innovation performance of firms in the middle-income European countries.

In this chapter we first explain the theoretical background and literature review with a focus on the determinants of innovation activities of firms. Next, the data and methodology of the empirical analysis is discussed. After that, the results of the empirical analysis is presented and, finally, the last section concludes.

Theoretical Background and Literature Review

Since the beginning of 1900s, the determinants of innovation have been theoretically and empirically investigated in the literature and various factors such as microeconomic features and macroeconomic performance have been identified as the drivers of innovation (Avermaete et al. 2003).

Theoretical analyses of the determinants of innovation are mainly based on the studies of Schumpeter (1934, 1942). In the *Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest*

and the Business Cycle, Schumpeter (1934) explains that new firms that develop new products and processes can enter into markets easily and this leads to the disruption of existing production methods and the depletion of excess profits. Schumpeter (1934) defines this process as "Creative Destruction" and points out the role of new firms in the innovation process.

In *Capitalism, Socialism and Democracy*, Schumpeter (1942) emphasises the relationship between firm size and innovation and argues that large firms are in a better position than small firms with regard to innovation activities since they have the necessary sources (large-scale production, knowledge stock, access to external financial resources, etc.) to conduct innovation and technological development. However, Arrow (1962) asserts that the likelihood to innovate is higher for competitive firms than for monopolists. The reasons why small firms are more likely to be innovative than large firms are that small firms can make decisions with regard to innovation projects more quickly than large firms, they have less bureaucratic process, have a more flexible structure and adapt more easily to change than large firms (Dean et al. 1998; Chandy and Tellis 2000; Damanpour 2010).

In the existing literature, there are many empirical studies that examine the relationship between the size and the innovation performance of firms. However, in line with the theoretical explanations, the results of these studies are inconclusive and the debate about this issue still continues (Avermaete et al. 2003)[1].

One of the earlier empirical analyses that focuses on the effect of firm size on innovation is that by Acs and Audretsch (1987) who examine the influence of firm size and the structure of markets on the innovation performance of the firms by taking into account the different characteristics of large and small firms in different industries. In the empirical analysis, the authors use a comprehensive dataset that covers 172 innovative and 42 highly innovative industries and find that whilst large firms are more innovative in markets where imperfect competition prevails, small firms are more innovative in markets that have the characteristics of a competitive model (Acs and Audretsch 1987). Archibugi et al. (1995) investigated the relationship between concentration, firm size and innovation performance by drawing on a dataset comprised

of 6839 Italian firms. According to the empirical results, Archibugi et al. (1995) suggest that there is a positive relation between firm size and innovation performance both in highly innovative industries and at the aggregate level. Cohen and Klepper (1996) assess how the size of firms determines the amount of process and product innovations by putting forward a theory and testing it empirically. The authors use patent data developed by Scherer and business unit sales data from the Federal Trade Commission's Line of Business Program and find that larger firms are more likely to innovate than smaller firms (Cohen and Klepper 1996). Similar to the study by Acs and Audretsch (1987), Van Dijk et al. (1997) analysed the effect of different market structures on the innovation performance of large and small firms in the Netherlands using a different innovation measure at a different aggregation level. According to the empirical results, Van Dijk et al. (1997) argue that concentration does not have a different effect on the innovation performance of large firms in comparison with small firms.

Rogers (2004) examined the determinants of innovation in Australia by drawing on a dataset obtained from the Australian Bureau of Statistics Growth and Performance Survey. In the empirical analysis, Rogers (2004) estimated a Probit model for manufacturing and non-manufacturing firms separately and found that the determinants of innovation changes together with the firm size. By taking into account these results, Rogers (2004) asserts that market share and industry concentration have very little effect on the innovation performance of the firms. Bhattacharya and Bloch (2004) assessed the influence of firm size, market structure, profitability and growth on the innovation performance of small- and medium-sized Australian manufacturing enterprises. By drawing on a dataset obtained from the Business Longitudinal Survey of the Australian Bureau of Statistics in the empirical analysis, the authors argue that size, R&D intensity, market structure and trade shares have a positive effect on the innovation performance of both the full sample and high-tech firms (Bhattacharya and Bloch 2004). Wagner and Hansen (2005) investigated the effect of firm size on innovation performance in the wood products industry. The authors used a dataset attained from 43 interviews with top managers of firms in the wood products industry in the US and Chile (Wagner

and Hansen 2005). According to the results of the empirical analysis, Wagner and Hansen (2005) suggest that firm size has an effect on the type of the innovation of companies in this industry. Hong et al. (2016) analysed the drivers of innovation in New Zealand using four iterations (2005, 2007, 2009, 2011) of the Business Operations Survey, which includes over 22,000 observations. The authors estimated a multivariate Probit regression model and came to the conclusion that factors such as R&D capability, major technology change, application to formal intellectual property protection, accessing new export markets and firm size have positive influences on the innovation performance of firms (Hong et al. 2016).

As clearly seen from these explanations, the results of existing empirical studies examining the relationship between firm size and innovation performance are mixed and this issue is yet to be resolved.

Besides firm size and market structure, the issue of the effect of macroeconomic factors on the innovation performance of firms has re-emerged in recent years, especially after the 2008 global economic crisis (Thompson and Stam 2010). In the literature, economists put forward 'supply–push' and 'demand–pull' models of innovation to explain the relationship between macroeconomic activity and innovation performance of firms (Geroski and Walters 1995). According to the supply–push model[2], basic research is the starting point of innovation and the source of applied research that leads to new production and its diffusion (Godin 2006). The supply–push model asserts that the main reason for fluctuations in economic activity is fluctuations of innovation activities of the firms (Geroski and Walters 1995). On the other hand, the demand–pull model, proposed by Schmookler (1966), argues that innovative activities of the firms are determined by the sales in the relevant class of products (Crespi 2004).

In recent years, academics and policy-makers have generally accepted that both supply–push factors such as science and technology and demand–pull factors such as sales or profitability (Geroski and Walters 1995) mutually determine the innovation performance of firms (Di Stefano et al. 2012). However, there are very few empirical studies in the existing literature that examine the effects of different macroeconomic dynamics on innovation (Thompson and Stam 2010).

Sun and Du (2010) analysed the determinants of innovation in Chinese industries by drawing on 2004 census data. Unlike most of the other studies in the literature, Sun and Du (2010) used industry-level explanatory variables such as the number of patents, percentage of new products and R&D spending out of gross output of the sectors, spending on licensing for foreign and domestic technologies, spending on technology upgrading and renovation, percentage of exports out of gross sales of the sectors, and percentage of foreign-invested companies out of total assets of the sectors. According to the results of the empirical analysis, Sun and Du (2010) conclude that R&D spending is the most significant factor of innovation activities at the sectoral level. Khan and Roy (2011) examined the determinants of innovation performance in BRICS (Brazil, Russia, India, China and South Africa) and OECD (Organisation for Economic Co-operation and Development) countries by taking into account macroeconomic, fiscal and social factors. The explanatory variables used in the empirical analysis are the percentage of people with internet access, per capita consumption of electricity, openness (defined as the ratio of foreign trade to GDP) and diversity (defined as the ratio of percentage sum of all other minorities to the percentage of the largest ethnic group in the country) (Khan and Roy 2011). The empirical results of this study indicate that while progressing generation and distribution of electricity consumption, investment in higher education and trade liberalisation have a positive effect on the innovation performance of emerging countries, increasing R&D expenditures is more efficient with regard to innovation activities in OECD countries than in BRICS countries (Khan and Roy 2011). Thompson and Stam (2010) investigated the effects of macroeconomic factors (real GDP growth, consumption rates, long-term interest rates and unemployment rates) on the innovation performance in the Netherlands by employing a comprehensive dataset comprised of a random sample of surveys conducted between 1999 and 2009. In the empirical analysis, the authors used a number of control variables such as firm size, inter-firm cooperation in a renewal project and having employees who work on renewal projects together with macroeconomic variables and found that whilst real GDP growth and the unemployment rate have

a positive effect on innovation, the interest rate has a negative effect on the innovation performance of the firms (Thompson and Stam 2010).

As stated earlier, empirical analyses that focus on the influence of macroeconomic factors on the innovation performance of firms are scarce. Hence, this chapter tries to fill in this gap in the existing literature by investigating the influence of a number of macroeconomic indicators on the innovation performance of firms in the middle-income European countries.

Data and Methodology

Similar to the analysis by Thompson and Stam (2010), in this study the effects of macroeconomic factors on the innovation performance of firms are investigated empirically. The countries under investigation are the middle-income European countries that are either member or formal/potential candidates for membership of the EU. These countries are Albania, Bosnia and Herzegovina, Bulgaria, the Former Yugoslav Republic of Macedonia, Montenegro, Romania and Serbia. The World Bank's classification is taken into account in order to determine middle-income European countries (World Bank 2016a). According to this classification, Kosova and Turkey are among the middle-income countries that are also either a member or formal/potential candidates of the EU. However, these two countries do not have data for the year 2005. Because of this, Turkey and Kosovo are not included in the dataset.

The empirical analysis uses individual firm-level survey data obtained from the World Bank Enterprise Survey (World Bank 2016b), which consists of information compiled from individual firms about the business environment of countries, how this environment affects the firms, and various factors that limit the performance of the firms and their growth. Furthermore, the survey has a number of questions about the innovation performance of the firms (World Bank 2016b). The first question that is employed as the dependent variable in this empirical analysis asks whether the firm introduced any new products or services in the last 3 years (World Bank 2016b). The answer to this question takes the value of 1 if the respondent firm produced new products

or services and 0 otherwise (World Bank 2016b). Since the countries under investigation are middle-income European countries, introducing new products and services is more difficult than improving existing products and services for this group in comparison with high-income European countries. Because of this, another question that asks whether the firm upgraded an existing product line or services in the last 3 years is also used as the dependent variable in the estimations (World Bank 2016b). Similar to the previous question, the answer to this question takes the value of 1 if the respondent firm upgraded its products and services and 0 otherwise (World Bank 2016b).

As stated earlier, this empirical analysis is similar to the analysis by Thompson and Stam (2010) and mainly examines the influence of macroeconomic factors on the innovation performance of the firms. So, the key independent variables are real GDP growth rate, unemployment rate as a percentage of total labour force, deposit interest rate, domestic credit to private sector as a percentage of GDP and final consumption expenditure as a percentage of GDP. These data are obtained from the World Bank World Development Indicators database (World Bank 2016c). Since 2005 and 2009 Enterprise Surveys are used in the empirical analysis and the questions ask about the last three years three year averages (2002, 2003 and 2004 for the year 2005 and 2006, 2007 and 2008 for the year 2009) of the macroeconomic variables are taken into account in the empirical analysis. Together with macroeconomic factors, a number of firm-level control variables are also employed in the empirical analysis. These variables are whether the firm spent on R&D activities either in-house or contracted with other companies (outsourced) and firm size (World Bank 2016b). The first control variable takes the value of 1 if the respondent firm spent on R&D activities and 0 otherwise (World Bank 2016b). The second control variable takes the value of 1 if the firm is small (between 5 and 19 employees), 2 if the firm is medium (between 20 and 99 employees) and 3 if the firm is large (more than 100 employees) (World Bank 2016b). The models estimated are stated as follows:

$$\begin{aligned} innovation_{ckt} = {} & \alpha_{1t} randd_{ckt} + \alpha_{2t} firmsize_{ckt} \\ & + \alpha_{3t} macroeconomy_{kt} + \alpha_{4t} \mu_k + \varepsilon_{ckt} \end{aligned} \tag{1}$$

$$upgrade_{ckt} = \alpha_{1t} randd_{ckt} + \alpha_{2t} firmsize_{ckt} + \alpha_{3t} macroeconomy_{kt} + \alpha_{4t}\mu_k + \varepsilon_{ckt} \quad (2)$$

In Eq. 1, *innovation* represents whether the firm introduced any new products or services in the last 3 years. Similarly, in Eq. 2 *upgrade* indicates whether the firm upgraded an existing product line or services in the last 3 years. In both of the equations *randd* represents whether the firm spent on R&D activities, *firmsize* shows how big the firm is (small, medium, large), *macroeconomy* indicates the macroeconomic variables (real GDP growth rate, unemployment rate, deposit interest rate, domestic credit to private sector and final consumption expenditure), μ_k is the country dummy and ε_{ckt} is the error term. The subscripts c, k and t indicate firms, countries and time, respectively. These equations are estimated for every macroeconomic variable separately. The firms that participated in the survey are not the same for 2005 and 2009 (World Bank 2016b) and, hence, panel estimation techniques are not used. Since the dependent variables are categorical and take the value of 1 or 0, a logistic regression model is employed in order to estimate the equations.

Results

Table 1 shows the results of regressions in which innovation (whether the firm introduced any new products or services in the last 3 years) is used as the dependent variable. Since the model is estimated for every macroeconomic variable separately, each column in the table presents the results of a regression that is estimated using one of the macroeconomic variables as the key independent variable.

When the coefficient estimates of control variables in Table 1 are examined, it is found that spending money on R&D activities increases the probability of introducing new products or services by the firms. Moreover, firm size is a significant determinant of a firm's innovation performance and being a medium-sized firm (firm size (2)) has a positive effect on the probability of engaging innovation activities.

Table 1 Estimation results (dependent variable: innovation)

	(1)	(2)	(3)	(4)	(5)
R&D expenditure	0.39597***	0.399926***	0.398137***	0.388385***	0.394962***
	(0.0237)	(0.0237)	(0.0237)	(0.0239)	(0.0238)
Firm size (2)	0.116169***	0.118967***	0.116887***	0.11313***	0.115774***
	(0.0222)	(0.0221)	(0.0222)	(0.0223)	(0.0222)
Firm size (3)	0.028631	0.03334	0.023182	0.024338	0.030024
	(0.0262)	(0.0262)	(0.0263)	(0.0262)	(0.0262)
Real GDP growth	0.029848**				
	(0.0138)				
Unemployment		0.002156			
		(0.0064)			
Interest rate			−0.01842***		
			(0.0051)		
Domestic credit				0.004028***	
				(0.0011)	
Consumption expenditure					−0.00524*
					(0.0027)
Country dummy	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.1111	0.1100	0.1131	0.1133	0.1109
Observations	3084	3084	3084		3084

Source Author's estimations

The coefficient estimates are marginal effects. Standard errors are in parentheses

GDP and *R&D* represent gross domestic product and research and development respectively, $*p \leq 0.10$, $**p \leq 0.05$, $***p \leq 0.01$

According to the coefficient estimates of the macroeconomic variables, real GDP growth rate, deposit interest rate, domestic credit to private sector and final consumption expenditure are statistically significant determinants of innovation performance of the firms. However, unemployment rate does not have a statistically significant effect on innovation activities. When the sign and the magnitude of these variables are investigated, it is found that GDP growth rate has a positive influence on innovation and a 1% increase of the GDP growth rate leads to a 0.03% increase in the probability of introducing new products or services (column 1). In contrast to the effect of GDP growth rate, deposit interest rate negatively influences the innovation performance of the firms (column 3). The coefficient estimate of this variable indicates that a 1% increase of deposit interest rate results in 0.02% decrease in the probability of introducing new products and services.

With regard to domestic credit to private sector, the results show that this variable has a positive effect on the innovation performance of the firms (column 4). According to the coefficient estimate, a 1% rise in the domestic credit to private sector increases the probability of introducing new products and services by 0.004%. Finally, the results of regression, which is estimated using final consumption expenditure as the key macroeconomic variable, demonstrate that consumption expenditure negatively affects the innovation performance of the firms (column 5). The coefficient estimate of this variable indicates that a 1% increase of final consumption expenditure leads to a 0.005% decrease in the probability of introducing new products or services by the firms.

As explained in Section "Data and Methodology", since the countries under investigation are middle-income European countries, it is more likely that this group of countries will upgrade existing products or services instead of introducing new products and services. Hence, in order to better understand the effect of macroeconomic factors on the innovation performance of the firms, the model is estimated once again using a dependent variable that represents whether the firm upgraded an existing product line or service in the last 3 years. Table 2 shows the results of these regressions.

Similar to the previous results, the control variables are statistically significant determinants of the innovation performance of firms.

Table 2 Estimation results (dependent variable: upgrade)

	(1)	(2)	(3)	(4)	(5)
R&D expenditure	0.361609***	0.363509***	0.367744***	0.3589***	0.362125***
	(0.0246)	(0.0246)	(0.0245)	(0.0247)	(0.0246)
Firm size (2)	0.110956***	0.112975***	0.115518***	0.110537***	0.111212***
	(0.0205)	(0.0205)	(0.0204)	(0.0205)	(0.0205)
Firm size (3)	0.044119	0.048313*	0.054961**	0.043705*	0.046938*
	(0.0256)	(0.0255)	(0.0256)	(0.0257)	(0.0255)
Real GDP growth	0.03543***				
	(0.0127)				
Unemployment		–0.01616***			
		(0.0059)			
Interest rate			0.005742		
			(0.0045)		
Domestic credit				0.002484***	
				(0.0010)	
Consumption expenditure					–0.00528**
					(0.0025)
Country dummy	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.1231	0.1231	0.1216	0.1228	0.1223
Observations	3073	3073	3073	3073	3073

Source Author's estimations

The coefficient estimates are marginal effects. Standard errors are in parentheses

GDP and *R&D* represent gross domestic product and research and development respectively, $*p \leq 0.10$, $**p \leq 0.05$, $***p \leq 0.01$

Moreover, the coefficient estimates of these variables indicate that spending money on R&D activities and being a medium-sized firm has a positive effect on upgrading an existing product line or service. Here, being a large firm also has a positive influence on the innovation performance of firms (columns 2, 3 and 4). However, according to the results of regressions in which unemployment rate and domestic credit to private sector are used as the key independent variables, being a large firm is statistically significant only at the 10% level. Thus, these results do not provide robust evidence in relation to the effect of being a large firm on the upgrading activities of firms.

When the regression results with regard to macroeconomic variables are investigated, it is found that real GDP growth rate, unemployment rate, domestic credit to private sector and final consumption expenditure have statistically significant effects on the upgrading activities of the firms. According to the coefficient estimates, while a 1% increase in the GDP growth rate leads to a 0.04% increase in the probability of upgrading an existing product line or service a 1% increase in the unemployment rate decreases the probability of upgrading activities of firms by 0.02%. The coefficient estimates of domestic credit to private sector and final consumption expenditure are similar to the previous results. A 1% rise in the domestic credit to private sector results in a 0.02% increase in the upgrading activities of the firms. Finally, a 1% increase of final consumption expenditure decreases the probability of upgrading an existing product line or service by 0.005%.

In summary, according to these results, it is argued that real GDP growth rate, domestic credit to private sector and final consumption expenditure affect both the introduction of new products and services and upgrading an existing product line or service. However, deposit interest rate (introducing new products and services) and unemployment rate (upgrading an existing product line or service) influence only one of the innovation activities of firms. When the coefficient estimates of these variables are investigated it is found that real GDP growth rate and domestic credit to private sector have a positive effect on the innovation performance of the firms. This result is as expected since economic expansion and increasing financial resources facilitate firms' innovation activities. However, final consumption expenditure has a negative

influence on the innovation performance of firms. This may stem from the fact that most of the consumers prefer existing products instead of new ones. Finally, deposit interest rate and unemployment rate negatively affect the innovation activities of firms. This result is conceivable since rising interest rates increase the cost of financial resources. Under these conditions, firms have difficulties finding necessary resources in order to conduct innovation activities. Similarly, rising unemployment rates generally indicate economic contraction, which makes the innovation activities of firms more difficult. Hence, when the coefficient estimates of real GDP growth rate and unemployment rate are taken into account together, it is suggested that the innovation performance of the firms in middle-income European countries is pro-cyclical.

Conclusion

Technological development and innovation activities are widely accepted as some of the fundamental determinants of economic growth and development in recent years. Hence, establishing the effects of these activities on the economic performance of countries and determining the factors that influence innovation activities have become hotly debated issues both in developed and developing countries.

Although the number of studies that empirically investigate the effect of technological development and innovation activities on the economic growth and development rates of countries and the relationship between firm-level characteristics and the innovation performance of firms is quite high, the number of empirical analyses that examine the influence of macroeconomic factors on the firms' innovation activities is very low. This study tries to fill in this gap in the existing literature by providing new empirical evidence with regard to the relationship between macroeconomic factors and the innovation performance of firms.

In the empirical analysis, the effect of macroeconomic factors on the innovation activities of firms is investigated by using firm-level data for the middle-income European countries that are either members or formal/potential candidates for membership of the EU. The macroeconomic factors that are taken into account in the empirical analysis are

real GDP growth rate, unemployment rate, deposit interest rate, domestic credit to private sector and final consumption expenditure. In addition to these macroeconomic indicators, a number of control variables such as spending on R&D activities and firm size are also used in the empirical analysis. Since the countries under investigation are middle-income countries, it is more likely that this group of countries will improve existing product lines or services instead of introducing new products or services. Because of this, both of these activities are taken into account in the empirical analysis.

The results of the empirical estimations indicate that most of the macroeconomic factors under investigation affect the innovation performance of firms in the middle-income European countries. While real GDP growth rate, domestic credit to private sector and final consumption expenditure affect both introducing new products or services and upgrading an existing product line or services, deposit interest rate (introducing new products or services) and unemployment rate (upgrading an existing product line or services) influence only one of the innovation activities of firms. According to coefficient estimates, real GDP growth rate and domestic credit to private sector have a positive effect on the innovation performance of firms. However, deposit interest rate, final consumption expenditure and unemployment rate have negative effects on the firms' innovation activities. The positive influence of real GDP growth rate and domestic credit to private sector is conceivable since economic expansion and increasing financial resources facilitate engagement of innovation activities. Moreover, when the effect of real GDP growth rate and unemployment rate are taken into account together, it becomes clear that innovation performance of the firms in the middle-income European countries is pro-cyclical. The negative influence of deposit interest rate indicates that increasing costs of financial resources makes engaging innovation activities more difficult for firms. Finally, the negative effect of final consumption expenditures on firms' innovation performance shows that consumers prefer existing products or services instead of new ones.

In conclusion, according to the results of empirical estimations, it is argued that most of the macroeconomic factors under investigation influence the innovation performance of firms. Hence, policy-makers

should take into account macroeconomic factors together with other firm-level characteristics in order to design economic policies that lead to high and sustainable economic growth and development rates in the middle-income European countries.

Notes

1. For a comprehensive literature review see Kamien and Schwartz (1982), Cohen and Levin (1989), Becheikh et al. (2006) and Damanpour (2010).
2. In the literature, although the exact source of the supply–push model seems dubious, some authors state that it is put forward by V. Bush in his work *Science: The Endless Frontier* (1945) (Bush 1995; Godin 2006).

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