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Connecting the dots between democracy and innovation: The role of pro-market institutions and information processing

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ABSTRACT

Prior studies examining the democracy-innovation relationship have reported mixed results. To resolve this tension, our framework grounded in information processing and institutional theory proposes two mechanisms through which democracy influences innovation—pro-market institutions and information processing. Our analysis reveals that democracy indirectly affects innovation primarily through information processing rather than pro-market institutions. While gradually or increasingly democratizing states tend to focus on adopting pro-market systems without considering information freedom (e.g., lifting censorship), our results underscore the importance of information processing for strengthening the democracy-innovation relationship. Our study extends the literature on national innovation rates by shedding light on the information processing implications of democratic institutions.

Keywords: Democracy, Information Processing, Innovation, Pro-Market Institutions
JEL Classifications: L26, M13, O30, P16

1. INTRODUCTION

With the rise of authoritarian and state capitalism, there has been a growing interest among scholars to understand democracy's role in innovation (Gao et al., 2017; Keane, 2009; Mahmood & Rufin, 2005; Popper, 1945, 1959; Wang et al., 2021). Neoclassical and institutional economists, as well as philosophers postulate that democracy provides a free environment encouraging initiatives and creativity (e.g. Acemoglu & Robinson, 2012; North, 1990; Ober, 2008; Popper, 1945, 1959; Schumpeter, 1942). As such, independence from authority and hierarchy fosters information exchange and tolerance to failure that spurs idea circulation, knowledge recombination, and innovation (Florida, 2014; Aghion et al., 2008).

Yet, China and Vietnam provide illustrative examples of countries that, despite having historically authoritarian regimes, have become rapidly innovative (Dutta et al., 2018; Lee & Malerba, 2017; Lundvall & Rikap, 2022). Their rapid technological catching-up is due to the government-led top-down research culture (instead of a collegiate research culture) that induces innovators to conform to national priorities on technological development. This accelerates resource allocation and knowledge production (Audretsch et al., 2023; Nograd y, 2021). By implication, autocratic governments are decisive and effective in solving coordination problems to administer resources for innovation more efficiently than democratic countries (Huntington & Dominguez, 1975).

With these different views in mind, studies examining the democracy-innovation relationship have reported mixed results. Although some studies have found that democracy promotes innovation (Wang et al., 2021), others have found it discourages innovation or has no effect (Gao et al., 2017, p. 1277). Considering the inconsistent empirical findings and insignificant relationships documented by the literature (Gao et al., 2017; Wang et al., 2021), one implication is that the literature might have omitted key variables that serve as critical pathways to innovation (Persson & Tabellinni, 2005; Blume et al., 2009). Accordingly, we

pose the following research question: “Even if democracy does not have a direct effect on innovation, might it have an indirect effect?”

We address this question by building upon Popper’s insights (1945, 1959) who noted the potential of democratic institutions to support innovation. Popper criticized centrally planned economies, pointing out their inherent inefficiencies and the threats they pose to economic freedom. He stressed the dangers of allowing the state to control all aspects of economic life, advocating instead for a system that fosters competition, innovation, and individual initiative. Moreover, censorship emerges as a central concern in Popper's work, as he underscores the importance of open discourse and the free exchange of ideas. He warns against the suppression of dissenting voices and the manipulation of information by authoritarian regimes, recognizing that such actions undermine the foundations of democratic societies.

Following these insights, we draw from information processing and institutional theory to postulate that pro-market institutions[1] and information processing[2] act as critical pathways for the relationship between democracy and innovation by motivating innovators to actively pursue economic opportunities and facilitating the open exploration and integration of knowledge. We test our theoretical arguments using a large dataset that includes 1,278 country-year observations from 121 countries. We find that democracy affects innovation primarily through the channel of information processing. Our results shed light on the information processing implications of democratic institutions that received limited attention. For instance, autocratic states can enact censorship laws to shut down online search engines

[1] Pro-market institutions is an institutional configuration where free market policies direct economic transaction by limiting the role of government in the economy (Bennett et al., 2023; Cuervo-Cazurra et al., 2019).

[2] Information processing refers to an environment where individuals can easily search and acquire information, and actively express their ideas (e.g., lower degree of government censorships) (Kong et al., 2022; Yeganegi et al., 2021; Zheng & Wang, 2020).

and media companies, suppressing independent and critical thinking and the expression of innovators, thereby diminishing innovation (Audretsch & Moog, 2000; Zheng & Wang, 2020). Therefore, we underscore the importance of understanding how a political institutional environment, whether it grants or suppresses information flow, influences innovators to recombine information and knowledge to cope with uncertainty and form the basis of innovation (Dosi & Nelson, 2010; Forbes, 2007; Hansen & Allen, 1992; Lord & Maher, 1990; Vaghely & Julien, 2010; Zheng & Wang, 2020).

Our primary contribution is to the innovation literature by integrating institutional theory with information processing theory to explain the underlying mechanism behind the democracy-innovation relationship. We show that, by reducing the search cost for innovators, democracy influences innovation through the information processing channel. Given the mixed findings on the relationship between democracy and innovation, it is critical to advance our understanding of the underlying mechanisms. For instance, while some studies conjecture that democracy encourages innovation (Carayannis & Campbell, 2014; Ober, 2008; Popper, 1945, 1959; Taylor & Wilson 2012), others report it discourages innovation or has no effect (Gao et al., 2017). Hence, we offer an explanation for these inconclusive findings and help to resolve an important tension in the literature.

Our study also extends the national innovation rates literature (e.g., Bennett & Nikolaev, 2021; Fagerberg & Srholec, 2008; Furman et al., 2002; Shane, 1993; Taylor & Wilson, 2012; Yoon et al., 2024) by drawing attention to the need for considering the political institutional environment's implications for information processing. Although it is well-established that economic institutions foster innovation (Bennett & Nikolaev, 2021; Bjørnskov & Foss, 2013; Boudreaux et al. 2019; Bjørnskov & Foss, 2008; Gohmann et al. 2008; McMullen et al., 2008; Nikolaev et al. 2018; Sobel, 2008), political institutions' information processing implications on innovation require more attention. Because the

quality of economic institutions and information processing environment are not always correlated (e.g., while Singapore is one of the most pro-market countries in the world, censorship is salient), distinguishing between these two institutional implications is theoretically valuable. Empirically, we include pro-market institutions and information processing in the same econometric model to isolate the variation in national innovation as it relates to democracy, and to avoid confounding issues. Thus, we complement prior studies by underscoring institutions' information processing implications.

2. THEORETICAL BACKGROUND

2.1. Democracy and Innovation

Following Bollen (1980, p. 372), we define democracy as the extent to which political power of the elites is minimized and that of non-elites is maximized. Here, political power refers to the extent that political leaders exert control over the national governing system, and elites refer to members of a society wielding a disproportionate amount of political power. Democracy hence allows competitive and open recruitment of executives, provides constraints on the elected chief executive, provides political competitions, and drives changes in the institutionalized qualities of governing authority (Bollen, 1990; Högström, 2013). Further, democracy does not always entail pro-market institutions and information freedom. For example, Singapore, United Arab Emirates, and Bahrain have lower levels of democracy yet greater levels of pro-market institutions (Peev & Mueller, 2012; Saha et al., 2009; Shirazi et al., 2009). Moreover, both authoritarian regimes and democratic countries such as Austria, Greece, and Japan have undermined information processing in recent decades (Freedom House, 2019). As such, there is a need to systematically examine democracy's consequences on these two institutional characteristics—pro-market institutions and information processing.

Although studies have hypothesized a direct relationship between democracy and innovation, findings have been mixed (e.g., Gao et al., 2017; Ober, 2008; Popper, 1945, 1959; Taylor & Wilson 2012; Wang et al., 2021). Importantly, however, they have not considered the underlying mechanisms that might explain *how* democracy encourages innovation. Our study is novel because we offer one explanation of how pro-market institutions and information processing are viable institutional mechanisms to channel democracy toward innovation. Our study provides a more nuanced approach that explains democracy's *indirect* effect on innovation activity, which has received less attention. Subsequently, we develop our framework beginning with an overview of institutional and information processing theory.

2.2. Theoretical Foundations of Pro-Market Institutions and Information Processing

The role of institutions in innovation is well-recognized because it is concerned with the conception of innovation systems—national, regional, sectoral, and technology-oriented—that influence the levels and rates of innovation (Nelson & Nelson, 2002). Fundamentally, institutions are the "rules of the game" that constrain and enable human behavior (North, 1990) and influence organizational behavior (Bylund & McCaffrey, 2017; March & Olsen, 1989; Powell & DiMaggio, 1991; Tonoyan et al., 2010). However, there are several streams in institutional theory (for an excellent comparison of views, see Pacheco et al., 2010) ranging from formal vs. informal institutions (Baumol, 1990; Denzau & North, 1994; North, 2005; Williamson, 2000) to regulative, normative, and cultural-cognitive institutions (Scott, 1995). Among others, we adopt the economic approach to operationalize "pro-market institutions" (Bennett et al., 2023; Bennett & Nikolaev, 2021; Boudreaux et al., 2019; Bjørnskov & Foss, 2008; Gohmann et al., 2008; McMullen et al., 2008; Nikolaev et al., 2018; Sobel, 2008).

The institution-based view has advanced our understanding of the economic implications of institutions such as investment behavior, the functioning of markets, and wealth generation (e.g., Levine & Renelt, 1992). Extending this view, we carefully underscore the information processing implications of institutions for innovators. For instance, it is well known that innovators face uncertainty while engaging in innovation activities and generating innovation outputs (Arikan et al., 2020; Foss & Klein, 2015; Foss et al., 2019). In this line, a basic tenet of information processing theory is that selection, acquisition, and interpretation of information is particularly demanding in complex environments (Forbes, 2007; Lord & Maher, 1990) characterized by high information diversity (Hansen & Allen, 1992). This is the context of our study where innovators face uncertainty while generating innovation outputs.

By implication, institutions allowing free flow of information helps innovators easily select, acquire, interpret, and link patterns of information from various sources to cope with uncertainty and form the basis of new opportunities for innovation (Forbes, 2007; Hansen & Allen, 1992; Lord & Maher, 1990; Vaghely & Julien, 2010). Hence, the role of institutions in enabling the flow of diverse information and knowledge is critical for innovators to combine and process ideas and generate innovation (Dosi & Nelson, 2010; Zheng & Wang, 2020). As such, information processing theory has been associated with problem solving and decision-making (Simon, 1991), opportunity alertness and recognition (Kirzner, 1979), and innovation (Schumpeter, 1934). Thus, this theory helps shed light on the role of the information processing environment for innovators to access and process information to engage in innovation activities.

3. HYPOTHESES DEVELOPMENT

In line with Popper's insights, the overarching reasoning in our prediction relies on the following premises. First, because innovators encounter substantial costs and distributive

effects of scientific research and technological change, innovators must evaluate risk and uncertainty to generate innovation (Acemoglu, 2009; Tan, 2001). In this sense, if institutions do not offer a favorable business environment and compensate innovators for the benefits they create for society, then little incentive exists to innovate (Baumol, 1990; Sarooghi et al., 2015). Second, the role of institutions in enabling the flow of (diverse) information and knowledge is critical for entrepreneurs to combine ideas and generate innovation (Dosi & Nelson, 2010; Zheng & Wang, 2020). Such emphasis on creating and recombining unconventional ideas can be found in the innovation literature (Mueller & Thomas, 2001; Steiner, 1995; Tiessen, 1997). Based on these premises, we propose two indirect effects of democracy on innovation via pro-market institutions and information processing, respectively.

3.1. Pro-market Institutions as a Pathway to Innovation

We first argue that democracy increases the chances of a country to adopt a pro-market economic system. Studies from the political science and economics literature have shown that democracy drives the transition into pro-market institutions (De Haan & Sturm, 2003; Lundström, 2005) because democracy respects property rights and economic freedom (Olson, 2000). Further, in a democratic society, leaders may be more likely to adopt pro-market policies because they are responsive to the preferences of the electorate (Milner & Kubota, 2005; Stroup, 2007; Wibbels, 2005). Relatedly, several studies have identified democracy as an indirect determinant of economic growth operating through the channels of pro-market institutions (Acemoglu et al., 2019; Doucouliagos & Ulubasoglu, 2008). For example, in a meta-analysis of 483 estimates from 84 studies on democracy and growth, Doucouliagos & Ulubasoglu (2008) discover that democracy affects economic growth through higher levels of pro-market institutions. Democracy, therefore, can be the "meta-institution" for building pro-market institutions (Rodrik, 2000).

Subsequently, we contend that pro-market institutions encourage innovation by reducing uncertainty and providing powerful market incentives (Bylund & McCaffrey 2017). Specifically, we explain how the strength of the legal system and property rights, sound money, and business friendly regulations that accompany pro-market institutions encourage innovation.

First, a stronger legal system and better property rights protection helps innovators to appropriate the value from their inventions and patents (Boudreaux, 2017; Fang et al., 2017; Furukawa, 2010; Lai, 1998). While innovation is fraught with risk and uncertainty (Jalonen, 2012), both of which increase transaction costs (York & Venkataraman, 2010), a strong legal system and protection of property rights are vital to reduce such risk and uncertainty for innovators (Van Waarden, 2001). In contrast, innovators can be reluctant to engage in innovation activities under a weak intellectual property protection regime, which hinders innovators from capturing values from their innovations. For these reasons, both the protection of property rights and quality of legal system should support innovators' activities.

Second, a stable monetary policy can motivate innovators to take risks and to innovate by reducing economic uncertainty and financial risks. For example, studies have found that macroeconomic uncertainty, commonly measured as the standard deviation of inflation, is negatively correlated with risk-taking activities such as private investment (Aizenman & Marion, 1993) and loan demand (Baum et al., 2006). Similarly, both Hayek (1944) and Friedman (1977) argue macroeconomic uncertainty causes uncertainty in the market information of prices, which reduces economic activity (Feng, 2001). This reasoning suggests when monetary policy is unstable, it leads to greater uncertainty, which hampers private investment, capital demand, and innovation activity. When monetary policy is stable, however, innovation activity should increase.

Third, business-friendly regulations lower the entry barriers for new entrants and reduce the limitations on the activities that innovators can perform (Tirole, 1988). As such, well-designed business-friendly regulations reduce uncertainty and help guide firms to invest in innovative activities (Porter & van der Linde, 1995). Yet, if regulations are onerous, they limit innovators' right to exchange, work, gain credit, and freely operate a business (Gwartney et al., 2019). Complying with burdensome regulations increases costs and restricts innovators' autonomy and initiatives to take actions (Palmer et al., 1995). Pro-market institutions promote a sound regulatory environment with reasonable and adequate levels of regulation (Gwartney et al., 2019; Lucas & Boudreaux, 2020), thereby supporting innovation activities.

In sum, theory and evidence suggests that democracy drives pro-market institutional reforms, which in turn, positively influences innovation. Formally:

Hypothesis 1: *Pro-market institutions mediate the relationship between democracy and innovation.*

3.2. Information Processing as a Pathway to Innovation

As a first step, we argue that democracy enhances information processing. Since the laws and principles of democracy are essential for free and diverse voices to emerge, countries closer to the democratic model provide greater discretion and plurality enabling information search and acquisition (Siebert et al., 1956; Woods, 2007). While democracy enhances the flow of ideas encouraging knowledge recombination, authoritarian states often disrupt such flow and knowledge recombination process by blocking internet contact with the outside world to prevent the spread of politically damaging news (Zheng & Wang, 2020). Likewise, countries with the authoritarian model often suppress information flows to avoid challenges to its power (Mahmood & Rufin, 2005). As a result, authoritarian regimes censor and suppress

communication. This discourages the dissemination of diverse opinions and perceptions to broad audiences because people are fear of government repression (Weaver, 1977).

We further argue that democracy allows greater access and exchange of information and ideas that encourage innovators to increase their breadth of knowledge and to interact with a wider range of networks and perspectives (Fleming, 2001; Mahmood & Rufin, 2005). More specifically, we explain how the access and exchange of information encourages innovation.

Because information access enables innovators to be creative and gain exposure to new technologies, information processing is crucial for innovators to discover and exploit opportunities (Audretsch et al., 2014; Fiet & Patel, 2008). As such, any reduction in information access on trends, new technologies, and platforms that yield insights for innovators can compromise innovators' ability to identify commercial opportunities (Yeganegi et al., 2021). As such, a lack of information availably compromises the ability of innovators to cope with uncertainty, pursue knowledge recombination, and exploit market opportunities in a timely manner (Shane & Venkataraman, 2003). By implication, information processing enables innovators to freely exchange their ideas and opinions and provides a forum for innovators to search for diverse ideas. Such an environment allows innovators to freely reject and criticize other ideas, thereby driving the creation and exchange of novel ideas. This widely publicized interchange reveals the strengths and weaknesses of various proposals and leads to the adoption of the best ideas to create innovation (Graber, 1986). In this line, many famous scientific breakthroughs were the result of random connections that occurred through a free associative process, where innovators generate many unusual combinations between different bodies of available knowledge and information (Schilling & Green, 2011, p. 1321). In other words, the free flow of information helps innovators deviate from the established paradigm to generate innovation (Reid et al., 2014;

Shane, 1993). Thus, information processing contributes to innovation by allowing innovators to cycle through these many different combinations of ideas and knowledge to generate patents (Dutta et al., 2011).

Conversely, in countries that exert direct control over communication, information processing focuses on stories and knowledge that benefit existing incumbents and politicians, rather than what matters to innovators (Dutta et al., 2011). Diminishing information availability with censorships can put innovators at a disadvantage in accessing news, reports, books, political statements, and search engines or social media platforms like Google and Twitter that can inspire innovation (Yeganegi et al., 2021). As such, censorship limits information processing and constrains innovators from accessing and recombining unbiased and the latest information and knowledge to carry out innovative activities. For instance, contemporary innovators heavily rely on the Internet to access information and knowledge. Thus, government censorship programs impose barriers on innovators' online searches, which can limit innovation. Further, authoritarian regimes suppress information processing, and the fear of authorities reporting them for subversive behavior fosters mistrust among innovators (Burt, 2016; Rock, 1993). As innovators are mistrustful of others in such environments, they are less likely to exchange information, which hinders innovation recombination (Ding et al., 2015; Nguyen & Rose, 2009). Trust is also a key element of innovation networks. It fosters the uninhibited exchange of ideas needed for innovation (Fukuyama, 1995; Porter, 1998), which is more salient in a democratic society. Diminishing information processing triggered by an authoritarian state will increase innovators' conformity with existing ideas and paradigms, thereby reducing the emergence of new inventions and patents.

In sum, theory and evidence suggests that democracy encourages information processing, which in turn, positively influences innovation. Formally:

Hypothesis 2: *Information processing mediates the relationship between democracy and innovation.*

4. METHODS

4.1. Data and Variables

We constructed our dataset by relying on several sources including the USPTO and NBER (National Bureau of Economic Research) patent databases (Hall et al., 2001), the democracy data from Polity IV Project by the Center for Systemic Peace (Marshall et al., 2014), the World Press Freedom Index from the Reporters Without Borders (Becker et al., 2007; Faccio, 2006), the Economic Freedom of the World index (EFW) from the Fraser Institute (Gwartney et al., 2019), and the secondary schooling data from Barro-Lee Educational Attainment Dataset (Barro & Lee, 2013). We collected other national-level economic indicators from the World Bank Open Data. After merging the data from these sources, we obtained an unbalanced panel dataset with 1,278 country-year observations from 121 countries over the period 2000 to 2010.

4.1.1. Dependent variable

To operationalize national innovation output, we consider the patent count, which is one of the most widely used proxies for innovation (Furman et al., 2002; Hall et al., 2001). In line with many studies, we use the patent data provided by the USPTO and NBER patent databases (Acharya & Subramanian 2009; Bhattacharya et al., 2017; Gao et al., 2017; Taylor & Wilson, 2012; Yoon et al., 2024). Consistent with these studies we measure national innovation output for a given country as the natural logarithm of the number of patents granted by the USPTO (Furman et al., 2002; Gao et al., 2017; Taylor & Wilson, 2012).

4.1.2. Independent variable

To measure the degree of democracy in a country and year, we rely on the Polity2 score from the Polity IV project database. This measure captures the extent to which countries lean

toward democracy (Marshall et al., 2014). The Polity2 score considers the following five perspectives: (1) the competitiveness of executive recruitment, (2) the openness of executive recruitment, (3) the constraints on the chief executive, (4) the regulation of participation, and (5) the competitiveness of political participation. The score ranges from -10 (minus ten) to 10 (ten), where a higher score implies a stronger presence of a democratic regime, and a lower score implies a stronger presence of an autocratic regime.

4.1.3. Mediating variables

Following recent studies (Bennett et al., 2023; Bennett & Nikolaev, 2021; Cuervo-Cazurra et al., 2019; Dau & Cuervo-Cazurra, 2014), we measure pro-market institutions using the economic freedom index obtained from the Fraser Institute (Gwartney et al., 2019). The index publicizes the extent to which a country has greater pro-market institutions by considering the following five dimensions: (1) size of government, (2) legal system and protection of property rights, (3) sound money, (4) international trade, and (5) regulation. We exclude (1) size of government and (4) international trade from our analysis because studies have argued that the size of government does not belong with the other components (Bergh, 2020; Ott 2018), and international trade overlaps with the information processing environment because it measures the free flow of goods and knowledge (Acs et al., 2009; Audretsch & Lehmann, 2005; Liu & Ma, 2016). We construct the pro-market institutions variable as the average value of these three remaining areas where a higher score implies greater pro-market institutions within a country.

To measure information-processing, we rely on the World Press Freedom Index published by the Reporters Without Borders. This is a non-profit organization tasked with protecting or preaching the right to information (Becker et al., 2007; Faccio, 2006). The index captures the quality of information processing in a particular country (Masrorkhah & Lehnert, 2017). It considers violations directly affecting free flow of information on the internet,

journalists (such as murders, imprisonment, physical attacks, and threats), and media (independence, the quality of the infrastructure, censorship, transparency, confiscation of issues, searches, and harassment). Lower values on the index indicate higher levels of information processing (press freedom).[3] To ease interpretation we rescaled the variable as follows: we subtracted each country's score from the maximum value recorded for the given year. Thus, higher values indicate greater information processing.[4] For our robustness test, we also use a variable on government censorship from the V-Dem institute (Coppedge et al., 2018).

4.1.4. Control variables

To account for any idiosyncratic differences across countries and years, we include country and year fixed effects in all regressions. Moreover, we include several country-specific controls for innovation proposed by prior studies, as follows.

We include gross domestic product (GDP) per capita because national prosperity reflects the resource availability or the ability to capitalize resources to induce innovation (Dau & Cuervo-Cazurra, 2014; Furman et al., 2002). We also include urbanization, because urban areas facilitate agglomeration that enables innovators to gather and test more novel ideas, thereby creating more innovation (Andersson et al., 2009; Carlino et al., 2007). Because a country might benefit from the spillover effect of trade or FDI for innovation, we include economic openness, which is the sum of exports and imports as a share of GDP (Furman et al., 2002). Furthermore, we use the time-varying ethnic fractionalization measure drawn from the Historical Index of Ethnic Fractionalization Data set (HIEF) (Drazanova, 2019) because ethnic diversity empowers the role of the creative class in a society. This, in turn, enhances their creative capacity to generate innovation (Baycan-Levent, 2010;

[3] This was their approach until 2012.
[4] As a robustness check, we multiplied the index by negative one where higher values indicate greater information processing. The results are qualitatively similar.

Boudreaux, 2020; Qian, 2013). Because access to the Internet promotes innovation (Xu et. al., 2019), we also include the ratio of individuals using the Internet from the World Bank. Lastly, because more educated societies can generate more innovation (Varsakelis, 2006), we include the average years of secondary schooling for the population above age 15 (Barro & Lee, 2013; Gao et al., 2017).

4.2. Econometric Model

To estimate the mediating effects of pro-market institutions and information processing on the relationship between democracy and innovation (see the below equations), we use the widely used mediation models suggested by Baron & Kenny (1986) and a bootstrapping method (MacKinnon et al., 2004).

To deal with simultaneity issues between national innovation output and other variables, we follow prior innovation studies (Dechezleprêtre et al., 2015; Rong et al., 2017) and lag all right-hand-side variables except the democracy variable, by one year as expressed in the below equations. We lagged our main explanatory variable, democracy, by two years (Furman & Hayes, 2004) to allow one year time lag and two-year time lag on our mediating variables and dependent variable, respectively. Our equations are the following:

$$I_{it+1} = \beta_0 + \beta_1 D_{it-1} + X'_{it}\gamma + \lambda Y_t + \delta C_i + \varepsilon_{it} \quad (1)$$

$$PM_{it} = \beta_0 + \beta_1 D_{it-1} + X'_{it}\gamma + \lambda Y_t + \delta C_i + \varepsilon_{it} \quad (2)$$

$$IP_{it} = \beta_0 + \beta_1 D_{it-1} + X'_{it}\gamma + \lambda Y_t + \delta C_i + \varepsilon_{it} \quad (3)$$

$$I_{it+1} = \beta_0 + \beta_1 D_{it-1} + \beta_2 PM_{it} + \beta_3 IP_{it} + X'_{it}\gamma + \lambda Y_t + \delta C_i + \varepsilon_{it} \quad (4)$$

where the subscripts i and t denote the country and year, respectively. I_{it+1} denotes the national innovation output; D_{it} denotes democracy; PM_{it} denotes pro-market institutions; and IP_{it} denotes information processing. X_{it} denotes our control variables, and Y_t and C_i denote year and country fixed effects, respectively. Lastly, ε_{it} is our stochastic error term.

Our interest is with estimating the parameters β_1, β_2, and β_3. More specifically, $\beta_1$in equation (1) measures the direct effect of democracy on national innovation output, and β_1 in equations (2) and (3) measure the effect of democracy on pro-market institutions and information processing. The Structural Equation Model (SEM) approach is to simultaneously estimate these three equations to calculate both the direct and indirect effect of democracy on national innovation output[5][6]. We thus compare the estimates of β_1 in equation (1) and $\beta_1$in equation (4). That is, mediation is present if the inclusion of pro-market institutions and information processing alters the parameter estimate of democracy on national innovation, β_1, between equations.

5. RESULTS

We report the summary statistics and bivariate correlations in Table 1. We observe a correlation between national innovation output and all variables except for economic openness. Regarding multi-collinearity concerns, the variance inflation factor (VIF) score for each variable is well below the acceptable threshold of 10.

We also report the difference between democratic and autocratic countries. According to Table 2, democratic countries demonstrate higher levels of national innovation output, pro-market institutions, and information processing, among others.

-- Insert Table 1 here—

-- Insert Table 2 here—

5.1. Main Analyses

Table 3 reports panel regression estimates including year and country fixed effects. As a baseline, model 1 presents the relationship between democracy and national innovation output; model 2 tests the effect of democracy on pro-market institutions; model 3 tests the

[5] To calculate the indirect effect operating through the channel of pro-market institutions, we multiply β_1 in equation (2) and β_2 in equation (4).
[6] To calculate the indirect effect operating through the channel of information processing, we multiply β_1 in equation (3) and β_3 in equation (4).

effect of democracy on information processing; and model 4 tests the effects of democracy, pro-market institutions and information processing on national innovation output.

The control variables used to explain the national innovation output (see model 1 and 4) are stable in terms of their directionality. According to the results reported in Model 1 and 4, GDP per capita and population have a positive and significant effect on national innovation output showing that a more prosperous and wealthier country will generate more patents.

-- Insert Table 3 here--

Hypotheses 1 and 2 predict the mediating effects of pro-market institutions and information processing on the democracy-national innovation output relationship. Models 2 and 3 of Table 3 show that democracy is positively and significantly related to pro-market institutions ($\beta = .023$, $p = .014$, ci = [.005 .040]) and information processing ($\beta = .931$, $p = .020$, ci = [.152 1.711]). Model 4 reports that information processing has a positive and significant effect on national innovation output ($\beta = .005$, $p = .034$, ci = [.000 .010]), while the effects of democracy and pro-market institutions on innovation output are positive but statistically insignificant ($\beta = .036$, $p = .699$, ci = [-.149 .221]). These results indicate that democracy indirectly influences national innovation output, through the channel of information processing.

-- Insert Table 4 here--

To estimate the indirect effects of democracy on national innovation output, we follow the bootstrap procedure (Shrout & Bolger, 2002) using 5,000 bootstrap samples using equations 2, 3, and 4 with the coefficient multiplication approach. Table 4 presents the results using the bootstrapping method, which shows comparable results to our findings in Table 3. Table 4 shows that democracy is positively and significantly related to our mediators, pro-market institutions ($\beta = .023$, $p = .006$, ci = [.013 .036]) and information processing ($\beta = .931$, $p = .001$, ci = [.398 1.477]). Moreover, whereas the indirect effect of democracy on national

innovation output via information processing is positive and statistically significant (β = .005, p =.078, ci = [.001 .012]), the indirect effect of democracy on national innovation output via pro-market institutions is not statistically significant (β = .001, p =.672, ci = [-.003 .005]).

Because we use the log-transformed value for national innovation, the coefficient is approximately the percentage change in national innovation. Given that the democracy variable needs to increase by about 12 units for an autocratic state to become a democratic state (-6 to 6), we can report our findings based on the following scenario: Consider a country, Morocco, experiencing a radical shift from being an autocratic state to a democratic state since the 1990s (Monjib, 2011). If an autocratic country becomes democratic, the change in national innovation through the indirect effects is about 6.9%. Under the same scenario, the increase in national innovation via information processing is about 5.9%. Stated differently, one half of a standard deviation (3.05) increase in democracy is associated with about 1.75% increase in national innovation via its indirect effects or about 1.50% increase in national innovation via information processing, while 0.25% increase via pro-market institutions. This is the scenario where Armenia (with the average democracy value of 5 in our sample) reaches a similar level of democracy to South Korea (with the average democracy value of 8). The effect size is about six times greater for the channel via information processing, although the difference in the effect size is difficult to compare because of different scales for pro-market institutions and information processing. If we interpret it in terms of the relative change with their standard deviations, the difference in the effect size is even greater for information processing because its standard deviation is much larger.

In addition to the mediation approach and the bootstrapping method, we also estimated the KHB (Karlson–Holm–Breen) model to decompose the mediating effects, regardless of their statistical significance (Karlson et al., 2012). The KHB model illustrates

the extent to which the indirect effect mitigates the negative direct effect of democracy (as seen in Model 4), culminating in an overall effect of democracy (presented in Model 1). For a coherent comparison of effects using coefficients, it is imperative to estimate the models with identical samples. We report the results from this analysis in Table A1 of the Appendix. The total effect of democracy (β = -.029, p = .087, ci = [-.062 .004]) has a more pronounced negative direct effect (β = -.034, p = .038, ci = [-.066 -.002]). The disparity, .005, represents the indirect effects channeled through pro-market institutions and information processing. This positive indirect influence curtails the negative direct impact of democracy by 15.7%. Among these indirect effects, the results reveal that 95% of the mediation operates through information processing and 5% of the mediation operates through pro-market institutions[7].

Taken together, our analyses show that democracy affects innovation primarily through information processing rather than pro-market institutions.

5.2. Additional Analyses and Robustness Tests

We ran several additional tests to assess the robustness of our findings. First, we used SEM (Structural Equation Modeling), which is a popular method to examine mediation effects as shown in Figure 1. Table 5 presenting the SEM results[8] shows that democracy is positively and significantly related to pro-market institutions (β = .023, p = .012, ci = [.005 .040]) and information processing (β = .931, p = .017, ci = [.165 1.697]). Model 3 presents information processing (β = .005, p = .029, ci = [.001 .010]) is positively and significantly related to innovation outputs, while pro-market institutions (β = .036, p = .695, ci = [-.145 .217]) is not statistically meaningfully related to innovation outputs. This finding is in line with our main result when using the analytical approach of SEM.

[7] To run the KHB model, we used 756 observations in Model 4 of Table 3 as shown in Table A1 of the Appendix. The mediation effect through pro-market institutions is about .0012 and information processing is about .005065. This means that pro-market institutions account for about 5 percent (.000279/[.000279+.005065]) while information processing accounts 95 percent (.005065/[.000279+.005065]) of the mediation effects.

[8] We used *gsem* command in the Stata for the SEM estimation.

-- Insert Table 5 here—

-- Insert Figure 1 here--

Furthermore, we used alternative measures of democracy, pro-market institutions, and information processing to mitigate the possibility that our choice of variables drives our findings. Specifically, we used data on democracy, pro-market institutions, and government censorship available from the Quality of Government Data (Dahlberg et al., 2022), the Heritage Foundation (Miller et al., 2012) and the V-Dem institute (Coppedge et al., 2018), respectively. Table 6 shows similar findings with these alternative variables.

-- Insert Table 6 here--

We also ran instrumental variable analysis to better adjust for potential endogeneity concerns. The instrumental variable used in this paper follows the approach of Acemoglu et al. (2019), employing regional democracy waves as an instrument for democracy. We adopt their approach to calculate the regional democracy waves by averaging other countries' binary values of democracy, excluding the focal country, within the focal country's region. We modified the instrument to measure the relative regional waves of democratization for each country.[9] That is the difference between the regional wave of democratization and the country's normalized democracy level, scaled between -1 to 1. Like Acemoglu et al. (2019), we consider that differences between the past regional wave of democratization and a country's democracy level drive the country to converge to its regional wave, which can be viewed as converging to regional group pressure. Since this is a regional dynamic of the democracy wave, it is not directly related to national innovation outputs, conditioning on the lagged dependent variable and the country fixed effects. Thus, we include the first to fourth lags of this instrument for democracy[10] in the model like Acemoglu et al. (2019). As shown

[9] Using only the region averages resulted in low first stage F-statistics.

[10] As we used the lagged value of democracy in the model, the instrument is the 2nd to 5th lagged values.

in Table 7, the first-stage F-stat exceeds 10 and shows a highly statistically significant Wald score, reinforcing the validity of the relative regional democracy waves as an instrument.

-- Insert Table 7 here--

In addition to relative regional wave of democratization, we use the Women's Political Empowerment Index (WPEI) from V-Dem institute (Coppedge et al., 2018) as an instrumental variable. Previous studies show that the higher levels of women's political empowerment are associated with democratic governance (Beer, 2009; Sundström et al., 2017; Watson & Moreland, 2014), while historical and cultural factors that influence WPEI are unrelated to our outcomes of interest. Using this alternative instrument variable, we also find consistent results as shown in Table A5 of Appendix. Therefore, the outcomes derived from the IV regression methods align with our main findings, thereby reinforcing the robustness of our findings regarding the indirect effect of democracy via information processing.

Additionally, we used the Coarsened Exact Matching (CEM) method by using a country's democracy status in the initial year as the primary criterion for matching. This approach encompasses comparable cases, thereby minimizing selection bias and enhancing causal inference. Specifically, the CEM method matches countries according to several country characteristics. Using the CEM method, we observed a similar indirect effect of democracy on national innovation through information processing as shown in Table 8.

-- Insert Table 8 here--

Moreover, we conducted the same set of analysis without any control variables (not reported in the manuscript but available upon request) to provide additional support that our main findings are unaffected by the exclusion of the control variables (Glaser et al., 2016). Finally, we examined whether the indirect effects of pro-market institutions differ by the area of pro-market institutions. The results are consistent with our primary findings, as illustrated

in Tables A2, A3, and A4 of the Appendix. In all cases, the results remain stable and qualitatively similar, which supports the indirect relationship between democracy and national innovation output via information processing.

6. DISCUSSION AND CONCLUSION

Studies examining the democracy-innovation relationship have proposed mixed views and generated inconclusive findings (Audretsch & Moog, 2020; Doucouliagos & Ulubaşoğlu, 2008; Gao et al., 2017 Huntington & Dominguez, 1975; Mahmood & Rufin, 2005; Ober, 2008; Persson & Tabellini, 2006; Popper, 1945, 1959). To advance our understanding of the democracy-innovation relationship, we developed a theoretical framework that informs our knowledge of the specific mechanisms through which democracy influences innovation. Until now, these mechanisms have not been explored. Specifically, we theorized two mechanisms—pro-market institutions and information processing—which operate as mediators of the relationship between democracy and innovation. We found that democracy has an indirect effect on innovation primarily through the channel of information processing rather than pro-market institutions. That is, democracy encourages information processing, which in turn, encourages innovation. Hence, although democracy might not exert a direct effect on innovation, we identify an indirect effect through information processing.

Our findings are consistent with earlier studies like Gao et al (2017) who found a negative and statistically insignificant relationship between democracy and innovation. Moreover, our finding that democracy influences innovation indirectly through the channel of information processing advances the discussion from *whether* democracy affects innovation to *how*. It is thus important to identify potential mechanisms that help explain why some democracies are more innovative than others. Future studies might consider these and other mechanisms to help shed light on the ways democracy influences innovation.

One explanation is that democratic countries often have coordination problems owing to a variety of opinions and views that hurt government decisiveness in resource allocations to innovate (Huntington & Dominguez, 1975). As a result, the transition from an autocratic to a democratic system can have a disruptive effect on the viability of healthy and technologically advanced firms (Gao et al., 2017; Kogut and Zander, 2000). As such, China and Vietnam, despite having historically authoritarian regimes, have become rapidly innovative through state-led initiatives (Dutta, Lanvin, & Wunsch-Vincent, 2018).

Although we hypothesized that democracy would also exert an indirect effect on innovation through the channel of pro-market institutions, our results do not support this hypothesis. One potential explanation might be related to the Friedman-Hayek hypothesis that states democracy encourages pro-market institutions but not vice versa (Lawson & Clark, 2010). For example, there are several Asian countries (e.g., Singapore and Hong Kong) and Middle-Eastern countries (e.g., UAE) that have high economic freedom and little democracy, but we can think of few examples of the reverse**.** More recent work on the Friedman-Hayek hypothesis has explained that pro-market institutions and information processing go hand in hand (Bjørnskov, 2018). Our findings are consistent with this literature. We found that democracy had a positive effect on pro-market institutions. Yet, pro-market institutions had no significant effect on innovation. It is therefore plausible that democracy encourages both information processing and pro-market institutions, but the information processing channel dominates the pro-market institutions channel.

Our conceptual framework and empirical findings generate several theoretical contributions and implications. First, we advance our understanding of two mechanisms— pro-market institutions and information processing— that facilitate indirect relationships between democracy and innovation. While it is well-known that innovation requires intense search and recombination of existing knowledge with new knowledge (Dosi & Nelson, 2010;

Fleming, 2001; Katila & Ahuja, 2002; Nelson & Winter, 1982), the role of democratic institutions in facilitating information and knowledge flows within societies for innovators has received less attention from national innovation studies. Our findings therefore underscore the important role of information processing as a key mediator between democracy and innovation. As such, democracy facilitates information processing that can benefit innovators to combine broader domains of knowledge and a wider range of networks and perspectives, thereby generating innovative outputs.

Second, although institutional theory has been important to the innovation literature, limited attention has been paid to the information-processing implications of democratic institutions. This is important because innovators are motivated to engage in innovation not only to materialize their economic interest, but also to pursue their special interest in a knowledge and information domain to build their advanced and distinctive competence as a labor of love (Croidieu & Kim, 2018; Glynn, 2008). Subsequently, in line with the broad definition of institutions as the "rules of the game" that constrain and enable human behavior (North, 1990), our study blends institutional theory and information processing theory to theorize that institutions not only (economically) incentivize innovators to innovate but also encourage innovators to freely combine information and ideas to generate innovation. Thus, these two complementary perspectives enable us to provide a more conclusive picture of the mechanisms that bridge the democracy-innovation link.

More broadly, our study provides new insights for researchers in disciplines where individual freedom may be of interest. Specifically, we offer a new perspective on the academic debate about media and internet censorship. Although censorship studies focus on understanding how governments practice media controls (Lorentzen, 2014) or how internet censorship affects personal attitudes or beliefs (Chen & Yang, 2019), our study extends this literature by revealing policy's real economic consequences.

Our study also offers important policy implications. Gradually or increasingly democratizing states often tend to focus on pursuing a free-market model to incentivize their innovators without considering freeing the information flow. Counter to this approach, our study shows that information processing is more important for democratizing states to generate more innovations than adopting pro-market institutions. Nonetheless, countries with different institutional settings may take a different approach. For instance, during the period when some East Asian economies (e.g., South Korea and China) made a rapid technological and economic catching-up, they were governed under a dictatorship or an authoritarian regime (Hahm & Plein, 1995; Kim, 2004; Motohashi & Yun, 2007). Despite some exceptions, policymakers should consider stimulating the independent flow of information, thereby fostering innovation.

Finally, scholars often assume that prosperous nations, which include some of the largest and oldest elected democracies in the world, have greater information processing autonomy than poorer countries. However, this trend is far from consistent. Even elected leaders in democratic countries, which are known for having independent media, have tried to silence critical outlets and promote those that offer favorable coverage. In this sense, future studies could investigate how the characteristics of elected leaders and parties influence national innovation.

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Tables

Table 1. Correlation matrix and descriptive statistics

		1	2	3	4	5	6	7	8	9	10	11
	Dependent Variable											
1	National innovation output[a]	1										
	Independent Variable											
2	Democracy	0.422	1									
	Mediator Variables											
3	Pro-market institutions	0.619	0.434	1								
4	Information processing	0.327	0.734	0.504	1							
	Control Variables											
5	Secondary schooling year	0.577	0.303	0.625	0.290	1						
6	GDP per capita[a]	0.618	0.324	0.767	0.376	0.683	1					
7	Population[a]	0.407	0.018	-0.211	-0.227	-0.073	-0.166	1				
8	Urbanization	0.449	0.229	0.570	0.281	0.578	0.757	-0.133	1			
9	Econ openness	-0.019	-0.034	0.336	0.072	0.188	0.248	-0.362	0.172	1		
10	Ethnic fractionalization	-0.343	-0.191	-0.394	-0.060	-0.345	-0.388	-0.016	-0.289	-0.045	1	
11	Internet user ratio	0.611	0.423	0.760	0.479	0.626	0.779	-0.149	0.567	0.227	-0.315	1
	Number of Observations	1038	1278	1154	1034	1278	1278	1278	1278	1278	1278	1278
	Mean	2.856	4.469	6.703	81.595	2.675	8.530	16.286	58.896	83.073	0.442	22.552
	S.D.	2.911	6.090	1.233	21.996	1.400	1.571	1.410	22.303	46.728	0.253	24.980

[a] Logarithm transformed.

Table 2. Summary statistics on democracy

	Democratic countries[11] mean	Autocratic countries mean	difference	p-value
National innovation output[a]	3.585	1.894	-1.691	0.000
Pro-market institutions	7.024	6.544	-0.480	0.000
Information processing	92.040	50.898	-41.142	0.000
Secondary schooling year	2.926	2.610	-0.316	0.004
GDP per capita[a]	9.005	8.799	-0.206	0.115
Population[a]	16.329	16.313	-0.016	0.923
Urbanization	62.819	65.734	2.916	0.156
Economic openness	81.634	78.515	-3.119	0.286
Ethnic fractionalization	0.401	0.515	0.114	0.000
Internet user ratio	29.877	15.507	-14.370	0.000
Number of observations	798	151	949	

[a] Logarithm transformed.

[11] For a scale ranging from -10 to 10, a country with a score greater than 6 is considered democratic, while a score below -6 denotes an autocracy. Based on the Polity IV country reports, a country with a score between -5 and 5 is considered neither autocratic nor democratic (Marshall et al., 2014).

Table 3. Predicting national innovation output with mediation analysis using the fixed effect regression

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.034	0.023	0.931	-0.034
	(0.019)	(0.009)	(0.394)	(0.016)
	[0.074]	[0.014]	[0.020]	[0.038]
Pro-market institutions				0.036
				(0.093)
				[0.699]
Information processing				0.005
				(0.002)
				[0.034]
Secondary schooling year	0.082	-0.203	-2.991	0.044
	(0.151)	(0.096)	(2.251)	(0.132)
	[0.590]	[0.037]	[0.186]	[0.740]
GDP per capita[a]	1.161	1.179	-3.607	1.016
	(0.274)	(0.250)	(6.233)	(0.309)
	[0.000]	[0.000]	[0.564]	[0.001]
Population[a]	1.262	0.482	5.890	1.710
	(0.441)	(0.322)	(6.873)	(0.496)
	[0.005]	[0.138]	[0.393]	[0.001]
Urbanization	0.020	0.003	-0.064	-0.000
	(0.018)	(0.015)	(0.500)	(0.022)
	[0.268]	[0.844]	[0.898]	[0.985]
Economic openness	0.002	0.001	0.047	0.000
	(0.001)	(0.002)	(0.023)	(0.002)
	[0.020]	[0.626]	[0.043]	[0.851]
Ethnic fractionalization	2.037	-1.236	42.263	3.694
	(2.340)	(2.173)	(38.558)	(3.103)
	[0.386]	[0.571]	[0.275]	[0.237]
Internet user ratio	0.007	-0.000	0.008	0.005
	(0.003)	(0.002)	(0.070)	(0.004)
	[0.021]	[0.983]	[0.903]	[0.172]
Constant	-30.207	-10.694	-5.233	-36.241
	(8.938)	(6.389)	(143.325)	(10.219)
	[0.001]	[0.097]	[0.971]	[0.001]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.159	0.328	0.406	0.150
Number of countries	107	114	121	100
Number of observations	1038	1154	1034	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table 4. Predicting the indirect effects of democracy on national innovation output with bootstrapping

	coeff	bias	se	p-value	Lower CI	Upper CI
Direct effects						
Democracy -> Pro-market institutions	0.023	0.000	0.006	0.000	0.013	0.036
Democracy -> Information processing	0.931	-0.003	0.275	0.001	0.398	1.477
Indirect effects						
Democracy -> National innovation output via pro-market institutions	0.001	0.000	0.002	0.672	-0.003	0.005
Democracy -> National innovation output via information processing	0.005	0.000	0.003	0.078	0.001	0.012
Total indirect effect						
Total indirect effects of democracy -> National innovation output	0.006	0.000	0.004	0.106	0.000	0.014

Table 5. Predicting the national innovation output using SEM

Dependent Variable	Model (1) Pro-market institutions	Model (2) Information processing	Model (3) National innovation output[a]
Democracy	0.023	0.931	-0.034
	(0.009)	(0.391)	(0.016)
	[0.012]	[0.017]	[0.033]
Pro-market institutions			0.036
			(0.092)
			[0.695]
Information processing			0.005
			(0.002)
			[0.029]
Secondary schooling year	-0.203	-2.991	0.044
	(0.096)	(2.234)	(0.130)
	[0.034]	[0.181]	[0.736]
GDP per capita[a]	1.179	-3.607	1.016
	(0.248)	(6.185)	(0.305)
	[0.000]	[0.560]	[0.001]
Population[a]	0.482	5.890	1.710
	(0.320)	(6.819)	(0.490)
	[0.132]	[0.388]	[0.000]
Urbanization	0.003	-0.064	-0.000
	(0.015)	(0.496)	(0.021)
	[0.843]	[0.897]	[0.984]
Economic openness	0.001	0.047	0.000
	(0.002)	(0.023)	(0.002)
	[0.622]	[0.039]	[0.849]
Ethnic fractionalization	-1.236	42.263	3.694
	(2.156)	(38.259)	(3.065)
	[0.566]	[0.269]	[0.228]
Internet user ratio	-0.000	0.008	0.005
	(0.002)	(0.069)	(0.004)
	[0.983]	[0.902]	[0.163]
Constant	-11.915	-33.284	-36.538
	(6.073)	(136.500)	(9.660)
	[0.050]	[0.807]	[0.000]

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table 6. Robustness tests using alternative variables.

	Alternative democracy				Alternative pro-market institutions				Alternative information processing			
	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]	Model (5) National innovation output[a]	Model (6) Pro-market institutions	Model (7) Information processing	Model (8) National innovation output[a]	Model (9) National innovation output[a]	Model (10) Pro-market institutions	Model (11) Information processing	Model (12) National innovation output[a]
Democracy					-0.034	0.109	0.931	-0.032	-0.034	0.023	0.056	-0.042
					(0.019)	(0.111)	(0.394)	(0.016)	(0.019)	(0.009)	(0.022)	(0.020)
					[0.074]	[0.330]	[0.020]	[0.050]	[0.074]	[0.014]	[0.013]	[0.037]
Alternative democracy	-0.063	0.070	3.128	-0.068								
	(0.038)	(0.021)	(0.845)	(0.035)								
	[0.099]	[0.001]	[0.000]	[0.058]								
Pro-market institutions				0.037								0.034
				(0.095)								(0.073)
				[0.693]								[0.639]
Alternative pro-market institutions								(0.009)				
								[0.779]				
								0.004				
Information processing				0.005				(0.003)				
				(0.003)				[0.088]				
				[0.047]				(0.009)				
Alternative information processing												0.088
												(0.054)
												[0.110]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.151	0.333	0.418	0.141	0.159	0.086	0.406	0.148	0.159	0.328	0.092	0.166
Number of countries	108	114	122	100	107	121	121	107	107	114	121	100
Number of observations	1052	1154	1050	756	1038	1259	1034	798	1038	1154	1291	958

[a] Logarithm transformed. We used the same set of control variables as before. We do not show them in the table for the brevity. Standard errors at the country level are in parentheses and p-values are in squared brackets.

Table 7. Dynamic panel IV regression using regional democracy waves as an instrument for democracy

Dependent Variable	Model (1) National innovation	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation
Democracy	-0.028	0.018	1.423	-0.033
	(0.021)	(0.011)	(0.707)	(0.020)
	[0.174]	[0.090]	[0.047]	[0.113]
Pro-market institutions				0.026
				(0.084)
				[0.753]
Information processing				0.005
				(0.002)
				[0.020]
Log of National innovation output[a]	0.25	0.019	0.277	0.150
	(0.055)	(0.036)	(0.934)	(0.058)
	[0.000]	[0.597]	[0.767]	[0.011]
Secondary schooling year	0.056	-0.197	-3.969	0.030
	(0.112)	(0.095)	(2.302)	(0.111)
	[0.615]	[0.042]	[0.088]	[0.789]
GDP per capita[a]	0.940	1.071	0.443	0.855
	(0.193)	(0.233)	(5.419)	(0.264)
	[0.000]	[0.000]	[0.935]	[0.002]
Population[a]	1.074	0.281	11.884	1.509
	(0.328)	(0.358)	(6.312)	(0.432)
	[0.001]	[0.435]	[0.062]	[0.000]
Urbanization	0.014	-0.001	-0.030	-0.002
	(0.014)	(0.015)	(0.440)	(0.019)
	[0.326]	[0.970]	[0.945]	[0.924]
Econ openness	0.001	0.001	0.051	0.000
	(0.001)	(0.002)	(0.027)	(0.002)
	[0.037]	[0.799]	[0.061]	[0.826]
Ethnic fractionalization	1.451	-1.900	63.580	3.333
	(1.867)	(2.184)	(40.846)	(2.708)
	[0.439]	[0.386]	[0.123]	[0.221]
Internet user ratio	0.005	0.001	-0.020	0.004
	(0.003)	(0.003)	(0.073)	(0.004)
	[0.038]	[0.851]	[0.788]	[0.254]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
First stage F-test	200.83	184.47	132.66	99.468
First stage F-test p-value	0.000	0.000	0.000	0.000
First stage Wald	54.151	50.555	44.129	29.707
First stage Wald p-value	0.000	0.000	0.000	0.000
Number of observations	1038	1058	914	756

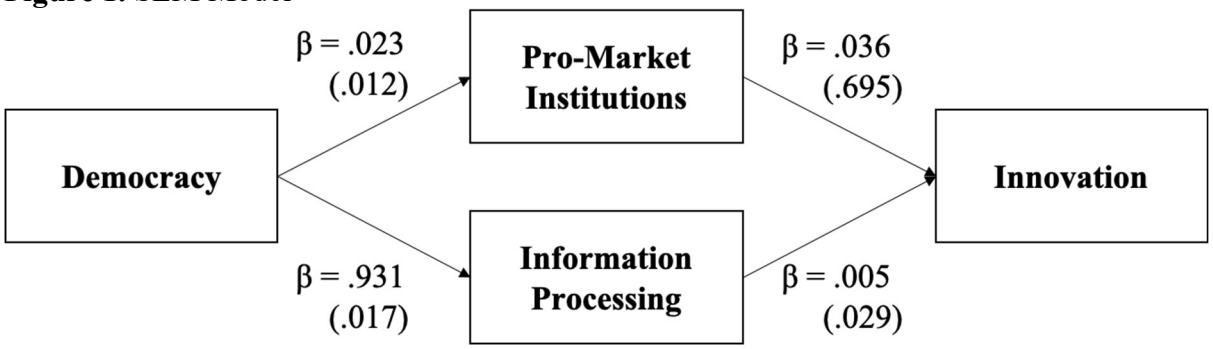
[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table 8. CEM results

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.024	0.005	1.346	-0.037
	(0.018)	(0.012)	(0.488)	(0.017)
	[0.178]	[0.690]	[0.009]	[0.043]
Pro-market institutions				0.141
				(0.114)
				[0.224]
Information processing				0.010
				(0.004)
				[0.011]
Secondary schooling year	0.417	-0.326	-6.554	0.550
	(0.379)	(0.216)	(5.116)	(0.532)
	[0.278]	[0.140]	[0.208]	[0.308]
GDP per capita[a]	0.937	1.836	24.918	1.366
	(0.432)	(0.651)	(11.973)	(0.775)
	[0.036]	[0.008]	[0.044]	[0.087]
Population[a]	1.422	-0.270	7.706	-0.132
	(1.646)	(1.716)	(21.989)	(1.651)
	[0.393]	[0.876]	[0.728]	[0.937]
Urbanization	0.024	-0.048	-1.091	-0.011
	(0.035)	(0.039)	(0.610)	(0.040)
	[0.503]	[0.220]	[0.082]	[0.791]
Economic openness	0.001	0.004	0.055	-0.002
	(0.001)	(0.007)	(0.017)	(0.005)
	[0.200]	[0.602]	[0.002]	[0.633]
Ethnic fractionalization	10.606	1.593	40.878	13.651
	(3.753)	(6.253)	(56.081)	(4.783)
	[0.007]	[0.800]	[0.471]	[0.007]
Internet user ratio	0.017	-0.005	-0.197	-0.002
	(0.011)	(0.010)	(0.131)	(0.012)
	[0.126]	[0.661]	[0.141]	[0.860]
Constant	-36.684	-1.996	-208.604	-15.509
	(27.092)	(28.959)	(377.215)	(25.536)
	[0.184]	[0.945]	[0.583]	[0.548]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.181	0.476	0.485	0.188
Number of countries	39	36	39	35
Number of observations	383	378	340	273

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Figure 1. SEM Model



Note: Standard errors clustered at the country level are in parentheses.

Appendix

Table A1. Predicting national innovation output with mediation analysis using the fixed effect regression using the complete observations

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.029	0.008	0.960	-0.034
	(0.017)	(0.008)	(0.452)	(0.016)
	[0.087]	[0.349]	[0.036]	[0.038]
Pro-market institutions				0.036
				(0.093)
				[0.699]
Information processing				0.005
				(0.002)
				[0.034]
Secondary schooling year	0.022	-0.078	-3.707	0.044
	(0.132)	(0.067)	(2.313)	(0.132)
	[0.871]	[0.252]	[0.112]	[0.740]
GDP per capita[a]	1.035	0.800	-1.851	1.016
	(0.318)	(0.273)	(5.569)	(0.309)
	[0.002]	[0.004]	[0.740]	[0.001]
Population[a]	1.830	0.734	17.577	1.710
	(0.487)	(0.353)	(9.592)	(0.496)
	[0.000]	[0.040]	[0.070]	[0.001]
Urbanization	0.001	0.015	0.143	-0.000
	(0.022)	(0.016)	(0.501)	(0.022)
	[0.969]	[0.365]	[0.776]	[0.985]
Economic openness	0.000	-0.001	0.008	0.000
	(0.002)	(0.002)	(0.044)	(0.002)
	[0.846]	[0.801]	[0.851]	[0.851]
Ethnic fractionalization	3.669	-2.196	10.448	3.694
	(3.174)	(2.644)	(38.230)	(3.103)
	[0.250]	[0.408]	[0.785]	[0.237]
Internet user ratio	0.006	0.000	0.130	0.005
	(0.004)	(0.003)	(0.080)	(0.004)
	[0.128]	[0.959]	[0.105]	[0.172]
Constant	-37.763	-12.121	-205.297	-36.241
	(10.200)	(7.787)	(186.448)	(10.219)
	[0.000]	[0.123]	[0.274]	[0.001]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.142	0.264	0.474	0.150
Number of countries	100	100	100	100
Number of observations	756	756	756	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table A2. Sub-area of pro-market institutions: Legal system and property rights

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.034	0.014	0.931	-0.034
	(0.019)	(0.010)	(0.394)	(0.016)
	[0.074]	[0.144]	[0.020]	[0.036]
Pro-market institutions: Legal systems and property rights				0.038
				(0.070)
				[0.584]
Information processing				0.005
				(0.002)
				[0.032]
Secondary schooling year	0.082	-0.067	-2.991	0.043
	(0.151)	(0.089)	(2.251)	(0.131)
	[0.590]	[0.455]	[0.186]	[0.746]
GDP per capita[a]	1.161	0.941	-3.607	1.018
	(0.274)	(0.288)	(6.233)	(0.305)
	[0.000]	[0.001]	[0.564]	[0.001]
Population[a]	1.262	1.219	5.890	1.705
	(0.441)	(0.394)	(6.873)	(0.481)
	[0.005]	[0.002]	[0.393]	[0.001]
Urbanization	0.020	0.016	-0.064	0.000
	(0.018)	(0.018)	(0.500)	(0.021)
	[0.268]	[0.359]	[0.898]	[0.987]
Econ openness	0.002	0.000	0.047	0.000
	(0.001)	(0.001)	(0.023)	(0.002)
	[0.020]	[0.760]	[0.043]	[0.865]
Ethnic fractionalization	2.037	-3.700	42.263	3.872
	(2.340)	(1.555)	(38.558)	(3.178)
	[0.386]	[0.019]	[0.275]	[0.226]
Internet user ratio	0.007	-0.001	0.008	0.005
	(0.003)	(0.002)	(0.070)	(0.004)
	[0.021]	[0.598]	[0.903]	[0.177]
Constant	-30.207	-21.819	-102.733	-35.740
	(8.938)	(8.647)	(143.325)	(10.020)
	[0.001]	[0.013]	[0.475]	[0.001]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.159	0.282	0.149	0.150
Number of countries	107	114	121	100
Number of observations	1038	1154	1034	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table A3. Sub-area of pro-market institutions: Sound money

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.034	0.045	0.931	-0.034
	(0.019)	(0.020)	(0.394)	(0.016)
	[0.074]	[0.027]	[0.020]	[0.038]
Pro-market institutions: Sound money				0.027
				(0.040)
				[0.501]
Information processing				0.005
				(0.002)
				[0.036]
Secondary schooling year	0.082	-0.530	-2.991	0.048
	(0.151)	(0.229)	(2.251)	(0.133)
	[0.590]	[0.022]	[0.186]	[0.717]
GDP per capita[a]	1.161	1.496	-3.607	1.026
	(0.274)	(0.557)	(6.233)	(0.308)
	[0.000]	[0.008]	[0.564]	[0.001]
Population[a]	1.262	-0.739	5.890	1.732
	(0.441)	(0.928)	(6.873)	(0.474)
	[0.005]	[0.427]	[0.393]	[0.000]
Urbanization	0.020	-0.003	-0.064	-0.000
	(0.018)	(0.032)	(0.500)	(0.021)
	[0.268]	[0.928]	[0.898]	[0.995]
Econ openness	0.002	0.001	0.047	0.000
	(0.001)	(0.006)	(0.023)	(0.002)
	[0.020]	[0.901]	[0.043]	[0.807]
Ethnic fractionalization	2.037	2.531	42.263	3.508
	(2.340)	(5.651)	(38.558)	(3.074)
	[0.386]	[0.655]	[0.275]	[0.257]
Internet user ratio	0.007	0.005	0.008	0.005
	(0.003)	(0.006)	(0.070)	(0.004)
	[0.021]	[0.409]	[0.903]	[0.177]
Constant	-30.207	7.090	-5.233	-36.611
	(8.938)	(16.405)	(143.325)	(9.943)
	[0.001]	[0.666]	[0.971]	[0.000]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.159	0.123	0.406	0.151
Number of countries	107	114	121	100
Number of observations	1038	1154	1034	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table A4. Sub-area of pro-market institutions: Regulation

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.034	0.008	0.931	-0.034
	(0.019)	(0.009)	(0.394)	(0.016)
	[0.074]	[0.372]	[0.020]	[0.037]
Pro-market institutions: Regulation				-0.080
				(0.060)
				[0.184]
Information processing				0.006
				(0.002)
				[0.028]
Secondary schooling year	0.082	-0.013	-2.991	0.047
	(0.151)	(0.096)	(2.251)	(0.129)
	[0.590]	[0.889]	[0.186]	[0.716]
GDP per capita[a]	1.161	1.099	-3.607	1.126
	(0.274)	(0.204)	(6.233)	(0.310)
	[0.000]	[0.000]	[0.564]	[0.000]
Population[a]	1.262	0.965	5.890	1.829
	(0.441)	(0.305)	(6.873)	(0.489)
	[0.005]	[0.002]	[0.393]	[0.000]
Urbanization	0.020	-0.005	-0.064	0.003
	(0.018)	(0.016)	(0.500)	(0.021)
	[0.268]	[0.781]	[0.898]	[0.873]
Econ openness	0.002	0.002	0.047	0.001
	(0.001)	(0.002)	(0.023)	(0.002)
	[0.020]	[0.249]	[0.043]	[0.782]
Ethnic fractionalization	2.037	-2.541	42.263	3.311
	(2.340)	(1.581)	(38.558)	(3.152)
	[0.386]	[0.111]	[0.275]	[0.296]
Internet user ratio	0.007	-0.004	0.008	0.005
	(0.003)	(0.003)	(0.070)	(0.004)
	[0.021]	[0.185]	[0.903]	[0.215]
Constant	-30.207	-17.352	-102.733	-37.940
	(8.938)	(6.041)	(143.325)	(10.207)
	[0.001]	[0.005]	[0.475]	[0.000]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R^2	0.159	0.386	0.149	0.152
Number of countries	107	114	121	100
Number of observations	1038	1154	1034	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.

Table A5. IV regression using the WPEI as an instrument for democracy

Dependent Variable	Model (1) National innovation output[a]	Model (2) Pro-market institutions	Model (3) Information processing	Model (4) National innovation output[a]
Democracy	-0.051	0.049	1.886	-0.047
	(0.042)	(0.033)	(0.898)	(0.041)
	[0.224]	[0.136]	[0.038]	[0.255]
Pro-market institutions				0.041
				(0.093)
				[0.662]
Information processing				0.006
				(0.003)
				[0.066]
Secondary schooling year	0.088	-0.198	-2.810	0.043
	(0.147)	(0.095)	(2.428)	(0.130)
	[0.549]	[0.039]	[0.250]	[0.744]
GDP per capita[a]	1.247	1.139	-4.652	1.022
	(0.292)	(0.253)	(6.224)	(0.315)
	[0.000]	[0.000]	[0.456]	[0.002]
Population[a]	1.800	0.382	0.249	1.730
	(0.450)	(0.354)	(11.387)	(0.497)
	[0.000]	[0.283]	[0.983]	[0.000]
Urbanization	0.020	0.003	-0.054	-0.001
	(0.018)	(0.015)	(0.437)	(0.022)
	[0.285]	[0.841]	[0.901]	[0.957]
Econ openness	0.002	0.001	0.031	0.000
	(0.001)	(0.002)	(0.029)	(0.002)
	[0.057]	[0.725]	[0.285]	[0.816]
Ethnic fractionalization	2.021	-1.343	36.337	3.822
	(2.340)	(2.187)	(41.187)	(3.115)
	[0.390]	[0.540]	[0.379]	[0.223]
Internet user ratio	0.008	0.000	0.030	0.005
	(0.003)	(0.002)	(0.076)	(0.004)
	[0.011]	[0.874]	[0.697]	[0.238]
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
First stage F-test	108.32	120.83	128.40	70.438
First stage F-test p-value	0.000	0.000	0.000	0.000
First stage Wald	13.381	14.209	12.223	8.253
First stage Wald p-value	0.000	0.000	0.000	0.004
Number of observations	1027	1154	1028	756

[a] Logarithm transformed. Standard errors clustered at the country level are in parentheses and p-values are in squared brackets.