Düzce İktisat Dergisi, 7(1), 17-28.
Nisan 2026

Düzce Economics Journal, 7(1), 17-28.
April 2026

Examining the Relationship Between Market Concentration Level and Innovation for G-20 Countries

G-20 Ülkeleri İçin Pazar Yoğunlaşma Düzeyi ile Yenilik Arasındaki İlişkinin İncelenmesi

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Abstract

There has been a vast literature on the relationship between market concentration, firm size and innovation. Having conveyed the literature briefly, this study tries to find the intensity and direction of the relation between market concentration and level of innovation with the help of panel data analysis in the G-20 countries for the years 2009-2019. Therefore, patent applications are set as the dependent variable for the analysis while FDI, trade openness, level of competition in the market, HHI, expenditure on R&D and per capita GDP are taken as independent variables. The analysis suggests that there is a positive relationship between the competition and innovation in the market for the G-20 countries for the years 2009-2019. The original contribution of this study lies in its empirical investigation of the relationship between market concentration and innovation using a comprehensive panel data set covering G-20 countries. In this respect, the study fills an important gap in the literature.

Keywords: *Competition, innovation, market concentration*

JEL Classification: *D41, O31, D47*

Öz

Pazar yoğunlaşması, firma büyüklüğü ve yenilik arasındaki ilişkiye dair geniş bir literatür bulunmaktadır. Literatür kısaca aktarıldıktan sonra bu çalışma, G-20 ülkelerinde 2009-2019 yılları için pazar yoğunlaşması ile yenilik düzeyi arasındaki ilişkinin yoğunluğunu ve yönünü panel veri analizi yardımıyla bulmaya çalışmaktadır. Bu nedenle analiz için patent başvuruları bağımlı değişken olarak belirlenirken, doğrudan yabancı yatırım, ticari açıklık, piyasadaki rekabet düzeyi, HHI, Ar-Ge harcamaları ve kişi başına düşen GSYİH bağımsız değişkenler olarak alınmıştır. Analiz, 2009-2019 yılları için G-20 ülkeleri için pazardaki rekabet ve yenilik arasında pozitif bir ilişki olduğunu ortaya koyuyor. Çalışmanın orijinal katkısı, G-20 ülkelerini kapsayan kapsamlı bir panel veri seti kullanarak pazar yoğunlaşması ve inovasyon arasındaki ilişkinin ampirik olarak araştırılmasında yatmaktadır. Çalışma bu yönüyle literatürde önemli bir boşluğu doldurmaktadır.

Anahtar Kelimeler: *Rekabet, yenilik, pazar yoğunlaşması*

JEL Sınıflandırması: *D41, O31, D47*

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Geliş Tarihi: 16.02.2026; Revizyon Tarihi: 12.03.2026;
Kabul Tarihi: 28.03.2026;
Çevrimiçi Yayımlanma: 30.04.2026.

Received: 16.02.2026; Revised: 12.03.2026;
Accepted: 28.03.2026;
Available Online: 30.04.2026.

Düzce Economics Journal, 7(1), 17-28.
April 2026

1. Introduction

Markets, market structures and the concept of competition have always been at the centre of economic thought. Market structures can be labelled according to the number of firms they involve, whether firms market different or identical products, and how easy or difficult for the new players to have an existence in markets. For example, a perfectly competitive market emerges when identical products are sold in the market, the price is not affected by market share, there is no entry or exit barriers, buyers have full or complete information, and firms are incapable to set prices. In classical economic theory, it is accepted that the perfect competition market is the model that maximizing social welfare if the necessary conditions are met. The monopolistic market model is at the opposite direction of the hypothetical perfect competition market model. In between these two market structures are mixture forms called monopolistic competition (where there are many small firms supplying slightly different goods and services) and oligopoly (where there are a few large competing firms), which share some characteristics of both perfect competition and monopoly (Baumol and Blinder, 2011).

Market efficiency has a simple definition: the allocation of market-generated resources can be said to be efficient if there is no alternative feasible resource allocation that would improve the situation of an individual without worsening that of another.

Adam Smith suggested that a fully competitive market structure uses society's scarce resources at maximum efficiency (Baumol and Blinder, 2011). In contrast, monopolies lead to restrictions on production to obtain above-competitive prices. Monopolies are also said to be the enemy of good management since there is no incentive for improvement in the market. When comparing the perfect competition market and monopoly situation, monopoly production is always less and the price is higher (Smith, 1776). This leads to the monopoly gaining extra-normal profits and at the same time leads to inefficiency and loss of welfare in the market.

Schumpeterian theory argues that the capitalist competition model considers products and production processes as given, then examines which market structure will lead to the lowest prices for consumers. The model assumes that the market structure will be competitive when there are many sellers and a competitive market structure will result in lower prices for the consumer. The model also assumes that the monopolistic firm sets higher price and produces less quantity. Having accepted the result of standard this model, Schumpeter claims that it overlooks the fundamental issue when evaluating a market structure. For him, the most important question is what kind of market structure will bring the growth that will ensure the survival of capitalism. According to him, the driving force of capitalism is new goods, new production methods, new methods of production and distribution, new markets and new industrial formations created by capitalist enterprise. The of Creative Destruction, which constantly radically changes the economic structure, eliminates the old structure and replaces it with a new one is the fundamental reality of capitalism (Schumpeter, 1943). Therefore, contrary to the classical economic theory that sees monopoly as an evil, for Schumpeterian theory it may actually be a necessary evil (Schumpeter, 1943). Schumpeter argues that large firms, firms that face few competitors and can charge monopolistic or at least oligopolistic prices, are associated with the type of R&D that drives technological, thus capitalist change. In other words, according to this theory, a monopolistic market or a market with high market concentration may be more effective when dynamic factors are taken into account, even if it seems statically inferior than the perfect competition market. Because it leads to more innovation, and this wave of innovation (in Schumpeter's words, the perennial gale of creative destruction) brings economic growth.

This argument claiming that large firms, monopolistic firms that face a small number of competitors, or firms that can engage in monopolistic or oligopolistic are more capable of creating innovation that will drive technological change, thus capitalist change, challenged the dominant views on the virtues of free market capitalism. Therefore, it has been the subject of much empirical research (Raider, 1998). While it is accepted that innovation is of great importance for growth, policies designed to support innovations at the firm level have become one of the main areas of focus for policy makers (Dalgıç et al, 2023).

The aim of our study is thus to try to determine this issue which market structure creates more suitable conditions for innovation.

The literature exemplifies various measures of innovative or technological activity. These measures can be classified as the amount of innovative input or output. Examples of innovative output measures include the number of patents, the number of significant innovations, and the market value of innovations. The most frequently used input criteria in the innovation process are R&D expenditures and personnel involved in R&D (OECD, 1996).

However, there are some problems with all these measurements. For example, susceptibility to errors and malpractice tendencies arising from financial reporting are the problems associated with R&D expenditures and employment data. Additionally, some R&D activities may not be performed within a firm's formal/registered R&D operation. The amount of R&D performed those may be underestimated even though informal R&D occurs within the firm, because many small firms do not have separate R&D units (Cohen and Levin, 1989).

Schmookler, who conducted one of the first studies on this subject says that statistics on patent applications, issued patents, number of important discoveries in the field of technology, and articles and books in the field of technology will be useful for measuring innovation; and statistics on the number of employees and students in various technical fields can also be used in a similar way. However, such data can hardly be interpreted as an index of creative activity, since the number of inventions in any given field depends in part on the number of technical workers; as minority of such workers in the field are traditionally engaged in research activities (Schmookler, 1951). Scherer took the number of patents as an innovation criterion and explained the reason for this as many companies do not employ or report any R&D personnel (Scherer, 1965). Blundell, Griffith and Van Reenen noted that R&D activities are not reported by many companies, are treated as an input rather than an output, and are often reported somewhat haphazardly in company accounts (Blundell et al., 1999).

The main problems with the number of patents, are that they vary greatly in terms of their economic value and the patenting trend can vary significantly between sectors/industries. On the other hand, attempts to count the number of important innovations are open to some arbitrariness and possible bias in the evaluation procedure. Besides, some innovations are more important than others. Plus, great innovations are often inefficient at first, they undergo a series of small, incremental improvements that make their market value greater than the value of the initial innovation. Patent counting has another drawback. It assumes that all technologies covered by patents have equal economic and social value. Major innovations need quite a lot resource which are typically only available to large firms. These large firms are more likely to be located in industries where market is concentrated. On the other hand, less concentrated industries tend to have many smaller firms with the capacity to create minor innovations. Product differentiation is frequently high in competitive industries with low levels of concentration. Extensive patenting resulting from product differentiation is observed in competitive industries, because product differentiation often causes the patenting of minor changes to existing technologies. Given that simple patent counting treats the technologies covered by patents equally in terms of their economic and social value, this measure is likely to lead to empirical results showing that less intensive industries produce more patents thus more innovation. However, this would not be the correct conclusion, because most patents in less intensive industries are registered minor technologies which is possible the result of product differentiation driven by competition (Gayle, 2003).

Finally, attempts have also been made to create indices of the market value of innovations, such as innovation-related sales, stock market reaction to patent grants, and patent renewals. These variables can be inaccurate for the true value of innovations and have not been frequently used in studies on Schumpeterian approaches (OECD, 1996).

2. Literature

Studies examining the effect of market concentration or firm size on innovation started with Schumpeter (1943) and continued with the studies of Galbraith (1952), Arrow (1962), Scherer (1965a, 1965b), Dasgupta and Stiglitz (1980), Kamien and Schwartz (1982), Cohen Levin (1989) and Acz and Audretsch (1990). In recent studies done by Nickell and Van Reenen (2001), Furman et al. (2002), Baldwin, Hanel and Sabourin (2002), Bhattacharya and Bloch (2004), Carlin, Schaffer and Seabright (2004), Assink (2006), Studies by Shapiro (2012), Yagi and Managi (2013), Correa (2012), Spescha (2018), Aghion, Bergeraud and Van Reenen (2021), Griffith and Van Reenen (2021), Dalgıç, et al. (2023), it was observed that in addition to firm size and concentration rate, variables such as the level of competition felt by the companies, R&D budget, share of employment in R&D units, size of the allocated resources to R&D and ownership structure were also used as explanatory variables in the analyses.

Briefly, the positive relationship between market concentration and innovation is found in the works of Schumpeter (1943), Galbraith (1952), Dasgupta and Stiglitz (1980), Aghion and Howitt (1992), Blundell et al. (1995), Baldwin, Hanel and Sabourin. (2002), Bhattacharya and Bloch (2004), Griffith and Van Reenen (2021), Dalgıç et al. (2023).

Contrary to the views that firms dominating the market (and at the extreme, monopoly) will be more innovative, the literature that competitive and therefore less concentrated markets create more suitable environment for innovation creation becomes evident with Arrow's studies.

Therefore, according to the studies of Arrow, (1962), Scherer (1965a), Williamson (1965), Acs and Audretsch (1988, 1990), Subodh (2002), Carlin et al. (2004), Correa (2012), Shapiro (2012), Yagi and Managi (2013) and Spescha (2018), there is a negative relationship between market concentration and innovation.

3. Empirical Research: The Relationship Between Market Power, Level of Competition and Innovation

The aim of this study is to determine which market structure -symbolized by the perfect competition market and monopoly in the two most extreme cases- provides a more suitable environment for innovation.

3.1.Data

Per capita national income, trade openness, foreign direct investment, per capita R&D expenditures, the country's level of competition in the markets and the Hirschman-Herfindahl index (as an indicator of concentration in the country) are set as variables affecting the innovation which is measured as number of patent applications. Consistent with the definitions in the literature (OECD, 1996; Gayle, 2003; OECD, 2018), patent applications made by residents are accepted as a measure of innovation.

The study investigates the relationship between variables in the years 2009-2019. Data is obtained from the Global Competitiveness Reports of World Economic Forum, World Bank Data Centre, OECD Data Centre and World Intellectual Property Organization Statistics Centre.

The countries within the scope of the analysis are G-20 countries.

In the analysis, the number of patent applications (NP) made by countries is set as the dependent variable, and the abbreviations for the dependent and independent variables are as follows:

- NP: Number of Patent Applications
- PerCapita: National Income Per Capita
- CTR: Trade Openness Rate
- FDI: Foreign Direct Investment

• RD: R&D Expenditure per Person

• HHI: Hirschman-Herfindahl Index

• Level of Competition in the Market

The model aims to estimate the factors in G-20 countries affecting patent applications. In addition to the variables affecting the patent application, in previous studies, we wanted to measure the effect of concentration and degree of competition in the markets on innovation, which is the main subject of our study. In this context, the Level of Competition index in the product market efficiency section of the Global Competitiveness Index published by the World Economic Forum, and the Hirschman-Herfindahl index data published by the World Bank were used in the model.

The model is as follows:

$$LnNPit=\alpha i+\beta 1FDIit+\beta 2RDit+\beta 3PerCapitait+\beta 4TOit+\beta 5CompetitionLevelit+\beta 6HHI+Uit$$

Measures used to measure innovation can be classified as the amount of innovative input or output. Examples of innovative output measures include the number of patents, the number of significant innovations and the market value of innovations. The most frequently used input criteria for innovation process are R&D expenditures and personnel involved in R&D. Within the scope of this study, R&D expenditures are currently used as one of the factors affecting innovation. The rationale for using the number of patent applications as a dependent variable is the fact that it is important for any innovation is commercialized and the first stage of this commercialization occurs in the form of a patent application.

In the model, β refers to the slope coefficient and α refers to the constant term. While i shows the cross-sectional units consisting of G-20 countries, t shows the time series of the panel and U shows the error term. Stata 15 software program was used to determine the relationship between the series in line with the model equation.

Information about the variables is given below:

NP: The dependent variable used in the model is taken from the data kept by the World Intellectual Property Organization (WIPO) Statistics Centre. The number of patent applications includes direct applications and applications made within the scope of the Patent Cooperation Agreement.

The procedure under the Patent Cooperation Treaty (PCT) consists of two main stages. The procedure begins with the filing of an international application and ends (in case of a positive result for the applicant) with the granting of a number of national and/or regional patents. The PCT is a multilateral agreement signed in Washington in 1970 and entered into force in 1978. PCT is administered by the WIPO International Bureau, headquartered in Geneva (Switzerland).

FDI: It is compiled from the World Bank data. Foreign direct investment is the net investment inflow to acquire a non-temporary management interest (10 percent or more of the voting interest) in an active enterprise in an economy different from that of the investor. FDI, shown in the balance of payments as the sum of equity, reinvestment of earnings, other long-term capital, and short-term capital, represents the net inflows (new investment inflows minus disinvestment) from foreign investors in the economy providing the data.

RD: R&D expenditure, expressed as a percentage of GDP, consists of gross domestic expenditure and includes both capital and current expenditure in four main sectors: commercial enterprise expenditure, expenditure by public institutions, expenditure by institutions of higher education, and profit expenditures made by private non-profit organizations. RD includes basic research, applied research and experimental development. RD is calculated based on 2015 US Dollars.

PerCapita: GDP per capita (national income per capita) at purchaser prices is the figure calculated by including all product taxes in the gross added value of all resident producers in an economy and subtracting from it all subsidies not included in the value of the products. This figure is calculated without taking into account the deduction/reduction due to depreciation or due to depletion and degradation of natural resources. Data are constant 2015 prices expressed in US dollars, converted from local currencies using 2015 official exchange rates. An alternative conversion coefficient has been used for a few countries where the official exchange rate does not reflect the rate applied to actual foreign exchange transactions.

TO: This ratio is an index calculated by dividing imports and exports by GDP and is used to measure the degree of freedom or rigidity of the policy in the commercial activities of countries with foreign countries after liberalization in trade. However, a low trade openness rate does not necessarily mean high (tariff or non-tariff) barriers to foreign trade, and a low value may also result from factors such as the size of the country's economy and geographical distance from potential trading partners (OECD, 2011).

Level of Competition in the Market: This index is included in the "6th Chapter" in the Global Competitiveness Index Reports published annually by the World Competitiveness Forum. It is one of the sub-indexes of the "Section/Product Markets Efficiency" section.

The World Competitiveness Forum has been scoring and ranking countries in various areas within the scope of the global competitiveness index since 2004. Part of this ranking is accomplished by answering survey questions. Most questions in the survey follow a structure that asks respondents to rate a specific aspect of the business environment (economic environment) in which they operate on a scale of 1 to 7. At one end of the scale, 1 represents the worst possible case, and at the other end, 7 represents the best case. The World Economic Forum cooperates with more than 150 Partner Institutes for this survey, which was answered by people active in the business field (in the field of economy) at the national level. Joint Institutes are often recognized economic experts, relevant departments of national universities, independent research institutes or commercial organizations. In addition, the survey process is carried out in cooperation with Harvard University School of Business Administration (World Economic Forum, 2009).

The data used in this study is the Market Competition Level Index which is calculated with the answers given between 1 and 7 to the question of how intense competition is in local markets [1 = not at all intense; 7 = extremely intense].

HHI: The Hirschman-Herfindahl index is based on the total number and size distribution of companies in the sector and is calculated as the sum of the squares of the relative shares of all companies in the sector (Khemani, 1993: 24). As a matter of fact, the literature examining the relationship between market structure and innovation generally uses market concentration indices such as concentration ratios (CR) and HHI to examine Schumpeter hypotheses (Raider, 1998:3).

For the estimation of equation (1) above; the effects of GDP, Trade Openness, R&D Expenditure, Foreign Direct Capital, Market Competition Level and HHI data on the number of patent applications made by the same countries in G-20 countries were examined.

3.2.Model

There are a total of 209 observations in terms of the dependent variable and the time period. In terms of independent variables, observations are 209 for all independent variables. The 17 missing data in the R&D expenditure (RD) data and the 4 missing data in the patent application number (NP) data were completed with the linear interpolation method in the Stata program. Therefore, it can be seen that the panel data set is a balanced short panel.

The random effects estimator is used in the model. The autocorrelation problem is serious, there is heteroscedasticity but no correlation between units. Thus, independent variables influencing number of patent applications (NP) were estimated using the Generalized Least Square Test (GLS) in order to remove heteroscedasticity and autocorrelation problems. The GLS estimation method takes heteroscedasticity into account and can produce BLUE estimators (Gujarati, 2001). If the variance structure across groups is known, the random effects model is estimated with generalized least squares (GLS). On the other hand, if the variance structure is unknown, the appropriate generalized least squares (FGLS) method is suitable to estimate the variance structure (Eom et al., 2008). The estimator used is the GLS estimator, and if the covariance between units is unknown, the FGLS estimator makes more consistent estimates. It is also discussed in the literature whether the GLS and/or FGLS estimator can be used if the number of units used in the model is more than the number of periods (Kassi et al., 2019; Marques and Fuinhas, 2012), and recently it has been suggested GLS models could also be used in which the number of units is greater than the number of observations. (Wu, 2020; Priyanto et al., 2023; Thoa et al., 2020; Dhiab, 2021; Javaid et al., 2022; Garba et al., 2013).

In this context, the FGLS estimator was used in the model. This estimator can also give better predictions in the presence of one some or all of these issues: inter-unit dependency, homoscedasticity and autocorrelation (Gujarati, 2001; Danish et al., 2020; Garba et al., 2013. The regression results are given in Table-1 below:

Table1. The Regression Results

NP	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig.
RD.D	120450.1	54251.544	2.22	.026	14119.027	226781.17	**
LD	146815.47	55044.339	2.667	.008	38930.548	254700.39	***
L2D	12523.786	32188.999	.389	.697	-50565.492	75613.064	
PerCapita.D	23.595	11.38	2.073	.038	1.291	45.899	**
TO	-2379.683	410.511	-5.797	0	-3184.27	-1575.096	***
FDI	-2746.361	3018.879	-.91	.363	-8663.255	3170.534	
Level of Competition	46693.576	11378.12	4.104	0	24392.871	68994.281	***
HHI	-27330.81	28110.381	-.972	.331	-82426.144	27764.524	
Constant	-42158.122	65191.855	-.647	.518	-169931.81	85615.566	
Mean dependent var		137052.829		SD dependent var		286827.240	
Number of obs		152		Chi-square		63.595	

*** *p<.01*, ** *p<.05*, * *p<.1*

The equation of the model is as follows:

$$LnNP_{it} = 42158 - 2746.36FDI_{it} + 120450RD_{it} + 23.595PerCapita_{it-1} - 2379.683TO_{it} + 46693.576LevelofCompetition_{it} - 27330.81HHI + U_{it}$$

[0.518] [0.363] [0.026] [0.038] [0.000] [0.000] [0.033]

3.3.Emprical Findings

It is seen that NP is positively affected by the level of competition in the market. One-unit increase in the level of competition in the market leads to a 46.693.576-unit increase in NP. Therefore, it is seen that the increase in the level of competition in the market positively affects innovation. Other variables being constant, a one-unit increase in the level of competition in the long run causes an increase of 46.693.576 units in NP, while one-unit increase in the HHI leads to a decrease of 27.330.810 units in NP. On the other hand, although a one-unit increase in the HHI leads to a decrease of 27.330.810 units in NP, the significance level is above 0.05 and it is not possible to make a meaningful prediction in this context.

One-unit increase in RD and PerCapita variables will lead to an increase of 120,450.1 and 23,594 units in NP; while one unit increases in TO and FDI variables lead to decreases of 2,379,683 and 2746,361 units, respectively. However, the relationship between the RD and the FDI variable and NP in the second period is not statistically significant.

In summary, the study examines the relationships between R&D expenditures, per capita national income, trade openness, foreign direct investment, level of competition in the market and the

Hirschman-Herfindahl index, and the number of patent applications of in G-20 member countries for the years 2009-2019. According to the estimation results, R&D expenditures, per capita national income and level of competition in the market variables positively affect the number of patent applications. Trade openness rate and foreign direct investment rate negatively affect the number of patent applications. Although the statistical significance is low, it is found that the HHI and foreign direct investment rate variables also negatively affect the number of patent applications.

Similar to the literature, the increase in the foreign direct investment rate variable reduces the number of patent applications. On the one hand, foreign direct investment encourages local manufacturers to increase their R&D efforts and leads to greater knowledge flow which in turn leads to innovation (Wang and Kafouros, 2009). On the other hand, the FDI may also cause a brain drain of skilled labor to foreign countries and exclude small firms from innovation activities (Fu and Gong, 2011). Secondly, the FDI can have positive effects on productivity not only because it is a source of capital, but also because it is an important source of human capital increase, technology change, and the diffusion of ideas/technologies between countries through multinational companies. However, despite the investment provides technology transfer to the host country, the impact of investments to the host country can be expected to be limited or negative as the existing technologies have already been patented by the country or investor that exports the technology (Lee et al., 2011). Therefore, the findings obtained are also compatible with the literature cited in Malik's study (Malik, 2020).

As a result of the analysis, it is seen that as the level of trade openness increases, there is a decrease in the number of patent applications (albeit smaller than the effects of other variables). In this context, it is thought that the reason for the decrease can be determined more accurately by a study that also takes foreign trade balances into account and by taking into account the foreign trade balance as well as the trade openness rate.

Although it has a low statistical significance level of 0.31, it can be said that the fact that the HHI variable has an opposite effect with the competition level variable in the market actually strengthen the consistency in the analysis. Market power is used for measuring the level of competition in a market, and market power is defined as the ability of a firm to influence the market. Market power is measured by calculating the deviation from the theoretical situation of a perfectly competitive market, two of the assumptions of which are that there are many buyers and sellers in the market and that firms are price takers (Aghion et al., 2021). Therefore, an increase in the level of competition in any market means an increase in the number of players so that a decrease in concentration in the same market. This in turn means a decrease in the HHI. On the contrary, an increase in HHI means a decrease in the level of competition. It is therefore consistent with the model that an increase in HHI (in the opposite way to an increase in the level of competition) reduces the number of patent applications.

Conclusions

According to Adam Smith, competition and the existence of regulations that prevent social harms are, in principle, good for markets and trade. However, competition and market regulations always face the danger of being undermined and circumvented, leading to highly profitable monopolies thus major problems for people (Kurz, 2015). Moreover, privileges such as monopoly rights are the great enemy of good governance (Smith, 1776), as they leave no incentive for improvements in the market.

On the contrary, for Schumpeter a system that makes the best of its possibilities at any point in time may nevertheless be inferior in the long run to a system that does not do so at any point in time, because this “failure” of the latter may be a condition for the level or pace of long-term performance (Schumpeter, 1943). He believes that the basis of analysis of capitalism is its constant change; the aim is to find the element that causes it to be destroyed on the one hand, and to bloom again and again on the other. He labels this element is creative destruction (Schumpeter, 1943). What enables creative destruction in the capitalist economy is not price competition, which is a static element, but creating new combinations of existing resources and the most productive economic activity occurs not through constant adaptation but through revolutions in productive means.

In this context, Schumpeter is not against the large firm or the firm that dominates the market, concentration or centralization. Contrarily, he puts the innovator and entrepreneur at the centre of capitalism as a necessary driving force. In this context, Schumpeter is not against large or dominant companies or concentration; he deems these situations as a necessity for innovation.

Therefore, our study aims to convey the views on how the presence or absence of competition in the market affects innovation, then to test the suitability of these views. In this context, it is analysed in which situations the innovation finds a more suitable environment to be revealed by determining the direction and significance of the relationship between the level of competition and innovation in the market. There is a vast literature investigating the relationship between innovation and the level of competition in the market signifying results in both directions. In our study, per capita national income, foreign direct investment, trade openness level and R&D expenditures were included in the econometric analysis as factors affecting innovation. In addition to these variables, the Hirschman-Herfindahl index (HHI) and the level of the competition index were also used as independent variables.

In the econometric model results created using the data of G-20 countries between 2009 and 2019, it was seen that the increase in the level of competition in the market led to a positive change (increase) in innovation. In addition, albeit a low significance, the model also showed that an increase in the level of concentration in the market led to a negative change in innovation. The concept of market power, is used in order to measure the level of competition in a market. Market power is measured by taking into account the deviation from the theoretical situation of a perfectly competitive market, two of the assumptions of which are "the existence of a large number of buyers and sellers in the market" and "firms being price takers" (Aghion et al., 2021). Therefore, an increase in the level of competition in any market means an increase in the number of players thereby a decrease in concentration in the same market. This leads to a decrease in HHI, one of the criteria used to measure market concentration. On the contrary, an increase in HHI means a decrease in the level of competition, therefore it seems consistent with the model that an increase in HHI (in the opposite way to an increase in the level of competition) reduces the number of patent applications. Therefore, the effects of both variables on the number of patent applications are expected to be opposite and the model results are in line with this expectation.

The results reveal similar findings to those of [Arrow, (1962), Scherer (1965a), Williamson (1965), Acs and Audretsch (1988, 1990), Nickell and Van Reenen (2001), Carlin et al. (2004), Correa (2012), Shapiro (2012), Yagi and Managi (2013) and Spescha (2018)] asserting that the competitive structure positively affects innovation. Therefore, within the scope of the data and countries discussed, results are consistent with the views that the existence of a competitive order in the market and/or an increased competition yield more innovation. However, it should be reminded that there are a large number of studies in which both results can be reached (Raider, 1998), so the studies conducted are still considered inconclusive at best (Cohen and Levin, 1989). In addition, there is relatively limited literature on macroeconomic factors affecting innovation (Akduğan and Doğan, 2022). Therefore, the study can be said to make a unique contribution to the literature on macroeconomic factors affecting innovation.z.

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