

Connecting the dots between democracy and innovation: The mediating role of economic freedom and press freedom

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ABSTRACT

Grounded in information processing and institutional theory, this paper theorizes the mechanisms through which democracy influences innovation. We posit the democracy-innovation relationship is channelled through an institutional configuration where entrepreneurs can freely take economic actions (i.e. economic freedom) and process information (i.e. press freedom). Our analysis shows that whereas the democracy-innovation relationship is positively mediated by press freedom, economic freedom surprisingly does not mediate the democracy-innovation relationship. While gradually or increasingly democratizing states tend to focus on enhancing their economic freedom to incentivize their entrepreneurs without much consideration on freeing the information flow, our analysis underscores the importance of improving information access through which the democracy-innovation relationship is strengthened.

Keywords: Democracy, Economic Freedom, Entrepreneurship, Innovation, Press Freedom

INTRODUCTION

With the downfall of communist regimes since 1989, the renewed success of the U.S. economy relative to the Asian "tigers" in the late 1990s, and the emergence of the state-driven Chinese economy in recent decades, there has been a growing interest in the role of democracy in economic and technological development (Keane, 2009; Mahmood & Rufin, 2005; Popper, 2005, 2012). While some postulate that democracy provides a free environment encouraging initiatives and creativity (Ober, 2008; Popper, 2005, 2012), others argue that democracy is unable to solve coordination problems and hurts government decisiveness in resource allocations (Huntington & Dominguez, 1975). In response to the mixed view, studies have explored the implications of democracy such as development (Persson & Tabellini, 2006), economic growth (Doucouliagos & Ulubaşoğlu, 2008), and entrepreneurship (Audretsch & Moog, 2020).

While prior studies are immensely insightful, limited attention has been paid to the democracy-innovation relationship. Since entrepreneurs¹ often use (technological) innovation as their basis upon which to build new businesses and industries, the question of whether democracy promotes innovation should be of critical importance (Shane, 1993; Taylor & Wilson, 2012). Notably, the democracy-innovation literature has overlooked the mechanisms through which democracy influences innovation (see Gao, Zhang, Roth, & Wang, 2017). This is salient, and the failure to consider these mechanisms likely explains the inconsistent empirical findings and insignificant relationships found in prior studies (Gao et al., 2017). One implication then is that the literature omits key variables functioning as a critical pathway to innovation since democracy is often treated only as a voting system (Persson & Tabellini, 2005; Blume, Müller, Voigt, & Wolf, 2009).

¹ According to Schumpeter (1934, p. 78), “everyone is an entrepreneur only when he[*/she*] actually ‘carries out new combinations’” of resources. Following this view, our study posits that creating a new technology (i.e. patenting) is an act of combining resources in untried ways by entrepreneurs (Link & Ruhm, 2011).

In addition, the key assumption underlying in a number of studies on democracy (e.g. de Mesquita & Downs, 2005; Gunther & Mughan, 2000; Nam, 2012) is that democracy cannot exist without citizens possessing the ability to use their voice and for the capability to hold political leaders accountable. In this line, prior studies postulate that freedom (e.g. economic freedom and press freedom) can reduce the chance that an autocratic government will survive. Many expect that political reform is destined to follow economic reform. Yet, this assumption does not hold in practice. For instance, autocratic states can expropriate private enterprises (Zhou, Ge, Li, & Chandrashekar, 2020) as well as enact laws to shut down media companies and arrest journalists. Moreover, autocrats can become entrenched when society prospers economically, thereby reducing opposition to the political leader (Holcombe and Boudreaux, 2013). These acts inhibit both economic freedom and press freedom. These findings and complications are entirely consistent with the Hayek–Friedman hypothesis suggesting that “politically free societies must be economically free; it does not say that economically free societies must be politically free” (Lawson & Clark, 2010, p. 231).

Seeking to address these issues, the purpose of this paper is to examine the role of economic freedom and press freedom as critical mediators of the relationship between democracy and innovation. Drawing on information processing and institutional theory, we theorize that democracy will increase innovation by allowing and enabling entrepreneurs to freely take economic actions (i.e. economic freedom) and process information (i.e. press freedom). The proposed conjecture linking the relationship between democracy and innovation with the constructs of economic freedom and press freedom is in line with several studies suggesting that democracy reflects freedom that influence the ability of people and organizations to engage in innovative behaviour and activities (Audretsch & Moog, 2020; Bradley & Klein, 2016; Lazear, 2005).

To test these hypotheses, we collected cross-national patent data from the USPTO (US Patent and Trademark Office) and NBER (National Bureau of Economic Research) databases (Hall, Jaffe, & Trajtenberg, 2001). Next, we gathered democracy data from the Polity IV project (Marshall, Gurr, Davenport, & Jaggers, 2002), economic freedom data from the Fraser Institute (Gwartney, Lawson, Hall, & Murphy, 2019), and press freedom data from the Reporters Without Borders (Faccio, 2006). After merging these databases and constructing various control variables, we were left with 1,395 observations comprised of 130 countries and 10 years (2000-2010). Our analysis reveals that democracy affects innovation primarily through the channel of press freedom. More specifically, democracy encourages press freedom, which in turn, positively influences country-level innovation.

Our study contributes to the entrepreneurship and innovation literatures in several ways. First, while some studies conjecture that democracy encourages innovation (Carayannis & Campbell, 2014; Ober, 2008; Popper, 2005, 2012; Taylor & Wilson 2012), others find democracy has no effect (Gao et al., 2017). Given the mixed empirical findings, the democracy-innovation link requires further theoretical development. We speak to this literature by offering an explanation for these inconclusive findings—the underlying mechanisms behind the democracy-innovation relationship have not been considered. Our theoretical framework grounded in information processing and institutional theory informs our knowledge of the specific mechanisms through which democracy influences innovation namely economic freedom and press freedom.

Secondly, although the role of economic freedom in fostering innovation is well acknowledged (Boudreaux, 2017; Van Waarden, 2001), the implication of freeing information flow (i.e. press freedom) on innovation has been overlooked by prior studies. Considering and distinguishing between these two mechanisms is theoretically valuable, because economic freedom and press freedom are not always positively associated (e.g. while Singapore is one

of the most economically free countries in the world, it was ranked 158th in the 2020 Press Freedom Index by Reporters Without Borders). By controlling for economic freedom and press freedom in the same econometric model, we are better able to isolate the variation in national innovation as it relates to democracy, avoiding issues with confounding. Our empirical analysis shows that democracy affects innovation through the mediating channel of press freedom, and to a lesser extent, economic freedom. This, in turn, enables us to develop a more nuanced understanding of the relationship between democracy and innovation.

Lastly, prior studies have acknowledged the difficult task of obtaining causal estimates of the effect of democracy on innovation (Gao et al., 2017). Our study circumvents this challenge by empirically testing the hypotheses using several different regression models as well as quasi-experimental methods for identification. We use linear regression methods with country and year fixed effects, bootstrapping methods, structural equation models (SEM), instrumental variables (IV) two-stage least squares (2SLS), and difference-in-differences (DID) estimates. All methods provide qualitatively similar and robust results showing that press freedom is a more salient mediator between democracy-innovation relationship than economic freedom.

THEORETICAL FOUNDATION

Following Bollen (1980, p. 372), we define democracy as the extent to which the 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). This conceptualization of democracy is widely used in the literature on democracy to explain its

implications for economic growth, development, and institution creation and/or destruction (Acemoglu 2005; Acemoglu and Robinson, 2000; Acemoglu et al., 2005a; Acemoglu et al., 2005b).

Subsequently, we develop our framework of democracy-(economic and press) freedom-innovation beginning with an overview of on information processing theory and institutional theory.

A basic tenet of the 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 levels of information diversity (Hansen & Allen, 1992). This is the case in the general context of our study where entrepreneurs face uncertainty while generating innovation outputs. Under such uncertain environments, information processing theory underscores the importance of linking patterns of information from various sources to form the basis of new business opportunities and innovation (Vaghely & Julien, 2010). In this line, information processing theory has been associated with problem solving and decision-making (Simon, 1991), entrepreneur's opportunity alertness and recognition (Kirzner, 1979), and innovation (Schumpeter, 1983). Thus, this theory helps shed light on the role of freedom for entrepreneurs to access and process information to engage in innovation activities.

The role of the institutional theory in innovation is well-recognized, because it is concerned with the conception of innovation systems—national, regional, sectoral, and technology-oriented—that ultimately influence the levels and rates of innovation (Nelson & Nelson, 2002). At a fundamental level, institutions are the “rules of the game” that constrain and enable human behaviour (North, 1990) as well as influencing organizational behaviour (Bylund & McCaffrey, 2017; March & Olsen, 1989; Powell & DiMaggio, 1991; Tonoyan, Strohmeier, Habib, & Perlitiz, 2010). There is however a variety of 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 formal institutions as economic freedom (Bennett & Nikolaev, 2020; Boudreaux, Nikolaev, & Klein, 2019; Bjørnskov & Foss, 2008; Gohmann, Hobbs, & McCrickard, 2008; McMullen, Bagby, & Palich, 2008; Nikolaev, Boudreaux, & Palich, 2018; Nystrom, 2008; Sobel, 2008).

HYPOTHESES DEVELOPMENT

While prior studies have conjectured the direct relationship between democracy and innovation, concluding with inconsistent findings (Gao et al., 2017; Ober, 2008; Popper, 2005, 2012; Taylor & Wilson 2012), they have not considered the underlying mechanisms that might explain *how* democracy encourages innovation. Our study is novel in this sense because we explain how economic freedom and press freedom are two viable mechanisms to channel democracy toward innovation. This explanation provides a more nuanced approach than previous studies and explains democracy's *indirect* effect on innovation activity.

Subsequently, the overarching reasoning in our prediction relies on three key premises. First, innovation depends on a "creative class" of entrepreneurs who are typified by tolerance and open-mindedness (Florida, 2002). Such emphasis on creative, unconventional entrepreneurs and societies that tolerate, or even foster them, can be found in innovation scholarship (Mueller & Thomas, 2001; Steiner, 1995; Tiessen, 1997). Second, entrepreneurs need to take high-levels of risk and uncertainty to generate innovation, because they are confronted with the costs and distributive effects of scientific research and technological change (Acemoglu, 2009; Tan, 2001). In this sense, if institutions do not offer a favourable business environment and compensate entrepreneurs for the benefits they create for society,

then little incentive exists to innovate (Baumol, 1990; Sarooghi, Libaers, & Burkemper, 2015). Third, the role of institutions in enabling the flow of (diverse) information and knowledge is critical for entrepreneurs to combine and process ideas and generate innovation (Dosi & Nelson, 2010; Zheng & Wang, 2020).

Economic Freedom as a Pathway to Innovation

We posit economic freedom as our first mediating mechanism in the democracy-innovation relationship. Economic freedom measures the extent of market activity in the economy that captures various institutional constraints according to five domains: the size of government, the legal system and property rights, sound monetary policy, freedom to conduct international trade, and regulatory freedom (Gwartney et al., 2019). Studies from the political science and economics literature have identified democracy as an indirect determinant of economic growth operating through the channels of market institutions and economic freedom (Acemoglu, Naidu, Restrepo, & Robinson, 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 economic freedom. Democracy, therefore, can be the “meta-institution” for building pro-market institutions (Rodrik, 2000). Furthermore, Hayek (1944) argued that capitalism is only possible in a democratic society, and Friedman (1962) added that there are few instances throughout history where societies have high levels of political freedom without commensurate economic freedom (Friedman, 1962; Hayek, 1944). Lawson & Clark (2010) examine the Hayek-Friedman hypothesis and find overall support for the strong relationship between political freedom and economic freedom. Hence, economic freedom and political freedom (i.e., democracy) often go hand in hand.

The above reasoning highlights how democracy relates to economic freedom. Yet, it is also well-documented that economic freedom relates to innovation (Boudreaux, 2017; Van

Warrden, 2001). In the space below, we explain how each component of economic freedom—size of government, legal system and property rights, sound money, freedom to trade internationally, and regulation—relates to innovation.

Size of Government. The first dimension of economic freedom relates to the size and scope of government activity in the economy. As government spending, taxation, and the size of government-controlled enterprises increases, entrepreneurs' decision-making is replaced by the government, and economic freedom decreases (Gwartney et al, 2019). This creates two conflicting mechanisms that could either increase or decrease innovation. On the one hand, higher taxes and more government spending often correlate with increased budget deficits and a larger national debt (Cebula, 1995). In this context, a large public sector may decrease the scope of the market available for potential entrepreneurs and reduces the incentives for wealth formation, which are important for enabling entrepreneurs to innovate (Henrekson, 2005; Nyström, 2008). From a political perspective, issuing government bonds is more feasible than raising taxes, and this 'crowding out' of financial capital from the private sector could lead to reduced capital stock and lower innovation rates (Furman, 2016). On the other hand, governments often are directly involved in either R&D activity or financing of R&D. Putting crowding out arguments aside (Wallsten, 2000), more government spending on R&D is likely to motivate entrepreneurs to rely on R&D subsidies and engage in innovation activities (Clausen, 2009; Oughton, Landabaso, & Morgan, 2002). As a result, we anticipate that the net effect of government size freedom on innovation depends on the presence or absence of private sector crowd out. If crowding out is present, a larger government (i.e., less economic freedom) corresponds to less innovation. If crowding out is absent, then a larger government might potentially increase innovation.

Legal System and Property Rights. The second dimension of economic freedom relates to the quality of the legal system and protection of property rights. Countries with more

economic freedom according to this indicator protect the right to buy, sell, lease, and mortgage one's property. This protection also extends to intellectual property rights, which are vital to the development of R&D and innovation activity (Boudreaux, 2017; Fang, Lerner, & Wu, 2017; Furukawa, 2010; Lai, 1998). For instance, entrepreneurs can be reluctant to engage in innovation activities under a weak intellectual property protection regime, which hinders entrepreneurs from appropriating values from their following inventions. The legal system also supports an environment conducive to innovation. Innovation is fraught with risk and uncertainty (Jalonen, 2012), both of which increase transaction costs (York & Venkataraman, 2010). However, a major function of the legal system is to reduce such risk and uncertainty for entrepreneurs (Van Waarden, 2001). Indeed, studies find that both economic freedom and legal origins are important determinants of entrepreneurship (Nikolaev et al., 2018). For these reasons, both the protection of property rights and quality of legal system should support entrepreneurs' innovation activity. Consequently, we anticipate a positive relationship between the legal system and property rights, the second component of economic freedom and innovation.

Sound Money. The third dimension of economic freedom relates to sound monetary policy. Macroeconomic uncertainty, commonly measured as the standard deviation of inflation rates, has been found to be negatively correlated with private investment (Aizenman & Marion, 1993) and loan demand (Baum, Caglayan, Ozkan, & Talavera, 2006). 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 a key linkage between stable monetary policy and innovation. When monetary policy is unstable, it leads to greater uncertainty, which affects private investment, capital demand, and innovation activity. When monetary policy is stable, however, innovation activity should be increased. In other words, stable monetary policy can motivate entrepreneurs to take risks and

innovate by reducing economic uncertainty and financial risks. For these reasons, we expect a positive relationship between sound monetary policy, the third component of economic freedom, and innovation.

Freedom to Trade Internationally. The fourth dimension of economic freedom relates to the freedom to trade internationally. Freedom to exchange—buying, selling, and making contracts, and sharing ideas—is essential to economic freedom (Gwartney et al., 2019). Major trade liberalization episodes, in particular, are often followed by a surge of innovation (Liu & Ma, 2016). Economic freedom also encourages free and open trade and inquiry, which allows for new knowledge and ideas to flow between nations. These flows of goods and information are likely to encourage innovation, since spillovers exist in innovation activity (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009; Audretsch & Lehmann, 2005). In addition, the opportunities to engage in international trade will enhance the market potential of an entrepreneur's innovation (Nyström, 2008). In a similar vein, the more freedom in international trade will reduce the transaction costs for entrepreneurs to commercialize their innovation for international market (Nyström, 2008). Hence, we expect freedom, according to the international trade component, to be positively correlated with innovation activity.

Regulation. The fifth dimension of economic freedom relates to the regulatory component. Governments often develop a variety of rules and regulations. On the one hand, if regulations are onerous, they limit entrepreneurs' right to exchange, work, gain credit, and freely operate a business (Gwartney et al., 2019). Banking deregulation, for example, can have contrasting effects on innovation—when banks' market power increases, the level and risk of innovation decreases and vice versa (Chava, Oettl, Subramanian, & Subramanian, 2013). Regulation thus can be too restrictive and siphon off entrepreneurs' innovation activity. On the other hand, too lax a regulatory environment can also harm innovation. Behind this “sweet-spot” of regulation, are opposing forces that can either enhance or constrain innovation activity.

Well-designed regulation reduce uncertainty and help guide firms to invest in innovative activities (Porter & van der Linde, 1995). Yet, complying with regulations increases costs and restricts entrepreneurs' freedom to take actions and innovate (Palmer, Oates, & Portney, 1995). Studies have shown that the effect of regulations on innovation depends on the extent of market uncertainty—when coupled with high market uncertainty, formal standards can help promote innovation, but, when coupled with low market uncertainty, regulation can promote innovation (Blind, Peterson, & Riillo, 2017). Economic freedom promotes a sound regulatory environment with reasonable and adequate levels of regulation (Gwartney et al., 2019; Lucas & Boudreaux, 2020). For these reasons, we anticipate a positive relationship between economic freedom's final component, i.e., a sound regulatory environment—neither too onerous nor too lax—and innovation.

In sum, theory and evidence suggests that democracy encourages economic freedom, which in turn, positively influences innovation. Based on this logic, we propose our first hypothesis:

Hypothesis 1: Economic freedom mediates the relationship between democracy and innovation.

Press Freedom as a Pathway to Innovation

We posit press freedom as our second mediating mechanism in the democracy-innovation relationship. According to Weaver (1977), press freedom is conceptualized as (a) the relative absence of government restraints on the media, (b) the relative absence of non-governmental restraints and (c) the existence of conditions to insure the dissemination of diverse ideas and opinions to large audiences. Relying on the first two conceptualization approach, mass communication and political science literature often postulate that press freedom exposes politicians and governments to public scrutiny, elucidates choices during elections and urges people to participate in the political process (McQuail, 2000). In a similar

vein, several empirical studies found that press freedom reduces corruption (Brunetti & Weder, 2003; Chowdhury, 2004) and political longevity of office holders (Besley & Prat, 2001).

While prior studies focus on the political implications of press freedom, our analysis of explaining national innovation output takes the view that press freedom guarantees the dissemination of information, thoughts, and opinions without restraint or censorship and influences the ability of entrepreneurs to freely access, process, and recombine the information and ideas (Picard, 1985). In line with our view, there is a well-established understanding that innovation is cumulative and its development requires intense search and recombination of existing knowledge with other available knowledge (Dosi & Nelson, 2010; Fleming, 2001; Katila & Ahuja, 2002; Nelson & Winter, 1982). For instance, in a 'free' environment, entrepreneurs could easily acquire and process information, as any news become public knowledge immediately through mediums including various electronic media and published materials. However, in countries characterized by a low degree of press freedom tend to show a poor quality of information processing (Masrorkhah & Lehnert, 2017), thereby hindering entrepreneurs' pursuit of innovation.

Given the above reasoning, we argue that democracy can enhance press freedom as a first step. Since the laws and principles of democracy are essential for free and diverse voices to emerge, countries closer to the democratic model can secure greater freedom and plurality to search and acquire information (Siebert, Peterson, & Schramm, 1956; Woods, 2007). While democracy enhances the flow of ideas encouraging knowledge recombination, authoritarian states often disrupt such flow and knowledge recombination process by shutting off internet contact with the outside world to prevent the spread of politically damaging news (Zheng & Wang, 2020). Likewise, countries with the authoritarian model often curtail information flows to avoid challenges to its power (Mahmood & Rufin, 2005). As a result, press repression is

often salient in authoritarian states, where the conditions ensure the dissemination of diverse opinions and perceptions to large audiences or combinations of both is absent (Weaver, 1977).

Subsequently, we further argue that democracy allowing the free flow of information and ideas will lead to better decision-making by encouraging entrepreneurs to combine broader domains of knowledge and interact with a wider range of networks and perspectives (Fleming, 2001; Mahmood & Rufin, 2005). Press freedom ensuring the diversity of opinions throughout the country provides a forum for entrepreneurs to search for many conflicting ideas. Such an environment with less or without censorship allows entrepreneurs to freely reject and criticize others' ideas, thereby driving the creation and exchange of novel ideas. This widely publicized interchange reveals the strengths and weaknesses of various proposals and, ultimately, leads to the adoption of the soundest ideas to create innovation (Graber, 1986). In this line, it is known that many famous scientific breakthroughs were the result of seemingly random connections that occurred through a free associative process, where an entrepreneur generates many unusual combinations between different bodies of available knowledge and information (Schilling & Green, 2011, p. 1321). In other words, the work vetted from multiple angles and inputs allowed by the free flow of information can deviate substantially from the established paradigm to generate innovation. Thus, a free press contributes to innovation by allowing entrepreneurs to cycle through these many different combinations of ideas and knowledge to generate patents (Dutta, Roy, & Sobel, 2011).

Conversely, without a free press, entrepreneurs do not have unbiased and rich information and knowledge to carry out innovative activities. Diminishing press freedom will increase information asymmetry between the actors with vested interests (e.g. state-owned enterprises and established firms) and entrepreneurs (Mahmood & Rufin, 2005). This is because the actors with vested interests are in favour of opposing the competition from the entry of new entrepreneurs with innovation, which could be immediately deployed (Mahmood

& Rufin, 2005). Due to the presence of entry barriers created by the information asymmetry under the absence of a free press, entrepreneurs will not have sufficient resources and incentives to generate novel ideas and innovation. In addition, authoritarian regimes favouring a lower level of information or press freedom are inducing a high level of mistrust among entrepreneurs, due to the fear of being reported for subversive behaviour (Burt, 2016; Rock, 1993). As entrepreneurs are mistrustful of each other in such environments, they are less likely to engage in the exchange of information hampering recombination for innovation (Ding, Au, & Chiang, 2015; Nguyen & Rose, 2009). Trust is 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. Thus, diminishing press freedom triggered by an authoritarian state will increase entrepreneurs' conformity with existing ideas and paradigms, thereby reducing the novelty and creativity of their invention (patent) to be granted.

In sum, theory and evidence suggests that democracy encourages press freedom, which in turn, positively influences innovation. Based on this logic, we formally state that:

Hypothesis 2: Press freedom mediates the relationship between democracy and innovation.

METHODS

Data and Variables

We constructed our dataset by relying on a variety of 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, Gurr, & Jaggers, 2014), the World Press Freedom Index from the Reporters Without Borders (Becker, Vlad, & Nusser, 2007; Faccio, 2006), the Economic Freedom of the World index (EFW) from the Fraser Institute (Gwartney et al., 2018), and the secondary schooling data from Barro-Lee Educational Attainment Dataset (Barro & Lee, 2013). Other national-level economic indicators were collected from the World Bank Open Data. After merging the data from the above

sources, we obtained an unbalanced panel dataset for our analysis with 1,395 country-year observations consisting of 130 countries over the period 2000 to 2010.

Dependent variable

To operationalize national innovation output, we consider the patent count, which is one of the most widely used proxies for innovation (Furman, Porter, & Stern, 2002; Hall et al., 2001). In line with a number of studies, we employ the patent data provided by the USPTO and NBER patent databases for cross-national analyses (Acharya & Subramanian 2009; Bhattacharya, Hsu, Tian, & Xu, 2017; Gao et al., 2017; Taylor & Wilson, 2012). 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).

Independent variable

To measure the degree of democracy per 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 is computed by considering the following five perspectives including (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 the higher score implies stronger presence of democratic regime, while the lower score implies stronger presence of autocratic regime.

Mediating variables

Following recent studies (Bennett, 2019; Bjørnskov & Foss, 2013; Boudreaux et al., 2019; Graafland & Noorderhaven, 2020; Lucas & Boudreaux, 2020), we use the Economic Freedom of the World index (EFW) from the Fraser Institute (Gwartney et al., 2018), which is arguably the most widely used measure of economic freedom. The index publicizes the extent

to which country has a greater economic freedom by considering the following five dimensions: (1) size of government, (2) legal system and security property rights, (3) sound money, (4) freedom to trade internationally, and (5) regulation. The index score ranges from zero to ten, where the higher score of the index implies greater economic freedom provided to economic actors within a country. There has been a debate in the literature concerning whether or not the first dimension (i.e., size of government) truly belongs with the other four dimensions (Bergh, 2020; Ott 2018). In additional robustness checks, we found similar results when we use the entire economic freedom index or the index excluding the first dimension.

To measure press freedom, we rely on the World Press Freedom Index published by the Reporters Without Borders, which is a non-profit organization for protecting or preaching the right to freedom of information (Becker et al., 2007; Faccio, 2006). Press freedom captures the quality of information processing in a particular country (Masrorkhah & Lehnert, 2017). It takes into account violations directly affecting journalists (such as murders, imprisonment, physical attacks and threats), news media (censorship, confiscation of issues, searches and harassment), and free flow of information on the internet as well. We use the rankings and scores of the Press Freedom Index for our main analysis and robustness test, respectively. Higher ranking (lower index score) indicates a lower press freedom and vice versa. To ease the interpretation, we multiply the ranking by negative one, so that higher values on the ranking indicate greater freedom. We further rescale the ranking value by 1/100 which changes the magnitude by 1/100 of the estimated coefficients without altering the significance of our analysis.

Control variables

To account for any idiosyncratic differences across countries and years, we employ fixed effects specifications (for year and country) throughout these regressions. Moreover, we include several country-specific controls for innovation proposed by prior studies, as follows.

We control for gross domestic product (GDP) per capita, because national prosperity reflect the resource availability or the ability to capitalize resources to induce innovation (Dau & Cuervo-Cazurra, 2014; Furman et al., 2002). We also control for population density and urbanization, because such dense locations as urban areas are the place where entrepreneurs gather and more ideas flourish, thereby creating more innovation (Andersson, Quigley & Wilhelmsson; Carlino, Chatterjee, & Hunt, 2007). As a country could benefit from the spillover effect of trade or FDI for innovation, we control for economic openness, which is the sum of exports and imports as a share of GDP (Furman et al., 2002). Finally, we include the average years of secondary schooling for the population whose age are 15 or above as a control variable (Barro & Lee, 2013; Gao et al., 2017), as societies with higher education levels can generate more innovation (Varsakelis, 2006).

Econometric Model

In order to estimate the mediating effects of economic freedom and press freedom on the relationship between democracy and innovation (see the below equations), we first employ the widely used mediation models suggested by Baron & Kenny (1986). Yet, as our framework focuses on theorizing the mediation effect without predicting the main effect of democracy on innovation, we also use a bootstrapping method (MacKinnon, Lockwood, & Williams, 2004) in our main analysis. The bootstrapping method can capture the indirect effect of democracy on innovation via mediators without having to satisfy the first step (see the below equation 1) of the Baron & Kenney's (1986) classical mediation approach (Shrout & Bolger, 2002). For instance, Shrout & Bolger (2002, p. 429) noted "*Because the test of the $X \rightarrow Y$ association may be more powerful when mediation is taken into account, it seems unwise to defer considering mediation until the bivariate association between X and Y is established*". In line with the logic, the latest study by Gao et al., (2017) examining the relationship between democracy and innovation found a non-significant relationship. Thus, our analytical approach focusing on

testing the mediation model is aligned with several studies (see Hayes, 2009; Preacher & Selig, 2008; Schneider, Ehrhart, Mayer, Saltz, & Niles-Jolly, 2005).

To deal with possible simultaneity issues between the national innovation output and our other variables, we follow prior studies on patents and innovation (Dechezleprêtre, Neumayer, & Perkins, 2015; Rong, Wu, & Boeing, 2017) and lag all explanatory variables (including control variables) by one year as expressed in the below equations. For the robustness tests, we also lagged our explanatory variables by two years (Furman & Hayes, 2004) and allowed one year time lag on our mediating variables. Our equations are the following:

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

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

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

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

where the subscripts i and t denote the country and year respectively. I_{it+1} denotes the national innovation output; D_{it} denotes democracy; E_{it} denotes economic freedom; and P_{it} denotes press freedom. 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, β_1 in equation (1) measures the direct effect of democracy on national innovation output, and β_1 in equations (2) and (3) measures the effect of democracy on economic freedom and press freedom. 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 output²³. The Baron & Kenny (1986) approach is to compare the estimates of β_1 in equation (1) and β_1 in equation (4). That is, mediation is present if the inclusion of economic freedom and press freedom alter the parameter estimate of democracy on national innovation, β_1 , between equations.

RESULTS

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

-- Insert Table 1 here--

Main Analyses

Table 2 reports ordinary least squares (OLS) regression estimates including year and country fixed effects by following Baron & Kenney's (1986) approach. As a baseline, model 1 presents the relationship between democracy and national innovation output; model 2 tests the effect of democracy on press freedom; model 3 tests the effect of democracy on economic freedom; and model 4 tests the effects of democracy, press freedom, and economic freedom on national innovation output. As the country and year coverage of the economic freedom is richer than those of national innovation output, press freedom, and democracy, Model 2 has more observations than the other models. We have fewer observations for Model 3 and Model 4, because press freedom data is not available for some countries.

² To calculate the indirect effect operating through the channel of economic freedom, we multiply β_1 in equation (2) and β_2 in equation (4).

³ To calculate the indirect effect operating through the channel of press freedom, we multiply β_1 in equation (3) and β_3 in equation (4).

Model 1 and Model 4 of Table 2 report that democracy is not directly related to national innovation output. This result is in line with the robust finding by Gao et al., (2017). 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 has a positive and significant effect on national innovate output showing that a more prosperous and wealthier country will generate more patents.

-- Insert Table 2 here--

Hypothesis 1 and 2 predict the mediating effects of press freedom and economic freedom on the democracy-national innovation output relationship. Models 2 and 3 of Table 2 show that democracy is positively and significantly related to economic freedom ($\beta = .024$, $p < .05$, $ci = [.005 .043]$) and press freedom ($\beta = .016$, $p < .05$, $ci = [.0036 .0286]$). Model 4 reports that press freedom has a positive and significant effect on national innovation output ($\beta = .335$, $p < .01$, $ci = [.145 .526]$), while the effects of democracy and economic freedom on innovation output are not statistically significant. These results indicate that democracy only indirectly influences national innovation output, through the channel of press freedom, providing support for hypothesis 2.

-- Insert Table 3 here--

To accurately 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 3 presents the results using the bootstrapping method, which shows qualitatively similar results to our findings in Table 2. Similar to these results, Table 3 shows that democracy is positively and significantly related to our mediators, economic freedom ($\beta = .024$, $p < .01$, $ci = [.014 .036]$) and press freedom ($\beta = .016$, $p < .01$, $ci = [.007 .026]$). Moreover, whereas the indirect effect of democracy on national innovation output via press freedom is positive and statistically

significant ($\beta = .005$, $p < .05$, $ci = [.002 .011]$), the indirect effect of democracy on national innovation output via economic freedom is not statistically significant ($\beta = .003$, $p > .10$, $ci = [-.002 .008]$).

As we use the log-transformed value for the national innovation, we can consider that the coefficient is approximately similar to the percentage change in national innovation. Given that the democracy variable needs to increase by at least 11 units for an autocratic state to become a democratic state, we can report our finding based on the following scenario where a country, such as Morocco, experiencing a radical shift from being an autocratic state to a democratic state since the 1990s (Monjib, 2011). In this vein, if an autocratic country becomes democratic, the change in national innovation is about 8.8%. Under the same scenario, the increase in national innovation via press freedom is about 5.5%. Stated differently, a one standard deviation (2.68) increase in democracy is associated with about 2.14% increase in national innovation or about 1.34% increase in national innovation via press freedom. This is the scenario where Thailand (with the average democracy value of 5.45 in our sample) reaches a similar level of democracy to South Korea (with the average democracy value of 8).

In addition to the Baron & Kenney (1986) mediation approach and the bootstrapping method (Shrout & Bolger, 2002), we also estimated the KHB (Karlson–Holm–Breen) model to decompose the mediating effects, regardless of their statistical significance. The results reveal that 75 percent of the mediation operates through press freedom and 25 percent of the mediation operates through economic freedom⁴.

Taken together, our analyses finds support for hypothesis 2 but not for hypothesis 1.

⁴ To run the KHB model, 807 observations in Model 4 of Table 2 were utilized. The mediation effect through economic freedom is about .0014 and press freedom is about .0043. This means that economic freedom accounts for about 25 percent ($.0014/ [.0014+.0043]$) while press freedom accounts 75 percent ($.0043/ [.0014+.0043]$) of the mediation effects.

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. Table 4 presenting the SEM results⁵ shows that democracy is positively and significantly related to economic freedom ($\beta = .024$, $p < 0.05$, $ci = [.005 .042]$) and press freedom ($\beta = .016$, $p < 0.05$, $ci = [.004 .028]$). It also reports that out of the three variables—democracy, press freedom, and economic freedom—only press freedom is positively and significantly related to innovation outputs ($\beta = .335$, $p < 0.01$, $ci = [.149 .522]$). This finding is in line with our main result assuring the robustness of our findings, when even using the analytical approach of SEM.

-- Insert Table 4 here--

In order to make a causal inference between democracy and innovation considering economic freedom and press freedom, we need to find a valid identification strategy. Such an approach needs to minimize the concern that our findings are affected by (1) key omitted variables, (2) measurement error, and (3) simultaneity problems. To address these concerns, we used DID (Difference in differences) and IV (Instrumental variable)-2SLS (two stage least-square) methods to draw causal inference.

For the DID, we follow Gao et al. (2017, p. 1276) and consider democratizing or de-democratizing countries as a treatment group and countries with no such change as a control group. Specifically, to create a democratizing or de-democratizing status for the treated group, we viewed a country as a democratic state if its value of democracy is greater than six (see Marshall et al., 2014) and constructed a time-varying indicator for a given country and year. This indicator used for the DID analysis takes the value of 1, if a country changes its political regime to the democratic authority within our sample period. This way we are able to model whether gaining or losing the status as a democratic state causes the changes in innovation

⁵ We used *gsem* command in the Stata for the SEM estimation.

outputs considering economic freedom and press freedom over time. For the DID method to be valid, a key assumption is that the dependent variable for both the treatment and control group must follow the same trends before and after treatment (i.e., common trends assumption) (Angrist & Pischke, 2014). Regarding the common trends assumption, Figure 1 illustrates the average trends in the national innovation outputs for democratic, democratizing and autocratizing countries during our sample period. Among the three types of countries, national innovation outputs of democratizing countries are increasing more rapidly than the others, implying that democratization is positively related with national innovation outputs. Our main findings still hold with this DID analysis as shown in Table 5. Being a democratic country, denoted as DID in Table 5, is positively and significantly related with economic freedom ($\beta = .133$, $p < .01$, $ci = [.068 .198]$) and press freedom ($\beta = .084$, $p < .01$, $ci = [.030 .137]$). In addition, while press freedom is positively associated with national innovation output ($\beta = .317$, $p < .01$, $ci = [.137 .496]$), the effects of democracy and economic freedom on national innovation output are not statistically significant. Furthermore, our DID approach is similar to Gao et al. (2017) except they dropped the countries categorized as a democratic state during their sample period. We find a similar result even if we drop the democratic country during the whole sample period.

-- Insert Figure 1 here--

For the IV-2SLS method, we used the government fractionalization index as an instrumental variable for democracy. We obtained this variable from the Database of Political Institutions (Beck et al., 2001). This variable captures the extent of fractionalization of a composition of a party or members of legislators.

IVs must satisfy two criteria to be considered valid. The first criterion is known as relevance. That is, our IV must be sufficiently correlated with our endogenous variable, democracy. The government fractionalization index captures the extent of fractionalization of

a party or members of legislators. As a result, the more fractionalized they are, the more likely they will work on independent policies and raise more decentralized voices toward the government (Bjorvatn, Farzanegan, & Schneider, 2012). This implies that the government fractionalization index is positively correlated with democracy. Subsequently, the rule of thumb on the first stage F-statistic recommends that its value exceeds 10 (Staiger & Stock, 1997). While Models 7 and 8 in Table 5 clearly exceeds the threshold, Models 5 and 6 in Table 5 indicate values that are approximately 10.

To ensure our instrument does not suffer from a weak instruments problem, we follow this literature's recommendations (Andrews, Stock, & Sun, 2019). Specifically, the literature suggests the *two step confidence sets* approach: (1) assess the identification strength, and (2) report a confidence set chosen based on the assessment (i.e., First Stage $F \geq 10$ (or not)). The "problem" of weak instruments then is that, rather than reporting the correct confidence set (i.e., identification-robust when weak instruments are suspected) researchers often decide to either look for a different specification or simply decide not to report the results altogether (Andrews, 2018). Hence, screening entirely on F-statistics can make published results less reliable. In line with these recommendations and in addition to first-stage F-statistics, we report the first-stage t-statistics and their robust confidence set. We find the government fractionalization is statistically significantly associated with democracy in the first stage regressions across all the models: Model 5 ($\beta = 1.182$, t-value = 3.10, $p < .01$, ci = [.433 1.931]), Model 6 ($\beta = 1.226$, t-value = 3.10, $p < .01$, ci = [.449 2.003]), Model 7 ($\beta = 1.828$, t-value = 4.62, $p < .01$, ci = [1.052 2.604]) and Model 8 ($\beta = 1.619$, t-value = 3.39, $p < .01$, ci = [.682 2.557]). Moreover, following the advice by Andrews (2018) and Andrews et al. (2019), we report the robust-confidence set⁶ for our second-stage regression results: Model 5 ($p = .348$, ci

⁶ The robust-confidence set is the Anderson-Rubin (AR) test statistic for the 95 percent confidence interval (Andrews, 2018; Andrews et al., 2019).

= [-.098 .450]), Model 6 ($p = .407$, $ci = [-.074 .169]$), Model 7 ($p = .000$, $ci = [.066 .218]$), and Model 8 ($p = .548$, $ci = [-.267 .148]$). These robust-confidence sets support our hypothesis that democracy influences innovation through the channel of press freedom. The robust-confidence sets and First-stage F-statistic also suggest government fractionalization as an instrumental variable satisfies the relevance criterion. Furthermore, even when following the most conventional criterion, the usage of our IV can still be justified, as the F-statistic for Models 7 and 8 of Table 5 clearly exceeds 10, thereby re-affirming the indirect mediation effect of press freedom.

The second criterion is that IVs must satisfy the exclusion restriction, which says the IV must be uncorrelated with the error term. That is, the IV must not directly influence the dependent variable except through the endogenous variable, not be affected by the dependent variable except through the endogenous variable, and not be correlated with omitted variables in the model (Wooldridge, 2010). Democratic countries are likely to have more political parties, as democracy typically guarantees people to freely choose their governing legislators. Since the composition of different political parties purely reflects a party system characteristics (Dalton, 2008), it does not have industrial or economic implications. For instance, it is not difficult to argue that the diversity of political parties does not determine the policy orientation of a country toward its industrial and economic agenda. Thus, we use the government fractionalization index as an instrumental variable to generate the result as shown in Table 5.

The IV results show a similar pattern to our earlier findings with one exception—democracy is no longer related to economic freedom. Despite the difference, it does not alter our main findings on the indirect effect of democracy on national innovation output via press freedom.

-- Insert Table 5 here--

Furthermore, we employ alternative measures of economic freedom and press freedom to rule out the possibility that our findings are driven by the mediating variables. Instead of relying on the data from the Fraser Institute (Gwartney et al., 2019) and the Reporters Without Borders (Faccio, 2006), we utilized the economic freedom and press freedom indices from the Heritage Foundation (Miller, Holmes, & Feulner, 2012) and the Freedom House (Freille, Haque, & Kneller, 2007), respectively. Moreover, as some studies raised a concern that the size of government is not a congruent measure of economic freedom (Bergh, 2020, Ott, 2018), we calculated the economic freedom variable by excluding the size of government.

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, Stam, & Takeuchi, 2016). Finally, we lagged our explanatory variables by two years (Furman & Hayes, 2004) and allowed one year time lag on our mediating variables.

In all cases, the results remain stable and qualitatively similar, which supports the indirect relationship between democracy and national innovation output via press freedom.

DISCUSSION AND CONCLUSION

Prior research examining the democracy-innovation relationship 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, 2005, 2012). In order to advance our understanding of the democracy-innovation relationship, this study develops a novel theoretical framework that informs our knowledge of the specific mechanisms through which democracy influences innovation, which hitherto have not been understood. Specifically, we theorize the two possible mechanisms, which consider economic freedom and press freedom as mediators of the relationship between democracy and innovation. Using a large sample of 1,395 country-year

observations consisting of 130 countries over the period 2000 to 2010, we found that whereas the democracy-innovation relationship is positively mediated by press freedom, economic freedom does not mediate the democracy-innovation relationship.

Our conceptual framework and empirical findings generate several theoretical contributions and implications. First, we advance our understanding of the two possible mechanisms, which consider economic freedom and press freedom as mediators of the relationship between democracy and innovation. In particular, while it is well known that innovation requires intense search and recombination of existing knowledge with other available knowledge (Dosi & Nelson, 2010; Fleming, 2001; Katila & Ahuja, 2002; Nelson & Winter, 1982), the role of press freedom as a mechanism to facilitate information and knowledge flow within societies for entrepreneurs has been largely overlooked by national innovation studies. In line with the gap in the literature, our findings underscore the important role of press freedom as a mediator between democracy and innovation, while economic freedom does not show a statistically significant mediating effect. As such, democracy facilitating press freedom by freeing information flow can benefit entrepreneurs to combine broader domains of knowledge and a wider range of networks and perspectives, thereby generating innovative outputs.

Secondly, although institutional theory immensely contributed to the entrepreneurship and innovation literature, limited attention has been paid to the information-processing implications of institutions for entrepreneurs. This is an important point to consider because entrepreneurs 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 behaviour (North, 1990), our study blends institutional

theory and information processing theory to theorize that institutions not only (economically) incentivize entrepreneurs to innovate but also encourage entrepreneurs to freely combine information and ideas to generate innovation. Thus, these two complementary perspectives enable us to provide a more convincing 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 censorship. In particular, prior censorship studies focus on understanding how governments practice media controls (Lorentzen, 2014) or how censorship affects personal attitudes or beliefs (Chen & Yang, 2019). Therefore, our study broadens this literature by revealing the real economic consequences of such policy.

The current study also offers important policy implications. Gradually or increasingly democratizing states often tend to focus on pursuing free market model to incentivize their entrepreneurs without much consideration on freeing the information flow. In this line, our analysis finds that democracy enhances economic freedom. Interestingly, we also report that economic freedom does not significantly mediate the relationship between democracy and innovation, while press freedom significantly mediates the relationship between democracy and innovation. Thus, our study highlights the importance of improving information access through which the democracy-innovation relationship is strengthened.

In this sense, our finding underscores the importance of establishing a fair and free press in the development of an innovative society. Although our analysis shows that democracy enhancing press freedom played a key role in national innovation, countries with different institutional settings may take a different approach. For instance, during the period when some East Asian economies made a rapid technological and economic catching-up, they were governed under a dictatorship or an authoritarian regime (see Hahm & Plein, 1995; Kim, 2004;

Motohashi & Yun, 2007). Despite some exceptions, policymakers in general should put more effort into propagating and promoting a more independent and fair press to stimulate the independent flow of information, thereby fostering innovation.

Finally, it is often taken for granted that prosperous nations, which include some of the largest and oldest elected democracies in the world, tend to have greater press freedom than poorer countries. However, this trend is far from consistent. Even elected leaders in democratic countries, which are known for having free and independent media, have tried to silence critical outlets and promote those that offer favourable 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
Dependent Variable										
1	1									
Independent Variable										
2	0.42*	1								
Mediator Variables										
3	0.55*	0.51*	1							
4	0.43*	0.74*	0.58*	1						
Control Variables										
5	0.58*	0.29*	0.59*	0.36*	1					
6	0.62*	0.31*	0.72*	0.49*	0.68*	1				
7	0.41*	0.01	-0.20*	-0.21	-0.07*	-0.17*	1			
8	0.14*	0.10*	0.24*	0.01	0.03	0.16*	-0.13*	1		
9	0.45*	0.22*	0.56*	0.35*	0.58*	0.76*	-0.13*	0.13*	1	
10	-0.02	-0.03	0.34*	0.05	0.19*	0.25*	-0.36*	0.26*	0.17*	1
Number of Observations										
	1720	1762	1462	1461	1562	2095	2321	2321	2321	2025
Mean										
	2.07	3.46	6.72	-0.83	2.59	8.41	15.15	4.29	56.34	90.85
S.D.										
	2.68	6.47	0.98	0.49	1.41	1.54	2.34	1.58	24.52	52.00

^a Logarithm transformed. * denotes 0.05 statistical level

Table 2. Predicting the national innovation output with mediation analysis using the fixed effect regression

	Model (1) Number of patents ^a	Model (2) Econ freedom	Model (3) Press freedom	Model (4) Number of patents ^a
Democracy	-0.028 (0.02)	0.024** (0.01)	0.016** (0.01)	-0.023 (0.02)
Economic freedom				0.111 (0.12)
Press freedom				0.335*** (0.10)
Secondary schooling year	0.156 (0.15)	-0.150** (0.07)	-0.078 (0.06)	0.071 (0.13)
GDP per capita ^a	1.098*** (0.24)	0.903*** (0.22)	-0.119 (0.11)	0.825*** (0.28)
Population ^a	5.570 (5.50)	-2.842 (3.23)	0.111 (2.47)	9.585*** (3.63)
Population density ^a	-4.495 (5.63)	3.572 (3.33)	-0.040 (2.54)	-8.421** (4.07)
Urbanization	0.019 (0.02)	-0.004 (0.01)	0.000 (0.01)	0.008 (0.02)
Economic openness	0.001** (0.00)	0.000 (0.00)	0.001*** (0.00)	0.001 (0.00)
Constant	-80.754 (67.17)	31.179 (39.04)	-1.245 (30.24)	-128.110*** (43.53)
Year Fixed	Yes	Yes	Yes	Yes
Country Fixed	Yes	Yes	Yes	Yes
R ²	0.133	0.267	0.193	0.135
Number of countries	115	123	129	106
Number of observations	1132	1250	1119	807

*p < 0.10, ** p < 0.05, *** p < 0.01. ^a Logarithm transformed. Robust standard errors are in parentheses.

Table 3. Predicting the indirect effects of democracy on national innovation output with bootstrapping

	coeff	bias	se	p-value	Lower CI	Upper CI
Direct effects						
Democracy -> Economic freedom	0.024***	0.000	0.006	0.000	0.014	0.036
Democracy -> Press freedom	0.016***	0.000	0.005	0.001	0.007	0.026
Democracy -> National innovation	-0.023*	0.000	0.012	0.052	-0.050	-0.001
Indirect effects						
Democracy -> National innovation via economic freedom	0.003	0.000	0.002	0.285	-0.002	0.008
Democracy -> National innovation via press freedom	0.005**	0.000	0.002	0.018	0.002	0.011
Total indirect effect						
Total indirect effects of democracy -> National innovation	0.008**	0.000	0.003	0.021	0.002	0.016

*p < 0.10, ** p < 0.05, *** p < 0.01.

Table 4. Predicting the national innovation output with mediation analysis using the structural equation modeling

	Model (1) Economic freedom	Model (2) Press freedom	Model (3) Number of patents ^a
Democracy	0.024** (0.01)	0.016** (0.01)	-0.023 (0.02)
Economic freedom			0.111 (0.11)
Press freedom			0.335*** (0.10)
Secondary schooling year	-0.150** (0.07)	-0.078 (0.06)	0.071 (0.13)
GDP per capita ^a	0.903*** (0.22)	-0.119 (0.11)	0.825*** (0.27)
Population ^a	-2.842 (3.20)	0.111 (2.46)	9.585*** (3.59)
Population density ^a	3.572 (3.31)	-0.040 (2.52)	-8.421** (4.03)
Urbanization	-0.004 (0.01)	0.000 (0.01)	0.008 (0.02)
Economic openness	0.000 (0.00)	0.001*** (0.00)	0.001 (0.00)
Constant	32.147 (40.87)	-2.255 (31.53)	-132.907*** (45.14)
N	1250	1119	807

*p < 0.10, ** p < 0.05, *** p < 0.01. ^a Logarithm transformed. Robust standard errors are in parentheses.

Table 5. Robustness tests using DID and IV-2SLS

	DID				IV-2SLS			
	Model (1) Number of patents ^a	Model (2) Economic freedom	Model (3) Press freedom	Model (4) Number of patents ^a	Model (5) Number of patents ^a	Model (6) Economic freedom	Model (7) Press freedom	Model (8) Number of patents ^a
DID	-0.112 (0.07)	0.133*** (0.03)	0.084*** (0.03)	-0.107 (0.08)				
Democracy					0.089 (0.10)	0.041 (0.05)	0.119*** (0.03)	-0.052 (0.09)
Economic freedom				0.090 (0.08)				0.122 (0.12)
Press freedom				0.317*** (0.09)				0.358*** (0.13)
Secondary schooling year	0.171* (0.09)	-0.149*** (0.05)	-0.088** (0.04)	0.075 (0.10)	0.325** (0.14)	-0.176*** (0.06)	-0.093 (0.06)	0.112 (0.13)
GDP per capita ^a	1.109*** (0.16)	0.910*** (0.08)	-0.121 (0.07)	0.851*** (0.23)	1.273*** (0.21)	0.903*** (0.09)	-0.021 (0.11)	0.819*** (0.31)
Population ^a	5.639 (3.89)	-2.595 (2.03)	-0.059 (1.95)	9.797* (5.53)	7.978 (4.89)	-1.395 (2.10)	3.944 (3.12)	11.578* (6.76)
Population density ^a	-4.592 (3.95)	3.341 (2.07)	0.121 (1.97)	-8.625 (5.68)	-7.610 (5.20)	1.700 (2.20)	-4.802 (3.22)	-10.902 (7.05)
Urbanization	0.019* (0.01)	-0.004 (0.01)	0.001 (0.00)	0.007 (0.02)	0.013 (0.01)	-0.008 (0.01)	-0.001 (0.01)	0.012 (0.02)
Economic openness	0.001 (0.00)	0.000 (0.00)	0.001*** (0.00)	0.001 (0.00)	-0.001 (0.00)	-0.001 (0.00)	0.000 (0.00)	0.001 (0.00)
Constant	-81.638* (47.53)	28.054 (24.60)	0.916 (23.83)	-130.847* (67.54)	-109.555* (59.33)	15.529 (25.33)	-45.652 (38.25)	-150.693* (82.52)
Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.124	0.254	0.182	0.129				
First stage F-stat					9.584	9.589	21.386	11.511
Number of countries	115	123	129	106	114	122	128	105
Number of observations	1132	1250	1119	807	1050	1178	1051	759

*p < 0.10, ** p < 0.05, *** p < 0.01. ^a Logarithm transformed. Models 1-4 are estimated with DID method, while Models 5-8 are estimated with IV-2SLS using government fractionalization index as an instrumental variable. Standard errors are in parentheses.

Figure 1. The trend of national innovation outputs across different types of countries

