What Affects Innovation More: Policy or Policy Uncertainty?

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ABSTRACT
Motivated by a theoretical model, we empirically examine for 43 countries whether it is policy or policy uncertainty that affects technological innovation more. We find that innovation, measured by growth in patent counts, citations, and originality, is not, on average, affected by which policy is in place. Innovation, however, drops significantly during times of policy uncertainty measured by national elections. To address endogeneity concerns, we use close presidential elections whose timings are pre-determined and results are unpredictable and ethnic fractionalization that are likely exogenous to policy and policy uncertainty. Political compromise, our paper concludes, is a plus for encouraging innovation.

Keywords: innovation; policy uncertainty; policy; political party

JEL classification: G18, G38, O31, D80, E66
1. Introduction

The important role of technological innovation in promoting a nation’s long-term economic growth and competitive advantage has been established since the seminal work of Solow (1957).1 Although a growing literature has examined various empirical links between innovation and firm- or market-specific characteristics, rigorous empirical studies that explore how politics affects technological innovation are sparse. Politics is important to innovation because politicians make policy and regulatory decisions that frequently alter the economic environment in which innovative firms operate, which ultimately affects a nation’s innovation growth. For example, in the 2013 edition of the Global Innovation Index (Dutta and Lanvin, 2013) that serves as a comprehensive measure of innovation in an economy, the very first two indicators are political stability and government effectiveness under the political environment category.2 In this paper, we contribute to this nascent literature by examining the real effects of politics on innovation. Specifically, we study whether technological innovation is more affected by policy or by policy uncertainty.

Innovation is a special investment in long-term, intangible assets. It is different from regular investment in tangible assets such as capital expenditures because of its longer investment time horizon and higher tail risk. The economic factors affecting it are also different from the economic factors affecting regular investment.3 Hence, while existing studies show that policy uncertainty adversely affects investment in tangible assets (e.g., Alesina and Perotti, 1996; Bloom, Bond, and Van Reenen, 2007; Julio and Yook, 2012; and Gulen and Ion, 2015), it is unclear how policy uncertainty affects investment in intangible assets that cause technological innovation. Further, though one can measure the effect of policy uncertainty on quantity of ordinary capital investment, one cannot easily judge its effect on quality and originality of ordinary capital investment. We do not face this issue for technological innovation. In patent data, which we use to capture innovation, we observe both the number of patents a country generates

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1 According to Rosenberg (2004), about 85% of economic growth is attributable to technological innovation.
2 The Global Innovation Index (GII) is an index ranging from 0 to 100 that is developed by the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations.
3 For instance, the IPO literature shows that going public allows firms to raise equity capital to increase capital expenditures. However, Lerner, Sorensen, and Stromberg (2011) show that private instead of public ownership promotes innovation because private ownership allows more failure tolerance from investors. While existing studies argue that financial analysts reduce information asymmetry and the cost of capital, which in turn increases capital expenditures (e.g., Derrien and Keckes, 2013), Benner and Ranganathan (2012) and He and Tian (2013) find that analysts hinder innovation because they impose short-term pressure to meet earnings target on managers.
(quantity of innovation) and the number of citations these patents receive subsequently (quality of innovation). In addition, based on the distribution of citations across technology classes, we are even able to calculate the originality of these patents, which allows us to gauge the fundamental value of the innovation.

We propose two hypotheses in this paper regarding the relative importance of policy or policy uncertainty in determining technological innovation, based on the existing literature. Our first hypothesis, the “policy hypothesis”, states that it is policy that most affects innovation. If one defines policy in the left-right spectrum (as does the World Bank, where we obtain our policy data from), a right-leaning (left-leaning) government would (would not) prefer labor-saving innovations in robotic technology. If one defines policy in the liberal-conservative spectrum, a conservative (liberal) government would (would not) prefer innovations in old and established industries like oil and gas. If one defines policy in the religious spectrum, a secular (religious) government would (would not) prefer innovations in birth control. The point of our first hypothesis is simply that policies matter for innovation.

An alternative, though not a mutually exclusive hypothesis, referred to as the “policy uncertainty hypothesis”, argues that it is policy uncertainty that most affects innovation. Starting from Bernanke (1983), various theoretical models (e.g., Chen and Funke, 2003; Bloom, Bond, and Van Reenen, 2007; and Bloom, Draca, and Van Reenen, 2011) show that if investment projects are not fully reversible, firms become cautious and hold back on investment in the face of uncertainty because uncertainty increases the value of the option to wait. The value of the option to wait is particularly important for investments in research and development (R&D), given that innovation is the exploration of unknown approaches and untested methods (Holmstrom, 1989; and Aghion and Tirole, 1994) that requires considerable investment in intangible assets. The value of the option to wait is even more important for innovation in an uncertain political environment because, as we discussed earlier, the value of success in innovative exploration depends on which government is in power. The following example from the United States illustrates this point. The “left” in the U.S. prefers to subsidize innovations in solar and wind energy, whereas the “right” in the U.S. prefers to subsidize innovations in fracking methods in oil and gas. An energy company, which is deciding on whether to spend its R&D dollars on developing prototypes of better solar cells or better fracking pumps for oil and
gas, may wish to postpone this decision until after the elections. Therefore, the uncertainty hypothesis argues that it is policy uncertainty that most affects innovation.

To illustrate the relative importance of policy versus policy uncertainty in determining innovation, we develop a simple model based on Manso (2011) and Ferreira, Manso, and Silva (2014) that incorporates the merits of both hypotheses. Though insights on the effect of uncertainty and on modeling innovation have been developed in the past literature, our theoretical model is needed because it helps us understand and develop testable implications on the argument that is completely new in our paper – the horse-race between policy and policy uncertainty.

Our model considers an economy in which businesses adapt to their policy environment to produce appropriate innovations, but innovations produced under one policy environment are less appropriate for a different policy environment. Though our model has four testable implications, the implication that is not obvious at all and that is most relevant for our case is: policy uncertainty is more important than policy in countries where a political party does not dominate in the realm of efficiency in promoting innovation, and vice versa. To save space, we show our model in Appendix.

To empirically test the above implication, we have to overcome two main empirical hurdles. First, though the World Bank defines policy for researchers (left-of-center, center, or right-of-center), it is difficult to capture policy uncertainty. Although existing work has used various firm-specific proxies to capture the uncertainty faced by firms and other economic agents (these proxies include stock return volatility, the dispersion in analyst forecasts, and input and output prices, as well as certain types of macroeconomic policy such as fiscal, monetary, and social security policies), these measures do not capture the overall level of policy uncertainty in the economy. To clear this hurdle, following Julio and Yook (2012), we use national elections (including presidential and parliamentary elections) in 43 countries to capture policy uncertainty. Because election outcomes are relevant to all aspects of policies such as fiscal,

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4 An alternative proxy is the political risk rating in the International Country Risk Guide (ICRG) database. As argued in Henisz (2000), those ratings are based on subjective opinions and are not closely linked to political institutions.
monetary, trade, social security, industry regulation and taxation, national elections are a reasonable proxy for overall policy uncertainty.5

The second hurdle of our study is to identify the causal effect of policy or policy uncertainty on technological innovation, which is due to both omitted variables and reverse causality concerns. Certain unobservable country characteristics that affect both policy or policy uncertainty and innovation could potentially bias our estimation and make correct statistical inferences hard to draw (the omitted variables problem). In addition, expected differences in nations' innovation intensity and innovation potential could affect their current policy as well as policy uncertainty (the reverse causality concern).

To deal with omitted variables that do not vary with time, we include country-industry fixed effects in our regressions. This strategy implies that our research design exploits the time-series variation within country-industry units; the cross-sectional variation across these units just adds power. This research design also dictates our choice of countries: we can use only 43 countries that have elections in which different parties not only can win but do win. To deal with time-varying omitted variables as well as reverse causality, we use close presidential elections. As argued by Julio and Yook (2012), presidential elections around the world provide a natural and clean experimental framework for studying how politics influences many economic decisions – in their case it was firm investments in tangible assets – because the timing of presidential elections is out of the control of any firms, and is fixed in time by constitutional rules for presidential elections. We move one step further and focus on close presidential elections because the election results are unpredictable and reasonably exogenous.

Our second identification attempt is to rely on ethnic fractionalization, which is exogenous to most economic and political factors (see Alesina et al. (2003) for a discussion). Because the social disruptions caused by elections are more pronounced in a society of higher disagreement, higher distrust, and greater ethnic tension, we expect that ethnic fractionalization amplifies the adverse effect of policy and policy uncertainty on innovation (e.g., Connor, 1994; La Porta, Lopez-de-Silanes, Shleifer, and Vishny, 1999; and Radro i Miquel, 2007).

To capture innovation in the cross-country framework, we use observable innovation outputs (successful patent applications) to assess a country’s innovativeness at both country and

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5 We mainly focus on policy uncertainty instead of economic uncertainty. Nevertheless, we find that the occurrence of national elections is significantly and positively correlated with the occurrence of over-50% growth in the economic uncertainty index of Baker, Bloom, and Davis (2013).
country-industry levels. Our use of patenting as a proxy for innovation has become standard in the innovation literature (e.g., Acharya and Subramanian, 2009; Bloom, Draca, Van Reenen, 2011; and Hsu, Tian, and Xu, 2014). We collect country-industry-level innovation data from two databases that contain detailed information of U.S. patents and their inventors. For each industry in each country every year, we calculate the annual growth of patent counts, patent citations, and patent originality, because the economics literature has extensively documented the value-relevance of these three patent-based measures. In addition, we also consider the annual growth of total R&D expenses reported by all publicly-listed firms in the Worldscope database as a supplementary proxy of innovation.

We then collect national elections and political characteristics data from the 2010 version of the Database of Political Institutions (DPI2010). Because a national election is our key variable of interest, we restrict our sample to countries with free elections. The intersection of these two databases is a panel data set of 43 countries over the period 1976-2005. Our sample includes countries from different continents, cultures, and ethnicities, and has both developed and emerging economies.

Our regression results based on country-industry-year observations show that the growths in patent counts, patent citations, and patent originality are not affected by which policy (left, right, or center) is in power; nevertheless, they decrease significantly during election years (a measure of significant policy uncertainty). We use the growth instead of the level in patent-based measures because the patent level tend to be time-persistent and vary across countries to a great extent. We also find that R&D growth is not affected by policy but is negatively affected by policy uncertainty. In these tests, we control for country-industry fixed effects, year fixed effects, and other variables that existing literature has shown to affect industry-level innovation growth. Our finding is robust to controlling for tertiary school enrollment, public education spending, and intellectual property protection in these multivariate tests. Our results continue to hold for close presidential elections, which as we discussed before, ameliorates some of the endogeneity concerns in our empirical setting. We further mitigate endogeneity concerns by showing that the

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6 The first database is the Harvard Business School (HBS) Patent Inventor Database of Lai et al. (2011) that contains detailed information of patent inventors’ residences and allows us to measure innovation activities in each country and industry. The second database is the NBER Patent Database developed by Hall, Jaffe, and Trajtenberg (2001) that includes technology classes and citations of granted patents. We use U.S. patents instead of patents issued by individual economies to ensure the consistency and comparability of the quality, economic value, legal protection, and application procedure in patent output across different economies (e.g., Jaffe and Trajtenberg, 2002; and Lerner, 2009).
negative effect of political uncertainty on innovation is stronger among ethnically heterogeneous countries. Since it is difficult to think of an omitted variable that is correlated with (or at least coincidently correlated with) ethnic fractionalization and affects both policy uncertainty and innovation, this result is consistent with a causal interpretation for the relation between policy uncertainty and innovation.

Finally, we explore one possible underlying mechanism through which policy and policy uncertainty may affect innovation. We find that individuals’ and organizations’ incentives to innovate (measured by the numbers of patent inventors and patenting organizations that have filed at least one patent in the sample year) are not affected by policy but are negatively affected by policy uncertainty. This finding supports the logic of our theoretical model that policy uncertainty lowers firms’ incentives to innovate and thus results in fewer inventions.

How do we interpret our results in the light of our model? First, our model suggests that the dependent variable should be the input of innovation (R&D), not the output of innovation (patents). We use patents as our main innovation proxy because R&D data has some issues, e.g., available only for public firms, not available for emerging markets in the earlier time period, and varies largely across countries due to difference in accounting conventions (Keller, 2004). Nevertheless, we obtain consistent results when we redo our tests using R&D data. Second, the main testable implication of our model is that policy uncertainty is more important than policy in countries where a political party does not dominate in the realm of efficiency in promoting innovation, and vice versa. A cross-sectional dissection of our results shows that in 37 of the 43 countries we study no political party dominates in the realm of innovation efficiency. That is why we find that, on average, policy uncertainty affects innovation more than policy does. In the other 6 countries, this is not true: right-leaning governments are best for innovation in 4 countries (New Zealand, South Korea, Sweden, and U.K.), and left-leaning governments are best for innovation in 2 countries (Austria and Israel). Other testable implications – close election years hurt innovation the most amongst all years and innovation is not affected by policy at all in non-election election years – are also largely supported by our empirical results.

Our paper adds to the growing literature on the negative effect of policy uncertainty on both the firm’s real investment decisions and stock market performance. On the real investment front, the empirical literature probably starts with Alesina and Perotti (1996), who show that income inequality increases political instability, which, in turn, reduces investments, using data
data and show that firms’ investment response to stimulus is weaker when uncertainty is higher.
In a series of papers, Julio and Yook (2012, 2013) find that during election years, firms reduce
capital expenditures as well as foreign direct investment flows to foreign affiliates compared to
nonelection years. Gulen and Ion (2015) similarly find that policy uncertainty is negatively
related to firm and industry level capital investment.

On the capital market front, Pastor and Veronesi (2012) build a general equilibrium
model and show that although a policy change might increase the potential cash flow, it also
increases discount rates because the new policy’s impact on profitability is more uncertain.
Combining these two effects, announcement of new policy can depress stock returns. Pastor and
Veronesi (2013) further show that political uncertainty reduces the value of the implicit put
protection offered by the government, which increases the risk premium. Durnev (2011) finds
that policy uncertainty reduces firm investment’s sensitivity to stock prices and attributes this
finding to increased noise contained in stock prices. Butchkova et al. (2012) show that both
national and global political uncertainty (e.g., national elections) leads to higher stock return
volatility. Brogaard and Detzel (2012) find that economic policy uncertainty is negatively
(positively) associated with contemporaneous (future) stock returns. Kelly, Pastor, and Veronesi
(2014) examine the pricing of political uncertainty and show that options whose lives span
political events, and therefore provide protection against the risk associated with political events,
tend to be more expensive.

While existing literature appears to reach a consensus view that policy uncertainty
reduces investment in tangible assets such as capital expenditures, our paper compliments this
literature by studying the effect of policy uncertainty on investment in long-term, intangible
assets like technological innovation that is vital for nations’ economic growth and competitive
advantage. We also, to the best of our knowledge, are the first to show that innovation, on
average, is more affected by policy uncertainty than by policy.

Our paper also contributes to the literature that links various macroeconomic and firm-
specific factors to innovation. However, existing studies have largely ignored the role played by

7 Existing studies find that financial market development (Hsu et al., 2014), a larger institutional ownership (Aghion,
Van Reenen, and Zingales, 2013), banking competition (Cornaggia et al., 2015), corporate venture capital
(Chemmanur et al., 2014), and private rather than public equity ownership (Lerner et al., 2011) promote innovation.
Other studies have examined the effects of product market competition, bankruptcy laws, general market conditions,
politics. Our paper contributes to this line of research by filling in this gap, and provides new insights on the impact of politics on innovation activities.

2. Proxies and sample construction

2.1 Proxies for policy and policy uncertainty

Our proxy for policy uncertainty is national elections, both presidential and parliamentary. We focus on election events, instead of numeric political risk indices, in our baseline analysis for several reasons. First, the data on numeric political indices are sparse. Second, national elections in which political leaders are elected and economic policies are determined serve as an effective set-up to examine the effects of policy uncertainty on real activities such as investment and equity trading (e.g., Julio and Yook, 2012; Bouchkova et al., 2012). Third, elections are not subject to biases in survey sampling and model estimation.

Our proxy for policy is the orientation of the party or individual that makes policy in a country. We collect this information from the Database of Political Institutions (DPI) developed by the World Bank (Keefer, 2010) that includes political system, policy orientation, and elections of 180 countries from 1970 to 2010. We use the DPI variable, SYSTEM, and define country i’s political system in year t \((\text{System}_{i,t})\) as the value of SYSTEM in country i in year t. We use the DPI categorization for SYSTEM: Presidential (0), assembly-elected president (1), and parliamentary (2). We define an election dummy \((\text{Election}_{i,t})\) that equals one if country i holds any legislative or executive election in year t, and zero otherwise. We again use the DPI data – legislative election (LEGELEC) years or executive election (EXELEC) years to define election years – which, as we discussed before, will be our main proxy for policy uncertainty.

stock liquidity, firm boundaries, and investors’ attitudes toward tolerance on firm innovation (e.g., Aghion et al., 2005; Acharya and Subramanian, 2009; Nanda and Rhodes-Kropf, 2013; Fang et al. 2014; Seru, 2014; and Tian and Wang, 2014).

8 The economic policy uncertainty indices developed by Baker, Bloom, and Davis (2013) cover only nine countries: Canada, China, France, Germany, India, Italy, Spain, U.K., and U.S. Among these covered countries, only China and India are developing economies and their time series indices are short (the indices for China and India start from 1995 and 2003, respectively).

9 Presidential system is defined as (a) countries with unelected executives, (b) countries with presidents who are elected directly or by an electoral college in cases where there is no prime minister, (c) countries with both a prime minister and a president, but the president can veto legislation, can appoint and dismiss prime minister, or can dissolve parliament and call for new elections. Parliamentary system is defined as countries in which the legislature elects the chief executive and can easily recall the chief executive. Assembly-elected presidential system is defined as countries in which the legislature elects the chief executive and cannot easily recall the chief executive.
The DPI also categorizes the party orientation (EXECRLC) of country executives (presidents or prime ministers) into three major groups using a consistent standard: right (1), center (2), and left (3). Similarly, the DPI categorizes the party orientation (GOV1RLC) of government parties into right (1), center (2), and left (3). To make the interpretation of these values more intuitive, we shift the values of EXECRLC and GOV1RLC from right (1), center (2), and left (3) to right (–1), center (0), and left (1), respectively. We define country i’s policy in year t (Policyi,t) as EXECRLC of country i on January 1st in year t; when EXECRLC of country i in year t is missing, we let Policyi,t equal GOV1RLC of country i on January 1st in year t. This variable is our proxy for policy.

It is worth noting that DPI adopts a country-specific standard in assigning political orientation; it is possible in their classification that the policies of one country’s right-wing parties may be more left than the policies of another country’s left-wing parties (for example, in many dimensions, the right-wing Christian Democrats in Germany are more “left” than the left-wing Democrats in the U.S.). It should also be noted that in our analysis of policy, since we use country-adjusted innovation in the univariate analysis and country-fixed effects in the multivariate analysis, the policies are country-specific. Further, though DPI uses the terms “left”, “center” and “right” for classifying policy, and so do we, we do not interpret our results with this political jargon.

2.2 Proxies for aggregate innovation

We first construct empirical proxies for country-level innovation using the Harvard Business School (HBS) Patent Inventor Database of Lai et al. (2011) that contains detailed information of patents granted by the United States Patent and Trademark Office (USPTO) from

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10 Right denotes parties that are defined as right-wing, Christian democratic, or conservative. Left denotes parties that are defined as left-wing, communist, socialist, or social democratic. Center denotes parties that are defined as centrist or when party position can best be described as centrist. There is another category “Other” that includes all those cases which do not fit into the above-mentioned three categories. We exclude the other category from our sample because our main goal is to understand the policy-innovation relation.

11 Put differently, in terms of our paper, we can classify policies as “x”, “y” and “z”, and nothing will change.
1976 to 2006. We obtain data on the top 60 countries with the most patents granted by the USPTO over the period of 1976-2005.

We define several innovation measures at the country level. Later, we will use a similar definition for industry-level innovation in regression analyses. The first innovation proxy is patent growth of country \( i \) in year \( t+1 \) as \( \text{Patent}_{i,t+1} = \ln(\text{patent}_{i,t+1} / \text{patent}_{i,t}) \), where patent\(_{i,t}\) denotes the number of successful patent applications in the U.S. (i.e., patent applications that are later granted by the USPTO) that are invented by residents of country \( i \) and filed to the USPTO in year \( t \).

Despite the straightforward interpretation of \( \text{Patent}_{i,t+1} \), we recognize that this growth measure based on patent counts does not identify the influence of groundbreaking inventions. Therefore, we consider the next innovation proxy based on the number of citations received by granted patents: \( \text{Citation}_{i,t+1} = \ln(\text{citation}_{i,t+1} / \text{citation}_{i,t}) \), where citation\(_{i,t}\) denotes the number of adjusted citations received by patents that are invented by residents of country \( i \) and filed to USPTO in year \( t \). As suggested in prior studies (e.g., Trajtenberg, 1990; Harhoff et al., 1999; and Aghion, Van Reenen, and Zingales, 2013), patent citations reflect the influence of inventions and better capture the quality of aggregate innovation and its market value.

In addition to the quantity and quality of patents, we consider patent originality that reflects the fundamental value of innovation. Following Hall, Jaffe, and Trajtenberg (2001), we define a patent’s originality score as one minus the Herfindahl index of the six technology categories distribution of all the patents it cites. A high originality score suggests that the patent is based on a more diverse array of existing technologies; thus, the patent is considered to be more original because it follows traditional technology trajectories less. Existing literature has shown that innovation often demands the use of multi-disciplined knowledge (Arora and

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12 As discussed before, using U.S. patent data to measure cross-country innovation performance has been widely adopted in recent studies (e.g., Griffith, Harrison, and Van Reenen, 2006; Acharya and Subramanian, 2009; and Hsu et al., 2014). This approach is commonly adopted in the literature for three reasons. First, the territorial principle in U.S. patent laws requires anyone intending to claim exclusive rights for inventions in the U.S. to file U.S. patents. Second, following prior studies, we assume that all important inventions from other countries have been patented in the U.S. because the U.S. has been the largest technology consumption market in the world over the past few decades. Third, the use of U.S. patents ensures the consistency and comparability of the quality, economic value, legal protection, and application procedure in patent output across different economies (e.g., Jaffe and Trajtenberg, 2002; and Lerner, 2009).

13 http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_at.htm

14 This measure is sometimes referred to as “citation-based patent counts” in the literature. Since the NBER patent database tracks citations until 2006, appropriate adjustment for such a truncation bias is necessary. Therefore, we use a weighting factor developed by Hall, Jaffe, and Trajtenberg (2001) to adjust the number of patent citations.
Gambardella, 1990; and Ahuja, 2000), and patents with higher originality scores tend to carry higher market value (Hirshleifer, Hsu, and Li, 2014). We then aggregate individual patents’ originality scores at the country level and compute our third innovation growth measure:

\[ \text{Originality}_{i,t+1} = \ln(\frac{\text{originality}_{i,t+1}}{\text{originality}_{i,t}}), \]

where originality\(_{i,t}\) denotes the originality scores of all patents that are invented by residents of country \(i\) and filed to USPTO in year \(t\).

A few issues about our innovation measures are worth discussing. First, we calculate the number of annual country-level patents, citations, and originality scores based on their application years instead of grant years because the application years are better aligned with the time when firms make their decisions (Griliches, Pakes, and Hall, 1988; and Hall, Jaffe, and Trajtenberg, 2001, 2005). Second, we assign patents to countries by their inventors instead of assignees (i.e., owners) to better measure the intensity of innovative activities in each country and to avoid a potential sampling bias due to the fact that some multi-national enterprises outsource their research activities overseas (see Chung and Alcácer, 2002). Third, we use the logarithmic scale to mitigate the skewness in patent growth. Fourth, and last, we use annual growth instead of annual level in patents as our main variable of interest because patent levels tend to be persistent and vary across countries to a great extent.

### 2.3 Sample construction

Among the top 60 patent-filing economies in the USPTO, we exclude China, Hong Kong, Kuwait, Saudi Arabia, and United Arab Emirates (UAE) because there is no election data in these economies from DPI. We exclude Belgium, Cuba, Iran, Taiwan, and Thailand because there is only one party orientation (right, left, or center) in these economies. Egypt, Indonesia, Malaysia, and Singapore are excluded because their party orientation is categorized as “others” across all years. Czech, Slovenia, and Yugoslavia are excluded from our sample due to data availability issues. These filtrations lead to the following 43 countries in our final sample: Argentina, Australia, Austria, Bulgaria, Brazil, Canada, Chile, Colombia, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Romania, Russia, South Africa, South Korea, Spain, Sweden, Switzerland, Turkey, Ukraine, Uruguay, UK, USA, and Venezuela.
Our final data set is a panel for these 43 countries. The panel starts in 1975 and ends in 2005 because our innovation measures, which are one year ahead of policy and election variables, are available from 1976 to 2006. Our panel contains annual data for these 43 counties on their political systems, policies, policy uncertainty (election year), and various innovation measures. Other control variables of these countries are available from the World Development Indicators and Global Development Finance (WDI/GDF) database. An important control variable is the annual growth in gross domestic product (GDP), because this variable is likely to correlate with subsequent innovation. \( \text{GDP}_{i,t} \) denotes the growth of GDP in country \( i \) in year \( t \).

2.4 Summary statistics

Table 1 reports the descriptive statistics and correlation coefficients of all variables used in our analyses.

Table 1 Panel A shows the time series averages and standard deviations of the political variables. We first observe that 29 countries have never changed their political system (System) throughout the sample period. Among them, 10 countries adopt the presidential system (0) in all years, while 19 countries adopt the parliamentary system (2) in all years. In terms of policy, all countries have switched between policies (this is by sample construction), some more frequently than others. Denmark, France, Germany, and Greece have the highest standard deviations in Policy: 1.01. Luxembourg, Iceland, and Colombia are the most stable countries in Policy with standard deviations of 0.37, 0.42, and 0.44, respectively. Moreover, the average of all countries’ standard deviations is as high as 0.79, suggesting that we have substantial variation in Policy. In addition, we find that the frequency of right-wing governments is higher than that of left-wing governments in our sample countries: 26 countries have an average under 0 and 17 countries have an average over 0 (recall that we code the right as –1 and the left as 1).

Table 1 Panel A also presents the cross-sectional variation in the frequency of national elections. U.S., Portugal, Russia, and Ukraine lead other countries in Election with averages larger than 0.40, corresponding to having at least one election every two and half years. Uruguay, Bulgaria, Luxembourg, and Chile appear to have the lowest electoral frequencies (with an average Election < 0.20). Hence, there is substantial variation in the other variable of interest: Policy uncertainty. In the same panel, we find that South Korea has the highest GDP growth on
average (6.8% per year), while Ukraine is the only country with a negative average GDP growth (–1.6% per year) in the sample period.

Table 1 Panel A also provides the time series average and standard deviations of our innovation growth measures (Patent, Citation, and Originality). South Korea leads all countries in all three growth rates with an average Patent, Citation, and Originality of 0.23, 0.13, and 0.27, respectively.

Table 1 Panel B reports the Pearson correlation coefficients (and p-values in parentheses) of System\(_{it}\), Policy\(_{it}\), Election\(_{it}\), GDP\(_{it}\), Patent\(_{it+1}\), Citation\(_{it+1}\), and Originality\(_{it+1}\). We report the correlation between all innovation growth measures in year \(t+1\) and all other variables in year \(t\) because, following the literature, we focus on the effect of policy and policy uncertainty in year \(t\) on innovation performance in year \(t+1\). The assumption is that the success or failure of an innovative project, and the subsequent decision to file a patent, is determined one year after the innovative experiment is undertaken.\(^{15}\) We recognize that the election month may matter in the sense that the consequence of an election held in the first half of the year may occur earlier than that held in the second half of the year. To address this concern, we also examine the effect of elections held in the last-half year on innovation in year \(t+2\) in later analyses.

Table 1 Panel B shows that political system, policy, policy uncertainty, and GDP growth are not correlated with each other (except that System\(_{it}\) is positively correlated with Election\(_{it}\)). More importantly, the correlation between political system and patent growth and the correlation between GDP growth and patent growth are insignificant, suggesting that neither political systems nor prosperous economic development leads to more innovation. Even more importantly, we find that patent growth is negatively correlated with policy and policy uncertainty with correlation coefficients of –0.05 and –0.06 (p-values are 0.08 and 0.02), respectively, suggesting that right-wing governments are more beneficial to innovation than left-wing governments, and that policy uncertainty, measured by electoral frequency, is negatively related to innovation. Moreover, we find that citation growth and originality growth also negatively correlate with Election\(_{it}\) with correlation coefficients of –0.04 and –0.08 (p-values are 0.16 and 0.01),

\(^{15}\) Although it takes time for policies and policy uncertainty to affect innovation, prior studies suggest that the average lag between R&D investment and patent applications is often within one year (see Hausman, Hall, and Griliches, 1984; and Hall, Griliches, and Hausman, 1986). This viewpoint is widely accepted in contemporary empirical studies for determinants of innovation in high-tech industries (e.g., Lerner and Wulf, 2007; Aghion, Van Reenen, and Zingales, 2013; and Bloom, Schankerman, and Van Reenen, 2013). Thus, it seems reasonable to assume that policy and policy uncertainty in year \(t\) affect innovation investment in year \(t\) and patent filings in year \(t+1\). This also is an assumption of our theoretical model.
respectively. Although the evidence appears to suggest that national elections slow down patent growth and originality growth, these estimates are just meant to be suggestive because the effects of other control variables, such as industry effects, country effects, and year effects, are not taken into consideration. Nevertheless, Table 1 points to an intriguing relation between politics and innovation, and motivates our further analyses.

3. Multivariate regression results

3.1 Policy, policy uncertainty, and innovation

We construct a country-industry-year panel to examine the effects of policy and policy uncertainty on innovation. Some countries may be more diversified amongst different technologies, while others may be more concentrated in some specific technologies. For the latter countries, the predominance of some industries could affect our analysis of the effect of policy and policy uncertainty on innovation in two ways. First, countries and politicians may use R&D tax credit and government resources to support some selected high-tech industries. So the innovation growth of those countries could be driven by one or two industries that are particularly sensitive to policy orientation and political stability. Second, technological innovation is subject to exogenous country and industry endowments because some industries are particularly well developed in certain countries due to natural resources and geographic reasons (e.g., Ellison and Glaeser, 1997). For these industries, they are naturally less subject to government instability. All these issues make it necessary to look into the effect of policy and policy uncertainty on innovation in a multivariate regression framework, using a country-industry-year panel and controlling for country-industry fixed effects.

We estimate the following panel regression model to examine the effect of policy and policy uncertainty on innovation:

\[
\text{Innovation}_{j,i,t+1} = \alpha + \beta_1 \text{Election}_{i,t} + \beta_2 \text{Policy}_{i,t} + \beta_3 \text{GDP}_{i,t} + \beta_4 \text{Innovation}_{j,i,t+\tau} + \gamma_{j,i} \text{Country-industry}_{j,i} + \rho_t \text{Year}_t + e_{j,i,t+\tau},
\]  

(1)

where the dependent variable, \( \text{Innovation}_{j,i,t+\tau} \), is the logarithmic growth rate of one of our innovation measures (\( \text{Patent}_{j,i,t+\tau} \), \( \text{Citation}_{j,i,t+\tau} \), and \( \text{Originality}_{j,i,t+\tau} \)) in industry \( j \) in country \( i \) in
To better capture the effect of elections and associated policy orientation on innovation, we let \( \tau = 1 \) when there is an election in the first-half of year \( t \), and we let \( \tau = 2 \) when there is an election in the second half of year \( t \).

The first key independent variable is \( \text{Election}_{i,t} \). It is an indicator variable that equals one if there is at least one election in country \( i \) in year \( t \) and zero otherwise. This variable measures policy uncertainty. The sign and magnitude of the estimate of \( \beta_1 \) suggest how and to what extent policy uncertainty influences country-industry-level innovation growth.

The second key independent variable is \( \text{Policy}_{i,t} \) which is either \( \text{Left}_{i,t} \) or \( \text{Right}_{i,t} \). \( \text{Right}_{i,t} \) is an indicator variable that equals one if country \( i \)'s government is right-wing in year \( t \) and zero otherwise, and \( \text{Left}_{i,t} \) is an indicator variable that equals one if country \( i \)'s government is left-wing in year \( t \) and zero otherwise. These variables measure policy. Note that by using the above research design, we examine whether the right is better than the rest, and then whether the left is better than the rest. Therefore, the sign and magnitude of the estimate of \( \beta_2 \) suggest whether one economic policy is significantly more effective in promoting innovation than others do.

The other control variables are as follows. \( \text{GDP}_{i,t} \) denotes the growth of GDP of country \( i \) in year \( t \). GDP growth controls for the effect of aggregate economic conditions on innovation. \( \text{Innovation}_{j,i,t+\tau-1} \) denotes lagged innovation growth. Lagged innovation growth controls for the persistence of industry-level technological progress. This attenuates the reverse causality issue, which could occur if \( \text{Innovation}_{j,i,t+\tau} \) is persistent and directly affects the timing of national elections in year \( t \) or \( t+1 \).

Finally, we include country-industry fixed effects (\( \text{Country-industry}_{j,i} \)) and year fixed effects (\( \text{Year}_t \)), following Julio and Yook (2012). Country-industry fixed effects capture any characteristics associated with specific industries in certain countries, and take care of the concern that our analysis of policy uncertainty on innovation is biased by some particular
industries or countries. Year fixed effects control for any time-varying common component in either global business cycles or time-series patterns in U.S. patent grants. Year fixed effects also help to correct the bias related with application lags and vintage issues, if any. We cluster standard errors in two ways by both country-industry and year to accommodate time series errors in the same industry in the same country and cross-correlational errors in the same year. Further, we winsorize the innovation growth variables at the 1st and 99th percentiles to prevent inference biases driven by outliers. We separately report the results in all 43 sample countries (Panel A) and 37 countries in which no policy dominates (Panel B) in Table 2. In the robustness check section, we control for school enrollment, intellectual property protection, and public education investment.

Columns (1) and (2) of each panel in Table 2 report the results estimating Equation (1) in which innovation is measured by patent growth. As shown in these columns, the coefficient estimate of $Election_{i,t}$ is negative and significant, suggesting that patent growth declines on average one year after national elections in all 43 countries and also in all the 37 countries in which a policy does not dominate. The economic magnitude of such a drop in innovation ranges from 10.2% to 12.4%, which is larger than that documented in Julio and Yook (2012), who find that policy uncertainty reduces capital expenditures by an average of 4.8%. This finding is consistent with the intuition that intangible investment is in general riskier than physical investment, due to the potential leverage of growth options, and so is affected by policy uncertainty to a greater extent.

We find that in all columns, the coefficient estimate of $Policy_{i,t}$ (where policy is $Left_{i,t}$ or $Right_{i,t}$) is not statistically different from zero. This observation suggests that patent growth is not affected by policy in all 43 countries and also in all the 37 countries where a policy does not dominate. These findings suggest that economic policy does not affect subsequent innovation in general.

In addition, the coefficient estimate of $GDP_{i,t}$ is insignificant, indicating that economic prospects do not affect intangible investment. Moreover, the significantly negative coefficient estimate of lagged patent growth suggests that patent growth tends to revert in the next year. When we consider the benchmark model in which we exclude $Election_{i,t}$, we find similar

18 In Table A6 in the Internet Appendix, we find that right-oriented policy dominates others in promoting innovation in New Zealand, South Korea, Sweden, and UK, and that left-oriented policy dominates others in promoting innovation in Austria and Israel. The other 37 countries exhibit no such dominance by a policy.
coefficients of these control variables, suggesting that the election-innovation relation is distinct from other forces.

Columns (3) and (4) of each panel in Table 2 report the results based on citation growth. The evidence suggests a stronger adverse effect of policy uncertainty (as measured by Election) on innovation from a quality perspective. As shown in these columns, the coefficient estimate of Election_{i,t} is statistically negative. The economic magnitude of such a drop in innovation ranges from 10.5% to 14.0%. In comparison with patent growth, we find that policy uncertainty has a larger effect on innovation quality than on innovation quantity. In addition, we note that policy does not appear to affect citation growth.

Columns (5) and (6) of each panel in Table 2 give even stronger results based on patent originality growth. The coefficient estimate of Election_{i,t} is negative and significant in all specifications. The magnitude of such a drop in innovation ranges from 13.2% to 15.6%, which is economically sizable, suggesting that policy uncertainty leads to less original inventions. Again, we see that policy does not affect patent originality growth.

Overall, the results presented in Table 2 support the hypothesis that policy uncertainty (as measured by elections) adversely affects innovation quantity, quality, and originality. Firms under policy uncertainty tend to generate fewer and less influential inventions and engage in less original projects. The other important result is that policy, on average, does not affect innovation quantity, quality, or originality.

We also estimate Equation (1) using the industrial R&D growth as the dependent variable, which is defined as ln( R&D_{j,i,t+\tau} / R&D_{j,i,t+\tau-1} ), where R&D_{j,i,t+\tau} denotes the total R&D expenses reported by all public-listed firms in industry j in country i in year t+\tau in the Worldscope database. The test results reported in Table 3 indicate that the finding using R&D expenditures as a proxy for innovation is consistent with our baseline results. As shown in Columns (1) and (2), the coefficient estimate of Election_{i,t} is –4.5% and significant at the 1% level, suggesting that firms’ incentives to invest in R&D activities significantly decline on average after national elections in all 43 countries.19

Although these R&D results are supportive, we have to interpret them with caution due to data completeness, managerial discretions, and heterogeneous accounting standards of R&D

19 We do not exclude the six countries (Austria, Israel, New Zealand, South Korea, Sweden, and UK) in which one policy dominates others in promoting innovation because these six countries are identified based on patent-based innovation measures instead of R&D activities.
expenses.\textsuperscript{20} Thus, we treat R&D as a supplementary proxy instead of the major one used in our main analysis.

3.2 Close Presidential Elections

To further strengthen our identification for the causal relation between political uncertainty and innovation, we consider close presidential elections as an alternative event of interest. Presidential elections are more exogenous than parliamentary elections. According to Julio and Yook (2012), all presidential elections in countries in our sample are held on a regular basis and can thus be considered as having exogenous timing. On the other hand, parliamentary elections may be subject to endogenous timing (e.g., Heckelman and Berument, 1998).

If election outcomes are predictable, there should be little uncertainty about future policy. Therefore, we further classify presidential elections as close and not close. Close presidential elections are better proxies for policy uncertainty. These elections introduce exogenous shocks and thus raise political uncertainty (e.g., Snowberg, Wolfers, and Zitzewitz, 2007). Therefore, a strong relation between close presidential elections and subsequent innovation growth would imply a stronger causal effect of policy uncertainty on innovation.

Because DPI does not report the percentages of votes received by runner-ups in presidential elections that are necessary for us to define close elections, we resort to the Election Results Archive (ERA), a collection of electronic files that contain data on global election results and are maintained by the Center on Democratic Performance in Binghamton University. The ERA also reports the percentages of votes received by all presidential candidates, allowing us to construct our variable of interest ($CloseElection_{i,t}$) for country $i$ in year $t$. We code this variable as one if there occurs a presidential election in which the margin between the winner’s vote percentage and the runner-up’s is within the 5% range in country $i$ in year $t$, and zero otherwise. Based on this definition, we obtain 11 close presidential election events: Argentina in 2003, Colombia in 1978 and 1994, Philippines in 1992 and 2004, Poland in 1995, Uruguay in 1994, the United States in 1976, 2000, and 2004, and Venezuela in 1978.

\textsuperscript{20} Complete country-level R&D data for developing countries are unavailable until most recently (e.g., Keller, 2004). However, these data are usually unavailable at the industry level; thus, we resort to the Worldscope database, which covers only publicly traded firms and leaves out R&D efforts that privately held firms and individuals conduct. In addition, the practice of reporting R&D is sensitive to accounting standards such as whether it should be capitalized or expensed, as argued by Acharya and Subramanian (2009). In fact, many non-U.S. firms do not report or are not required to report R&D expenses in their financial statements. Lastly, R&D activities may be subject to managerial discretions and associated agency costs due to their accounting treatment (Dechow and Sloan, 1991; Lev, 1999).
We run the regression estimating Equation (1) and replace \( E_{i,t} \) with \( C_{i,t} \), which is an indicator variable equal to one if there is one close presidential election in country \( i \) in year \( t \) and zero otherwise. The other variables and the interpretations of their coefficient estimates remain the same as in Equation (1).

Table 4 reports the results for close elections. As in Table 2, we report the results for patent growth rate, citation growth rate, and originality growth rate when we include all 43 countries (Panel A) and the 37 countries where a policy does not dominate (Panel B). Columns (1) and (2) of each panel show that the coefficient estimates of \( C_{i,t} \) are negative and significant at the 1% level for future patent growth and range from –65.4% to –74.0%. These estimates are much larger in magnitudes in comparison with those in Table 2, consistent with the intuition that a higher level of policy uncertainty captured by close elections leads to a greater effect on innovation. We observe similar patterns in Columns (3) and (4) for citation growth and Columns (5) and (6) for originality growth. All these findings suggest that firms engage in a lower level of intangible investments and pursue less influential and original inventions when policy uncertainty rises in close elections. These results help strengthen the causality that runs from policy uncertainty to innovation.

Meanwhile, we notice in Table 4 that policy still does not affect innovation. First, the coefficient estimates of \( R_{i,t} \) and \( L_{i,t} \) are insignificant in all panels, consistent with our prior findings that policy does not affect innovation on average. Overall, we do not find consistent evidence that left-center or center or right-center policies are more or less beneficial to innovation.

3.3 Subsample analysis based on ethnic fractionalization

We next explore how ethnic fractionalization (i.e., how divided and diverse a country is in terms of ethnic composition) alters the effect of policy and policy uncertainty on innovation to further establish the causal link. We postulate that ethnic fractionalization amplifies the adverse effect of policy uncertainty on innovation because it has the following features.\(^{21}\) First, ethnic

\[^{21}\text{It is common in the economics and political science literature to treat ethnic distribution as an exogenous variable to political dynamics and economic growth. According to Alesina et al. (2003), “Ethnic fractionalization indices are generally taken as exogenous in cross-country regressions, based on the fact that group shares are sufficiently stable that changes only have a minor impact on fractionalization measures. This seems a reasonable assumption at the 30 year horizon of the typical cross-country regression, even though this assumption may be less tenable for a much longer horizon.”}\

19
division likely increases political polarization and thereby impedes the formation of social consensus on economic policies (Easterly and Levine, 1997). Second, Knack and Keefer (1997) find that ethnically homogeneous countries possess greater “social capital” (i.e., trust and civic norms). Third, Connor (1994) suggests that the real source of civil violence and rebellion is often ethnic nationalism. Finally, La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1999) and Padro i Miquel (2007) argue that, in ethnically heterogeneous societies, it is common for the in-power ethnic group to adopt discriminative policies to maintain political dominance. Therefore, when a society is full of disagreement and distrust, lacks social norms and fairness, and is subject to potential civil violence, it is more likely for any political election to result in a greater disruption among all socioeconomic groups.

To empirically test our conjecture, we collect ethnic distribution of all our countries from the CIA World Factbook, and construct two ethnic concentration proxies following the literature. The first proxy is the share of the largest ethnic group (e.g., Keefer and Knack, 2002), and the second one is the Herfindahl index based on the shares of different ethnic groups (e.g., Alesina et al., 2003). It is clear that these two indices are negatively related to ethnic fractionalization status. In each year, we assign a country to be the high (low) ethnic concentration group if its ethnic concentration is above (below) the yearly median.

Our strategy is to conduct subsample regressions and to compare the coefficients on the variable of interest across the two subsamples. Specifically, we conduct the regression of Equation (1) for the high and low subsamples and then test if the coefficient on Election_,_ from the low ethnic concentration group (i.e., high ethnic fractionalization group) is significantly lower than that from the high ethnic concentration group (i.e., low ethnic fractionalization group). Due to space limitations, we report the main results based on patent growth in 43 countries in Table 5 and leave all other specifications to Table A1 in the Internet Appendix. Panel A presents the results based on the share of the largest ethnic group. In Model 1, we find that the coefficient estimates on Election_,_ are –5.9% and –15.5% in the high and low concentration groups with t-statistics of –2.08 and –3.23, respectively. These estimates suggest that innovation growth drops by 5.9% (15.5%) when there is an election in an ethnically homogenous (heterogeneous) country. Moreover, the difference between these two estimates (in the bottom of the panel) is 9.6% and

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22 We are able to collect the data for the following years: 1982, 1984-1987, and 1989-2006. We fill in the missing data (1976-1981 and 1983) using the 1982 data.
statistically significant \((t\) statistic is \(-2.01\)). In Model 2, we find that the coefficient estimates on \(Election_{i,t}\) are \(-6.0\%\) and \(-15.2\%\) in the high and low concentration groups with \(t\)-statistics of \(-2.14\) and \(-3.18\), respectively, and the difference in coefficient estimates is \(-9.3\%\) and statistically significant \((t\) statistic is \(-1.95\)).

Panel B presents the results based on the Herfindahl index of ethnicity distribution. Again, the coefficients on \(Election_{i,t}\) are in general lower in countries with higher ethnic fragmentation. The economic magnitude and statistical significance in the difference between the coefficients are similar to Panel A. Table 5 thus suggests that patent growth after election in an ethnically heterogeneous country drops almost 10\% more than that in an ethnically homogenous country.

Table A1 in the Internet Appendix presents similar results when we examine other innovation proxies (citation growth and originality growth) and use the 37 countries where a policy does not dominate. In Panels A and B, we find that citation growth (originality growth) after election in an ethnically heterogeneous country drops around 17.1\% (6.3\%) more than that in an ethnically homogenous country.

Overall, our subsample regressions based on ethnic fragmentation suggest that when policy uncertainty occurs, the heterogeneity in population seems to strengthen the negative effect of policy uncertainty. This finding helps strengthen the causal interpretation for policy uncertainty on innovation. If both elections and innovation growth are driven by an omitted variable, then the influence of this omitted variable should be consistent with the observed cross-sectional variation of ethnic fractionalization. It is, however, difficult to think of an omitted variable that affects both policy uncertainty and innovation and is also correlated with ethnic fractionalization in this way. Hence, the documented effect of policy uncertainty on innovation is likely to be causal.

### 3.4 Policy, policy uncertainty, and the incentive to innovate

We next explore possible mechanisms through which policy and policy uncertainty affect innovation. Individuals can choose to become an inventor, and firms can choose to engage in conventional projects or innovative projects. Given that population size is stable across years, more individuals and firms filing patents reflect a stronger incentive to innovate. We use the growth of the numbers of patent inventors and assignees to reflect the change in incentives to innovate. We define the former as the growth of the number of individuals that have filed at least
one patent in a sample industry-year, and the latter as the growth of the number of assignees (mainly firms but also including universities, governments, and hospitals) that have filed at least one patent in a sample industry-year.

We estimate the following panel regression model to examine the effect of policy and policy uncertainty on individuals’ and firms’ incentive to innovate:

\[
\text{Incentive}_{j,i,t+\tau} = \alpha + \beta_1 \text{Election}_{i,t} + \beta_2 \text{Policy}_{i,t} + \beta_3 \text{GDP}_{i,t} + \beta_4 \text{Incentive}_{j,i,t+\tau-1} + \gamma_{j,i \text{Country-industry}_{j,i}} + \rho_t \text{Year}_{t} + e_{j,i,t+1},
\]  

(2)

where the dependent variable, \(\text{Incentive}_{j,i,t+\tau}\), is either \(\text{Inventor}_{j,i,t+\tau}\) (Panel A) or \(\text{Assignee}_{j,i,t+\tau}\) (Panel B). \(\text{Inventor}_{j,i,t+\tau}\) denotes the growth rate in the number of patent inventors who have filed at least one patent in industry \(j\) in country \(i\) in year \(t+\tau\). \(\text{Assignee}_{j,i,t+\tau}\) denotes the growth rate in the number of patent assignees that have filed at least one patent in industry \(j\) in country \(i\) in year \(t+\tau\). Similar to Equation (1), we let \(\tau = 1\) when there is an election in the first-half of year \(t\), and let \(\tau = 2\) when there is an election in the second half of year \(t\). As defined earlier, \(\text{Election}_{i,t}\) and \(\text{Policy}_{i,t}\) capture policy uncertainty and policy, respectively. Other variable definitions are the same as before.

In Table 6, we find that the agent’s incentive to innovate in an economy is severely affected by policy uncertainty but not by policy. Panel A includes all 43 countries, while Panel B includes the 37 countries where a policy does not dominate. Columns (1) and (2) in Panel A report the test results estimating Equation (2) where incentive is measured by the growth of patent inventors. As shown in both columns, the coefficient estimate of \(\text{Election}_{i,t}\) is \(-6.9\%\) with statistical significance, suggesting that individuals’ incentives to invent significantly decline on average one year after national elections in all 43 countries. Columns (1) and (2) in Panel B present an even stronger pattern: the coefficient estimate of \(\text{Election}_{i,t}\) is \(-8.5\%\) and is significant at the 1% level. These estimates suggest that individual’s incentive to innovate drops by at least 6.9% when there is an election. In Columns (3) and (4) of each panel, we measure incentives to innovate by the number of patenting organizations. In these columns, the coefficient estimates of \(\text{Election}_{i,t}\) are negative with sizable magnitudes throughout all specifications but are not statistically significant. Nevertheless, in later robustness check, we find that the coefficient estimates of \(\text{Election}_{i,t}\) become statistically significant when we add more control variables in the regressions.
However, the coefficient estimate of $Policy_{i,t}$, regardless of whether it is $Left_{i,t}$ or $Right_{i,t}$, is not statistically different from zero in all columns in Table 6, suggesting that individuals’ or firms’ incentive to innovate is not affected by policy. This observation helps explain our main finding that a country’s policy does not appear to affect its innovation.

Overall, the results presented in Table 6 confirm our theoretical model’s testable implication that firms avoid innovative projects when policy uncertainty heightens. Further, the identification of this mechanism that explains why policy uncertainty is negatively linked to innovation lends further support to a causal interpretation of our main results.

4. Robustness checks

4.1. Robustness checks for baseline results

The first robustness check we do is to re-estimate Equation (1) by letting $\tau = 1$. This way, we examine the effect of elections in year $t$ on innovation growth in year $t+1$, regardless of whether elections are held in the beginning or at the end of year $t$. The regression results reported in Table A2 in the Internet Appendix support our previous finding. As Panel A shows, the coefficient estimates of $Election_{i,t}$ are significantly negative and range between $-7.7\%$ and $-8.7\%$ when we do the regressions in all 43 countries. When we restrict our sample to the 37 countries where a policy does not dominate, we find an even more severe effect of political uncertainty: the coefficient estimates of $Election_{i,t}$ are significantly negative and range between $-10.0\%$ and $-10.9\%$.

Our second robustness check is to augment Equation (1) with three country-level control variables that are expected to be important determinants of innovation. The first variable, tertiary school enrollment, is defined as the percentage of population attending tertiary education institutes (i.e., college and universities). The second variable, public education spending, is defined as the percentage of total public spending on education to GDP. We obtain both variables from the WDI/GDF database. The third variable is intellectual property protection index that is obtained from Ginarte and Park (1997) and Park (2008).23

Table A3 in the Internet Appendix suggests that our baseline results in Table 2 remain robust after controlling for these three innovation determinants. As all columns in Panel A show,  

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the coefficient estimates of \( Election_{i,t} \) are significantly negative and range between \(-8.1\%\) and \(-11.1\%\) in regressions including all 43 countries. In addition, Panel B shows that the coefficient estimates of \( Election_{i,t} \) are significantly negative and range between \(-13.3\%\) and \(-15.7\%\) in the 37 countries where a policy does not dominate. All coefficient estimates are commensurate to their counterparts in Table 2. Policy, however, still does not affect innovation in all columns except one.

Table A4 in the Internet Appendix suggests that our results from Table 6 – policy uncertainty rather than policy reduces individuals’ incentive to innovate – remain robust after controlling for tertiary school enrollment, public education spending, and intellectual property protection index. Meanwhile, the coefficient estimates of \( Election \) become significant for firms’ incentive to innovate after controlling for the three variables.

4.2. Univariate analysis for individual countries

Till now we have reported the results based on the sample that groups all the countries together. One concern is that our results may be driven by outlier countries. To address this concern, we conduct a univariate analysis for individual countries by comparing the time series averages of each country’s innovation conditional on having elections or not, or policy orientation being left, center, or right. To facilitate our analysis, we use the country-adjusted patent growth as our innovation proxy:

\[
Innovation_{i,t+1}^* = Innovation_{i,t+1} - \text{Average}_i(Innovation_{i,t+1}),
\]  

where \( Innovation_{i,t+1} \) denotes one of our innovation growth measures at the country level: \( Patent_{i,t+1} \), \( Citation_{i,t+1} \), or \( Originality_{i,t+1} \). \( \text{Average}_i(Innovation_{i,t+1}) \) denotes country \( i \)’s average innovation growth of each of these three measures across all sample years.

We first examine whether policy uncertainty is associated with innovation by grouping each country-year sample in “No election” or “Election” and computing the average innovation growth in these two groups in each country. The “Election” group is expected to have higher policy uncertainty in comparison with the “No election” group.

Figure 1 shows the effect of policy uncertainty on innovation. Panel A of Figure 1 shows the pooled average of all country-adjusted patent growth from year \( t-1 \) to \( t+3 \), where \( t \) is the
election year. Panels B and C of Figure 1 show the equivalent figures in citation growth and originality growth, respectively. Dotted lines represent the 90% confidence intervals in all three panels.

We first observe in Panel A that patent growth drops significantly from year $t-1$ to year $t$ (the election year), and further drops in year $t+1$; it recovers gradually in years $t+2$ and $t+3$. This pattern supports our model implications and economic intuition by showing that policy uncertainty stifles patent growth not only in the same year but also in subsequent years $t+1$ and $t+2$. The effect in year $t+1$ is the strongest. Some recovery takes place at $t+2$, which can be explained in two ways: first, other economic forces in year $t+2$ increase innovation and thus weaken the relation; second, firms have adapted to policy changes. We observe a similar pattern in Panels B and C. Figure 1 thus suggests a long-term effect of policy uncertainty on innovation. Even if innovation growth returns to its pre-election level three years after elections, the realized loss due to elections is not fully recovered.

Panel A of Table A5 in the Internet Appendix shows the tabular results for country-adjusted patent growth rate for each country. Among all sample countries, 27 countries have a higher patent growth after no-election years, while the other 16 countries have a higher patent growth after election years. We find that no election years are associated with a significantly higher patent growth in four countries: Austria (the difference is 11% with a $t$-statistic of 2.09), Brazil (the difference is 26% with a $t$-statistic of 2.15), Luxembourg (the difference is 26% with a $t$-statistic of 2.08), and South Africa (the difference is 25% with a $t$-statistic of 2.50). The only country in which innovation is significantly higher in election years is Argentina (the difference is –37% with a $t$-statistic of 2.24). More importantly, when we pool all country-year observations together for comparisons in the very top row of Table A5 Panel A, we find that patent growth is 1.5% and –4.9% following no-election years and election years, respectively. The difference of 6.4% is statistically significant with a $t$-statistic of 2.31. We observe similar patterns in Panels B and C for country-adjusted citation growth rate and originality growth rate, respectively. Overall, Table A5 suggests that policy uncertainty, captured by national elections, is associated with a lower level of innovation quantity, quality, and originality, supporting our argument and baseline results.

24 To ensure that our results are not affected by elections in other years, we drop $Patent_{i,t-1}$, $Patent_{i,t+1}$, $Patent_{i,t+2}$, and $Patent_{i,t+3}$ from the calculation of pooled averages if country $i$ has election in year $t-1$, $t+1$, $t+2$, and $t+3$, respectively. Nevertheless, we find similar patterns if we do not impose the above restriction.
Figure 2 shows the effect of policy orientation on innovation. Figure 2 Panel A1 shows the difference in mean between country-adjusted patent growth in left-oriented governments and that in other governments (i.e., right and center) from year $t-1$ to $t+3$. Panel A2 shows the difference in mean between country-adjusted patent growth in center-oriented governments and that in other governments (i.e., left and right) from year $t-1$ to $t+3$. Panel A3 shows the difference in mean between country-adjusted patent growth in right-oriented governments and that in other governments (i.e., center and left) from year $t-1$ to $t+3$. Panels B1 through B3 show the equivalent figures for citation growth. Panels C1 through C3 show the equivalent figures for originality growth. We plot the 90% confidence intervals in dotted lines in all nine panels.

Lines in all nine panels are quite flat, suggesting that while innovation growth is the highest under right-wing parties and lowest under centrist parties, none of the policies dominates the rest. Overall, Figure 2 strongly supports that policy does not affect innovation in the average country.

Panel A of Table A6 in the Internet Appendix reports the results based on patent growth for each individual country. South Korea, the country with the highest innovation growth as reported in Table 1, presents patent growth of 8.3% (–15.9%) when the government is right-oriented (center-oriented). The $t$-statistic of the difference is 2.52, suggesting that right-oriented government is associated with a significantly higher patent growth in the next year. Right-oriented policies are also better than other policies when it comes to patent growth, as evidenced by positive and significant correlations, in New Zealand ($t$ statistic is 2.72), Sweden ($t$ statistic is 2.51), and UK ($t$ statistic is 2.75). We find a similar relation in Canada and Russia, but the correlation is marginally significant. On the other hand, we only observe two countries in which policy of the left-parties dominates other policies for patent growth (Austria and Israel). The left is weakly better for innovation productivity in Italy, but the difference is only marginally significant. In no country does center policy dominate. When we pool all country-year observations together for comparisons and report the results in the top row of Panel A, we find that patent growth is 2.0%, –1.1%, and –0.3% following right-center, center, and left-center policies, respectively, but the differences are not statistically significant.

25 The policy orientation is defined in January 1st of year $t$. To ensure that our results are not affected by policy changes, we drop $\text{Patent}_{i,t-1}$, $\text{Patent}_{i,t+1}$, $\text{Patent}_{i,t+2}$, and $\text{Patent}_{i,t+3}$ from the calculation of pooled averages if country $i$’s policy orientation in year $t-1$, $t+1$, $t+2$, and $t+3$, respectively, is different from that in year $t$. Nevertheless, we find similar patterns if we do not impose the above restriction.
We also do not find any significant differences in citation growth and originality growth in Panels B and C, respectively. Overall, Table A6 suggests that policy is not significantly related to innovation growth in the average country, although we do find it matters in a few countries if we look at individual ones.

5. Conclusion

This paper examines whether it is policy or policy uncertainty that affects technological innovation. Motivated by predictions from a theoretical framework, we empirically test whether policy uncertainty affects a country’s innovation, whether policy affects a country’s innovation, and which of these two affects a country’s innovation to a larger degree. We find that policy, on average, does not affect a country’s innovation quantity, quality, and originality. Policy uncertainty, however, adversely affects a country’s innovation in all these three dimensions. In addition, policy uncertainty hurts the economy’s incentive to innovate, which is a direct channel through which policy uncertainty negatively affects a country’s innovation performance. Moreover, the adverse effect of policy uncertainty on innovation is stronger among ethnically heterogeneous countries.

Our results suggest that businesses adapt to different policies, but face a problem when they do not know which policy to adapt to. Our research thus suggests that in terms of motivating innovation in most democracies, it really does not matter what policy prevails. What matters is political gridlock and the resultant policy uncertainty, because they have real adverse economic consequences – it reduces the quantity, quality and originality of innovation activities in a country. Political compromise, therefore, is good for innovation.
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Appendix. A Simple Model

A.1 Base case

In this section, we adapt the model of innovation developed by Manso (2011) and Ferreira, Manso, and Silva (2014) to include policy and policy innovation. These models employ a bandit problem framework and model investment as “exploitation” of existing ideas and innovation as “exploration” of new ideas.

A firm has to choose between two one-period projects, projects 1 and 2, at two consecutive dates, dates 0 and 1. Each project has two possible outcomes: success or failure. Success yields payoff $S$, and failure yields payoff $F$, with $S>F$. Without loss of generality, let $F=0$ and $S=1$. Following the literature (March, 1991), we call project 1 the exploitation of existing ideas and project 2 the exploration of new ideas. Intuitively, the former corresponds to the investment in well-known technologies that generate a reasonable payoff, while the latter corresponds to the discovery of innovative technologies which have higher idiosyncratic risk but may have higher profits in the remote future. Discount rates are zero.

If the firm chooses project 1, the conventional project, the probability of success is $p>0$. If the firm chooses project 2, the innovative project, the probability of success is $q>0$, which is unknown. Assume that $E[q|F]<E[q]<E[q|S]$. Also assume that $E[q|S]>p$ to eliminate the trivial case in which project 1 strictly dominates project 2. Also assume $E[q]<p$. Define $\delta$ and $\theta$ such that $\delta p = E[q]$ and $\theta p = E[q|S]$. Here $0<\delta<1$, and $1<\theta<1/p$. So,

$$\delta p = E[q] < p < E[q|S] = \theta p$$

(A1)

If the firm chooses the conventional project (project 1) at dates 0 and 1, the ex-ante value of the firm at $t=0$, gross of the initial investment cost, is

$$v_1 = p(1+p) + (1-p)p$$

(A2)

The first term in (A2) is the probability of success at time $t=1$ multiplied by the payoff if there is success (1 plus the expected payoff, $p$, at time $t=2$). The second term in (A2) is the probability of failure at time $t=1$ multiplied by the payoff if there is failure (0 plus the expected payoff, $p$, at time $t=2$).

If the firm chooses the innovative project (project 2) at date 0, the firm continues to use the innovative project (project 2) in the case of a success at date 1, but returns to the conventional project (project 1) in the case of failure at date 1. The ex-ante value of the firm at $t=0$, gross of the initial investment cost, is then
The first term in (A3) is the probability of success at time \( t=1 \) multiplied by the payoff if there is success (1 plus the expected payoff of project 2, \( \theta p \), at time \( t=2 \)). The second term in (A3) is the probability of failure at time \( t=1 \) multiplied by the payoff if there is failure (0 plus the expected payoff of project 1, \( p \), at time \( t=2 \)). The innovative project (project 2) is ex ante preferable to the conventional project (project 1) if and only if

\[
v_2 - v_1 = \delta (1 - p + p\theta) - 1 > 0
\]

i.e.

\[
v_2 > v_1 \iff \delta (1 - p + p\theta) > 1
\]

For innovation to happen, we assume Inequality (A4) holds. For convenience in interpreting economic intuition, we use the difference in the ex-ante values of an innovative project and a conventional project, \( v_2 - v_1 = p[\delta(1-p+\theta p)-1] \) to reflect the incentive to innovate.

A.2 Policy and policy uncertainty

We now adapt the base case model to include policy and policy uncertainty. Policy and policy uncertainty matter in our model because we assume that there is a deadweight cost at \( t=1 \) if any of the projects are undertaken at \( t=0 \) under a particular government policy, but another government policy comes into effect in the future.

We formalize this as follows. At date 0, the firm predicts that the current government policy will continue in the future with probability \( a \). This probability is independent of the probabilities of success and failure of the project.

Let \( c \) be a deadweight cost for the conventional project at \( t=1 \) if the above political prediction turns out to be incorrect. The ex-ante value of the firm if a conventional project is undertaken at time \( t=0 \) is then

\[
v'_1 = pa(1+p) + p(1-a)(1+p-c) + (1-p)ap + (1-p)(1-a)(p-c) = p(1+p) + (1-p)p - (1-a)(pc + (1-p)c)
\]

\[
(A5)
\]

The first term in the first equation in (A5) is the probability of success and correct political prediction at time \( t=1 \) multiplied by the payoff if there is success and correct political
prediction (1 plus the expected payoff, $p$, at time $t=2$). The second term in the first equation in (A5) is the probability of success and incorrect political prediction at time $t=1$ multiplied by the payoff if there is success and incorrect political prediction (1 minus $c$ plus the expected payoff, $p$, at time $t=2$). The third term in the first equation in (A5) is the probability of failure and correct political prediction at time $t=1$ multiplied by the payoff if there is failure and correct political prediction (0 plus the expected payoff, $p$, at time $t=2$). The fourth term in the first equation in (A5) is the probability of failure and incorrect political prediction at time $t=1$ multiplied by the payoff if there is failure and incorrect political prediction (0 minus $c$ plus the expected payoff, $p$, at time $t=2$).

The assumption for the innovative project is similar. We assume that the value of successful innovation is destroyed and reverts to the value of a conventional project if the political prediction turns out to be incorrect at time $t=1$. The ex-ante value of the firm if an innovative project is undertaken at time $t=0$ is then

$$v_2 = \delta p (1 + \theta p) + \delta p (1 - a) (1 + p - c) + (1 - \delta p) ap + (1 - \delta p) (1 - a) (p - c)$$

$$= \delta p (1 + a \theta p + (1 - a) p) + (1 - \delta p) (\delta p (1 - a) (p - c))$$

$$= \delta p (1 + \theta p) + (1 - \delta p) p - [(1 - a) (\delta p (\theta - 1) p + c)]$$

The first term in the first equation in (A6) is the probability of success and correct political prediction at time $t=1$ multiplied by the payoff if there is success and correct political prediction (1 plus the expected payoff, $\theta p$, at time $t=2$). The second term in the first equation in (A6) is the probability of success and incorrect political prediction at time $t=1$ multiplied by the payoff if there is success and incorrect political prediction (1 minus $c$ plus the expected payoff of a conventional project, $p$, at time $t=2$). The third term in the first equation in (A6) is the probability of failure and correct political prediction at time $t=1$ multiplied by the payoff if there is failure and correct political prediction (0 plus the expected payoff, $p$, at time $t=2$). The fourth term in the first equation in (A6) is the probability of failure and incorrect political prediction at time $t=1$ multiplied by the payoff if there is failure and incorrect political prediction (0 minus $c$ plus the expected payoff, $p$, at time $t=2$).

Clearly, $A_2 - A_1 = (1 - a) [\delta p (\theta - 1) p] > 0$ (A7)

Therefore, $v_2 - v_1 = v_2 - A_2 - (A_1 - A_1) = v_2 - v_1 - (A_2 - A_1) < v_2 - v_1$ (A8)

Equation (A8) shows that incentive to innovate (i.e., the difference in the ex-ante values
of an innovative project and a conventional project, \( v_2 - v'_1 = p[\delta - 1 + a\delta \theta (\theta - 1)] \) in election years is lower than that in non-election years \( (v_2 - v_1) \) because \( a < 1 \).

A.3 Inferences and testable implications

The following implications follow from the above results of this model:

1) Incentive to innovate is most affected in close election years, less so in election years, and is unaffected in non-election years. We test this implication.

**Explanation:** The term \( A_2 \) is the adverse effect of policy uncertainty on the innovation project. Notice from Equation (A6) that \( A_2 \) is decreasing in \( a \). As \( a \) is the probability of a correct forecast about the political party that will be in power next year, \( a \) is the highest in non-election years where it is fairly certain which party will be in power the next year, and it is the lowest in close election years where it is not at all clear which party will be in power the next year.

2) Innovation may or may not be affected by policy in non-election years. We test in which countries policies affect innovation the most in non-election years.

**Explanation:** From Section A.1, the difference in incentive to innovate between two political parties, \( i \) and \( j \), with respect to innovation in a non-election year is \( v_2 - v_1 = p[\delta(1 - p + p\theta_i) - 1] - p[\delta(1 - p + p\theta_j) - 1] = \delta p(\theta_i - \theta_j) \), which can be regarded as the effect of policy on innovative projects (relative to conventional projects). The \( \theta \), which we call the “innovation efficiency”, is policy specific. In some countries, \( \theta \) is higher for the left-of-center parties; in some countries, \( \theta \) is higher for the right-of-center parties; in some countries, \( \theta \) is higher for center parties; in some countries \( \theta \) is about the same for all parties. Therefore, in the first three sets of countries, innovation is affected by policy in the non-election years, whereas in the last and fourth set of countries, innovation is not affected by policy in the non-election years. This is an empirical issue.

3) Policy uncertainty is more important than policy in countries where a political party does not dominate in the realm of innovation efficiency, and vice versa. We test this implication and it is our most important test.

**Explanation:** From Section A.2, the difference in incentive to innovate between a close election year and a non-election year, \( (v'_2 - v'_1) - (v_2 - v_1) \) is \( (a - 1)\delta p(\theta_i - \theta) \) for a political party \( i \) and \( (a - 1)\delta p(\theta_j - \theta) \) for a political party \( j \).
– 1) \delta p(\theta_j - 1) \) for a political party \( j \). We note that the difference in these differences is \((a - 1) \delta p(\theta_j - \theta_j)\), suggesting that the important role of policy uncertainty (measured by \( 1 - a \)) given a fixed effect of policy on innovation, \( \theta_i - \theta_j \).²⁶

4) Policy uncertainty affects innovation more adversely than it affects ordinary investments. We do not test this implication because, as our focus is on innovation, it is beyond the scope of the paper.

Explanation: The term \( A_1 \) is the adverse effect of policy uncertainty on the conventional project, whereas the term \( A_2 \) is the adverse effect of policy uncertainty on the innovation project. Notice that \( A_2 > A_1 \) from Equation (A7).

²⁶ For example, \( a \) can range from 0.5 (in years with close election of two candidates) to 1 (no uncertainty in non-election years). On the other hand, it is difficult for us to think that \( \theta \) (the extra value for making successful innovation consistent with the policy) vary much across countries to such a great extent.
Table 1: Summary statistics

Panel A reports the time series averages and standard deviations of $System_{i,t}$, $Policy_{i,t}$, $Election_{i,t}$, $GDP_{i,t}$, $Patent_{i,t+1}$, $Citation_{i,t+1}$, and $Originality_{i,t+1}$ of 43 countries. Panel B reports the pairwise correlation coefficients and $p$-values (in parentheses) of all variables based on all country-year observations. $System_{i,t}$ are categorized into three values: parliamentary (2), assembly-elected president (1), and presidential (0). $Policy_{i,t}$ are also categorized into three values by orientations: right (-1), center (0), and left (1). $GDP_{i,t}$ denotes the annual growth of country $i$’s GDP in year $t$. $Election_{i,t}$ denotes an indicator variable that equals one if there is any national election in country $i$ in year $t$. $Patent_{i,t+1}$ denotes the growth in the number of successful patent applications that are invented by residents of country $i$ and filed to USPTO in year $t+1$. $Citation_{i,t+1}$ denotes the growth in the number of citations received by successful patent applications that are invented by residents of country $i$ and filed to USPTO in year $t+1$. $Originality_{i,t+1}$ denotes the growth in the number of originality scores of successful patent applications that are invented by residents of country $i$ and filed to USPTO in year $t+1$. The sample year $t$ is from 1976 to 2005.

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<td>Policy_{i,t}</td>
<td>Election_{i,t}</td>
<td>GDP_{i,t}</td>
<td>Patent_{i,t+1}</td>
<td>Citation_{i,t+1}</td>
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<td>(1.00)</td>
<td>(0.00)</td>
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</table>
This table reports the results of regressing Innovation\(i,t\) (i.e., innovation growth of industry \(j\) of country \(i\) in year \(t+\tau\), where \(\tau=1\) if the national election occurs in the first half of year \(t\) (January to June) and \(\tau=2\) if the national election occurs in the second half of year \(t\) (July to December)) on Election\(_{i,t}\) (an indicator variable that equals one if there is at least one election in country \(i\) in year \(t\) and zero otherwise), Right\(_{i,t}\) (an indicator variable that equals one if country \(i\)'s government is right-wing in year \(t\) and zero otherwise), Left\(_{i,t}\) (an indicator variable that equals one if country \(i\)'s government is left-wing in year \(t\) and zero otherwise), GDP\(_{i,t}\) (the growth of GDP of country \(i\) in year \(t\)), lagged innovation growth Innovation\(_{i,t+\tau-1}\), country-industry fixed effects, and year fixed effects. Innovation\(_{i,t+\tau-1}\) are defined as Patent\(_{j,i,t+\tau-1}\), Citation\(_{j,i,t+\tau-1}\), or Originality\(_{j,i,t+\tau-1}\). Innovation growth is winsorized at the 1st and 99th percentiles. In Panel A, we include all 43 countries in our sample; in Panel B, we consider only 37 countries by excluding Austria, Israel, Korea, New Zealand, Sweden, and UK because these six countries’ innovation is dominated by right or left orientation (see Table A6). Numbers reported in the parentheses are two-way clustered standard errors by country-industries and by years. The sample year \(t\) is from 1976 to 2005. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

### Table 2: Regression analysis for the relation between policy, policy uncertainty and innovation

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<tr>
<th>Innovation</th>
<th>Patent (t)</th>
<th>Citation (t)</th>
<th>Originality (t)</th>
<th>Patent (t)</th>
<th>Citation (t)</th>
<th>Originality (t)</th>
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<tbody>
<tr>
<td>(Election_{i,t})</td>
<td>-0.102***</td>
<td>-0.102***</td>
<td>-0.106***</td>
<td>-0.105***</td>
<td>-0.132***</td>
<td>-0.132***</td>
</tr>
<tr>
<td>(Left_{i,t})</td>
<td>-0.015</td>
<td>-0.025</td>
<td>-0.043</td>
<td>0.014</td>
<td>-0.023</td>
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<tr>
<td>(Right_{i,t})</td>
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<td>-0.012</td>
<td>-0.012</td>
<td>0.054</td>
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<td>-0.023</td>
</tr>
<tr>
<td>(GDP_{i,t})</td>
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<td>-0.903</td>
<td>-0.651</td>
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<td>Innovation(_{j,i,t+\tau-1})</td>
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<td>-0.142***</td>
<td>-0.160***</td>
<td>-0.160***</td>
<td>-0.147***</td>
<td>-0.147***</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FEs</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Obs.</td>
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<td>19,067</td>
<td>19,240</td>
<td>19,240</td>
<td>16,881</td>
<td>16,881</td>
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<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
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</table>
Table 3: Regression analysis for the relation between policy, policy uncertainty and R&D

This table reports the results of regressing $R&D_{j,i,t+\tau}$ (i.e., the logarithmic growth of R&D expenditures reported by industry $j$ of country $i$ in year $t+\tau$, where $\tau=1$ if the national election occurs in the first half of year $t$ (January to June) and $\tau=2$ if the national election occurs in the second half of year $t$ (July to December)) on $Election_{i,t}$ (an indicator variable that equals one if there is at least one election in country $i$ in year $t$ and 0 otherwise), $Right_{i,t}$ (an indicator variable that equals one if country $i$’s government is right-wing in year $t$ and 0 otherwise), $Left_{i,t}$ (an indicator variable that equals one if country $i$’s government is left-wing in year $t$ and 0 otherwise), $GDP_{i,t}$ (the growth of GDP of country $i$ in year $t$), lagged innovation growth $Innovation_{j,i,t+\tau-1}$, country-industry fixed effects, and year fixed effects. R&D growth is winsorized at the 1st and 99th percentiles. We include all 43 countries in our sample. Numbers reported in the parentheses are two-way clustered standard errors by country-industries and by years. The sample year $t$ is from 1976 to 2005. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

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<th>R&amp;D</th>
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<td>(1)</td>
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<td></td>
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<tr>
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<td>-0.045***</td>
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<td>(-3.145)</td>
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<tr>
<td>$Election_{i,t}$</td>
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</tr>
<tr>
<td>$Left_{i,t}$</td>
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<td>(0.757)</td>
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</tr>
<tr>
<td>$Right_{i,t}$</td>
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<td>-0.023</td>
<td></td>
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<tr>
<td>$GDP_{i,t}$</td>
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<td>(1.459)</td>
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<td>Yes</td>
<td></td>
<td></td>
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<tr>
<td>Year FEs</td>
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Table 4: Regression analysis for the relation between policy, policy uncertainty and innovation: Close presidential elections

This table reports the results of regressing $Innovation_{j,i,t}$ (i.e., innovation growth of industry $j$ of country $i$ in year $t+\tau$), where $\tau=1$ if the close presidential election occurs in the first half of year $t$ (January to June) and $\tau=2$ if the national election occurs in the second half of year $t$ (July to December)) on $CloseElection_{i,t}$ (an indicator variable that equals one if there is at least one presidential election in country $i$ in year $t$ in which the vote difference between the winner and the runner-up is 5% or less, and 0 otherwise), $Right_{i,t}$ (an indicator variable that equals one if country $i$'s government is right-wing in year $t$ and 0 otherwise), $Left_{i,t}$ (an indicator variable that equals one if country $i$'s government is left-wing in year $t$ and 0 otherwise), $GDP_{i,t}$ (the growth of GDP of country $i$ in year $t$), lagged innovation growth $Innovation_{j,i,t-1}$, country-industry fixed effects, and year fixed effects. $Innovation_{j,i,t}$ are defined as $Patent_{j,i,t}$, $Citation_{j,i,t}$, or $Originality_{j,i,t}$. Innovation growth is winsorized at the 1st and 99th percentiles. In Panel A, we include all 43 countries; in Panel B, we consider only 37 countries in the sample by excluding Austria, Israel, Korea, New Zealand, Sweden, and UK because these six countries' innovation is dominated by right or left orientation (see Table A6). Numbers reported in the parentheses are two-way clustered standard errors by country-industries and by years. The sample year $t$ is from 1976 to 2005. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

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Table 5: Regression analysis for the relation between policy, policy uncertainty and innovation quantity:
Subsample analysis for ethnic fractionalization

This table reports the subsample results of regressing $\text{Innovation}_{j,i,t}$ (i.e., innovation growth of industry $j$ of country $i$ in year $t$) on $\text{Elect}_{i,t}$ (an indicator variable that equals one if there is at least one election in country $i$ in year $t$) and $\text{Left}_{i,t}$ (an indicator variable that equals one if country $i$’s government is left-wing in year $t$), lagged patent growth $\text{Patent}_{j,i,t-\tau}$, country-industry fixed effects, and year fixed effects in the low or high subsample by ethnic concentration. In Panel A, we split all sample countries into high and low groups when their largest ethnic groups’ shares are above (below) the median in each year. In Panel B, we split all sample countries into high and low groups when their innovation is dominated by right or left orientation (see Table A6). $\text{Innovation}_{j,i,t}$ is defined as $\text{Patent}_{j,i,t}+\tau$, where $\tau=1$ if the national election occurs in the first half of year $t$ (January to June) and $\tau=2$ if the national election occurs in the second half of year $t$ (July to December). In Table A1 in the Internet Appendix, Panels A and B, the results of $\text{Citation}_{j,i,t}$ and $\text{Originality}_{j,i,t}$ are provided. In Table A1 in the Internet Appendix, Panels C ($\text{Patent}_{j,i,t-\tau}$) D ($\text{Citation}_{j,i,t-\tau}$) and E ($\text{Originality}_{j,i,t-\tau}$), we provide the results for 37 countries by excluding Austria, Israel, Korea, New Zealand, Sweden, and UK because these six countries’ innovation is dominated by right or left orientation (see Table A6).

The sample year $t$ is from 1976 to 2005. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. In the bottom of each panel, we report the difference (and $t$-statistic of the difference) for the coefficient of $\text{Elect}_{i,t}$ between the low and high subsamples.

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<th>Panel A: Largest ethnic group</th>
<th>Panel B: Herfindahl index</th>
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<td>Model 1</td>
<td>Model 2</td>
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<tr>
<td></td>
<td>High</td>
<td>Low</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>$\text{Elect}_{i,t}$</td>
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<td>-0.155***</td>
</tr>
<tr>
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<td>(-2.080)</td>
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</tr>
<tr>
<td>$\text{Left}_{i,t}$</td>
<td>0.081*</td>
<td>-0.111***</td>
</tr>
<tr>
<td></td>
<td>(1.924)</td>
<td>(-2.606)</td>
</tr>
<tr>
<td>$\text{Right}_{i,t}$</td>
<td>-0.052</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>(-1.102)</td>
<td>(0.822)</td>
</tr>
<tr>
<td>$\text{GDP}_{i,t}$</td>
<td>0.425</td>
<td>-1.982***</td>
</tr>
<tr>
<td></td>
<td>(0.403)</td>
<td>(-2.729)</td>
</tr>
<tr>
<td>$\text{Innovation}_{j,i,t-\tau}$</td>
<td>-0.187***</td>
<td>-0.131***</td>
</tr>
<tr>
<td></td>
<td>(-4.475)</td>
<td>(-2.894)</td>
</tr>
<tr>
<td>$\text{Country-}$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$\text{industry FEs}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{Year FEs}$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$\text{Obs.}$</td>
<td>10,297</td>
<td>8,770</td>
</tr>
<tr>
<td>$\text{R-square}$</td>
<td>0.04</td>
<td>0.029</td>
</tr>
<tr>
<td>$\text{Elect}_{i,t}$ (Low – High)</td>
<td>-0.096</td>
<td>-0.093</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>-2.005</td>
<td>-1.948</td>
</tr>
</tbody>
</table>

Note: Numbers reported in the parentheses are two-way clustered standard errors by country-industries and by years. The growth of GDP of country $i$ in year $t$, $\text{GDP}_{i,t}$, is winsorized at the 1st and 99th percentiles.
Table 6: Regression analysis for the relation between policy, policy uncertainty and incentive to innovate

This table reports the results of regressing $\text{Incentive}_{j,i,t+\tau}$ (i.e., growth of incentive measures in industry $j$ of country $i$ in year $t+\tau$, where $\tau=1$ if the national election occurs in the first half of year $t$ (January to June) and $\tau=2$ if the national election occurs in the second half of year $t$ (July to December)) on $\text{Election}_{i,t}$ (an indicator variable that equals one if there is at least one election in country $i$ in year $t$ and 0 otherwise), $\text{Right}_{i,t}$ (an indicator variable that equals one if country $i$'s government is right-wing in year $t$ and 0 otherwise), $\text{Left}_{i,t}$ (an indicator variable that equals one if country $i$'s government is left-wing in year $t$ and 0 otherwise), $\text{GDP}_{i,t}$ (the growth of GDP of country $i$ in year $t$), lagged incentive growth $\text{Incentive}_{j,i,t+\tau-1}$, country-industry fixed effects, and year fixed effects. $\text{Incentive}_{j,i,t+\tau}$ are defined as $\text{Inventor}_{j,i,t+\tau}$ (the growth in the number of individual inventors who have ever filed at least one patent) or $\text{Assignee}_{j,i,t+\tau}$ (the growth of the number of organizations that have ever filed at least one patent). In Panel A, we include all 43 countries in our sample; in Panel B, we consider only 37 countries by excluding Austria, Israel, Korea, New Zealand, Sweden, and UK because these six countries' innovation is dominated by right or left orientation (see Table A6). Incentive growth is winsorized at the 1st and 99th percentiles. Numbers reported in the parentheses are two-way clustered standard errors by country-industries and by years. The sample year $t$ is from 1976 to 2005. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

<table>
<thead>
<tr>
<th></th>
<th>Panel A: 43 countries</th>
<th></th>
<th>Panel B: 37 countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inventor (1)</td>
<td>Inventor (2)</td>
<td>Inventor (3)</td>
</tr>
<tr>
<td>Election_{i,t}</td>
<td>-0.069***</td>
<td>-0.069***</td>
<td>-0.033</td>
</tr>
<tr>
<td></td>
<td>(-2.615)</td>
<td>(-2.614)</td>
<td>(-1.155)</td>
</tr>
<tr>
<td>Left_{i,t}</td>
<td>-0.033</td>
<td>0.04</td>
<td>(-1.629)</td>
</tr>
<tr>
<td>Right_{i,t}</td>
<td>0.022</td>
<td>0.04</td>
<td>(0.831)</td>
</tr>
<tr>
<td>GDP_{i,t}</td>
<td>-0.793</td>
<td>-0.806</td>
<td>-0.114</td>
</tr>
<tr>
<td></td>
<td>(-1.146)</td>
<td>(-1.172)</td>
<td>(-0.145)</td>
</tr>
<tr>
<td>Incentive_{j,i,t+1}</td>
<td>-0.149***</td>
<td>-0.149***</td>
<td>-0.098**</td>
</tr>
<tr>
<td></td>
<td>(-4.666)</td>
<td>(-4.688)</td>
<td>(-2.510)</td>
</tr>
<tr>
<td>Country-industry FEs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FEs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Obs.</td>
<td>19,336</td>
<td>19,336</td>
<td>16,876</td>
</tr>
<tr>
<td>R-square</td>
<td>0.026</td>
<td>0.026</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Figure 1: Policy uncertainty and innovation

This table reports the pooled average (and 90% confidence interval) of country-adjusted innovation growth of country $i$ in years $t-1$, $t$ (election year), $t+1$, $t+2$, and $t+3$. Country-adjusted innovation growth of country $i$ in year $t+1$, $\text{Innovation}_{i,t+1}$, is defined as $\text{Innovation}_{i,t+1} - \text{Average}_{i}$. $\text{Innovation}_{i,t+1}$ are defined as $\text{Patent}_{i,t+1}$, $\text{Citation}_{i,t+1}$, and $\text{Originality}_{i,t+1}$ in Panels A, B, and C, respectively. To ensure that our analysis is not affected by other elections, we restrict that there is no election in years $t-1$, $t+1$, $t+2$, and $t+3$. In each panel, the solid line denotes the pooled averages, and dotted lines denote pooled averages $+ t(95\%)$*standard errors and pooled averages $- t(95\%)$*standard errors based on the $t$-test with null hypothesis of zero mean. The sample year $t$ is from 1976 to 2005.

Panel A: $\text{Patent}^*$

Panel B: $\text{Citation}^*$

Panel C: $\text{Originality}^*$
Figure 2: Policy and innovation

This table reports the pooled average difference (and 90% confidence level) in country-adjusted innovation growth in years $t-1$, $t$ (election year), $t+1$, $t+2$, and $t+3$. Country-adjusted innovation growth of country $i$ in year $t+1$, $\text{Innovation}_{i,t+1}$, is defined as $\text{Innovation}_{i,t+1} - \text{Average}_{i,t+1}$, where $\text{Innovation}_{i,t+1}$ are defined as $\text{Patent}_{i,t+1}$, $\text{Citation}_{i,t+1}$, and $\text{Originality}_{i,t+1}$ in Panels A, B, and C, respectively. The average difference in country-adjusted innovation growth is defined as left sample minus the rest in Panels A1, B1, and C1. The average difference in country-adjusted innovation growth is defined as center sample minus the rest in Panels A2, B2, and C2. The average difference in country-adjusted innovation growth is defined as right sample minus the rest in Panels A3, B3, and C3. To ensure that our analysis is not affected by other elections, we restrict that there is no policy change in years $t-1$, $t+1$, $t+2$, and $t+3$. In each panel, the solid line denotes the pooled average difference, and dotted lines denote pooled average difference $\pm t(95\%)$*standard errors and pooled average difference $- t(95\%)$*standard errors based on the $t$-test with null hypothesis of zero mean. When the F-test for the equality of variances is not rejected, we use pooled standard errors (i.e., the focal sample and the rest sample have the same variance); when the F-test is rejected, we use Satterthwaite standard errors (i.e., the focal sample and the rest sample have different variances). The sample year $t$ is from 1976 to 2005.

Panel A1: $\text{Patent}^*$ (Left vs. the rest)

Panel A2: $\text{Patent}^*$ (Center vs. the rest)

Panel A3: $\text{Patent}^*$ (Right vs. the rest)
Panel B1: Citation* (Left vs. the rest)

Panel B2: Citation* (Center vs. the rest)

Panel B3: Citation* (Right vs. the rest)
Panel C1: Originality* (Left vs. the rest)

Panel C2: Originality* (Center vs. the rest)

Panel C3: Originality* (Right vs. the rest)