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DOES DEMOCRACY SPUR TECHNOLOGICAL INNOVATION? *

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Exploring the factors that influence technological innovation is a fundamental area of research within the field of technological change and growth theory. This study aims to analyze the connection between political factors -specifically, democracy- and innovation across 101 countries from 1997 to 2018. The findings of the analysis indicate that democracy plays a positive role in promoting innovation. This conclusion is supported by various democracy indices and innovation indicators, such as the number of patent registrations with the USPTO and patent declarations with WIPO. Moreover, even within democratic nations, certain characteristics have been identified as contributing to higher levels of innovation performance. Countries with a majority-rule system, lower corruption levels, and stronger protection of property rights tend to exhibit greater innovation. Considering the ongoing hegemonic power struggle between the United States and China -a struggle that has evolved into a technology war centered around technological innovation, starting around the time of the 2008 global financial crisis- it has become increasingly important to investigate the relationship between democracy and innovation. Research in this area is expected to yield significant insights from both policy and strategic perspectives.

Keywords: Political Factors, Democracy, Innovation, Patent
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1. INTRODUCTION

The study of factors influencing technological innovation is a fundamental research area within technological change and growth theory. Both endogenous growth theory

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and evolutionary approaches to technological change have examined important factors, such as human capital accumulation, investment in research and development (R&D), learning effects, and forms of competition. In addition, the concept of the national innovation system has emerged as a significant mechanism for understanding technological innovation. Scholars such as Lundvall (1992) and Nelson (1993) have emphasized the role of institutions and policies in shaping technological innovation outcomes, highlighting that such outcomes are not solely determined by inputs, but also by various institutional and policy factors. This perspective, often referred to as the "institution-led innovation discourse," argues that disparities in institutions and policies contribute to differences in the speed and effectiveness of technological innovation among countries.

However, despite recognizing the importance of institutions and policies in the discourse on the national innovation system, there has been relatively limited attention given to the "political domain" in which these institutions and policies are discussed and formulated. In other words, the impact of the political system on innovation performance and the channels through which this influence occurs have been less explored. Nonetheless, researchers like Taylor (2016) and Acemoglu and Robinson (2012) have conducted studies investigating the relationship between political systems and the selection and sustainability of policies and systems related to technological innovation. Their findings suggest that the type of political system in an individual country influences the choice of policies and institutions related to technological innovation and their long-term stability. Consequently, the authors argue that research on technological innovation should also incorporate an examination of the political realm.

The research exploring the impact of political institutions on economic performance has predominantly been concentrated on the association between democracy and economic growth (Barro, 1999; Tavares and Wacziarg, 2001; Acemoglu et al., 2019) and democracy and income redistribution (Meltzer and Richard, 1981; Persson and Tabellini, 1994; Rodrik, 2014; Acemoglu et al., 2015). However, recent studies (Gao et al., 2017; Wang et al., 2021) have emerged, investigating the relationship between democracy and technological innovation. These studies draw upon Popper's hypothesis and examine whether democracy promotes innovation more effectively than dictatorship or authoritarianism. Democracy, due to its emphasis on individual freedom and protection of private property, is argued to provide a conducive environment for fostering individual creativity and systematically safeguarding intellectual property rights. Building upon this foundation, some studies suggest that democracy surpasses authoritarian regimes in terms of technological innovation.

However, the research findings from the field are mixed. Gao et al. (2017) does not find any evidence supporting a positive impact of democracy on technological innovation, whereas Wang et al. (2021) demonstrate a positive relationship between democracy and technological innovation. The Gao et al. (2017) study benefits from considering multiple variables related to innovation performance, including both quantitative indicators (such as the number of patent registrations with the US Patent

Office) and qualitative indicators (such as patent citations and patent originality). However, it fails to account for the fact that patent registrations and citations represent count data, meaning they are non-negative integers occurring within a specific time and space interval. To accurately model this phenomenon, it is necessary to employ a probability distribution that accommodates the unique characteristics of count data, such as using a Poisson probability distribution.

On the other hand, Wang et al. (2021) address endogeneity concerns by utilizing a generalized method of moments (GMM) approach to consider both the number of patents and the number of trademarks as proxy variables for innovation. This study relies on the total number of patent applications published by the World Intellectual Property Organization (WIPO), which includes applications from both residents and non-residents. However, incorporating non-resident or foreign patent applications in the count might lead to an overestimation of a country's innovation capability. Moreover, the WIPO patent data is compiled by national/regional intellectual property offices, each with its own set of patentability criteria, which poses a challenge when using this data. Therefore, it is crucial to compare the estimation results using patent examination data, such as data from the United States Patent and Trademark Office (USPTO), which follows consistent standards, with the results based on WIPO data.

Our research aims to explore the connection between political institutions and innovation, specifically focusing on how democracy influenced innovation in 101 countries from 1997 to 2018. We address the limitations of previous studies and introduce several important distinctions in our approach. Firstly, unlike Gao et al. (2017), we employ a Poisson regression model, which is based on a Poisson probability distribution. This model is specifically chosen to account for the count nature of patent data, which serves here as a proxy for measuring technological innovation. Secondly, in contrast to Wang et al. (2021), we adopt the number of patents registered with the US Patent and Trademark Office as our measure of innovation performance. This selection ensures a consistent standard of patentability for evaluating innovation. Finally, we conduct robustness checks by comparing the results obtained through various estimation methods -such as OLS and GMM- alongside the results obtained through Poisson estimation. Additionally, we incorporate both the number of patent applications filed by WIPO residents and the number of patents registered with the US Patent and Trademark Office as proxy variables for assessing innovation performance. This enables us to compare the estimated results using these two variables.

The structure of our paper is as follows: Section 2 provides a comprehensive literature review, Section 3 presents the data used and describes the estimation models employed, Section 4 presents the estimation results, and Section 5 concludes the paper with a summary of our findings.

2. LITERATURE REVIEW

The existing research on the relationship between political institutions and technological innovation is still limited. Previous studies have primarily focused on examining the influence of various policies, such as patent, trade, finance, education, and training, on innovation performance. Rather than directly impacting technological innovation, these studies have emphasized the importance of policy consistency and stability within political systems.

The emphasis on policy continuity and stability arises from the need to provide innovators with reliable expectations regarding their future return on investment and the protection of their intellectual property rights. As a result, previous studies have aimed to identify political systems that ensure the continuity and stability of policies related to technological innovation, particularly in the context of patent policies. For instance, Waguespack, Birnir, and Schroeder (2005) have conducted an analysis of data from 32 Latin American countries between 1973 and 1999. Their hypothesis suggests that greater political stability would lead to a higher number of patent applications. They expect democracies with higher political stability to generate higher levels of patent applications compared to authoritarian regimes. Additionally, they hypothesize that patent applications would be more prevalent in proportional representation systems, where multiple political actors possess veto power. The analysis, utilizing patent application data from the US Patent and Trademark Office and other national patent offices, reveals that irrespective of the political system type, longer-lasting political systems were associated with a higher number of patent applications. Specifically, democratic political systems that have endured for longer periods demonstrate a higher inclination for patents compared to long-lasting authoritarian systems. Furthermore, proportional representation systems, characterized by policy stability due to veto power, exhibit higher levels of patent applications compared to majority-rule systems. Similarly, Varsakelis (2006) empirically examines the impact of political institutions, particularly democracy, on innovation in 29 countries between 1995 and 2000. The number of patent registrations per million people serves as a proxy for technological innovation, while democracy-related variables such as a political rights index, civil liberties index, and free press index are considered. The findings indicate a positive effect of all three democracy-related indices on innovation.

In another study, Gao et al. (2017) explores the correlation between democracy and innovation based on Popper's hypothesis. Popper argues that democracy has a positive effect on innovation compared to dictatorship and authoritarianism due to its stronger protection of individual liberties, rights, and intellectual property. The authors empirically analyze the impact of democracy on innovation in 156 countries using the NBER patent database from 1964 to 2010, employing a fixed effects model. They use the number of patent registrations, the number of citations, and an originality index as measures of innovation performance. However, they do not find a direct effect of democracy on innovation based on these indicators.

The studies offer the advantage of utilizing both quantitative measures (number of patent registrations) and qualitative measures (number of citations and originality index) to assess innovation. Additionally, they use data from the US Patent and Trademark

Office, which maintains consistent standards for patent examination. However, considering that patent and citation data are count data, it is important to consider such data using a Poisson regression model (PRM) based on a Poisson probability distribution for estimation, in addition to employing OLS or fixed effect models.

In a different study, Wang et al. (2021) reevaluates Popper's hypothesis by varying the analysis period and methodology. The authors employ a panel GMM estimation method to address endogeneity concerns and use the number of patent applications and trademarks filed with the World Intellectual Property Organization (WIPO) as proxy variables for innovation. The findings demonstrate a positive effect of democracy on innovation, even when trademarks are considered as proxies. Taking both patents and trademarks as indicators of innovation represents progress, compared to the study conducted by Gao et al.

Nevertheless, it is crucial to note that Wang et al.'s study uses the total number of patent applications by residents and non-residents, as reported by WIPO. This approach carries the risk of overestimating a country's innovation capacity, as foreigners sometimes apply for patents in a country solely for market access. These innovators utilize the Patent Cooperation Treaty (PCT) to prioritize patent applications in larger markets. Consequently, measuring innovation capacity based on the number of patent applications by residents and non-residents may lead to an overestimation of the innovation capability of countries with larger markets.

3. MODEL SPECIFICATION AND DATA

3.1. Model Specification

To estimate the relationship between count-based measures of innovation (number of patent registrations) and democracy, we employ a Poisson regression model (PRM). The conditional expectation (denoted as $E(\cdot \mid \cdot)$) for these count-based measures of innovation can be expressed as follows:

$$E\left(I_{i,t} \middle| Dem_{i,t-1}, X_{i,t}, \mu_i,\ \tau_t\right) = \exp(\alpha Dem_{i,t-1} + X'_{i,t}\beta + \mu_i + \tau_t), \quad (1)$$

where $I_{i,t}$ is the count-based measure of innovation (number of patent registrations) of country i in year t; μ_i is the country fixed effect; τ_t represents the time dummies; Dem represents democracy; X is the vector of other control variables; and α is a coefficient that indicates whether democracy contributes to technological innovation. For the regression analysis of innovation proxies, we utilize the lagged values of the binary democracy index instead of the current values. This approach accounts for the fact that the influence of democracy on innovation is not immediate, taking some time for a democratic regime to impact innovation outcomes (Gao et al., 2017).

3.2. Data and Variables

In this study, we measure innovation based on the number of patents granted to each country (country i) in a specific year (year t) by the US Patent and Trademark Office (USPTO) during the period between 1997 and 2018. We prefer using USPTO data over data from the World Intellectual Property Office (WIPO) due to the consistent application of patentability criteria by the former. In contrast, WIPO data is compiled from various national/regional IP offices with different patentability criteria. Given that the United States is a significant global market for both commodities and technology, inventors worldwide tend to register their inventions with the USPTO when they deem them commercially viable and deserving of protection. Hence, the number of patents registered with the USPTO serves as a proxy variable for each country's innovation performance. To ensure robustness, we also test the data using the number of patent applications filed by residents, obtaining this data from the World Development Indicator (WDI) database maintained by WIPO.

We employ three separate measures of democracy in our analysis. First, we utilize the dichotomous measure of democracy proposed by Acemoglu et al. (2015). This index (hereafter Ace) combines information from multiple datasets, including Freedom House and Polity IV, and considers a country as democratic only when several sources concur. Second, we incorporate the democracy measure proposed by Boix, Miller, and Rosato (BMR) spanning the period from 1800 to 2015. This measure assigns values between 0 (non-democracy) and 1 (democracy) based on conditions of contestation and participation. Specifically, a country is considered democratic if it satisfies criteria for free and fair elections, with a threshold level of suffrage. Third, we utilize the Polity V (hereafter $PolV$) dataset, the latest version of the Polity data series, which provides coded annual indicators of democracy levels from 1800 to 2018. The Polity score ranges from -10 to +10, with values from -10 to 5 representing non-democratic systems (autocracies and anocracies) and values from 6 to 10 representing democratic systems.

In addition to democracy measures, our vector of economic control variables includes GDP per capita, population, degree of openness, and R&D expenditure. All economic indicators are sourced from the World Bank WDI (World Development Indicators). GDP per capita is measured in constant 2010 USD and serves as a representation of a country's economic development level, reflecting the state of various infrastructures that impact innovation. Higher levels of economic development are expected to coincide with stronger financial, education, and training systems, which contribute to innovation (Ambale, 1993). According to demand-pull innovation theory, higher income levels lead to increased consumer demand for sophisticated and high-quality products, stimulating innovation by providing incentives for firms and acting as a pressure for innovation (Porter and Kramer, 2006). Population size is another control variable, and it affects innovation through economies of scale. Larger populations tend to generate more innovative ideas, positively impacting innovation outcomes. However, if wages are relatively low due to abundant labor supply, population size may have a negative effect on the adoption of labor-saving technologies. The degree of openness, expressed as the ratio of trade to GDP, represents the level of a country's participation in international trade. Active engagement in international trade facilitates the diffusion of advanced technology from abroad, resulting in spillover effects. Intense competition in overseas markets motivates companies to innovate, promoting process innovation and product innovation to enhance competitiveness. Therefore, we anticipate a positive effect of the degree of openness on innovation. Lastly, we consider R&D investment, measured as R&D expenditure as a percentage of GDP. R&D investment serves as a proxy for input-side innovation, expanding the knowledge base through research and development activities. This contributes to the development of new products, processes, tools, and equipment based on the expanded knowledge base. Moreover, as noted by Cohen and Levinthal (1990), investment in R&D positively influences corporate innovation by enhancing absorptive capacity.

Table 1 presents the summary statistics for the variables used in this study.

Table 1. Descriptive Statistics

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Ace	5,082	0.53	0.50	0	1
$GDP\ per\ capita$	4,469	13,861.0	19482.4	187.5	141,200.4
$Population$	4,890	48,100,000	198,000,000	9323	1,840,000,000
$Openness$	4,160	90.58	58.34	0.16	860.8
$R\&D$	1,958	0.94	0.94	0.00	4.95
$PolV$	3,443	3.66	6.46	-10	10
BMR	3,525	0.58	0.49	0	1
$USPTO$	3,733	687.11	3814.85	0	56,005
$WIPO$	4,900	6,034.44	51,833.27	0	1,393,815
Pro	4,592	0.43	0.49	0	1
PPR	3,628	47.90	23.39	0	98.4
COR	1,408	41.44	20.17	0	92

Note: Pro, PPR, and COR represent respectively the presence of a proportional representation system, the property rights index of each country, and the degree of corruption in each country.

4. EMPIRICAL ANALYSIS

4.1. Baseline Results

Table 2 presents the main findings regarding the impact of democracy on technological innovation using the democracy index (Ace) proposed by Acemoglu et al. (2019) In Column 1, the results obtained from ordinary least square (OLS) estimates are reported. For this estimation, the dependent variable is $\ln(USPTO)$, and observations with zero patents are excluded. Columns 2 and 3 employ count data models, with Column 2 presenting the results of the Poisson regression and Column 3 providing the outcomes of the fixed effect Poisson model. Across all columns in Table 2, the coefficient for democracy is consistently positive and statistically significant, although there might be some variation in the magnitude of the coefficient depending on the estimation method used. These results indicate that democracy has a positive influence on innovation, as measured by the number of patents registered with the USPTO. Furthermore, the economic control variables demonstrate positive and statistically significant coefficients across all three estimation models. Therefore, GDP per capita, openness, population, and R&D investment all contribute positively to innovation, aligning with the expected outcomes.

Table 2. Estimation Results (Acemoglu et al., 2019)

Method Dependent variable	OLS $\ln(USPTO)$	Poisson $USPTO$	Poisson (FE) $USPTO$
Ace_{t-1}	0.6438 (0.0672)***	0.3884 (0.1078)***	0.0590 (0.0062)***
$\ln(GDP\ per\ capita)$	1.2108 (0.0308)***	1.3724 (0.0587)***	1.7454 (0.0140)***
$\ln(Population)$	1.0657 (0.0212)***	1.2588 (0.0261)***	3.3593 (0.0283)***
$\ln(Openness)$	0.4832 (0.0483)***	0.1524 (0.0552)***	0.1817 (0.0051)***
$\ln(R\&D)$	1.1951 (0.0290)***	0.9044 (0.0225)***	0.2345 (0.0034)***
Observations	1,351	1,600	1,576

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

4.2. Robustness Test

To further explore the relationship between democracy and innovation, Tables 3 and 4 were introduced, providing a comparison with the benchmark results from Table 2 by incorporating more diverse democracy-related indices. Table 3 presents the estimation outcomes using the Polity V democracy index mentioned earlier, while Table 4 displays the estimation results using the BMR democracy index. Consistent with the findings in Table 2, both Tables 3 and 4 reveal a positive impact of democracy on innovation. The Polity V index ($PolV$) and the BMR index (BMR), representing different measures of democracy, exhibit statistical significance across all estimation methods and demonstrate positive coefficients. Hence, Tables 2 to 4 collectively demonstrate that the positive influence of democracy on innovation remains robust, regardless of the specific democracy index employed. Additionally, all control variables exhibit statistical significance with positive coefficients, and the magnitude of the coefficients remains consistent across all three democracy indices.

Table 3. Estimation Results: Polity V Database

Method Dependent variable	OLS $\ln(USPTO)$	Poisson $USPTO$	Poisson (FE) $USPTO$
$AcePolV_{t-1}$	0.0488 (0.0046)***	0.0284 (0.0118)**	0.0250 (0.0023)***
$\ln(GDP\ per\ capita)$	1.1579 (0.0311)***	1.3682 (0.0681)***	1.7341 (0.0139)***
$\ln(Population)$	1.1085 (0.0221)***	1.2491 (0.0253)***	3.3464 (0.0284)***
$\ln(Openness)$	0.5483 (0.0474)***	0.1380 (0.0537)***	0.1942 (0.0048)***
$\ln(R\&D)$	1.2120 (0.0289)***	0.8913 (0.0257)***	0.2220 (0.0032)***
Observations	1,293	1,507	1,486

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 4. Estimation Results: BMR Database

Method Dependent variable	OLS $\ln(USPTO)$	Poisson $USPTO$	Poisson (FE) $USPTO$
BRM_{t-1}	0.4192 (0.0694)***	0.4833 (0.1304)***	0.1400 (0.0367)***
$\ln(GDP\ per\ capita)$	1.1595 (0.0320)***	1.3899 (0.0603)***	1.6019 (0.0165)***
$\ln(Population)$	1.0907 (0.0214)***	1.2703 (0.0262)***	3.5288 (0.0333)***
$\ln(Openness)$	0.5362 (0.0480)***	0.1949 (0.0546)***	0.1755 (0.0053)***
$\ln(R\&D)$	1.2604 (0.0311)***	0.9271 (0.0254)***	0.2720 (0.0040)***
Observations	1,191	1,408	1,386

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 5. Estimation Results: WIPO Database

Method Dependent variable	Poisson (FE) $WIPO$	Poisson (FE) $WIPO$	Poisson (FE) $WIPO$
Ace_{t-1}	0.5592 (0.0018)***		
$AcePolV_{t-1}$		0.0205 (0.0004)***	
BRM_{t-1}			0.9107 (0.0054)***
$\ln(GDP\ per\ capita)$	2.2084 (0.0016)***	2.3103 (0.0016)***	2.4072 (0.0019)***
$\ln(Population)$	1.8149 (0.0081)***	2.0964 (0.0088)***	2.2409 (0.0095)***
$\ln(Openness)$	-0.7255 (0.0012)***	-0.6529 (0.0012)***	-0.6400 (0.0014)***
$\ln(R\&D)$	0.0231 (0.0009)***	-0.1170 (0.0009)***	-0.0836 (0.0011)***
Observations	1,713	1,576	1,449

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 5 focuses on using the number of patent applications filed by residents, as counted by WIPO, as a measure of innovation. Unlike Wang et al., this analysis only considers applications filed by residents and excludes those filed by non-residents, thereby avoiding potential overestimation of a country's innovation performance. The reported results in Table 5 specifically pertain to the fixed effect Poisson model, which serves as the core of our study. All three democracy indices are estimated and analyzed. These findings align with those presented in Tables 2 to 4, indicating that democracy promotes innovation across all three democracy indices, even when employing an alternative proxy variable for innovation. However, it is worth noting that the degree of openness carries a negative coefficient when the number of applications, as counted by WIPO, is used as the dependent variable. In the case of patent applications recorded by WIPO, the number of applications represents the number of patents filed with patent offices in each country or region. Consequently, it can be inferred that WIPO-counted applications are primarily targeted at the domestic market, in contrast to patent registrations with the US Patent and Trademark Office, which have an international market focus. Therefore, it is expected that countries with a lower degree of openness, prioritizing their domestic market, would observe an increase in the number of patent applications.

4.3. System GMM Results

To assess the influence of democracy on technological innovation, we adopt the dynamic innovation function represented by equation (2):

$$I_{i,t} = \sum_{k=0}^{1} \alpha_k Dem_{i,t-k} + \sum_{k=1}^{2} \gamma_k I_{i,t-k} + X'_{i,t}\beta + \mu_i + \tau_t + \epsilon_{i,t}. \quad (2)$$

We estimate the dynamic innovation function in equation (2) using the Arellano-Bond generalized method of moments (GMM) difference estimator (Arellano and Bond 1991). This estimator corrects for bias in estimates of lagged dependent variables caused by correlation between a transformed lagged dependent variable and a transformed error term. In addition, the estimator is used to correct for bias stemming from the inclusion of a regressor subject to reverse causality.

Table 6. GMM Estimation Results

Method Dependent variable	SYS-GMM $\ln(USPTO)$	SYS-GMM $\ln(USPTO)$	SYS-GMM $\ln(USPTO)$
$\ln(USPTO_{t-1})$	0.4101 (0.0062)***	0.3909 (0.0056)***	0.4174 (0.0460)***
$\ln(USPTO_{t-2})$	0.2785 (0.0037)***	0.2528 (0.0056)***	0.2687 (0.0395)***
Ace_t	-0.0986 (0.0214)***		
Ace_{t-1}	0.0723 (0.0149)***		
$AcePolV_t$		-0.0071 (0.0009)***	
$AcePolV_{t-1}$		0.0150 (0.0032)***	
BRM_t			-0.1217 (0.3085)
BRM_{t-1}			-0.0657 (0.2908)
$\ln(GDP\ per\ capita)$	0.3576 (0.0265)***	0.4321 (0.0267)***	0.5093 (0.1957)***
$\ln(Population)$	0.3038 (0.0098)***	0.4188 (0.0140)***	0.3023 (0.0942)***
$\ln(Openness)$	0.1115 (0.0159)***	0.1139 (0.0295)***	-0.0837 (0.2342)
$\ln(R\&D)$	0.5889 (0.0209)***	0.6247 (0.0204)***	0.6495 (0.1740)***
Observations	1,184	1,133	974
Sargan test	1.00	1.00	1.00
AR1	0.00	0.00	0.00
AR2	0.21	0.39	0.20

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 6 presents the results of the GMM estimation, examining the impact of democracy on technological innovation as measured by the number of patents registered with $USPTO$. The estimated results for all three democracy indices are reported in Table 6. The Sargan test results, displayed in Table 6, indicate rejection of the null hypothesis of misspecification, thus confirming the validity of the instrument set used in the analysis. Additionally, the AR(1) test results suggest the rejection of the null hypothesis of no autocorrelation, while the AR(2) test results support the acceptance of the null hypothesis of no autocorrelation. When considering the democracy indices Ace and $PolV$, the lag values demonstrate a positive and statistically significant relationship. However, in the case of the BMR index, the relationship is not statistically significant. These findings indicate that, except for the BMR index, democracy has a positive effect on innovation even when employing GMM estimation to address the issue of endogeneity.

4.4. What Democracy Contributes to Innovation

While countries classified as democracies share a common political system, there are significant variations among them. These differences encompass electoral systems (such as majority-rule and proportional representation), levels of corruption (ranging from high to low), and the extent of private property rights protection. Previous studies have emphasized the influence of these institutional disparities on innovation. Therefore, rather than solely examining the impact of democracy on innovation, it is intriguing to explore which aspects of democracy have a more pronounced effect on innovation, focusing on electoral system variations, corruption levels, and degrees of private property rights protection.

As previously mentioned, Waguespack et al. (2005) argue that proportional representation leads to higher levels of innovation compared to majority systems. Their rationale is based on the notion that proportional representation ensures greater stability in patent and financial policies, enabling innovators to pursue long-term innovation strategies. The Database of Political Institutions 2017, published by the Inter-American Development Bank, provides information on the electoral systems (plurality and proportional systems) of 180 countries from 1975 to 2017 (Cruz et al., 2018). By employing a dummy variable, we assign a value of 1 to proportional representation systems (Pro) to examine its influence on innovation.

The impact of strengthening intellectual property rights on innovation has been subject to extensive debate (Kortum and Lerner 1999; Hall and Ziedonis 2001; Sakakibara and Branstetter 2001; Kanwar and Evenson 2003). However, according to the traditional economic approach exemplified by Nordhaus (1969), the guarantee of monopoly rent through intellectual property rights encourages R&D investment and technological innovation. Strengthening intellectual property rights also reduces transaction costs associated with intellectual property, promoting technology transfer. Moreover, enhancing patent rights enhances technology commercialization by increasing attractiveness to investors. Although Park (2008) provides an intellectual property protection index, the data is updated every five years, with the latest available being from 2005. Therefore, we utilize the property rights index from the Index of Economic Freedom, which is published annually by the Heritage Foundation. The property rights index (PPR) reflects a country's legal protection for private property rights and the enforcement of those laws. It comprises sub-factors such as physical property rights, intellectual property rights, strength of investor protection, risk of expropriation, and quality of land administration. The PPR value ranges from 0 to 100, with higher values indicating stronger protection of private property.

Table 7. Diversity of Innovative Achievements within Democratic Countries

Method Dependent variable	Poisson (FE) $USPTO$		
Ace_{t-1}	0.0637 (0.0062)***	-0.5815 (0.0403)***	0.8442 (0.0130)***
$Ace_{t-1} \times Pro_{t-1}$	-0.2977 (0.0481)***		
$Ace_{t-1} \times PPR_{t-1}$		0.0073 (0.0001)***	
$Ace_{t-1} \times COR$			-0.0161 (0.0023)***
$\ln(GDP\ per\ capita)$	1.7464 (0.0140)***	1.4843 (0.0165)***	1.5392 (0.0142)***
$\ln(Population)$	3.3527 (0.0283)***	3.6845 (0.0303)***	3.3982 (0.0284)***
$\ln(Openness)$	0.1801 (0.0051)***	0.3327 (0.0066)***	-0.0603 (0.0062)***
$\ln(R\&D)$	0.2358 (0.0034)***	0.1991 (0.0055)***	0.3583 (0.0039)***
Observations	1,570	1,468	1,534

Notes: 1) Standard errors are shown in parentheses. 2) *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Finally, we conduct an examination to assess the impact of corruption (COR) on innovation within democratic countries. Two distinct hypotheses regarding the influence of corruption on innovation exist. Studies emphasizing the positive effects of corruption (Leff, 1964; Huntington, 1968) argue that bribery, by circumventing bureaucratic obstacles, can facilitate resource allocation towards innovation activities and thereby enhance a firm's innovation performance. Conversely, a competing hypothesis posits that local corruption may deter firms' incentives to innovate, thereby exerting a negative effect on innovation. Several plausible reasons support this negative effect. Firstly, corruption can lead to excessive taxation on innovators, diminishing both their innovation efficiency and incentives to engage in risky research and development (Murphy, Shleifer and Vishny, 1991). Secondly, inefficient public procurement policies resulting from corruption can steer innovators toward rent-seeking behaviors instead of genuine innovation, thus impeding innovation. Thirdly, if a corrupt government restricts innovators and new companies from entering the market to protect vested interests, this will adversely impact innovation and the introduction of new technologies. To test these competing hypotheses, we utilize the Bayesian Corruption Index (BCI). The BCI is a composite index that measures the perceived overall level of corruption, with values ranging from 0 to 100. An increase in the index indicates a higher level of corruption. It incorporates information from 17 different surveys and 110 survey questions, encompassing the perceived level of corruption.

Starting with Table 7, we analyze the correlation between the electoral system and technological innovation in democratic countries. Contrary to previous research findings, our results indicate that the majority-rule system leads to higher performance in technological innovation compared to the proportional representation system. In democratic countries with a majority-rule system, the correlation coefficient is 0.0637, whereas for countries with a proportional representation system, it is -0.234.

Regarding the protection of private property, we find that democracy positively affects innovation only when the degree of protection for private property exceeds a certain threshold: $-0.5815 + 0.0073PPR > 0$. This implies that democracy has a positive impact on innovation when the degree of protection for private property reaches or exceeds 79.65.

Lastly, in relation to the degree of corruption, our findings reveal that democracy contributes to innovation solely in countries where corruption remains below a specific threshold: $0.8442 > 0.0161COR$. This indicates that democracy has a positive effect on innovation only in countries with a corruption level of 52.43 or lower.

5. CONCLUSION

Various studies have explored how government policies impact technology innovation, including education and training policies, intellectual property-related policies, and trade policies. However, the influence and outcomes of these policies vary significantly depending on the political system of each individual country. Democratic regimes, which prioritize the protection of individual rights and property, tend to offer more stable intellectual property protection compared to authoritarian governments. Furthermore, democratic countries are expected to provide equal protection to both domestic and foreign patents by adhering to international conventions related to intellectual property rights.

This study analyzes the relationship between democracy and technological innovation across 101 countries from 1997 to 2018. A key distinction from previous studies is our utilization of a Poisson regression model, which takes into consideration the nature of the data and utilizes the number of patent registrations as an indicator of innovation performance. Additionally, various democracy indices have been employed, and data from the US Patent Office has been utilized to facilitate equitable comparisons of innovation achievements between countries.

The main findings of this study are as follows.

First, democracy exhibits a positive effect on innovation across all three estimation methods (OLS, Poisson regression, and fixed effect Poisson model) and with all three democracy indices (Ace, BMR, and $PolV$). Second, even when using the number of domestic applications filed with WIPO as a proxy for innovation performance instead of the number of patent registrations with the USPTO, democracy still demonstrates a positive effect on innovation. Third, in the GMM estimation results aimed at addressing the endogeneity issue, democracy is found to have a positive effect on technological innovation when the democracy indices are Ace and $PolV$. Lastly, considering the significant differences between countries adopting democratic systems, the study examines how variances in electoral systems, degrees of property rights protection, and levels of corruption among democratic countries influence innovation. Contrary to previous studies, higher innovation performance is observed in democratic countries with a majority-rule system than in those with a proportional representation system. Additionally, innovation performance is higher in democracies with stronger property rights protection and lower corruption levels.

This study contributes to the relatively limited body of research on the relationship between democracy and innovation performance using cross-country data. Future research should focus on rigorously analyzing the mechanisms through which democracy affects innovation based on the findings of this study. Moreover, given the diversity between democratic countries, it would be interesting to categorize democracies based on objective criteria and compare their innovation performance. Finally, the escalating power struggle between the United States and China, encompassing politics, economics, military, and particularly, technology, in areas such as AI, 5G, and IoT, has brought to the forefront the importance of the connection between political systems and innovation. This link has become a vital policy and strategic concern, especially in light of the global financial crisis. Consequently, this research is expected to provide a strong basis for further discussion on this matter.

REFERENCES

Acemoglu, D., S. Naidu, P. Restrepo and J. Robinson (2019), “Democracy Does Cause Growth,” *Journal of Political Economy*, 127(1), 47-100.

_____ (2015), “Democracy, Redistribution, and Inequality,” in Atkinson, A.B., Bourguignon, F. (Eds.), *Handbook of Income Distribution*, Oxford: Elsevier, 885-1966.

Acemoglu, D. and J. Robinson (2012), *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, New York: Crown Business.

Amable, B. (1993), "Catch-up and Convergence: A Model of Cumulative Growth," *International Review of Applied Economics*, 7(1), 1-25.

Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, 58(2), 277-297.

Barro, R.J. (1999), "Determinants of Democracy," *Journal of Political Economy*, 107(S6), S158-S183.

Cheibub, J.A., J. Gandhi and J.R. Vreeland (2010), "Democracy and Dictatorship Revisited," *Public Choice*, 143(1/2), 67-101.

Cohen, W.M. and D.A. Levinthal (1990), "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, 35(1), 128-152.

Cruz, C., P. Keefer and C. Scartascini (2018), *Database of Political Institutions 2017*, Washington DC: Inter-American Development Bank.

Gao Y., L. Zang, A. Roth and P. Wang (2017), "Does Democracy Cause Innovation? An Empirical Test of the Popper Hypothesis," *Research Policy*, 46(7), 1272-1283.

Hall, B.H. and R.H. Ziedonis (2001), "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1975-1995," *RAND Journal of Economics*, 32(1), 101-128.

Huntington, S.P. (1968), *Political Order in Changing Societies,* New Haven, CT: Yale University Press.

Kanwar, S. and R. Evenson (2003), "Does Intellectual Property Protection Spur Technological Change?" *Oxford Economic Papers*, 55(2), 235-264.

Kortum, S. and J. Kerner (1999), "What Is Behind the Recent Surge in Patenting?" *Research Policy*, 28(1), 1-22.

Leff, N.H. (1964), "Economic Development Through Bureaucratic Corruption," *American Behavioral Scientist*, 8(3), 8-14.

Lundvall, B. (1992), *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning*, London: Pinter.

Meltzer, A.H. and S.F. Richard (1981) "A Rational Theory of the Size of Government," *Journal of Political Economy*, 89(5), 914-927.

Murphy, K., A. Shleifer and R. Vishny (1991), "The Allocation of Talent: Implications for Growth," *Quarterly Journal of Economics*, 106(2), 503-530.

Nelson, R. (1993), *National Innovation System: A Comparative Analysis*, New York: Oxford University Press.

Nordhaus, W.D. (1969), "An Economic Theory of Technological Change," *American Economic Review*, 59(2), 18-28.

Park, W.G. (2008), "International Patent Protection: 1960-2005," *Research Policy*, 37(4), 761-766.

Persson, T. and G. Tabellini (1994), “Is Inequality Harmful for Growth? Theory and Evidence,” *American Economic Review*, 84(3), 600-621.

Porter, M. and M. Kramer (2006), “Strategy and Society: The Link between Competitive Advantage and Corporate Social Responsibility,” *Harvard Business Review*, 84(12), 78-92.

Rodrik, D. (2014), “When Ideas Trump Interests: Preferences, Worldviews, and Policy Innovations,” *Journal of Economic Perspectives*, 28(1), 189-208.

Sakakibara, M. and L. Branstetter (2001), “Do Stronger Patents Induce More Innovation? Evidence from the 1988 Japanese Patent Law Reforms,” *RAND Journal of Economics*, 32(1), 77-100.

Taylor, M. (2016), *The Politics of Innovation*, New York: Oxford University Press.

Tavares, J. and W. Wacziarg (2001), “How Democracy Affects Growth,” *European Economic Review*, 45(8), 1341-1378.

Varsakelis, N. (2006), “Education, Political Institutions and Innovative Activity: A Cross-Country Empirical Investigation,” *Research Policy*, 35(7), 1083-1090.

Wang, Q., G. Feng, H. Wang and C. Chang (2021), “The Impacts of Democracy on Innovation: Revisited Evidence,” *Technovation*, 108, 1-13.

Waguespack, D., J. Birnir and J. Schroeder (2005), “Technological Development and Political Stability: Patenting in Latin America and the Caribbean,” *Research Policy*, 34(10), 1570-1590.

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