Competition Laws and Corporate Innovation

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Abstract

We examine the impact of competition laws on innovation. We create a firm-level dataset on patenting activities that includes about 1 million firm-year observations, across 66 countries, from 1991 through 2011. Using a new dataset on competition laws, we find that more stringent competition laws (laws designed to intensify competition) are associated with increases in the number, impact, and explorative nature of firms' patents. The innovative-enhancing effects of competition laws are stronger among firms that are better positioned to access external finance to invest in innovation, e.g., less financially constrained and publicly listed firms. The innovative-enhancing effects are smaller among family-controlled firms, where the family tends have a large proportion of its wealth concentrated in the firm and is correspondingly more averse to the firm making risky investments in innovation. Our results also hold when using a country-industry dataset covering 186 countries over the 1888-2011 period.

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1. Introduction

Does competition increase or decrease innovation? Schumpeter (1942) stressed that more intense competition discourages innovation by reducing post-innovation rents (Romer 1990; Aghion and Howitt 1992). In contrast, Arrow (1962) emphasized that more intense competition encourages innovation by making markets more contestable, spurring both currently dominant and other firms to invest more in the risky process of innovation. Since quantifying the impact of competition on innovation has implications for antitrust and trade policies, an enormous empirical literature assesses the competition-innovation nexus, using data on firm size, market concentration, merger outcomes, and price-cost margins to measure competition and data on R&D expenditures and patents to measure innovation (Nickell 1996; Blundell, Griffith, and Van Reenen 1999; Gilbert 2006; Jansen, Van Den Bosch, and Volberda 2006; Sutton 2007; Aghion et al. 2005, 2009; Hashmi 2013; Seru, 2014).

As summarized by Cohen (2010), however, several empirical challenges make it difficult to draw definitive conclusions about the impact of competition on innovation. Besides the difficulty of identifying exogenous sources of variation in market structure, common proxies for competition, such as firm size and industry concentration, might not accurately capture the contestability of markets. On innovation, R&D expenditures may include non-innovation-related outlays, and there could be substantial intertemporal and cross-sectional variation in the proportion of non-innovation-related outlays in overall R&D expenditures due to differences in the tax treatment of R&D expenditures. There are also challenges to using patenting as a proxy for innovation. Firms will choose to patent or not patent an innovation based on the expected benefits of the legal protection offered by the patent and the expected costs of disseminating detailed information about the innovation via the patent to competitors. Thus, in response to greater competition, firms might increase or decrease patents based on changes in these strategic cost-benefit calculations, not because of changes in actual innovation.

To address these challenges, we make three contributions to research on competition and innovation. First, we create two unique datasets on patenting. The first is a firm-level panel dataset with information on each firm's patents and financial accounts for public and private firms, across 66 countries, over the period from 1991 through 2011. We combine two global databases on patents (PATSTAT and OrbisIP) and link these patenting data with corporate income statements, balance sheet figures, and ownership structure data. This matching is extraordinarily labor intensive, as firm identifiers differ across datasets and change over time. Using this new dataset with about 1 million firm-year observations, we construct measures of the number, impact, and explorative nature of corporate patents. The second dataset includes country-industry information on patenting in 186 countries from 1888 through 2011. The scope and detail of our data means that we can provide the first examination of the relation between competition and patenting in a large, international panel of private and public firms with information on financing constraints, ownership structure, and other corporate traits. As we show, it is crucial to differentiate by these corporate characteristics in assessing how competition influences innovation.

Second, we combine these data with insights from corporate finance to (a) reduce concerns about using patents as a proxy for innovation, (b) enhance identification, and (c) explore whether and how the competition-patenting relation differs by corporate characteristics. While the Arrow-view stresses that competition increases incentives for firms to invest in innovation, corporate finance offers a corollary to this view: the impact of competition on a firm's investment in innovation depends on the extent to which (i) the firm is constrained in raising funds to make those investments and (ii) the firm's influential owners have large proportions of their personal wealth exposed to the firm, making them reluctant to having their firms invest more in risky projects. Evidence confirming these predictions would not only be consistent with the view that competition increases incentives for firms to invest in innovation. It would also reduce concerns that competition increases patenting primarily by adjusting the strategic cost-benefit calculations of patenting a given innovation, rather than by changing innovation per se. The reason is that corporate finance offers clear conceptual reasons for expecting that competition will increase investment in risky, innovative endeavors more in less financially-constrained firms and firms with less financially-exposed owners, but there are less clear arguments for why competition will differentially alter the strategic decision to patent or not patent a given innovation based on financing constraints and ownership structure.

Furthermore and relatedly, since the corporate finance corollary identifies particular mechanisms through which competition shapes innovation, empirically confirming these mechanisms enhances our ability to identify the impact of competition laws on innovation. Thus, we use firm-specific measures of financing constraints and ownership structure to assess how the competition-patenting nexus varies across corporations.

Third, we are the first to use a new, comprehensive dataset on competition laws across 123 countries from 1888 through 2010 to examine the relation between competition laws and patenting. That is, rather than analyzing measures of market structure, we examine the statutory laws that regulate competition among firms. Chilton (2018) and Bradford et al. (2019) compiled and codified data on the multiplicity of competition laws that regulate mergers and acquisitions, the use of anticompetitive agreements, the abuse of dominant positions, and who has the authority and tools to address and remedy violations of those statutes. These data are much more extensive with respect to the measurement of different competition laws and the coverage of countries and years than any other dataset on competition laws. Based on Bradford et al (2019), we examine both their overall index of competition laws (*Competition Law Index*) and the subcomponents that focus on laws governing mergers and acquisitions, anticompetitive agreements, the abuse of dominant positions and authority over antitrust. These data offer a unique opportunity to evaluate the connections between the competition laws that regulate competition among firms and patenting.

We begin our firm-level analyses by assessing the connections between patenting and the overall index of competition laws. Besides measuring the number of patents, we measure patent impact using indicators of forward citations to a firm's patents, the average number of citations per patent in a firm, and the extent to which a firm creates patents that have forward citations in the top 25% or 10% of all patents in a technology class. In addition, we measure the degree to which a firm's patents are explorative, meaning the inventions fall outside of the firm's historic base of innovative knowledge as reflected in its patent applications, or the patents are exploitative, meaning the inventions fall within the firm's historic technology classes. Each of these patenting measures is computed at the firm-year level. In our initial analyses, we regress patent-based measures of innovation on the *Competition Law Index* while controlling for firm fixed effects, industry-year fixed effects, lagged time-varying firm characteristics (e.g., size, leverage, profitability, and age), and an array of time-varying country traits, policies, laws, and regulations. Given these extensive controls, we view the results as providing suggestive evidence on the impact of competition laws on patenting. As discussed below, we employ additional strategies to better identify the effects of national competition laws on corporate innovation.

We find a strong positive connection between the stringency of competition laws and patenting. That is, when countries intensify the degree to which their laws encourage product market competition, patenting increases. The coefficient estimates suggest an economically large effect of competition laws on firm innovation, as measured by the number of patents, forward citations to patents, citations per patent, the number of very highly cited patents (top-quartile or top-10% of the citation distribution among patents in a year and technology class), and the number of explorative patents, i.e., patents that fall beyond a firm's historic base of innovative activities. For example, the coefficient estimates indicate that if a country's *Competition Law Index* increased by one standard deviation, then the total number of citations to patents received by firms in the country would increase by 10%. The results are robust to limiting the sample to manufacturing firms. Thus, it is unlikely that the results are driven by differences and changes in the industrial composition of firms across countries. Furthermore, we considered potential nonlinearities. Aghion et al. (2005) develop a model and provide evidence from the U.K. of a nonlinear, inverted-U shaped relation between the Lerner index of competition and citation-weighted patents. We consider a broad sample of countries and conduct our analyses at the firm-level. We do not find evidence of a nonlinear relation between competition laws and various patenting indicators, e.g., the number, impact, and explorative-nature of patents.

Next, we assess whether an intensification of competition induces a bigger effect on patenting (a) among less financially-constrained firms and (b) among firms that have owners with less of their personal wealth invested in the firm. To conduct this assessment, we use indicators of corporate financial constraints and ownership structure. First, we use the Hadlock and Pierce (2010) (HP) measure of the degree to which a firm is more financially constrained, which is based on firm size and age. Second, we differentiate between publicly-listed and privately-held companies, since public companies can generally tap equity and bond markets more readily to finance projects, including innovative projects (e.g., Acharya and Xu 2017). Third, we differentiate family-controlled firms—firms where a family owns more than 50% of the voting rights—from other firms, since those families will tend have a large proportion of their wealth concentrated in the firm. We differentiate by family ownership because a significant number of corporations around the world are controlled by families (e.g., La Porta, Lopez-de-Silanes, and Shleifer 1999; Claessens, Djankov, and Lang 2000). According to Smith and Stulz (1985) and Faccio, Marchica, and Mura (2011), families' wealth is largely concentrated in the firms they own, and therefore tend to be less diversified than other types of shareholders. From this perspective, risk-averse and poorly-diversified family owners will be more averse to their firms increasing risk than similarly risk-averse, but well-diversified owners of identical firms. In terms of innovation, wealth concentration will tend to make family owners more averse to their firms making large investments in the risky process of innovation than otherwise similar firms with owners holding more diversified portfolios. Thus, we re-evaluate the relation between competition and patenting while differentiating firms by these three corporate characteristics, i.e., we test the corporate finance corollary to Arrow's view of how competition shapes innovation.

We discover that intensifying competition laws is associated with smaller increases in the number, impact, and explorative-nature of patents among more financially-constrained firms and family-controlled firms (i.e., firms with controlling owners likely to have large proportions their personal wealth invested in the firm). Specifically, firms with below the median values of the HP measure of financing constraint experience significant increases in patenting activity following an intensification of competition laws, but those with above the median HP values do not. Using the public-private distinction as an indicator of financial constraints confirms these findings: Following an intensification of competition laws, patenting activity increases more among publicly-listed corporations than privately-held ones. On corporate ownership, intensifying competition laws is not associated with an increase in patenting among family-controlled firms. To further isolate whether these findings on family-controlled firms are driven by concentrated wealth exposure, or the possibility that family-controlled firms are more financially constrained, we control for the HP measure of financing constraints. The results on family ownership hold when controlling for financing constraints, suggesting that the personal wealth exposures of influential owners shape the willingness of firms to invest more in the risky process of innovation.

These findings on corporate characteristics offer three lessons. First, they demonstrate the importance of distinguishing firms by financing constraints and ownership structure in assessing the impact of competition on innovation. Second, they enhance identification by showing that the relation between competition and patenting varies across corporations in a manner consistent with the Arrow-view of competition and innovation. Third, they improve the ability to interpret patenting as a proxy for innovation—and not simply as reflecting a strategic decision about whether to obtain a formal property right over a given innovation. In particular, the corporate finance corollaries about competition and finance interact to shape innovation are about innovation per se. Thus, since the empirical findings are consistent with the particular mechanisms outlined by these theories, it reduces concerns about interpreting patenting as proxying for innovation in our study.

We also address the concern that omitted time-varying country traits confound the analyses. Specifically, we conjecture that if intensifying competition spurs innovation, the effects should be stronger among firms in more "innovative-intensive" industries, i.e., competition should have a bigger effect on innovation among firms in industries in which innovation is more important. To categorize industries as "innovative-intensive," we use the Eurostat definition of high-technology industries, e.g., pharmaceuticals, computer, electronics, and optical products. We then evaluate whether intensifying competition laws spur patenting more among firms in innovative-intensive industries while controlling for country-year fixed effects to eliminate concerns about omitted country factors. This approach is similar to the identification strategy employed by Moshirian et al., (2020) and Levine, Lin, and Wei (2017), who assess the impact of stock market liberalization and insider trading laws on innovation respectively. These cross-industry, cross-firm panel analyses indicate that among firms in innovative-intensive industries, intensifying competition laws increases the number, impact, and explorative-nature of patents. By controlling for country-year effects, these findings reduce omitted variable concerns.

Finally, we discover a positive relation between competition and patenting using our new industry-country level investigation that covers the period from 1888 through 2011 and includes a cross-section of 186 countries. We do not have firm-level data going back to the 19th century and cannot employ the strategy of differentiating firms by financing constraints and ownership structure in assessing the mechanisms linking competition laws and patenting. Nevertheless, we do have patenting data by industry, country, and year, so that we can differentiate industries by innovative-intensity and include country-industry, industry-year, and country-year fixed effects. The findings from the 124-year industry-country panel confirm those from the firm-level analyses.

Besides the large body of research on competition and innovation, our research relates to several other lines of inquiry. A growing literature examines the financial and institutional determinants of innovation, as reviewed by He and Tian (2020). We examine a different but important determinant of innovation: competition laws. Furthermore, a well-established literature shows that laws shape the functioning of financial institutions, the contestability of markets, and economic outcomes (e.g., La Porta et al. 1998; La Porta, Lopez-De-Silanes, and Shleifer 2008; Ellul, Pagano, and Panunzi 2010; Brown, Martinsson, and Petersen 2013). We build on this work by showing that particular laws regulating firm competition have a material impact on innovation. A related line of research explores the regulation of entry. Djankov et al. (2002) show that countries that make it more costly for start-up firms to enter a market typically suffer from higher corruption levels, supporting a public choice view of entry regulation. We focus on competition laws and their effects on innovation and our findings indicate that laws that limit anti-competition actions and activities are associated with faster rates of innovation. Researchers also show that competition shapes corporate valuations (e.g., Giroud and Mueller 2011). By showing the large impact of competition laws on firm innovation, our work offers an additional mechanism through which competition can influence firm valuations.

The remainder of the paper is organized as follows. Sections 2 and 3 respectively discuss the unique patenting and competition law data used in our study. Section 4 provides the firm-level regression analyses, and Section 5 presents the country-industry-year results. Section 6 concludes.

2. International Data on Patenting at the Firm and Country-Industry Levels

In this section, we first describe the construction of our firm-level dataset. These data include information on firms' patenting activity and financial accounts for a large panel of private and public firms across 66 countries for the period covering 1991 through 2011. We then describe the country-industry level dataset on patenting that covers the period from 1888 through 2011. We complete the section by providing summary statistics. To mitigate concerns that the United States might dominate the results, we exclude U.S. firms from the analyses. All of the findings reported below, however, hold when including U.S. data.

2.1 Firm-level patent and financial data

We compile a unique dataset that combines the two most comprehensive global databases on patents with detailed financial data on public and private firms. To the best of our knowledge, this is the first study to create and examine a firm-level dataset that contains panel information on each firm's financial accounts, patents, and the nature and impact of those patents for a broad range of firms, across many countries, and over an extensive time period.

The two global databases on patents are (1) the Worldwide Patent Statistical Database (PATSTAT), which is administered by the European Patent Office, and (2) OrbisIP, which is maintained by Moody's Bureau van Dijk (BvD). Each of these patent databases covers over 100 million patents filed with about 100 patent offices around the world, dating back to the 1800s. Each patent database provides detailed information on patents, such as application date, grant status, and technological class (e.g., International Patent Classification (IPC)). Our firm-level database covers the period starting in 1991 because we match these patenting data with firm balance sheet and income data that only starts in 1991 for a broad selection of firms. As discussed below, we also construct a country-industry-level dataset on patenting and use it to examine a longer time period.

The PATSTAT and OrbisIP datasets provide distinct and complementary information that we exploit to (1) measure patenting activity more accurately and (2) link these patenting datasets to firm-level datasets that contain income and balance sheet information. With respect to measuring patenting activity, researchers face the following challenge: firms can, and do, apply for and receive patents in multiple patent offices. This means that there are sometimes multiple patents on the same underlying invention. Failure to account for this can lead to measurement problems. For example, researchers might incorrectly (a) record a single invention multiple times for a firm that obtains a patent from multiple patent offices; (b) record the wrong innovation date depending on which patent office filing the researchers use, and (c) measure patent citations by counting all of the citations from a single invention that received patents in multiple patent offices.[1]

To address these measurement challenges, we focus on the original invention. PATSTAT provides unique "patent family" identifiers, where a patent family includes all of the patents filed in different patent offices on the single underlying invention. This information, however, is not readily available from OrbisIP. Based on the PATSTAT patent family identifier, we ascertain the first time that an invention is granted a patent and we call this the "original patent." We date patents using the application year of the original patent (rather than the date when the patent is granted) because the application year is closer to the invention date (Griliches, Pakes, and Hall 1987) and various factors can influence the gap between the application and grant dates (Hall, Jaffe, and Trajtenberg 2001). We also use the International

[1] For example, if patent A is cited by patent B and patent C, and patents B and C are simply the same invention filed in two different patent offices, then failure to link patents B and C as a single invention will mean that patent A will be recorded as having two citations rather than the correct value of one.

Patent Classification (IPC) of the original patent to define the technological section and subclass(es) of the invention.[2,3]

OrbisIP provides critical information—that is unavailable in PATSTAT—that allows us to link the patenting data with other firm-level datasets. In particular, OrbisIP provides unique identifiers (i.e., Bvd ID) for firms applying for patents that are the same as those in other Orbis databases that contain firm-level income and balance sheet data. OrbisIP links patent assignees, as shown in the patent documents, to their Orbis company counterparts.[4] Then, we merge patent records between PATSTAT and OrbisIP, and link firm records in OrbisIP and other Orbis databases. By combining these datasets, we can (1) use the patent family identifiers of PATSTAT to locate original patents filed by the firms to construct various innovation measures at the firm level, and (2) use the BvD ID of the firms to obtain financial data from other Orbis databases. In this way, we create a firm-level dataset on patenting and financial data for private and public firms around the world from 1991 through 2011.

There are two challenges in this merging process. First, while both patent databases use the patent application number from the original filing documents, PATSTAT and OrbisIP use different standardization methods for recording and presenting this "common" identifier. Moreover, the standardization rules changed over time and the different patent offices changed

[2] A typical IPC takes a form as follows: in the case of "A61K 36/815", the first character, "A", identifies the IPC "section". There are eight sections in total (from A to H). The first four characters, "A61K" provide the "subclass". With the next two characters ("36") and the last three characters ("815"), we can further identify the IPC at the "main group" and "sub-group" level. Since IPCs are not always available at the main group and sub-group level, we use the first four characters, i.e., the subclass level, as the most granular technological class in our analysis.

[3] As more than one IPC can be assigned to a patent, we follow the procedures in Levine et al. (2017). All patents have at least one inventive IPC. If the patent authority designates an inventive IPC as secondary ("L" in the ipc_position of the PATSTAT), we remove that IPC from further consideration. This leaves only inventive IPCs that the patent authority designates as primary ("F" in the ipc_position of the PATSTAT) or that the patent authority does not designate as either primary or secondary, but rather as an undesignated IPCs. In no case does a patent authority designate a patent as having two primary IPCs. In the few cases with multiple inventive IPCs where none are designated as primary, we keep the IPC with the highest alphabetical order.

[4] Although the exact procedure is proprietary, Orbis indicates that it follows the following five-step approach in matching firms across databases. First, it standardizes the format of each possible data matching field, including the name, street, city, postal code, and country of the patent assignees, to minimize the differences across databases. Second, it applies an automated fuzzy matching tool to search for the best potential candidate matches for each patent assignee. Third, it generates a weighted average proximity score across the data fields for each pair of potential matches and produces a quality indicator on the matches based on the score. Any match with a score below a certain threshold will go through a manual matching procedure. Fourth, OrbisIP conducts the manual matching procedure with its proprietary matching software, which examines whether each patent assignee record definitely matches, does not match, or might match one or more records in the Orbis databases. Records that cannot be matched automatically are presented to the software users so that they can accept or reject possible matches "manually." Finally, a patent assignee in OrbisIP can be linked to the appropriate BvD ID.

how they recorded the patent application number over time. Thus, we have reviewed the rules for each patent office and the standardization methods of the two patent databases and constructed our own unified identifiers to ensure a one-to-one matching between all patent records.[5]

A second challenge to compiling our firm-level dataset involves the retrieval of historical data from Orbis. For any particular version of Orbis, BvD only provides firm-level information for the most recent ten years. Thus, to cover the 1991-2011 period, we need to combine data from multiple versions of Orbis. However, the firm-level identifies (i.e., the BvD IDs) change over time, making it difficult to match firms over time across the different versions of Orbis. Thus, we had to check these records individually to resolve changes in a firm's BvD ID and eliminate duplicate records from overlapping years. By doing this, we construct what we believe is the broadest dataset containing a panel of firm-level data on patents and financial information for private and public firms worldwide.

2.2 Firm-level patent measures

We construct six patent-based measures of innovation for each firm in each year, which have been used by an extensive literature (see, e.g., Chang et al., 2015, 2019; Balsmeier, Fleming, and Manso, 2017; Lin, Manso, and Liu, 2019).

2.2.1 Patent quantity

Patent Count equals the natural logarithm of one plus the total number of eventually-granted patents that firm *f* applied for in year *t*, i.e., the application date of the original patent in year *t*. We use the natural logarithm of one plus the total number of eventually-granted patents because the distribution of the number of patents is right-skewed. *Patent Count* measures the quantity of patents, but it does not measure the quality of patents.

[5] Given the idiosyncrasies of patenting offices, we restrict our analyses to patent offices that granted at least 100,000 patents over their full history based on the records in PATSTAT. This accounts for more than 97% of the universe of eventually-granted patents in PATSTAT.

2.2.2 Patent impact

We also use four citation-based measures of the “impact” of patents.

Citation equals the natural logarithm of one plus the total number of forward citations received by all eventually-granted patents that firm *f* applied for in year *t*. Since a patent may continue to receive citations beyond the observable coverage of the database, we adjust for truncation bias using the approach employed in Hall et al. (2001, 2005) and Levine et al. (2017). This measure gauges the degree to which an innovation influences other inventions.

Cit/Pat equals the natural logarithm of one plus the *average* number of forward citations received by all eventually-granted patents that firm *f* applied for in year *t*. This measure captures the average impact, rather than the aggregate impact, of a firm’s patents in year *t*.

Cited Patent equals the natural logarithm of one plus the total number of eventually-granted patents that firm *f* applied for in year *t* that received at least one citation. We use *Cited Patent* to assess whether competition influences the degree to which firms create new patents that are cited by at least one other invention.

Top Cited Patent equals the natural logarithm of one plus the total number of eventually-granted patents that firm *f* applied for in year *t* that have forward citation counts falling in the top 25% of the forward citation count distribution for patents within the same technology class and application year. *Top Cited Patent (top 10%)* equals the natural logarithm of one plus the total number of eventually-granted patents that firm *f* applied for in year *t* that have forward citation counts falling in the top 10% of the citation count distribution for patents within the same technology class and application year. These gauge whether a firm created a very high-impact patent. We use these measures to assess the relation between changes in the competition laws facing firms and the likelihood that they create very impactful patents.

2.2.3 Explorative patents

Finally, in addition to measuring the quantity and impact of patents, we use an indicator of the extent to which a firm's patents are "explorative," meaning that the innovative activity reflected in the patent falls outside of the firm's typical line of research.

Explorative Patent equals the natural logarithm of one plus the total number of explorative patents that firm *f* applied for in year *t*. Following prior research (see, e.g., Manso, 2011; Balsmeier et al., 2017; Lin et al., 2019), a patent is defined as explorative if at least 60% of the citations to which it refers are neither to patents that the firm produced during the last five years nor to patents that were cited by the firm's others patents filed over the past five years. Thus, an explorative patent is an invention that falls outside of the firm's historic base of innovative knowledge as reflected in its patent applications. *Explorative Patent* gauges the degree to which a firm engages in more explorative inventions—inventions in areas different from the firm's past inventions and lines of research. Furthermore, *Explorative Patent (90% new knowledge)* equals one if at least 90% of the citations to which it refers are neither patents that the firm produced nor patents that were cited by the firm's other patents filed during the past five years.

2.3 Other firm-level characteristics and country traits

For the firm-level sample, we start the sample in 1991 because the availability of income and balance sheet data increases in 1990 and we constructed the firm-level control variables with a one-year lag. We follow the literature (see, e.g., Hsu, Tian, and Xu, 2014) and include the following control variables in our analysis: *Firm Size*, *Leverage*, *Profitability* and *Age*. *Firm Size* is the natural logarithm of total assets of a firm in a year. *Leverage* is the ratio between non-current liability and total assets of a firm in a year. *Profitability* is the net income scaled the total assets of a firm in a year. *Age* is the natural logarithm of the number of years since the incorporation of a firm.

We also include an assortment of country-level characteristics. *GDP per capita* is the natural logarithm of Gross Domestic Product (GDP in real U.S. dollar in 2010) of a country in a year, scaled by its total population. *Credit/GDP* is the ratio of total credit provided by the financial sector over GDP in a country-year. *Stock/GDP* is the ratio of total market capitalization of domestic firms over GDP in a country-year. The detailed definitions and sources of the variables introduced in this section are presented in Appendix Table A1.

By requiring non-missing values for these firm-level characteristics and the firm's industry classification and country traits, the final firm-level sample consists of about 150,000 firms from 66 countries over the period from 1991 through 2011.

2.4 Country-industry-level innovation measures

We complement the firm-level analyses with country-industry data. In moving to the country-industry-level, we extend the sample period to cover 124 years: 1888 through 2011. Thus, while we lose the granularity of firm-level data and the transactions-level information, we gain the ability to examine the connections between competition and patent-based measures of innovation for 186 countries over more than a century.

In constructing the country-industry-level patent-based innovation measures, we continue to (a) consider all eventually-granted patents, (b) use the PATSTAT "patent family" identifier to identify the original patent, (c) date patents using the application year of the original patent, and (d) use the IPC of the original patent to define the technological section and subclass(es) of each invention. To assign patents to industries, we convert the patent's IPC subclass level to the two-digit Standard Industry Classification (SIC) level using the latest mapping scheme from the World Intellectual Property Office (WIPO) and the United Nations Statistical Division.[6] To assign patents to countries, we use information from the original patent on the country of residence of the patent's primary assignee.

We construct four patent-based measures of innovation for each industry j, in country c, in year t from PATSTAT: *Patent Count-Ind*, *Citation-Ind*, *Top Cited Patent-Ind*, and *Explorative Patent-Ind*. *Patent Count-Ind*$_{c,j,t}$ equals the natural logarithm of one plus the total number of eventually-granted patents in industry j, in country c, in year t. *Citation-Ind* and *Top*

[6] We first map IPC subclasses to the International Standard Industrial Classifications (ISICs) using the mapping scheme at: https://are.ucdavis.edu/people/faculty/travis-lybbert/research/concordances-patents-and-trademarks/. Then, we convert the ISICs to SICs using the concordance scheme from the United Nations Statistical Division, which is available at: http://unstats.un.org/unsd/cr/registry/regdnld.asp?Lg=1.

Cited Patent-Ind are defined analogously, building on the firm-level variables defined above. For *Explorative Patent-Ind*, we need to identify the degree to which a patent involves innovation beyond the firm's past inventive activity. Thus, we first restrict the sample to those patents where OrbisIP has the applicants' BvD ID to (a) identify the firm connected to the patent and (b) evaluate whether the patent under consideration is considered as explorative for this firm.[7] Then, we count the number of explorative patents belonging to a certain IPC subclass that are filed by firms in a country-year, convert it to the two-digit SIC level, and take the natural logarithm of one plus the count to obtain the final value for *Explorative Patent-Ind*. Given the restrictions on the sample during construction, the number of industry-country-year observations with *Explorative Patent-Ind* available is smaller than that for the other patent-based innovation measures in the industry-country-level dataset. We require each industry-country to have at least one eventually-granted patent to be included in our analysis.

2.5 Summary information on patent-based measures of innovation

Table 1 provides summary statistics on patenting at (1) the firm-level for the period 1991-2011 on a maximum of 66 countries and (2) country-industry-level for the period 1888-2011 on a maximum of 186 countries. The average firm (a) develops 1.1 eventually-granted patents in a year and (b) receives 20 forward citations to the eventually-granted patents that it applies for in a year. Furthermore, about 0.21 of an average firm's 1.1 eventually-granted patents in a year generate forward citations that place the innovation in the top 25% of the forward citation distribution for all patents within the same technology class and application year. An average firm has 0.23 explorative patents (out of its 1.1 patents) in a year.[8] We follow the common practice in the literature and treat the firm-year observations without any patent records as containing a value of zero for these measures. All these measures of innovation are highly right skewed as shown by the standard deviations and values at the 10th, median, and 90th percentiles. The median size firm in our sample has total assets of US$5.2 million, with a leverage ratio of 7.6% and profitability (net income/assets) of 4.5%.

[7] This sample restriction is unnecessary for the other three patent-based measures of innovation.
[8] We exclude firms with no patents, so *Explorative Patent* does not measure firms innovating for the first time.

3. Competition Laws

Bradford and Chilton (2018) and Bradford et al. (2019) recently compiled the most comprehensive dataset on competition laws around the world and over time. The data cover 123 countries that have had a competition law in place over the period from 1888 through 2010. Their data go well beyond other datasets with respect to the coverage of (a) competition laws, (b) countries, and (c) years. Researchers have only begun to exploit the wealth of information contained in their dataset on the statutory laws that shape competition among firms (see, e.g., Bradford and Chilton 2018; Bradford et al. 2019).[9] In this section, we summarize features of their data that are central to our examination of competition laws and innovation.

Bradford and Chilton (2018) and Bradford et al. (2019) constructed the data as follows. First, they collected all laws containing provisions regulating market competition for 123 countries dating back to each country's first competition law or 1888, whichever came later. For example, the first relevant U.S. federal law regulating market competition is the Sherman Act of 1890. They then coded the content of those laws with respect to provisions concerning mergers and acquisitions, the abuse of dominant positions, anticompetitive agreements, and the authority for addressing and remedying violations of those provisions. In this way, Bradford and Chilton (2018) and Bradford et al. (2019) codify the multifaceted provisions of competition laws for a large panel of countries.

Bradford and Chilton (2018) aggregate data on individual competition laws into four indexes. *Authority* captures provisions concerning who has standing to raise concerns about the violation of competition laws and the remedies available for enforcing those laws. The next three indexes measure the regulation of (1) mergers and acquisitions (*Merger Control*), (2) agreements among firms that limit competition (*Anticompetitive Agreements*), and (3) strategies used by dominant firms to abuse their positions (*Abuse of Dominance*). In the remainder of this section, we discuss the codification of these four indexes. Appendix Table A1 provides more detailed definitions of these competition law indexes.

[9] See: http://comparativecompetitionlaw.org//.

In constructing the *Authority* index, Bradford and Chilton (2018) include information on (1) who can bring suits against firms that are alleged to have engaged in anticompetitive behavior, (2) the remedies that the authorities can impose on firms that violate competition laws, and (3) the scope of the law, i.e., the degree to which all industries and enterprises fall under the purview of a country's competition laws.

To gauge the extent to which competition laws regulate mergers and acquisitions, Bradford and Chilton (2018) create *Merger Control*, which includes information on each country's laws in each year with respect to (1) regulating pre-merger notification and approval, (2) granting expansive powers to the authorities to restrict mergers for economic and public interest reasons, and (3) permitting an assortment of arguments by firms to defend mergers and acquisitions and limiting the scope of laws, i.e., the degree to which all industries and enterprises are within the purview of the competition laws.

Competition laws often limit the ability of a dominant firm to abuse its power and limit competition. In a few countries, the law gives the authorities broad, general powers to prohibit abusive conduct. In most countries, the law identifies specific behaviors that are considered anticompetitive abuses of a dominant position. Bradford and Chilton (2018) compute an overall index, *Abuse of Dominance*, that measures the extent to which competition laws limit the ability of dominant firms to abuse their market positions in uncompetitive ways.

Competition laws often limit the ability of firms to form cartels and collude in setting prices, dividing-up markets, limiting supply, rigging bids, and engaging in other activities designed to limit competition. The *Anticompetitive Agreements* index is designed to measure the degree to which a country's competition laws prohibit firms from colluding—both horizontally and vertically—to constrain competition.

Following Bradford and Chilton (2018), we construct an overall *Competition Law Index* from these four sub-indexes. Bradford and Chilton (2018) assign a weight of 50% to *Authority* and a weight of 16.67% to each of the other three indexes: *Merger Control*, *Abuse of Dominance*, and *Anticompetitive Agreements*. Since the exact weighting is arbitrary, we (1) follow their weighting and (2) explore the relation between innovation and each of the four sub-indexes, which addresses concerns with this particular weighting.

To illustrate the broad relation between the stringency of competition laws and innovation, we plot the number of patents and citations against the *Competition Law Index* in Figure 1. Each observation represents one country. The number of patents is defined as the average number of patents in a country over the 1990 – 2011 period, while the number of citations is the average number of citations in a country over the same period. In particular, we first calculate the total number of patents (citations) in each country across all industries in a year using data from PATSTAT. We then compute the average annual number of patents (citations) for each country over the 1990 – 2011 period. As shown, there is a positive correlation between the stringency of competition laws (as measured by the *Competition Law Index*) and innovation (as measured by the number of patents and the impact of those patents). Since many confounding factors could account for these patterns, we now provide firm-level and then industry-country level analyses of the connections between the *Competition Law Index* and our patent-based innovation measures.

4. Firm-Level Results

4.1 Empirical Strategy

To evaluate the relation between national competition laws and firm innovation, we begin with the following regression specification.

$$Innovation_{f,c,t} = \alpha_0 + \beta \times Competition\ Law\ Index_{c,t-1} + \gamma \boldsymbol{X'}_{f,c,t-1} + \delta_f + \delta_{ind,t} + \varepsilon_{f,c,t}, \quad (1)$$

where f, c, and t index firm, country, and year, respectively. The dependent variable, $Innovation_{f,c,t}$, represents one of the patent-based measures of innovation for firm f in country c in year t defined in Section 2. The key explanatory variable, $Competition\ Law\ Index_{c,t-1}$ denotes the *Competition Law Index* in country c in year $t-1$. In robustness tests reported below, we separately examine the sub-indexes of the *Competition Law Index* (*Authority*, *Merger Control*, *Abuse of Dominance*, and *Anticompetitive Agreements*). $X'_{f,c,t-1}$ denotes a set of one-year-lagged time-varying firm characteristics (*Firm size*, *Leverage*, *Profitability*, and *Age*) and country traits (*GDP per capita*, *Credit/GDP*, and *Stock/GDP*). We include firm (δ_f) and industry-by-year ($\delta_{ind,t}$) fixed effects. In this way, our analyses account for all unobservable time-invariant firm characteristics (and hence for time-invariant country effects) and time-varying industry influences. The firm-level analyses cover the period from 1991 through 2011 for about 1 million firm-year observations.[10] We estimate Equation (1) using ordinary least squares (OLS) and cluster the standard errors at the country level since competition laws are defined at the country level.[11]

4.2 Validity Test

One potential challenge to drawing confident inferences about the influence of competition laws on innovation is reverse causality: changes in innovation among firms in an economy could trigger changes in its competition laws. As a first step toward addressing this concern, we examine whether innovation predicts changes in competition laws using the following regression equation.

$$Competition\ Law\ Index_{c,t} = \alpha_0 + \beta \times Innovation_{c,t-1} + \gamma \boldsymbol{X'}_{\boldsymbol{c,t-1}} + \delta_c + \delta_t + \varepsilon_{c,t}, \quad (2)$$

where the *Competition Law Index* and **X'** are the same as in equation (1). $Innovation_{c,t-1}$ is the average value of one of the innovation measures across firms in country *c* in year *t-1*. We include country (δ_c) and year (δ_t) fixed effects to account for any unobservable time-invariant country characteristics and time effects. We estimate Equation (2) using ordinary least square (OLS), with standard errors clustered at the country level.

As shown in Table 2, we find no evidence that innovation predicts changes in competition laws. The lagged patent-based innovation measures enter the regressions with estimated coefficients that are insignificantly different from zero. These findings are consistent with the view that changes in firms' innovative activity do not drive changes in competition laws, reducing reverse causality concerns.

[10] To match the data on competition laws, we end our sample in 2011 and, as noted, we use the one-year lagged value of the *Competition Law Index* in the regressions. Our results, however, are robust to ending the sample in 2012, 2013, or 2014 with the *Competition Law Index* and other explanatory variables entering the regressions with a two-, three-, and four-year lag, respectively. The results are shown in Appendix Table A3.

[11] In Appendix Table A4, we conduct the analysis using a Poisson model and find consistent results.

4.3 Firm Innovation

Table 3 presents our initial examination of the relation between national competition laws and firm innovation. The dependent variable, *Patent Count*, is a simple measure of the number of eventually-granted patents filed by a firm in a given year. The main explanatory variable, *Competition Law Index*, gauges the stringency of a country's competition laws.

As shown, the *Competition Law Index* enters positively and significantly in all specifications. The results are robust to conditioning on firm and year fixed effects (column 1) or firm and industry-year fixed effects (column 2). The results also hold when limiting the sample to manufacturing firms (column 3), which Moshirian et al. (2019) find are the most innovative industries. The estimated coefficients are similar in magnitude across each specification. Moreover, the estimated coefficients on *Competition Law Index* suggest an economically meaningful relation between competition laws and firm-level innovation as measured by *Patent Count*. For example, the estimates from column 2 indicate that a one standard deviation increase in the *Competition Law Index* would increase the number of patents by about 3% (=0.12*0.2517).

We next examine the connections between competition laws and firm-level measures of patent quality. That is, we move beyond simply measuring the quantity of patents (*Patent Count*) and measure the impact of a firm's patents using five citation-based indicators: (1) the total number of forward citations received by a firm's eventually granted patents (*Citation*), (2) the average number of citations per patent (*Cit/Pat*), (3) the total number of patents that have received at least one citation (*Cited Patent*), (4) the total number of patents whose citations fall in the top quartile or the top 10% of the citation distributions (*Top Cited Patent (25%)* or *Top Cited Patent (10%)*), and (5) the number of explorative patents (*Explorative Patent (60% new knowledge)* or *Explorative Patent (90% new knowledge)*).

The estimation results reported in Table 4 suggest that with stricter competition laws, firms produce higher impact and more explorative patents. Firms operating in countries in which competition laws are more focused on intensifying product market competition tend to produce higher-impact patents, as measured by the total number of citations (*Citation*), the average number of citations per patent (*Cit/Pat*), and the number of high impact patents (*Top Cited Patent*). For example, the coefficient estimates from columns 1, 2 and 4 indicate that if the *Competition Law Index* increases by one standard deviation, *Citation* would rise by 7% (=0.2872*0.2517), *Cit/Pat* would rise by 5% (=0.1793*0.2517), and *Top Cited Patent* would rise by 2% (=0.0592*0.2517). Furthermore, the *Competition Law Index* is positively associated with the extent to which patents are ever cited. The coefficient estimate in column 3 indicates that a one-standard-deviation increase in a country's *Competition Law Index* will raise the number of patents that are ever cited (*Cited Patent*) by 3% (=0.1146*0.2517). Also note positive connection between *Competition Law Index* and the extent to which firms engage in explorative innovation, as measured by *Explorative Patent*. In particular, the estimated coefficients in column 5 suggest that a one standard deviation increase in *Competition Law Index* will increase *Explorative Patent* by 3% (=0.1355*0.2517).

4.4 Robustness

We were concerned that changes in a country's competition laws could happen simultaneously with changes in other laws, regulations, and policies. By omitting these other variables from the analyses, we might be misinterpreting the results above as reflecting the impact of competition laws on innovation when the results are driven by omitted factors. We address this concern in two key ways. We now discuss a control function approach. Then, we differentiate across industries so that we can include country-year fixed effects.

For the control function approach, we condition on three policy indicators: *Financial Reform Index*, *PR & Legal Index*, and *Patent Law*. *Financial Reform Index* is an index of the degree to which a country's laws and regulations foster competition, the setting of market prices, private ownership, and liberalization more generally in the financial sector. This index, which was developed by Abiad, Detragiache, and Tressel (2010), includes information on credit controls, interest rate controls, capital controls, entry barriers, bank privatization, and the regulation of banks and securities markets and the extent of liberalization of the financial market. The *Financial Reform Index* ranges from 0 to 27, with higher values indicating fewer restrictions on a country's financial markets. *PR & Legal Index* is a measure of the strength of a country's system for protecting private property rights and fostering the rule of law and the effective enforcement of contracts. The *PR & Legal Index* was created by Gwartney, Lawson, and Hall (2015) for the Fraser Institute and includes information on (a) protecting private property rights and effectively enforcing contracts, (b) judicial independence, impartiality, and integrity, as well as the reliability of the police and military influence over the rule of law, (c) regulatory restrictions on the sale of real property, and (d) cost of crime to businesses. The index ranges from 0 (weakest) to 10 (strongest). *Patent Law* is an indicator that equals one in the years after a country enacts its first patent law, and zero otherwise. We obtain *Patent Law* from World Intellectual Property Organization (WIPO) Lex Database. Appendix Table A1 provides detailed definitions for these variables. We follow the same specification in equation (1) and present the results for key innovation measures in Table 5.

As shown in columns (1), (3), (5), (7) of Table 5, the results are robust to conditioning on these additional policy reform indicators. *Competition Law Index* continues to enter positively and significantly in regressions where the dependent variable is (1) the quantity (*Patent Count*) or patents, (2) the quality of patents as measured by either *Citation* or *Top Cited Patent*, or (3) the explorative nature of patents as measured by *Explorative Patent*. The economic magnitudes of the coefficients become slightly smaller than those from the baseline results but remain statistically and economically significant, and most of the coefficient estimates are within one standard deviation of those reported in Tables 3-4 and all are well within two standard deviations. These results mitigate concerns that the association between the competition law and patenting is driven by simultaneous changes of other policies.

Next, we test whether the innovation-enhancing effects of competition are more pronounced in innovative-intensive industries. We do this by differentiating industries by innovative intensiveness, which also allows to control for country-year fixed effects. To measure innovative-intensive, we use the Eurostat definition of high-technology industries and knowledge intensive industries, such as (a) basic pharmaceutical products and pharmaceutical preparation, (b) chemicals and chemical products, (c) computer, electronics, and optical products, (d) electrical equipment and machinery, and (e) telecommunication, computer programming and information service activities.[12] We then define *High-tech* as a dummy variable that equals one if a firm belongs to a high-technology industry and zero otherwise.

As in Levine, Lin, and Wei (2017), and other cross-firm studies of innovation, we conjecture that if more stringent competition laws (laws designed to intensify competition) spur innovation, the effects should be stronger among firms in more innovative-intensive industries. We evaluate whether more stringent competition laws spur innovation more among firms in innovative intensive industries by modifying equation (1) and including interaction between the *Competition Law Index* and *High-tech*. In particular, we use the following specification that allows us condition out time-varying country factors, including laws, policies, and regulations.

$$Innovation_{f,c,t} = \alpha_0 + \beta \times Competition\ Law\ Index_{c,t-1} \times High\ Tech_j + \gamma \boldsymbol{X'}_{f,c,t-1} + \delta_f + \delta_{j,t} + \delta_{c,t} + \varepsilon_{f,c,t}, \quad (3)$$

where f, j, c, and t index firm, industry, country, and year, respectively. *High Tech*$_j$ denotes the indicator of whether firm f in industry j belongs to a high-technology industry. Other variables have the same definition as in Equation (1) above. The coefficient of interest, β, captures the differential impact of the *Competition Law Index* on firms in innovative-intensive industries. In addition to firm (δ_f) and industry-by-year ($\delta_{ind,t}$) fixed effects, we include country-by-year fixed effects ($\delta_{c,t}$), which conditions out time-varying country characteristics. Note that these fixed effects subsume the linear terms, i.e., *Competition Law Index* and *High Tech*. We estimate Equation (3) using OLS regression and cluster the standard errors at the country level.

Consistent with the view that more stringent competition laws spur innovation more among firms in more innovative-intensive industries, we find that the interaction term, *Competition Law Index * High-Tech*, enters positively and significantly when the dependent variable is either *Patent Count*, *Citation*, *Top Cited Patent*, or *Explorative Patent*, as reported in columns (2), (4), (6), (8) of Table 5. These cross-firm analyses allow us to condition out

[12] The classification of high-tech and knowledge intensive industries is available at: https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf.

time-varying country characteristics, confirm the results explicitly controlling for country-level policy indicators, and hence mitigate omitted variable concerns.

So far we have examined an overall index of competition laws, the *Competition Law Index*, which is composed of data on (1) authority, (2) laws limiting mergers, (3) laws prohibiting anticompetitive agreements among firms, and (4) laws limiting the ability of firms to abuse their dominant positions in a market to restrict competition. We also separately examine the association between firm innovation and each of the sub-indexes of *Competition Law Index*: *Authority*, *Merger Control*, *Abuse of Dominance* and *Anticompetitive Agreements*. Appendix Table A2 presents the results.

As shown in Panel A, the findings hold for the individual sub-indexes *Authority*, *Merger Control*, and *Anticompetitive Agreements*. Each of these sub-indexes enters positively and significantly in all the regressions. These results are consistent with the view that competition laws that (a) grant greater authority to the antitrust regime, (b) contain a broader range of provisions regulating mergers, and (c) more stringently limit horizontal and vertical agreements between companies foster technological innovation and increase self-developed patents relative to the acquisition of patents from others.

Since the results in Panel A of Table A2 also demonstrate that the sub-index, *Abuse of Dominance*, enters insignificantly across all of the regressions, we dig deeper into its components. As constructed by Bradford and Chilton (2018), *Abuse of Dominance* is composed of (1) *Prohibition (Dom.)*, which accounts for the extent to which laws prohibit a firm from abusing its dominant market position (i.e., it is the summation of *General Prohibition*, *Market Access*, *Tying*, *Discounts*, *Discriminatory Pricing*, *Unfair Pricing*, *Predatory Pricing*, *Retail Price Maintenance*, *Other Abusive Acts*), (2) *Efficiency Defense (Dom.)*, which measures whether firms can argue that the economic efficiency benefits from abusive actions dominate the anticompetitive costs of those actions, and (3) *Public Interest Defense (Dom.)*, which measures whether firms can argue that the public interest benefits of abusive actions outweigh the adverse anticompetitive effects.

Dividing *Abuse of Dominance* into its components highlights a potential explanation for why the overall *Abuse of Dominance* index is not strongly correlated with innovation:

exploiting the dominant position created by a patent might be one mechanism that firms use to maximize the returns from innovation, so that limiting such "abuse" could reduce investment in innovation and hence future patenting. From the perspective of maximizing patent-based innovation, therefore, a legal system that allows firms to exploit their dominant positions based on efficiency considerations could boost innovation. Thus, in Panel B of Appendix Table A2, we examine the association between the sub-components of *Abuse of Dominance* (namely *Prohibition (Dom.)*, *Efficiency Defense (Dom.)*, and *Public Interest Defense (Dom.)*) and firm-level measures of innovation.

Consistent with the view that allowing firms to exploit their positions of dominance for economic efficiency reasons boosts innovation, we find that *Efficiency Defense (Dom.)* enters positively and significantly in the regressions of *Patent*, *Citation*, *Top Cited Patent* and *Explorative Patent*. These findings suggest that the presence of an efficiency defense for actions that would otherwise be classified as abusive enhances corporate inventive activities.

4.7 Cross-Sectional Heterogeneity

We now assess whether the positive association between the stringency of competition laws and corporate innovation varies across firms in a theoretically predictable manner.

4.7.1 Financial constraints

First, we differentiate firms by the extent to which they are more or less financially constrained. As innovation activities tend to be costly (e.g., He and Tian 2018), less financially-constrained firms should have greater capabilities in investing in costly innovative projects when facing more stringent competition laws. To measure financial constraints, we use the *Size-Age Index* (*SA Index*) developed by Hadlock and Pierce (2010), who show that firm size and age are particularly useful in predicting financial constraints.[13] We first compute *SA Index* for each firm in a year. We then calculate the average of *SA Index* across the sample period for each firm. A firm is classified as *More Constrained* financially if the value of *SA Index* is above

[13] *SA Index* = -0.737 * *Size* + 0.043 * *Size*^2 - 0.040 * *Age*, where *Size* is the natural logarithm of total assets and *Age* is the number of years since a firm is incorporated.

the sample median and *Less Constrained* otherwise. Finally, we evaluate whether more stringent competition laws spur innovation more among the *Less Constrained* firms.

Results reported in Table 6 suggest that the innovation-boosting effects of competition are stronger among firms that are comparatively less financially constrained. As shown, the coefficient estimates on *Competition Law Index* are positive and statistically significant in the less-constrained group, and insignificant with an economically small magnitude in the more-constrained group. The results hold when examining the total number of patents, the impact of patents, the number of highly cited patents, or the number of explorative patents.

4.7.2 Publicly-listed and privately-held firms

We also differentiate firms by whether they are public listed or privately held. Acharya and Xu (2017) show that public firms in high external-finance-dependence industries have more patent and citation counts than private firms, suggesting that public listing facilitates access to capital markets and alleviates financing constraints. Thus, we repeat the analyses in equation (1) while partitioning the sample into public listed and privately held firms.

Results in Table 7 suggest that the positive association between innovation and competition is more pronounced among publicly listed firms than privately held firms. As shown, the coefficient estimates on *Competition Law Index* are positive and statistically significant in the public group, except for where the dependent variable is *Top Cited Patent*. The coefficients on *Competition Law Index* between public and private groups are mostly significantly different. Overall, the evidence is consistent with the view that public listing enables easier access to cheaper capital, promoting firms' innovative activities.

4.7.3 Ownership structure

Furthermore, we examine whether the association between competition and innovation varies across firms' ownership structure. In particular, we disentangle firms by whether they have a family owner. According to La Porta, Lopez-de-Silanes, and Shleifer 1999) and Claessens, Djankov, and Lang (2000), a vast majority of firms around the world are closely held by controlling shareholders, such as families. As family owners tend to have their wealth concentrated in the firms they control and hold less-diversified portfolios, they have greater incentive to reduce the variance of the firm's value as implied in the model of Smith and Stulz (1985) and Faccio, Marchica, and Mura (2011). The risk aversion and concentrated wealth will in turn induce family-controlled firms to invest less in risky projects including innovation. From the agency perspective, since these large shareholders usually gained controls via complicated shareholding structures, they end up with excessive control rights over cash flow rights that subject them to tunneling incentives and other agency problems (Shleifer and Vishny, 1997; Claessens, Djankov, Fan and Lang, 2002). As a result, they are less likely to allocate the resources they control for long-term projects that maximizes overall shareholders' value at their own cost of private benefits, leading to a lower rate of innovation (Morck, Wolfenzon, and Yeung, 2005). Therefore, we conjecture that the effect of an intensification of competition will be smaller among family-controlled firms.

We obtain a firm's family ownership using the Bureau van Dijk Orbis Dataset, which provides information on each firm's ultimate controlling owner over the period from 2001 – 2011. Orbis traces control by calculating voting rights, not cash flow rights. Orbis defines an ultimate controlling owner as a legal entity controlling—either directly or indirectly—50 percent of the voting rights. We classify a firm as family-owned if more than 50% of voting rights are directly or indirectly held by families using the initial observation during the sample period.

Results presented in Table 8 show that only non-family-controlled firms boost innovation when facing more stringent competition. In contrast, we do not observe a significant increase in innovation among family firms. As shown, the coefficient estimates on *Competition Law Index* are positive and statistically significant among non-family firms, whereas those among family firms are insignificant. The coefficients on *Competition Law Index* between family and non-family firms are significantly different from each other. These findings are consistent with the conjecture that family firms, due to tunneling incentives and concentrated wealth portfolios, are refrained from pursuing risky innovative activities.

5. Country-Industry-Level Results

We complement these firm-level analyses with an industry-country level investigation. The industry-country level investigation covers a much longer period, 1888 (the first year that the *Competition Law Index* is available) through 2011 and includes a cross-section of 186 countries. In particular, we estimate the following regression:

$$Innovation_{j,c,t} = \alpha_0 + \beta \times Competition\ Law\ Index_{c,t-1} \times High\ Tech_j + \delta_{c,j} + \delta_{j,t} + \delta_{c,t} + \varepsilon_{j,c,t}, \quad (4)$$

where j, c, and t denote industry (2-digit SIC), country, and year, respectively. The dependent variable, $Innovation_{j,\ c,\ t}$, is one of the patent-based measures of innovation of industry j in country c in year t defined in Section 2. The key explanatory variable is the interaction between the $Competition\ Law\ Index_{c,t-1}$ and $High\ Tech_j$, where $High\ Tech_j$ represents the indicator of whether industry j is classified as a high-technology industry or not. For each industry at the two-digit SIC level, we define high-tech industries using the average growth rate of R&D expenditures of U.S. firms over the period from 1950 through 2010 (see, e.g., Hsu et al., 2014; Levine et al., 2017). *High-tech* equals one if the average growth rate is greater than the sample median value and zero otherwise.[14] We include the full array of possible fixed effects for this level of analysis: country-by-industry ($\delta_{c,j}$), industry-by-year ($\delta_{j,t}$), and country-by-year ($\delta_{c,t}$) fixed effects. We estimate the model using the OLS regression and cluster the standard errors at the country level.

The estimation results at the country-industry-year level reported in Table 9 confirm our earlier findings based on firm-level measures of innovation. The coefficient estimates on the interaction term, *Competition Law Index * High-Tech*, are positive and statistically significant in all columns, suggesting that the positive connections between stricter competition laws and innovation are particularly strong among innovation-intensive industries. The

[14] We use a different definition of High-tech industries in the firm-level and country-industry level data for the following reason. The industry code in the Historical Orbis firm-level data is NACE, and Eurostat defines industries as high-tech based on NACE. In contrast, the country-industry data are from PATSTAT, where the technological classes can be converted into SIC categories using the mapping scheme described above.

differential effects are economically meaningful. The estimated coefficients in column 1, for example, imply that a one-standard-deviation increase in a country's *Competition Law Index* would raise the number of patents among firms in the high-technology group by almost 4 percentage points more than that of the low-technology group (=0.1480*0.2517).

6. Conclusion

We examined the impact of competition laws on innovation. To conduct this study, we (1) used a new dataset on competition laws, and (2) created a large, international firm-level panel dataset with detailed information on patenting activity and financial accounts. These unique data allow us to evaluate the impact of different competition laws on a multiplicity of firm-level patenting activities, including the number of patents, the impact of those patents as measured by forward citations, and the explorative nature of those patents.

We discovered a tight connection between competition laws and firm innovation. First, more stringent competition laws are associated with sharp increases in firm innovation, as measured by the number of patents, forward citations to patents, citations per patent, the number of very highly cited patents, and the number of explorative patents. Second, the results are stronger among firms that are less financially constrained, publicly listed firms, and non-family-controlled firms. These results are robust to several robustness tests and extensions. For example, we confirm that these results hold when (a) differentiating by firms so that we can condition on country-year effects to mitigate omitted variable concerns, (b) examining the sub-component of the overall competition law stringency index, and (c) employing an industry-country panel that covers the period from 1888 through 2011 and includes 186 countries.

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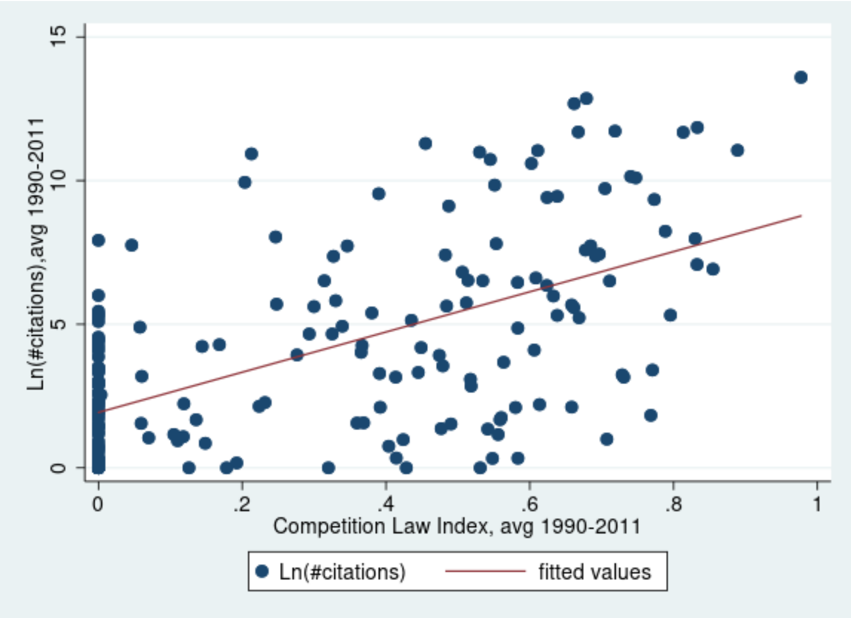
Figure 1. Cross-country innovation and CLI, 1990 – 2011

These figures plot (a) the average annual number of patents filed by entities from each country and (b) the average annual number of forward citations to patents filed by entities from each country against the average value of the *Competition Law Index*. The averaging is done over the years from 1990 through 2011. That is, we first calculate the total number of patents (citations) in each country in a year and then compute the average number of patents (citations) for each country over 1990 – 2011. Each dot represents one country.

(a1) # of Patents



(b1) # of Citations

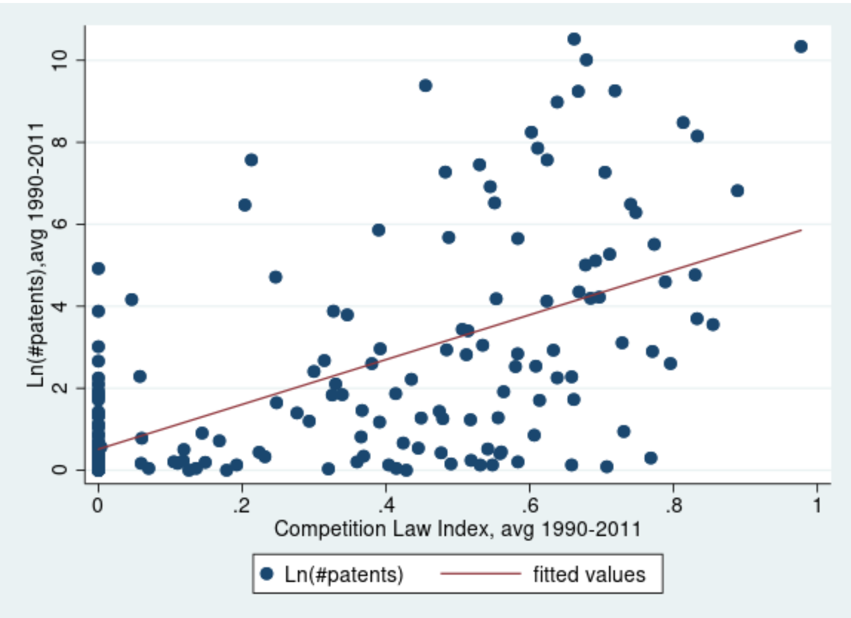


Table 1 Summary Statistics

This table presents the summary statistics of the variables used in our analysis. Statistics for firm-level variables are calculated based on the firm-level sample during 1991-2011; statistics for country-level and country-industry-level variables are based on the broadest country-industry level sample from 1888 to 2011.

Variable	N	Mean	Std. Dev.	P10	P50	P90
Innovation Measures						
Firm Level (log)						
Patent Count	855243	0.1796	0.5166	0	0	0.6931
Citation	855243	0.3482	1.091	0	0	1.534
Cit/Pat	855243	0.2619	0.8003	0	0	1.224
Cited Patent	855243	0.1272	0.4389	0	0	0.6931
Top Cited Patent (top 25%)	855243	0.04766	0.2669	0	0	0
Top Cited Patent (top 10%)	855243	0.02162	0.1759	0	0	0
Explorative Patent (60% new knowledge)	855243	0.1007	0.3549	0	0	0
Explorative Patent (90% new knowledge)	855243	0.08609	0.3138	0	0	0
Firm Level (non-log)						
Patent Count	855243	1.1	34.23	0	0	1
Citation	855243	20.39	960.6	0	0	3.636
Cit/Pat	855243	1.994	22.07	0	0	2.402
Cited Patent	855243	0.7354	24.34	0	0	1
Top Cited Patent (top 25%)	855243	0.2133	7.915	0	0	0
Top Cited Patent (top 10%)	855243	0.08007	3.152	0	0	0
Explorative Patent (60% new knowledge)	855243	0.228	0.9586	0	0	0
Explorative Patent (90% new knowledge)	855243	0.1771	0.7329	0	0	0
Firm characteristics						
Firm Size	855243	8.605	2.324	5.746	8.548	11.6
Leverage	855243	0.1651	0.2358	0	0.07601	0.4483
Profitability	855243	0.0365	0.2231	-0.09906	0.04482	0.214
Age	855243	2.6	1.004	1.386	2.639	3.85
Country-Industry Level (log)						
Patent-Ind	475687	0.3934	0.9125	0	0	1.553
Citation-Ind	475687	0.5276	1.206	0	0	2.285
Top Cited Patent-Ind (top 25%)	475687	0.1453	0.4306	0	0	0.4056
Top Cited Patent-Ind (top 10%)	475687	0.07671	0.2518	0	0	0.1534
Explorative Patent-Ind (60% new knowledge)	396212	0.3151	0.7769	0	0	1.166
Explorative Patent (90% new knowledge)	396212	0.289	0.7226	0	0	1.051
Country-Industry Level (non-log)						
Patent-Ind	475687	2.445	8.351	0	0	3.725
Citation-Ind	475687	6.526	22.78	0	0	8.829
Top Cited Patent-Ind (top 25%)	475687	0.347	1.213	0	0	0.5002
Top Cited Patent-Ind (top 10%)	475687	0.1278	0.4571	0	0	0.1658
Explorative Patent-Ind (60% new knowledge)	396212	1.552	5.61	0	0	2.21
Explorative Patent-Ind (90% new knowledge)	396212	1.258	4.506	0	0	1.861
CLI score and other country characteristics						
Competition Law Index	691	0.6079	0.2517	0.1731	0.6538	0.875
Authority	691	0.6332	0.2632	0.2143	0.6429	0.9286

Merger Control	691	0.57	0.2945	0.125	0.625	0.875
Abuse of Dominance	691	0.6449	0.2587	0.3636	0.7273	0.9091
Anticompetitive Agreements	691	0.5651	0.2506	0.1	0.6	0.9
GDP per capita	691	9.723	1.122	8.149	10.07	10.81
Credit/GDP	691	100.1	60.21	37	92.3	165.8
Stock/GDP	691	67.44	57.92	14.2	49	146.7

Table 2 Competition Law and Preexisting Innovation

This table reports the connection between pre-existing measures of innovation and the competition law index. The dependent variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. The key explanatory variables are one-year-lagged measures of innovation, *Patent Count*, *Citation*, *Top Cited Patent*, and *Explorative Patent*, averaged across each country. Country controls include GDP per capita, Credit/GDP and Stock/GDP. We include country and year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var.	Competition Law Index			
	(1)	(2)	(3)	(4)
Patent Count	0.0223			
	(0.053)			
Citation		0.0130		
		(0.018)		
Top Cited Patent			0.0544	
			(0.105)	
Explorative Patent				0.0213
				(0.064)
GDP per capita	0.0530	0.0471	0.0526	0.0594
	(0.124)	(0.124)	(0.127)	(0.131)
Credit/GDP	-0.0004	-0.0004	-0.0004	-0.0004
	(0.000)	(0.001)	(0.000)	(0.000)
Stock/GDP	0.0005*	0.0005*	0.0005*	0.0005*
	(0.000)	(0.000)	(0.000)	(0.000)
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	780	780	780	780
Adjusted R-squared	0.848	0.849	0.848	0.847

Table 3 Competition Law and Innovation Intensity

This table presents the effect of competition law on innovation intensity measured at the firm level based on different fixed effects, industries and time period. The dependent variable, Patent Count, is the natural logarithm of one plus the total number of (eventually granted) patents filed by a firm in a given year. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. Country controls include *GDP per capita*, *Credit/GDP* and *Stock/GDP*. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parenthesis. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count		
			Manufacturing industries
	(1)	(2)	(3)
Competition Law Index	0.1134**	0.1200***	0.1110***
	(0.044)	(0.038)	(0.038)
Firm Size	0.0245***	0.0242***	0.0311***
	(0.003)	(0.003)	(0.004)
Leverage	-0.0109	-0.0109*	-0.0121
	(0.007)	(0.006)	(0.012)
Profitability	0.0072	0.0079	0.0155*
	(0.007)	(0.008)	(0.009)
Age	-0.0118	-0.0117	-0.0119
	(0.008)	(0.007)	(0.013)
GDP per capita	0.5693***	0.5554***	0.5586***
	(0.094)	(0.093)	(0.104)
Credit/GDP	-0.0001	-0.0001	-0.0001
	(0.000)	(0.000)	(0.000)
Stock/GDP	0.0004*	0.0004**	0.0005**
	(0.000)	(0.000)	(0.000)
Firm FE	Y	Y	Y
Year FE	Y	N	N
Industry-Year FE	N	Y	Y
Observations	855,243	855,243	478,055
# of Firms	145,318	145,318	82,799
Adjusted R-squared	0.619	0.620	0.623

Table 4 Competition Law and Innovation Quality

This table presents the effect of competition law on innovation quality measured at the firm level. The dependent variable is Citation, Cit/Pat, Cited Patent, Top Cited Patent, and Explorative Patent. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. Country controls include *GDP per capita*, *Credit/GDP* and *Stock/GDP*. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Citation	Cit/Pat	Cited Patent	Top Cited Patent (Top 25%)	Top Cited Patent (Top 10%)	Explorative Patent (60% new knowledge)	Explorative Patent (90% new knowledge)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Competition Law Index	0.2872***	0.1793***	0.1146***	0.0592***	0.0288***	0.1355***	0.1211***
	(0.067)	(0.051)	(0.025)	(0.011)	(0.005)	(0.032)	(0.029)
Firm Size	0.0457***	0.0305***	0.0177***	0.0082***	0.0041***	0.0189***	0.0160***
	(0.005)	(0.003)	(0.003)	(0.002)	(0.001)	(0.003)	(0.003)
Leverage	-0.0206**	-0.0144**	-0.0078**	-0.0030	-0.0006	-0.0076	-0.0062
	(0.010)	(0.007)	(0.004)	(0.003)	(0.002)	(0.005)	(0.004)
Profitability	0.0069	0.0053	0.0053	-0.0011	-0.0020	0.0007	0.0014
	(0.017)	(0.012)	(0.007)	(0.003)	(0.001)	(0.004)	(0.004)
Age	-0.0309***	-0.0210***	-0.0072	-0.0051	-0.0040**	-0.0064	-0.0056
	(0.010)	(0.005)	(0.006)	(0.003)	(0.002)	(0.009)	(0.007)
Country Control	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y
Observations	855,243	855,243	855,243	855,243	855,243	855,243	855,243
# of Firms	145,318	145,318	145,318	145,318	145,318	145,318	145,318
Adjusted R-squared	0.522	0.370	0.639	0.644	0.627	0.548	0.500

Table 5 Competition Law and Innovation: Robustness to County-by-Year Factors

This table shows the effect of competition law on innovation conditional on a series of other policy reforms. In column (1), (3), (5), (7), we explicitly include Financial Reform Index, which measures the overall financial liberalization, PR & Legal Index, which measures the overall strength of legal system and property rights protection, and Patent Law, which equals to one in the years after a country enacts its first patent law, and equals zero otherwise. In column (2), (4), (6), (8), we differentiate the effect of competition law by the high-tech intensiveness of an industry, and control for country-year fixed effects that subsume all the time-varying variables at the country level. *High-tech* is an indicator variable equal to one if a firm belongs to industries classified as high-tech and knowledge intensive according to the Eurostat guidance, and zero otherwise. The dependent variable is *Patent Count*, *Citation*, *Top Cited Patent*, and *Explorative Patent*. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. Country controls include *GDP per capita*, *Credit/GDP* and *Stock/GDP*. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count		Citation		Top Cited Patent		Explorative Patent	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Competition Law Index	0.0906**		0.2394***		0.0500***		0.1027**	
	(0.045)		(0.075)		(0.012)		(0.040)	
Competition Law Index*High-tech		0.0729***		0.1004*		0.0298***		0.0794***
		(0.020)		(0.051)		(0.007)		(0.017)
Firm Size	0.0238***	0.0237***	0.0450***	0.0449***	0.0081***	0.0082***	0.0184***	0.0183***
	(0.003)	(0.004)	(0.005)	(0.006)	(0.002)	(0.002)	(0.003)	(0.003)
Leverage	-0.0108*	-0.0130***	-0.0205**	-0.0250***	-0.0030	-0.0041	-0.0074*	-0.0075**
	(0.006)	(0.005)	(0.009)	(0.009)	(0.003)	(0.003)	(0.004)	(0.003)
Profitability	0.0087	0.0096	0.0084	0.0098	-0.0008	-0.0006	0.0015	0.0022
	(0.008)	(0.008)	(0.017)	(0.018)	(0.003)	(0.003)	(0.004)	(0.005)
Age	-0.0125*	-0.0209***	-0.0321***	-0.0452***	-0.0053	-0.0065**	-0.0073	-0.0127*
	(0.007)	(0.006)	(0.010)	(0.007)	(0.003)	(0.003)	(0.009)	(0.007)
Financial Reform Index	Y		Y		Y		Y	
PR & Legal Index	Y		Y		Y		Y	
Patent Law	Y		Y		Y		Y	
Country Control	Y		Y		Y		Y	
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Country-Year FE		Y		Y		Y		Y
Observations	852,599	855,243	852,599	855,243	852,599	855,243	852,599	855,243
# of Firms	144,879	145,318	144,879	145,318	144,879	145,318	144,879	145,318
Adjusted R-squared	0.620	0.622	0.523	0.523	0.644	0.645	0.548	0.552

Table 6 Competition Law and Corporate Innovation: Differentiate by Financial Constraints

This table presents the association between competition laws and corporate innovation, while differentiating firms by the extent of financial constrained. We measure financial constraints using the Size-Age Index (SA Index) developed by Hadlock and Pierce (2010). The dependent variables are *Patent*, *Citation*, *Top Cited Patent*, and *Explorative Patent*. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. We include firm, industry-by-year, and country-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count		Citation		Top Cited Patent		Explorative Patent	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Less Constrained	More Constrained	Less Constrained	More Constrained	Less Constrained	More Constrained	Less Constrained	More Constrained
Competition Law Index	0.1636***	0.0003	0.3927***	0.0264	0.0792***	0.0048	0.1575***	0.0282**
	(0.053)	(0.032)	(0.092)	(0.051)	(0.014)	(0.005)	(0.055)	(0.013)
Firm Size	0.0384***	0.0122***	0.0726***	0.0228***	0.0151***	0.0024***	0.0297***	0.0097***
	(0.006)	(0.001)	(0.009)	(0.003)	(0.004)	(0.000)	(0.005)	(0.002)
Leverage	-0.0021	-0.0110***	-0.0019	-0.0234**	0.0019	-0.0042***	-0.0059	-0.0018
	(0.007)	(0.003)	(0.017)	(0.011)	(0.005)	(0.001)	(0.006)	(0.002)
Profitability	0.0310	0.0034	0.0535	-0.0031	0.0061	-0.0015	0.0149	0.0005
	(0.021)	(0.004)	(0.033)	(0.015)	(0.006)	(0.001)	(0.012)	(0.003)
Age	0.0059	-0.0019	0.0030	-0.0080	0.0012	0.0001	0.0097	0.0056*
	(0.010)	(0.005)	(0.017)	(0.012)	(0.004)	(0.001)	(0.008)	(0.003)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	427,261	427,259	427,261	427,259	427,261	427,259	427,261	427,259
# of Firms	66,707	77,897	66,707	77,897	66,707	77,897	66,707	77,897
Adjusted R-squared	0.689	0.303	0.586	0.273	0.686	0.271	0.594	0.311
p-value H_0: Less Constrained - More Constrained	0.000		0.000		0.000		0.001	

Table 7 Competition Law and Corporate Innovation: Differentiate by Publicly Listed vs. Privately Held Companies

This table presents the association between competition laws and corporate innovation, while differentiating firms by whether they are public listed or privately held. The dependent variables are *Patent*, *Citation*, *Top Cited Patent*, and *Explorative Patent*. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. We include firm, industry-by-year, and country-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count		Citation		Top Cited Patent		Explorative Patent	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Private	Public	Private	Public	Private	Public	Private	Public
Competition Law Index	0.0621	0.1704**	0.1468*	0.4846***	0.0219**	0.1034***	0.0784**	0.2287***
	(0.049)	(0.072)	(0.084)	(0.129)	(0.011)	(0.030)	(0.034)	(0.057)
Firm Size	0.0208***	0.0568***	0.0390***	0.1108***	0.0069***	0.0206***	0.0158***	0.0512***
	(0.004)	(0.010)	(0.006)	(0.017)	(0.002)	(0.004)	(0.002)	(0.011)
Leverage	-0.0074	-0.0346*	-0.0162	-0.0505	-0.0018	-0.0134	-0.0032	-0.0443***
	(0.005)	(0.021)	(0.010)	(0.051)	(0.003)	(0.009)	(0.004)	(0.016)
Profitability	0.0062	0.0554	0.0044	0.0974	-0.0012	0.0123	0.0009	0.0248
	(0.006)	(0.037)	(0.013)	(0.067)	(0.002)	(0.014)	(0.004)	(0.018)
Age	-0.0061	0.0287	-0.0186*	0.0335	-0.0022**	0.0099	-0.0004	0.0229
	(0.006)	(0.027)	(0.010)	(0.052)	(0.001)	(0.014)	(0.005)	(0.017)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	794,110	61,133	794,110	61,133	794,110	61,133	794,110	61,133
# of Firms	136,471	8,847	136,471	8,847	136,471	8,847	136,471	8,847
Adjusted R-squared	0.539	0.763	0.456	0.666	0.555	0.763	0.507	0.629
p-value H_0: Private - Public	0.137		0.004		0.004		0.011	

Table 8 Competition Law and Corporate Innovation: Differentiate by Family Ownership

This table presents the association between competition laws and corporate innovation, while differentiating firms by family ownership. The dependent variables are *Patent*, *Citation*, *Top Cited Patent*, and *Explorative Patent*. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. We include firm, industry-by-year, and country-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count		Citation		Top Cited Patent		Explorative Patent	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Non-family	Family	Non-family	Family	Non-family	Family	Non-family	Family
Competition Law Index	0.1175***	0.0276	0.3234***	0.1007	0.0769***	0.0142	0.1086**	0.0348
	(0.036)	(0.029)	(0.085)	(0.072)	(0.018)	(0.011)	(0.054)	(0.030)
Firm Size	0.0212***	0.0151***	0.0364***	0.0376***	0.0049***	0.0056***	0.0194***	0.0101***
	(0.004)	(0.003)	(0.005)	(0.009)	(0.001)	(0.002)	(0.004)	(0.001)
Leverage	-0.0097*	-0.0045	-0.0214**	0.0039	-0.0033	-0.0011	-0.0086	-0.0010
	(0.006)	(0.010)	(0.010)	(0.020)	(0.003)	(0.003)	(0.005)	(0.007)
Profitability	0.0158	0.0003	0.0224	-0.0216	0.0019	-0.0072***	0.0039	0.0024
	(0.011)	(0.009)	(0.023)	(0.016)	(0.003)	(0.002)	(0.006)	(0.009)
Age	-0.0217***	-0.0097	-0.0444***	-0.0377*	-0.0085*	-0.0047*	-0.0136	0.0030
	(0.008)	(0.008)	(0.014)	(0.021)	(0.005)	(0.002)	(0.011)	(0.007)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	535,670	63,585	535,670	63,585	535,670	63,585	535,670	63,585
# of Firms	103,030	12,070	103,030	12,070	103,030	12,070	103,030	12,070
Adjusted R-squared	0.644	0.545	0.549	0.445	0.680	0.519	0.563	0.541
p-value H_0: Non-family - Family	0.023		0.052		0.018		0.219	

Table 9 Competition Law and Corporate Innovation: Evidence from a Century's Observation, Country-industry-year Sample

This table shows the association between the CLI score and innovation at the country-industry(two-digit SIC)-year panel data, while differentiating industries by the degree of technological intensity. The dependent variables are *Patent Count-Ind*, *Citation-Ind*, *Top Cited Patent-Ind* and *Explorative Patent-Ind* in columns 1, 2, 3, and 4, respectively. High-tech is an indicator variable equal to one if it is a high-technology industry and equals zero otherwise. We define high-technology industry at the country-industry-year level sample as 2-digit SICs with an average industry R&D growth (benchmarked to the U.S.) above the sample median. We include a full set of country-by-industry, industry-by-year, and country-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var.	Patent Count-Ind	Citation-Ind	Top Cited Patent-Ind	Explorative Patent-Ind
	(1)	(2)	(3)	(4)
Competition Law Index*High-tech	0.1480***	0.1951***	0.0889***	0.1462***
	(0.044)	(0.057)	(0.024)	(0.046)
Time Period	1888-2011			
Country-Industry FE	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y
Country-Year EF	Y	Y	Y	Y
Observations	475,687	475,687	475,687	396,212
# of Country-Industry	6,853	6,853	6,853	5,370
Adjusted R-squared	0.929	0.898	0.872	0.900

Appendix

Appendix Table A1 Variable Definition

Variable	Definition	Source
Firm Level		
Patent Count	Log one plus the total number of patents filed by a firm in a given year.	PATSTAT and ORBIS Database
Citation	Log one plus the total number of truncation-adjusted forward citations made to patents filed by a firm in a given year; truncation-adjusted citation count is obtained by weight factors using the average life-time citation distribution of patents estimated within each technology class and application year.	
Cit/Pat	Log one plus the number of truncation-adjusted forward citations per patent filed by a firm in a given year.	
Cited Patent	Log one plus the total number of patents with at least one citation that are filed by a firm in a given year.	
Top Cited Patent	Log one plus the total number of patents at firm-year level whose citations fall in the top 25% (or 10% if indicated otherwise) of citation distribution across all patents in the same technology class in the same year.	
Explorative Patent	Log one plus the total number of explorative patents filed by a firm in a given year. A patent is defined as an explorative patent if at least 60% (or 90% if indicated otherwise) of the citations to which it refers are neither to patents that the firm produced during the last five years nor to patents that were cited by the firm's patents filed over the past five years.	
Firm Size	Log the book value of total assets (in thousand USD)	
Leverage	The ratio between non-current liabilities and total assets	
Profitability	The ratio between net income and total assets	
Age	Log of firm’s age	
Country-Industry Level		
Patent-Ind	Log one plus the total number of patents at country-industry-year level.	
Citation-Ind	Log one plus the total number of truncation-adjusted forward citations made to patents at country-industry-year level; truncation-adjusted citation count is obtained by weight factors using the average life-time citation distribution of patents estimated within each technology class and application year.	PATSTAT and ORBIS Database
Top Cited Patent-Ind	Log one plus the total number of patents at country-industry-year level whose citations fall in the top 25% of citation distribution across all patents in the same technology class in the same year.	

Explorative Patent-Ind	Log one plus the total number of explorative patents filed by a firm at country-industry-year level. A patent is defined as an explorative patent if at least 60% of the citations it refers are not from existing knowledge, which includes all the patents that the firm produced and all the patents that were cited by the firm's patents filed over the past five years.	
Country Level		
Competition Law Index	The overall competition law index, consisting of Authority, Merger Control, Abuse of Dominance and Anticompetitive Agreements.	Bradford and Chilton (2018)
Authority	An index that captures (1) who can bring suits against firms that are alleged to have engaged in anticompetitive behavior, (2) the remedies that the authorities can impose on firms that violate competition laws, and (3) the scope of the law, i.e., the degree to which all industries and enterprises fall under the purview of a country's competition laws. More specifically, *Authority* is the summation of eight components. *Private right of action* equals one if a country allows individuals and firms to bring suits against companies for violating competition rules. While governments typically enforce competition laws, some countries allow for an additional avenue for raising and then adjudicating claims of anti-competition actions: private actions by individuals and firms. Since allowing for these private actions expands the competition regime beyond government enforcement, Bradford and Chilton (2018) add one to the overall authority measure, *Authority*, when *Private right of action* equals one. The next five components of *Authority* concern remedial powers and scope. *Fines* equals one if the authorities have the authority to levy monetary fines on firms that violate competition laws. *Imprisonment* equals one if a country can imprison those who violate competition laws. *Divestiture* equals one if a country's authorities have the right to stop, reverse, or modify the structure of a merger or acquisition. *Damages* equals one if the authorities can reward damages to private parties as compensation for another entity violating competition laws. *Extraterritoriality* equals one when a country's authorities can address conduct by those operating outside of the geographic boundaries of the country if those action violate the country's competition laws and affect the competitive environment in the domestic economy. The next two components of *Authority* concern exemptions to the country's competition laws. As stressed by Bradford and Chilton (2018), the extent to which countries limit the purview of their competition laws by limiting their authority over market competition. Thus, *Industry Exemptions* equals -0.5 when a country's competition law provides any exemptions for industries (e.g., agriculture)	

	adhering to the nation's competition laws. Similarly *Enterprise Exemptions* equals -0.5 when there are any exemptions for enterprises (e.g., state-owned).
Merger Control	An index capturing information on each country's laws in each year with respect to (1) regulating pre-merger notification and approval, (2) granting expansive powers to the authorities to restrict mergers for economic and public interest reasons, and (3) permitting an assortment of arguments by firms to defend mergers and acquisitions and limiting the scope of laws, i.e., the degree to which all industries and enterprises are within the purview of the competition laws. *Merger Control* is the summation of seven components. The first two measure the degree to which competition laws require that firms get approval before undertaking a merger. *Pre-merger Notification* equals one if firms obtain approval before completing a merger voluntarily or mandatorily. *Mandatory Notification* equals one if firms must obtain approval before closing a merger. The next two components focus on the types of reasons that can be used to restrict mergers. *Economic Reason* equals one if the law grants the regulatory authority expansive powers to limit mergers on grounds that the merger would lessen competition or strengthen a firm's dominant position. *Public Interest* equals one if the country's competition laws permit merger restrictions on grounds that the merger would hurt the public interest. As stressed by Bradford and Chilton (2018), *Merger Control* is designed to capture the extent to which a country grants officials control over mergers and acquisitions. The next three components of *Merger Control* concern the arguments that firms can use to defend themselves against accusations that a merger is anticompetitive. *Efficiency Defense* equals -0.5 if firms can argue that the merger will enhance economic efficiency enough to outweigh any anticompetitive effects. This enters negatively into the *Merger Control* index because such a defense reduces regulatory control over mergers. Similarly, *Failing Firm Defense* equals -0.5 if a country's competition law allows firms to justify anticompetitive mergers when firms are failing and bankruptcy would eliminate the value of their assets. Finally, *Public Interest Defense* equals -0.5 if a country's competition laws allow firms to defend mergers based on the argument that the public interest benefits outweigh the anticompetitive costs.
Abuse of Dominance	An index that measures the extent to which competition laws limit the ability of dominant firms to abuse their market positions in uncompetitive ways. Abuses behaviors include price and nonprice related conduct, including discriminatory pricing, resale price maintenance, unfair (or excessive) pricing, predatory pricing, and anticompetitive discounts (price-related abuses), as well as tying and refusal to deal (nonprice related abuses). The index also incorporates information on the degree to which firms can

defend actions that would otherwise be classified as abusive actions based on efficiency or public interests.

Abuse of Dominance is the summation of eleven components. *General Prohibition* equals two if the country's competition law gives the authorities broad, general powers to prohibit abusive conduct. This type of blanket prohibition gives authorities discretion over what constitutes abusive conduct by a dominant company, which is why Bradford and Chilton (2018) give it a weight of two. We made one adjustment in constructing *Abuse of Dominance*. We redefined *General Prohibition*. In the original version, *General Prohibition* equals two if the law prohibits the abuse of a dominant position, either generically or by specifying actions that would constitute an impermissible abuse of a dominant position. We redefined *General Prohibition* as equal to two if the law prohibits the abuse of a dominant position generically, and equal to zero if the law enumerates any types of abusive action. Our results remain robust if we use the original definition of *General Prohibition*.

The next eight components of *Abuse of Dominance* involve laws prohibiting specific behaviors that are generally viewed as abusive when dominant firms perform them. *Market Access* equals 0.25 if the country's competition law prohibits a firm from limiting the supply of its goods or services to the market or restricting sales to downstream purchasers or consumers. *Tying* equals 0.25 if the law prohibits conditioning the sale of a product on the sale or acquisition of another product that is not directly connected. *Discounts* equals 0.25 if the law prohibits a dominant firm from offering discounts that incentivize the buyer to deal exclusively or predominantly with the dominant firm. *Discriminatory Pricing* equals 0.25 if the law prohibits setting different prices for the same products for different customers. *Unfair Pricing* equals 0.25 if the law prohibits setting the product's price at a supra-competitive level. *Predatory Pricing* equals 0.25 if the law prohibits setting prices below the costs of production to eliminate competitors. *Retail Price Maintenance* equals 0.25 if the law prohibits setting a minimum resale price at which retailers will ultimately sell their product to consumers. *Other Abusive Acts* equals 0.25 if the law prohibits firms from engaging in acts—other than those specified above—that abuse a firm's dominant position.

The next two components of *Abuse of Dominance* incorporate information on the degree to which firms can defend actions that would otherwise be classified as abusive actions. *Efficiency Defense (Dom.)* equals -0.5 if firms can argue that the actions will enhance economic efficiency enough to outweigh adverse effects from those abuse actions. This enters negatively because such a defense reduces regulatory power over behaviors by a dominant firm. Similarly, *Public Interest Defense (Dom.)* equals -0.5 if a country's competition laws allow dominant firms to defend abusive behaviors based on the argument that the public interest benefits outweigh the costs of those actions.

Anticompetitive Agreements	An index designed to measure the degree to which a country's competition laws prohibit firms from colluding—both horizontally and vertically—to constrain competition. In particular, *Anticompetitive Agreements* is the summation of ten components. The first four involve laws limiting horizontal agreements. *Price Fixing*, *Market Sharing*, *Output Limitations*, and *Bid Rigging* each equals 0.5 if a country's competition laws limit firms from colluding to (1) set market prices for a product, (2) divide the market along geographic, demographic, price, or other dimensions, (3) limit the overall supply of products, and (4) bid on products and contracts to obtain preferential prices, respectively. The next four components of the *Anticompetitive Agreements* index focus on limiting vertical agreements. *Exclusive Dealing*, *Resale Price Maintenance*, *Tying*, and *Eliminate Competitors* each equals 0.5 if a country's laws prohibit firms from colluding to (1) not sell/buy their products to/from specific companies or groups of companies, (2) set the price at which retailers will ultimately sell the product to consumers, (3) condition contracts on buying additional products that are not directly connected to the product that is the subject of the contract, and (4) engage in coercive practices that eliminate competitors or make it very difficult for them to increase market share. Finally, the last two components of *Anticompetitive Agreements* involve defenses that firms can employ against accusations that they entered into anticompetitive agreements. *Efficiency Defense (Anti.)* equals -0.5 if firms can defend anticompetitive agreements by arguing that the economic efficiency gains outweigh the costs of those agreements. Similarly, *Public Interest Defense (Anti.)* equals -0.5 if a country's competition laws allow firms to defend anticompetitive actions by arguing that the public interest benefits of those actions outweigh the costs.	
GDP per capita	Log real GDP per capita measured in 2010 U.S. dollar.	World Bank WDI
Credit/GDP	Credit provided by the financial sector as a share of GDP.	
Stock/GDP	Stock-market capitalization as a share of GDP.	
Financial Reform Index	The summation of Credit Control, Interest-Rate Control, Entry Barriers, Bank Supervision, Bank Privatization, Capital Control, and Securities Market. Credit Control measures the restrictiveness of reserve requirements, existence of mandatory credit-allocation requirements, and credit ceilings; Interest-Rate Control measures the extent to which the authorities liberalize interest rates; Entry Barriers measures the ease of foreign bank entry and the extent of competition in the domestic banking sector; Bank Supervision measures the degree of supervision over the banking sector; Bank Privatization measures the importance of state-owned banks; Capital Control measures restrictions on international	International Monetary Fund (IMF); Abiad, Detragiache, and Tressel (2008)

	capital flows; Securities Market measures the level of development of securities markets and restrictions on foreign equity ownership. The index ranges from 0 to 27, with higher values indicating less restrictive and more liberalized financial markets.	
PR & Legal Index	An index that measures the overall strength of the legal system and property-rights protection. It is the average value of nine components: judicial independence, impartial courts, protection of property rights, military interference in rule of law and politics, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, reliability of police, and business costs of crime. The index ranges from 0 (weakest) to 10 (strongest).	Fraser Institute; Gwartney, Lawson, and Hall (2015)
Patent Law	An indicator that equals one in the years after a country enacts its first patent law, and zero otherwise.	World Intellectual Property Organization (WIPO) Lex Database

Table A2 Competition Law and Innovation: Sub-index

This table presents the association between sub-components of the CLI score and firm-level measures of innovation. Panel A shows the relation between each sub-component (i.e., *Authority*, *Merger Control*, *Abuse of Dominance*, and *Anticompetitive Agreements*) and firm innovation. Panel B shows the relation between each sub-component of the *Abuse of Dominance* (i.e., *Prohibition (Dom.)*, *Efficiency Defense (Dom.)*, and *Public Interest Defense (Dom.)*) and firm innovation. We focus on five firm-level measures of innovation, namely *Patent Count*, *Citation*, *Top Cited Patent*, and *Explorative Patent*. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm control includes *Firm Size*, *Leverage*, *Profitability* and *Age*. Country control includes *GDP per capita*, *Credit/GDP* and *Stock/GDP*. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Panel A. Sub-Components of the CLI Score

Dependent Var.	Patent Count				Citation				Top Cited Patent				Explorative Patent			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Authority	0.1092***				0.2780***				0.0585***				0.1230***			
	(0.034)				(0.068)				(0.015)				(0.028)			
Merger Control		0.0735***				0.1648***				0.0321***				0.0829***		
		(0.021)				(0.037)				(0.006)				(0.017)		
Abuse of Dominance			-0.0068				-0.0190				0.0035				0.0161	
			(0.030)				(0.061)				(0.011)				(0.022)	
Anticompetitive Agreements				0.0852*				0.1292				0.0155				0.0631
				(0.044)				(0.083)				(0.013)				(0.041)
Firm Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243
# of Firms	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318
Adjusted R-squared	0.620	0.620	0.620	0.620	0.522	0.522	0.522	0.522	0.644	0.644	0.644	0.644	0.548	0.548	0.547	0.547

Panel B. Sub-Components of Abuse of Dominance

Dependent Var.	Patent Count			Citation			Top Cited Patent			Explorative Patent		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Prohibition (Dom.)	0.0307			0.0661			0.0174**			0.0492*		
	(0.023)			(0.043)			(0.007)			(0.027)		
Efficiency Defense (Dom.)		0.0450***			0.0979***			0.0152***			0.0359**	
		(0.014)			(0.025)			(0.004)			(0.014)	
Public Interest Defense (Dom.)			-0.0159*			-0.0251			-0.0041			-0.0119*
			(0.009)			(0.017)			(0.003)			(0.007)
Firm Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243	855,243
# of Firms	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318	145,318
Adjusted R-squared	0.620	0.620	0.620	0.522	0.522	0.522	0.644	0.644	0.644	0.547	0.547	0.547

Table A3 Competition Law and Innovation: Robustness to Alternative Sample Period

This table presents the effect of competition law on innovation measured at the firm level based on the alternative sample period. Panel A is over 1991-2012, where all the explanatory variables are measured with a two-year lag. Panel B is over 1991-2013, where all the explanatory variables are measured with a three-year lag. Panel C is over 1991-2014, where all the explanatory variables are measured with a four-year lag. The dependent variable is Patent Count, Citation, Cit/Pat, Cited Patent, Top Cited Patent, and Explorative Patent. The key explanatory variable, Competition Law Index, measures the overall stringency of a country's competition laws. Firm-level controls include Firm Size, Leverage, Profitability and Age. Country controls include GDP per capita, Credit/GDP and Stock/GDP. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Panel A. 1991-2012

Dependent Var	Patent Count	Citation	Cit/Pat	Cited Patent	Top Cited Patent (Top 25%)	Top Cited Patent (Top 10%)	Explorative Patent (60% new knowledge)	Explorative Patent (90% new knowledge)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Competition Law Index	0.1137***	0.2809***	0.1692***	0.1034***	0.0570***	0.0291***	0.2378***	0.2154***
	(0.037)	(0.064)	(0.050)	(0.023)	(0.012)	(0.006)	(0.056)	(0.051)
Firm Size	0.0192***	0.0352***	0.0223***	0.0132***	0.0071***	0.0037***	0.0149***	0.0122***
	(0.004)	(0.006)	(0.004)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
Leverage	-0.0097	-0.0168	-0.0114	-0.0076*	-0.0016	0.0007	-0.0038	-0.0029
	(0.006)	(0.011)	(0.008)	(0.004)	(0.003)	(0.001)	(0.004)	(0.003)
Profitability	0.0122*	0.0164	0.0126	0.0073	0.0015	-0.0008	0.0049	0.0037
	(0.006)	(0.012)	(0.008)	(0.005)	(0.002)	(0.001)	(0.003)	(0.003)
Age	-0.0120*	-0.0298***	-0.0199***	-0.0053	-0.0046	-0.0033*	-0.0087	-0.0064
	(0.006)	(0.010)	(0.007)	(0.005)	(0.003)	(0.002)	(0.007)	(0.006)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	827,540	827,540	827,540	827,540	827,540	827,540	827,540	827,540
# of Firms	140880	140880	140880	140880	140880	140880	140880	140880
R-squared	0.630	0.528	0.374	0.645	0.650	0.631	0.566	0.521

Panel B 1991-2013

Dependent Var	Patent Count	Citation	Cit/Pat	Cited Patent	Top Cited Patent (Top 25%)	Top Cited Patent (Top 10%)	Explorative Patent (60% new knowledge)	Explorative Patent (90% new knowledge)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Competition Law Index	0.1191***	0.2882***	0.1713***	0.0939***	0.0580***	0.0290***	0.1628***	0.1432***
	(0.036)	(0.076)	(0.058)	(0.028)	(0.014)	(0.007)	(0.043)	(0.037)
Firm Size	0.0133***	0.0206***	0.0111***	0.0076**	0.0047***	0.0027**	0.0100***	0.0081***
	(0.004)	(0.006)	(0.003)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)
Leverage	-0.0030	-0.0065	-0.0046	-0.0027	-0.0020	-0.0002	-0.0013	-0.0013
	(0.006)	(0.013)	(0.010)	(0.004)	(0.003)	(0.001)	(0.003)	(0.003)
Profitability	0.0084***	0.0191**	0.0174**	0.0084***	0.0004	-0.0013	0.0045	0.0039*
	(0.003)	(0.008)	(0.007)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)
Age	-0.0055	-0.0199**	-0.0141*	0.0007	-0.0021	-0.0014	-0.0056	-0.0037
	(0.005)	(0.009)	(0.008)	(0.004)	(0.003)	(0.002)	(0.006)	(0.005)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	800,495	800,495	800,495	800,495	800,495	800,495	800,495	800,495
# of Firms	137062	137062	137062	137062	137062	137062	137062	137062
R-squared	0.642	0.531	0.374	0.650	0.656	0.638	0.576	0.532

Panel C 1991-2014

Dependent Var	Patent Count	Citation	Cit/Pat	Cited Patent	Top Cited Patent (Top 25%)	Top Cited Patent (Top 10%)	Explorative Patent (60% new knowledge)	Explorative Patent (90% new knowledge)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Competition Law Index	0.0937***	0.2514***	0.1427***	0.0669***	0.0517***	0.0253***	0.1410***	0.1218***
	(0.030)	(0.067)	(0.049)	(0.025)	(0.012)	(0.006)	(0.029)	(0.025)
Firm Size	0.0092***	0.0098*	0.0040	0.0027	0.0032**	0.0018**	0.0067***	0.0051**
	(0.003)	(0.005)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Leverage	0.0039	0.0045	0.0027	0.0016	-0.0006	-0.0005	0.0022	0.0020
	(0.004)	(0.009)	(0.008)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)
Profitability	0.0076**	0.0237***	0.0194***	0.0094***	0.0021	0.0012**	0.0053**	0.0042*
	(0.003)	(0.008)	(0.007)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Age	-0.0036	-0.0157	-0.0144	0.0054	-0.0018	-0.0005	-0.0042	-0.0023
	(0.004)	(0.012)	(0.010)	(0.006)	(0.003)	(0.001)	(0.004)	(0.003)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	767,218	767,218	767,218	767,218	767,218	767,218	767,218	767,218
# of Firms	130677	130677	130677	130677	130677	130677	130677	130677
R-squared	0.654	0.531	0.371	0.647	0.658	0.637	0.585	0.541

Table A4 Competition Law and Innovation: Robustness to Poisson Regression

This table shows the effect of competition law on innovation based on Poisson model. The dependent variable is *Patent Count*, *Citation, Cit/Pat, Cited Patent*, *Top Cited Patent*, and *Explorative Patent*, which are count variables. The key explanatory variable, *Competition Law Index*, measures the overall stringency of a country's competition laws. Firm-level controls include *Firm Size*, *Leverage*, *Profitability* and *Age*. Country controls include *GDP per capita*, *Credit/GDP* and *Stock/GDP*. We include firm and industry-by-year fixed effects. Robust standard errors clustered at the country level are reported in parentheses. ***, **, * denote significance levels at 1%, 5% and 10% respectively.

Dependent Var	Patent Count	Citation	Cit/Pat	Cited Patent	Top Cited Patent (Top 25%)	Top Cited Patent (Top 10%)	Explorative Patent (60% new knowledge)	Explorative Patent (90% new knowledge)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Competition Law Index	0.6081**	0.6170**	0.3749*	0.5634**	0.8170***	0.9742***	1.7405***	1.7838***
	(0.306)	(0.251)	(0.226)	(0.262)	(0.209)	(0.252)	(0.466)	(0.459)
Firm Size	0.2304***	0.0919***	0.0788***	0.1960***	0.1299***	0.1039***	0.1600***	0.1592***
	(0.036)	(0.028)	(0.022)	(0.020)	(0.017)	(0.026)	(0.019)	(0.020)
Leverage	-0.1025	-0.0639	-0.0973***	-0.1148	-0.0782	-0.0086	-0.0261	-0.0179
	(0.076)	(0.079)	(0.037)	(0.074)	(0.078)	(0.074)	(0.039)	(0.032)
Profitability	0.2273	0.1597	-0.0146	0.1772	0.1246	0.0986	0.0826	0.1054
	(0.140)	(0.171)	(0.082)	(0.135)	(0.135)	(0.135)	(0.077)	(0.082)
Age	-0.1773***	0.0821	-0.0993*	-0.1524***	0.0044	0.0181	0.0153	0.0099
	(0.022)	(0.115)	(0.051)	(0.024)	(0.084)	(0.107)	(0.042)	(0.047)
Country Control	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	440,771	329,089	329,089	329,089	855,243	855,243	855,243	855,243
R-squared	0.879	0.941	0.527	0.874	0.887	0.875	0.662	0.628