Stock Market Liberalization and Innovation

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Abstract

We investigate the effect of stock market liberalization on technological innovation. Using a sample of 20 economies that experience stock market liberalization, we find that these economies exhibit a higher level of innovation output after liberalization, and this effect is disproportionately stronger in more innovative industries. The relaxation of financial constraints (the financing channel) and enhanced risk-sharing between domestic and foreign investors (the risk-sharing channel) are two plausible mechanisms that allow stock market liberalization to promote innovation. We, however, do not find supportive evidence for the corporate governance channel. Finally, we show that technological innovation is a mechanism through which stock market liberalization affects economic growth. Our paper provides new insights into the real effects of stock market liberalization on growth and on the economy.

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1. Introduction

Over the last three decades, stock market liberalization, which removes restrictions on foreign investors and allows them to participate in domestic equity markets, has had a substantial impact on the world economy. For example, according to Bekaert, Harvey, and Lundblad (2005), stock market liberalization leads to a 1% increase in a country's annual real economic growth. At the industry level, Gupta and Yuan (2009) show that stock market liberalization leads to a 1.9% increase in real value-added in the industry at the 75th percentile of external finance dependence relative to the industry at the 25th percentile. Mitton (2006) finds that an average investable firm in a country experiences a 1.9% increase in the real growth in sales relative to a noninvestable firm after the country liberalizes its stock market. These growth effects of liberalization are mainly driven by its impact on factor productivity growth, which has been documented in subsequent studies (e.g., Levine, 2001; Bonfiglioli, 2008; Gupta and Yuan, 2009; Bekaert, Harvey, and Lundblad, 2011). The underlying economic mechanisms through which stock market liberalization spurs productivity growth, however, are less well understood. In this paper, we propose one such mechanism: technological innovation.

Existing literature shows that innovation is vital for a country's productivity growth and hence economic growth (Solow, 1956; Romer, 1986).[1] The significant growth effect of innovation is justified by its unique features, which distinguish it from conventional investment such as capital expenditure. As Holmstrom (1989) points out, innovation involves long-term, risky, and idiosyncratic investment in intangible assets, requiring considerable exploration of unknown approaches, while conventional investment is simply the exploitation of well-known methods. Hence, in contrast to conventional investment, innovation entails the heavy use of a variety of intangible assets, such as human capital, knowledge, and organizational support. These distinctions between conventional investment and innovation result in two consequences. First, while some studies (e.g., Henry, 2000) show that stock market liberalization leads to an increase in capital expenditure, it is unclear *ex ante* how stock market liberalization affects a country's innovation activities. Indeed, an emerging body of literature shows that several economic factors

[1] According to Rosenberg (2004), 85% of economic growth could be attributed to technological innovation. Using an international sample of patents across 59 countries between 1980 and 2010, Chang et al. (2015) show that a one standard deviation increase in patent stock per capita portends a 0.85% increase in GDP growth.

affect conventional investment and innovation in substantially different ways.[2] Second, the use of equity is more suitable for financing and motivating innovation than the use of debt contracted over tangible assets (Hsu, Tian, and Xu, 2014). Therefore, innovation activities should be more sensitive to reforms in equity markets, such as equity market liberalization, than reforms in debt markets.[3]

Next, we examine three plausible economic channels through which stock market liberalization could potentially affect innovation, namely, the financing channel, the risk-sharing channel, and the corporate governance channel. First, we consider the most important consequence of stock market liberalization: the relaxation of financial constraints. According to the World Bank Enterprise Surveys (2006-2010), almost 40% of firms in emerging markets cite insufficient access to finance as the foremost obstacle to their operations and growth. Insufficient access to finance has an even more adverse effect on innovative firms that tend to exhaust their internal capital and thus rely heavily on external finance (Brown, Fazzari, and Petersen, 2009; Brown, Martinsson, and Petersen, 2013). Given that stock market liberalization allows foreign investors to purchase local shares (Gupta and Yuan, 2009), we postulate that stock market liberalization affects innovation by mitigating local firms' financial constraints – the financing channel.

Second, existing theories on corporate innovation (e.g., Holmstrom, 1989; Manso, 2011) argue that the innovation process is risky and has unforeseeable consequences involving multiple contingencies. As a result, a risk sharing scheme which encourages firms' risk taking activities, could spur corporate innovation. Because foreign investment induced by stock market liberalization enhances risk sharing between domestic and foreign investors (e.g., Henry, 2000; Chari and Henry, 2004; Bekaert, Harvey, and Lundblad, 2005), we expect that stock market liberalization also spurs innovation through the risk-sharing channel.

Third, corporate governance is essential to firm innovation. For example, the study of

[2] For instance, although traditional IPO literature documents that going public allows firms to raise capital and increase their capital expenditures, Lerner, Sorensen, and Stromberg (2011) find that it is actually private ownership, rather than public ownership, that promotes innovation. A second example is that although some studies argue that financial analysts reduce information asymmetry and the cost of capital, which in turn increases ordinary capital expenditures (e.g., Derrien and Kecskes, 2013), recent studies such as those by Benner and Ranganathan (2012) and He and Tian (2013) find that financial analysts actually hinder innovation by imposing excessive pressure on managers to meet short-term earnings targets.

[3] In contrast to capital account openness, which allows all types of capital to flow in, equity market liberalization involves the removal of any restrictions imposed on foreigners investing in local equities.

Brown, Martinsson, and Peterson (2013) reveals that strong shareholder protection plays a crucial role in innovative projects, which are mainly reliant on stock market financing, because these projects are highly uncertain and suffer from a larger degree of information asymmetry.[4] To the extent that the liberalization of domestic equity markets attracts more foreign investors who are better monitors and in turn enhance domestic firms' corporate governance (e.g., Aggarwal et al., 2011), stock market liberalization could restrain managers' opportunistic behaviors in innovative investment and promote domestic firms' innovation output. We call this mechanism the corporate governance channel.

Although we test these three underlying economic channels separately, we acknowledge that these channels are not necessarily mutually exclusive and could jointly contribute to the impact of stock market liberalization on technological innovation.

To measure a country's innovation output, we collect global patent information from the Bureau van Dijk's Orbis patent database. This data set allows us to observe both the number of patents a country generates and the number of citations these patents receive post-registration. Accordingly, we are able to explore the effect of stock market liberalization on both the quantity and the quality of innovation output by a country. Moreover, the examination of the technology class distribution of patent citations further allows us to better understand the fundamental nature of innovation activities occurring in a country after stock market liberalization.[5] Compared to the National Bureau of Economic Research (NBER) Patent and Citation database compiled based on the United States Patent and Trademark Office (USPTO), the Orbis database has a much broader coverage. In addition to the patents filed in the U.S. and administrated by the USPTO, the Orbis database covers patents filed in 93 non-U.S. patent offices (including national patent offices and regional and international organizations, such as the European Patent Office (EPO) and the African Intellectual Property Organization. Therefore, we are able to directly measure a country's innovation level using the Orbis database, instead of inferring it indirectly through the NBER database. We collect official stock market liberalization date information from Bekaert, Harvey, and Lundblad (2005). Our sample only focuses on public firms, which are directly

[4] However, it is also worth noting that strong shareholder protection can also impede innovation because it may increase the external pressure on managers and lead to managerial short-termism (Belloc, 2013; Lin, Liu, and Manso, 2017).

[5] These features of patent data provide a unique advantage of using innovation instead of conventional investment as the outcome variable because one cannot easily judge the change in the quality and fundamental nature of conventional investment such as capital expenditure, despite the change in the quantity.

affected by stock market liberalization. Our final sample includes 20 developed and emerging economies that experience stock market liberalizations during the 1981-2008 period.

Consistent with our conjectures, the country-industry level preliminary test shows that stock market liberalization increases a country's innovation output. Patent counts, citation counts, and the number of innovative firms of a country, on average, experience an increase of 15%, 18%, and 14%, respectively, after the country liberalizes its stock market. To tackle identification challenges, we use Acharya and Subramanian's (2009) country-industry-year level panel-based fixed effects identification approach as the main specification. We find that industries with higher innovation intensity, defined using U.S. data, exhibit a disproportionately higher level of innovation output after a country opens its equity market. For example, equity market liberalization increases the number of patents, the number of citations, and the number of innovative firms for industries with innovation intensity in the top quartile by 26%, 29%, and 21%, respectively, compared to those with innovation intensity in the bottom quartile. Our findings continue to hold in an extensive set of robustness checks using alternative subsamples, model specifications, and innovation measures, as well as additional tests to address the endogeneity issue.

Next, to examine the three underlying economic channels proposed earlier, we explore cross-sectional heterogeneity of our main results from three perspectives, namely equity market development, creditor rights, and investor protection. We find that stock market liberalization is more effective in enhancing innovation in innovative industries when a country has a less developed equity market prior to liberalization. Moreover, the positive effect of stock market liberalization on innovation output in innovative industries is more pronounced in countries with stronger creditor rights, which have been documented to greatly restrain firms' risk taking incentives (Acharya and Subramanian, 2009). We, however, do not find a significant difference in the liberalization effect on innovation in innovative industries between countries with weaker and stronger investor protection. These results provide supportive evidence to the financing channel and the risk-sharing channel, but not to the corporate governance channel.

Finally, we test the conjecture that technological innovation is the mechanism linking stock market liberalization with economic growth. First, consistent with Gupta and Yuan (2009), we show that equity market liberalization, on average, promotes the growth of industry value-added. In addition, we find that the positive effect of equity market liberalization on the growth of value-added is more pronounced in innovative industries, suggesting that equity market liberalization spurs economic growth mainly through enhancing innovation output. Second, by breaking down the effect of equity market liberalization into a temporary effect and a permanent effect, we show that equity market liberalization has both a temporary positive effect and a permanent positive effect on industry value-added growth. The permanent effect is, however, mainly attributed to innovative industries, which suggests that equity market liberalization promotes productivity in the long run by encouraging innovation.

Our paper contributes to two streams of literature. The primary contribution is to the literature on financial openness and economic growth. First, there is a debate about the growth effects of stock market liberalization. For example, while Bekaert, Harvey, and Lundblad (2005, 2011), Quinn and Toyoda (2008), Gupta and Yuan (2009), and Mitton (2006) find strong growth effects at the country, industry, and firm levels, Rodrik (1998) and Edison et al. (2004) find that the effects of stock market liberalization are weak. In a survey paper, Kose et al. (2009) summarize the collective evidence regarding the effect of financial liberalization on economic growth as "mixed."[6] Our findings substantiate a permanent effect of stock market liberalization on economic growth. Second, previous literature (e.g., Levine, 2001; Bonfiglioli, 2008; Gupta and Yuan, 2009; Bekaert, Harvey, and Lundblad, 2011) documents that stock market liberalization increases productivity growth. In addition, these studies show the positive effect of stock market liberalization on productivity growth. We contribute to this literature by identifying technological innovation as a specific economic mechanism through which stock market liberalization could affect economic growth.

Our paper also contributes to the literature on finance and innovation in a cross-country setting. Broadly speaking, existing studies (e.g., Acharya and Subramanian, 2009; Brown, Martinsson, and Petersen, 2013; Hsu, Tian, and Xu, 2014) explore how country-specific characteristics such as bankruptcy codes, legal institutions, and equity market development affect R&D investment and innovation output.[7] Unlike earlier studies, we explore how an important policy change, namely, stock market liberalization, affects a country's innovation output, as well as the underlying economic channels through which this effect occurs.

[6] There is another large body of literature linking finance and growth that goes back to Goldsmith (1969) and Shaw (1973). More recent research has shown that the size and depth of a country's financial system positively affects its future growth per capita, real income, employment, entrepreneurship, and output (e.g., King and Levine, 1993; Jayaratne and Strahan, 1996; Rajan and Zingales, 1998; Beck and Levine, 2002; Black and Strahan, 2002).
[7] See He and Tian (2018) for a survey of the literature on finance and innovation.

In particular, our paper is distinct from Hsu, Tian, and Xu (2014). Using a sample of 32 emerging and developed economies, they find that equity market development is beneficial to innovation. We develop this line of inquiry by showing that stock market liberalization exhibits a positive effect on innovation even after controlling for a country's equity market development. Based on economic theory, we identify and test three plausible alternative channels (i.e., the financing channel, the risk-sharing channel, and the corporate governance channel) through which stock market liberalization promotes innovation. Our evidence suggests that the effect of stock market liberalization on innovation is beyond what equity market development can capture.[8]

The rest of the paper is organized as follows. Section 2 describes sample selection and reports summary statistics. Section 3 presents our main empirical findings and a variety of robustness checks. Section 4 explores plausible underlying economic channels through which stock market liberalization affects innovation. Section 5 discusses the relations between stock market liberalization, innovation, and economic growth. Section 6 concludes.

2. Data, sample, and variables

2.1. Data and sample

We use Bureau van Dijk's Orbis patent database to construct our innovation variables. The source of this database is the Worldwide Patent Statistical Database (PATSTAT), which is maintained by the EPO. The Orbis patent database offers a comprehensive coverage of more than 83 million patent applications worldwide from 1850 to 2013.[9] These patents are filed by both publicly-traded and privately-held firms through 94 regional, national, and international patent offices.

The Orbis patent database has a much wider coverage than the NBER Patent and Citation

[8] Meanwhile, Fang, Tian, and Tice (2014) find that an increase in stock liquidity of U.S. firms leads to a reduction in these firms' innovation output. He and Tian (2013) use a sample of U.S. firms to show that financial analysts impede firm innovation by imposing too much pressure on short-term earnings targets. At first blush, these results appear inconsistent with our findings because stock liberalization is positively related to stock liquidity and analyst coverage (Levine and Zervos, 1998; Bae, Bailey, and Mao, 2006). However, we believe that their findings depend on the existence of a fully liberalized equity market, such as that of the U.S. In other words, the negative effects of stock liquidity and analyst coverage on innovation in U.S. firms along the intensive margin may not exist to the same extent along the extensive margin in other countries whose equity markets are less liberalized and developed. Therefore, the effect of stock market liberalization on innovation through its effect on stock liquidity and analyst coverage could be very different in our setting in which both developed economies (excluding the U.S.) and emerging economies are examined.

[9] Out of the 83 million patent applications, 36 million patents are ultimately granted.

database because the latter is based solely on patent filings to the USPTO. Although the NBER database has been widely used in the innovation literature (e.g., Hall, Jaffe, and Trajtenberg, 2005; Aghion, van Reenen, and Zingales, 2013), it has limitations in cross-country studies as it only covers patents filed in the U.S. and granted by the USPTO. Hence, the NBER database may result in biases (most likely underestimation) in judging the innovative performance of non-U.S. firms that do not file patent applications to the USPTO.[10] Another important feature of the Orbis database is the ease of identifying patent assignees (owners). The Orbis database identifies the majority of patent owners using its unique firm identifiers, with which we are able to identify patent owners' domicile, industry classification, and listing status. We provide a detailed comparison of the Orbis database with the NBER Patent and Citation database in Section A of the Internet Appendix.[11]

We collect data on the official stock market liberalization date of each country from Bekaert, Harvey, and Lundblad (2005). Furthermore, we extract industry level data from the United Nations Industrial Development Organization (UNIDO) Industrial Statistics database and country level data, such as gross domestic product (GDP) per capita and imports and exports as a fraction of GDP from the Penn World Table (PWT), version 8.0.

Our initial sample consists of firms in industries from countries that are jointly covered by the Orbis, the UNIDO, and the PWT databases.[12] We further filter the sample according to the following criteria. First, we remove non-public firms because stock market liberalization has a more direct impact on publicly-traded firms (Chari and Henry, 2008).[13] Second, we focus solely on manufacturing industries (SIC codes: 20-39) not only because the UNIDO database is limited to these industries, but also because manufacturing industries are the most innovative industries. According to the 2008 Business R&D and Innovation Survey (BRDIS) by the National Science Foundation (available at http://www.nsf.gov/statistics/infbrief/nsf11300), 22% of manufacturing firms introduced product innovation compared to only 8% of non-manufacturing firms in the

[10] Chang et al. (2015) show that many countries, especially emerging markets, do not file patent applications to the USPTO and this proportion varies across countries over time.
[11] See Figure A1 in the Internet Appendix for a detailed comparison between the NBER database and the Orbis database.
[12] The Orbis database uses the U.S. Standard Industrial Classification (SIC), while the UNIDO database employs the International Standard Industrial Classification (ISIC). Thus we match the two-digit U.S. SIC codes with the two-digit ISIC codes using the concordance table provided by the European Commission.
[13] However, we use private firms of countries experiencing liberalization during our sample period as the placebo group in one of our endogeneity tests in Section 3.5.5.

period from 2006-2008.[14] Third, following previous studies (e.g., Hirshleifer, Low, and Teoh, 2012), we exclude countries that did not produce a single patent during the entire sample period. Our main findings are robust to the inclusion of these countries. Fourth, we remove U.S. firms from our sample but use them to control for industrial patenting activities or innovation opportunities over time, following previous studies, e.g., Acharya and Subramanian (2009) and Hsu, Tian, and Xu (2014). Finally, to examine the time variation in corporate innovation before and after liberalization, we restrict our analysis to a sample of countries that experience stock market liberalization in the sample period.[15]

Our final sample consists of 20 industries in 20 countries that were liberalizing their equity markets between 1981 and 2008.[16]

2.2. Measures of innovation

Following previous studies (e.g., Aghion, van Reenen, and Zingales, 2013; Seru, 2014), we build the first innovation measure as the number of successful patent applications by public firms in each 2-digit SIC industry for each country each year (*Pat*). We use the patent application date rather than the grant date in the analysis because the former is closer to the actual invention date than the latter, according to Hall, Jaffe, and Trajtenberg (2001). Patent count captures innovation output based on the premise that manufacturing firms materialize inventions in the form of patents. However, a simple total sum of firms' patents applied at different patent offices could lead to overestimation, because inventors may obtain multiple patents in different countries to protect the same invention. To solve this issue, we count one patent per innovation. For example, if a Japanese firm patents an innovation in Japan, the U.S., and China, then we would count this as a single Japanese patent. Moreover, a patent application on the same invention can be filed to different patent offices on different dates. To determine the actual date of innovation for these cases, we choose the earliest application date (priority date) for an innovation.

[14] Patenting innovation is more important to manufacturing industries since these industries rely heavily on patents as a means of appropriating new technologies (Cohen, 1995).
[15] In one of the robustness tests in Section 3.5.4, we show that our results are insensitive to the inclusion of the liberalized sample and the non-liberalized sample.
[16] We start our sample from 1981 because we are only able to identify a firm's listing status from Orbis since 1980 and use one-year lagged industry innovation intensity in the regression analysis, and end our sample in 2008 because the UNIDO data are incomplete after 2008. There is, on average, a two to three year lag between the patent application date and the patent grant date according to Hall, Jaffe, and Trajtenberg (2001). However, since our sample period ends in 2008, the impact of this lag on our study is minimal.

One concern of a simple patent count is that it may only reflect the quantity rather than the quality of a firm's inventions. Given that a more significant patent is expected to be cited more frequently by other patents subsequent to it, forward citations of patents reflect the quality of a firm's innovation and thus better capture the technological or economic significance of the firm's inventions (Hall, Jaffe, Trajtenberg, 2005). This is particularly true for patents created by emerging economies because the technological development in these countries is relatively slow and their patents are less likely to be cited. An increase in the number of patent citations in emerging markets indicates that their technology level has reached a certain threshold, a trend widely acknowledged by the scientific community. Hence, our second innovation measure is the number of citations received by all firms' patents in each 2-digit SIC industry for each country each year. One potential concern of this variable is that, as Hall, Jaffe, and Trajtenberg (2005) point out, patents in certain technology classes and years tend to receive more citations. To address this issue, we adjust raw citations using time-technology class fixed effects recommended by prior literature, e.g., Atanassov (2013) and Hirshleifer, Low, and Teoh (2012). The citation counts adjusted for time-technology class fixed effects are defined as raw citation counts scaled by the average citations in the same year and in the same technology class (*Tcite*).[17]

Our third measure of innovation is the number of innovative firms, as suggested by Acharya and Subramanian (2009), which is defined as the number of public firms that have successful patent applications in each 2-digit SIC industry for each country and year (*Nfirm*).

Although the above measures are widely accepted and used in the innovation literature to capture the technological advances and the output of innovation (Acharya and Subramanian, 2009; Acharya, Baghai, and Subramanian, 2013; Hsu, Tian, and Xu, 2014), we fully acknowledge the limitations of using these measures as the proxy for innovation.[18] For example, not all innovations are patented, because some innovations do not satisfy patentability criteria, and because firms tend to keep the details of their technology secret for strategic reasons.

[17] In the Orbis database, technological classes are defined using the International Patent Classification (IPC) system and we adjust the raw citation counts using the one-digit IPC code.

[18] An alternative measure of innovation is R&D expenditure across different industries. However, this leads to several difficulties in the cross-country setting. For example, accounting treatment of R&D expenditure as expenses or capitalized intangible assets varies across countries. Furthermore, as raised in Lerner, Sorensen, and Stromberg (2011), not all R&D expenditures are used productively and some are even wasteful, thus making the interpretation of R&D expenditures difficult.

2.3. Control variables

We control for several industry and country characteristics that may potentially be correlated with stock market liberalization and innovation. First, to account for comparative advantages (Acharya and Subramanian, 2009) and heterogeneous developments of different industries in a country (Hsu, Tian, and Xu, 2014), we include the share of value-added in a two-digit SIC industry to the total value-added for each country each year (*VA*) as a control.

The second variable we consider is a country's macroeconomic conditions, because developed countries are more likely to open up their stock markets to the outside world (Bekaert, Harvey, and Lundblad, 2005), and wealthier countries may innovate more (Acharya and Subramanian, 2009; Acharya, Baghai, and Subramanian, 2013). We use the logarithm of gross domestic product (GDP) per capita in real terms at constant national prices in 2005 U.S. dollars (*Ln*(*GDP*)) as a proxy for a country's macroeconomic conditions.

Third, free trade may encourage firms to patent their innovations in order to protect domestic sales and secure foreign sales (Acharya and Subramanian, 2009). In addition, as a result of domestic macro-reforms, the liberalization of equity markets in a country could be coupled with the trade openness of the country (Bekaert, Harvey, and Lundblad, 2005). We thus include the share of imports in a country's GDP (*Import*) and the share of exports (*Export*) to capture the country's trade openness.

Last, we control for the time trend of industry-level patenting activities because Hall, Jaffe, and Trajtenberg (2001) show that patenting propensity in different industries varies over time.[19] Specifically, following Acharya and Subramanian (2009), we include the logarithm of one plus the average number of patents applied by U.S. firms in each 2-digit SIC industry and year as a proxy for industrial patenting propensity (*Intensity*).[20] We choose the U.S. as the benchmark to adjust for the time trend because the U.S. has the most comprehensive patent data across different technology classes over time, the most developed financial market for funding technological growth opportunities, and the most favorable research environment in the world.

2.4. Descriptive statistics

Table 1 Panel A presents the sample distribution by country. Panel A reports 20 countries

[19] See Hall, Jaffe, and Trajtenberg (2001) and Cohen, Nelson, and Walsh (2000) for a detailed discussion of this pattern.

[20] Using the median number of patents applied by U.S. firms in each 2-digit SIC industry each year as the measure of innovation intensity does not change our results.

in our sample, comprising a mixture of both developed and developing economies.[21] Columns (1) and (2) of Panel A report the official liberalization year and the number of observations for each country. Columns (3)-(5) report the aggregate innovation measures, i.e., patent counts, citation counts, and the number of innovative firms across industries in each country.

We observe that in our sample, Japan has the largest number of patents, the largest number of citations, and the largest number of innovative firm-years, while Indonesia has the lowest number of patents, Malaysia has the lowest number of citations, and Argentina has the lowest number of innovative firms. Although the general trends of the three innovation output measures are similar, there are some cross-country differences. For example, the number of patents in Turkey (963) is twice that of Spain (484). However, the number of citations in Spain (1,812) is similar in magnitude to that in Turkey (1,936). The result indicates that patents in Spain have a larger impact in terms of citations than those from Turkey. This observation highlights the importance of using different innovation measures to capture innovation output.

Overall, the large cross-country variation in innovation performance reflects not only different phases of technological development but also different levels of equity market capacity, i.e., the number of public firms in each country.

[Insert Table 1 about here]

Panel B of Table 1 shows the sample distribution of innovation output average values, the share of industry value-added, and the innovation intensity across 20 industries over all country-years. Columns (2) to (4) indicate that patents, patent citations, and the number of innovative firms vary significantly across different industries. Specifically, the industry of electronic and other electrical equipment and components, except computer equipment (SIC 36) has the highest number of patent counts, citation counts, and innovative firms. In contrast, leather and leather products industry (SIC 31) has the lowest number of patents, citations, and innovative firms.[22]

Moreover, as observed in column (5), industries that contribute the largest portions of industry value-added are food and kindred products (SIC 20) and chemicals and allied products (SIC 28), which account for approximately 16% and 11% of the total industry value-added in an average country, respectively. Industries that contribute the smallest portions are measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and

[21] Panel A of Table 1 also shows that stock market liberalization occurred across geographically diverse countries in our sample over the sample period, which is another noticeable feature of the liberalizing group.
[22] The tobacco products industry (SIC 21) has the second lowest number of 0.07 innovative firms on average.

clocks (SIC 38); and non-furniture lumber and wood products (SIC 24), which account for only 1% and 2% of the total industry value-added. Column (6) shows that innovation intensity defined using the U.S. data follows a similar pattern as that of innovation output despite some slight differences.

[Insert Table 2 about here]

Next, we report the descriptive statistics of the sample. In Table 2, the means of *Pat*, *Tcite*, and *Nfirm* are 81.35, 157.25, and 2.53, respectively, and we observe sizable standard deviations of these three variables. Given that innovation measures are highly skewed, we use the logarithm of one plus these variables (i.e., *Ln*(1+*Pat*), *Ln*(1+*Tcite*), and *Ln*(1+*Nfirm*)) in the regression analyses. For country level variables, the means of *Ln*(*GDP*), *Export* and *Import* are 3.18, 0.21, and 0.22, respectively. With respect to industry level variables, the means of *VA* and *Intensity* are 5.02% and 2.58, respectively.

3. Empirical findings

3.1. Univariate analysis

To investigate the relation between stock market liberalization and innovation, we start with a univariate analysis by examining the average changes in innovation output around liberalization for all sample industries, and comparing the differences in changes between more-innovative and less-innovative industries, which are classified according to the median industry innovation intensity each year. Specifically, we define liberalization year as event year 0 and compute the average changes in *Ln*(1+*Pat*), *Ln*(1+*Tcite*), and *Ln*(1+*Nfirm*) from two years before liberalization (i.e., event year -2) to one year before liberalization (i.e., event year -1) and from two years before liberalization to *t* years (*t* = 0, 2, and 4) after liberalization.[23]

Panel A of Figure 1 plots average changes in the number of patents (*Ln*(1+*Pat*)) for the event windows (-2, -1), (-2, 0), (-2, 2), and (-2, 4). We find that the average change in the number of patents from event year -2 to -1 is not significantly different from zero (*p*-value = 0.39) for all sample industries, and the difference in changes between more-innovative and less-innovative industries is also insignificant (*p*-value = 0.84). However, when we expand the event window to (-2, 0), our sample industries start to exhibit an increase in the number of patents,

[23] We exclude Japan in this analysis because Japan has the largest numbers of industry patents, industry patent citations, and industry innovative firms in our sample, which may bias the statistical comparisons of the average values of changes in innovation output. In an untabulated analysis, we include Japan and find that our results do not alter.

which is significantly different from zero (p-value = 0.06). A similar finding is observed when we compare more innovative industries with less innovative industries. Further extending the event window to (-2, 2) and (-2, 4), we find even larger increases in the number of patents, which are significantly different from zero at the 1% level (p-values = 0.00). These findings indicate that, on average, there is no significant change in the number of patents before liberalization but a significantly larger increase in patent counts after liberalization for our sample industries.

[Insert Figure 1 about here]

Panels B and C of Figure 1 plot average changes in the number of patent citations (*Ln*(1+*Tcite*)) and the number of innovative firms (*Ln*(1+*Nfirm*)), respectively. Similar to the pattern of the number of patents, we find that our sample industries, on average, experience a statistically significant increase in the number of patent citations (p-values = 1.00, 0.15, 0.07, and 0.00 for event windows (-2, -1), (-2, 0), (-2, 2) and (-2, 4), respectively) and the number of innovative firms (p-values = 0.26, 0.08, 0.00, and 0.00 for event windows (-2, -1), (-2, 0), (-2, 2) and (-2, 4), respectively) after liberalization. Moreover, we observe that the differences in changes in the number of patent citations and the number of innovative firms between more-innovative and less-innovative industries for the event windows (-2, -1) and (-2, 0) are statistically insignificant (p-values = 0.86 and 0.25 for the number of patent citations and p-values = 0.77 and 0.28 for the number of innovative firms), while those for the event windows (-2, 2) and (-2, 4) are statistically significant (p-values = 0.16 and 0.00 for the number of patent citations and p-values = 0.02 and 0.00 for the number of innovative firms).

Overall, the patterns in Figure 1 suggest that our sample industries are likely to exhibit an increase in innovation output post liberalization, and this effect is disproportionately stronger for more innovative firms than for less innovative industries. Given that we do not observe a significant change in innovation output or a significant difference between more-innovative and less-innovative industries before liberalization, the univariate results are consistent with our conjecture that stock market liberalization promotes innovation particularly in innovative industries. Despite interesting, these unconditional relations require more refined multivariate tests, which we turn to next.

3.2. The effect of stock market liberalization on innovation

We first examine the general effect of stock market liberalization on firms' innovation output in a country by estimating the regression model in Eq. (1) below:

$$Innovation_{i,j,t} = \alpha + \beta Lib_{i,t-3} + \gamma' X_{i,j,t-1} + Industry_j \times Country_i + Year_t + \varepsilon_{i,j,t} \quad (1),$$

where *Innovation* represents the three innovation output measures we construct, i.e., *Ln*(1+*Pat*), *Ln*(1+*Tcite*), or *Ln*(1+*Nfirm*), in industry *j* for country *i* in year *t*. *Lib*, our key explanatory variable, is defined as a binary variable that takes the value of one if the observation is in the year after country *i*'s official liberalization, and zero otherwise, measured in year *t*-3.[24]

X represents the share of value-added (*VA*) in industry *j* for country *i* in year *t*-1, GDP per capita (*Ln*(*GDP*)), the shares of exports and imports in GDP (*Export* and *Import*) in country *i* and year *t*-1, and industrial patenting propensity (*Intensity*) in industry *j* and year *t*-1. We also control for time-invariant industry characteristics in each country and business cycles by including country-industry fixed effects and year fixed effects. We cluster standard errors by country-industry.[25] Our key variable of interest is *Lib*, and its coefficient estimate, *β*, which captures the general effect of stock market liberalization on innovation.

[Insert Table 3 about here]

We present the results estimating Eq. (1) in Table 3. The results show that the coefficient estimates of *Lib* are positive and significant in all three columns, suggesting that firms' innovation output in a country increases after the country liberalizes its equity market. The positive effect is not only statistically significant but also economically sizable. For example, in countries that experience stock market liberalization during our sample periods, patent counts, citation counts, and the number of innovative firms, on average, experience an increase of 15%, 18%, and 14%, respectively, after they liberalize their stock markets.[26]

The coefficient estimates of control variables generally have signs that are consistent with previous evidence. For example, we find that *Ln*(*GDP*) has a significant and positive effect on innovation at the 1% level in all regressions. We also find that *Import* has a significant and negative effect on innovation, which suggests that a country is more likely to rely on foreign

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[24] For equity market liberalization to have an impact on innovation output in a country, a series of events need to happen: (1) the country deregulates their stock market; (2) capital flows into the country; (3) firms issue new equity; (4) firms undertake new innovation activities; (5) firms create something new; and (6) firms apply for patents. This time length is undoubtedly long. We hence assume that the stock market liberalization takes effect from three years after the official announcement year. In an untabulated robustness check, we conduct the analysis by assuming that stock market liberalization takes effect from one to five years after the liberalization year and find that the coefficients are still highly significant.

[25] Our results remain similar if we cluster the standard error by country.

[26] Because $d[Ln(1+y)]/dx = 1/(1+y) \times dy/dx$, $dy = d[Ln(1+y)]/dx \times (1+y)\, dx$. For example, when quantifying the effect of the change in *Lib* (*dx*) on the change in *Pat* (*dy*), we increase *Lib* from zero to one, so $dx = 1$. The change in *Pat* (*dy*) from its mean value (81.35) is then equal to $0.153 \times (1+81.35) \times 1 = 12.60$, which amounts to 15% of the mean value of *Pat*.

products if its technologies are not sufficiently innovative. Taken together, the findings in Table 3 suggest that stock market liberalization has a positive effect on firms' innovation output in a country.

3.3. The effect of stock market liberalization on innovation across industries

Following Acharya and Subramanian (2009), in this section, we examine how stock market liberalization affects innovation output differently across industries with different innovativeness by undertaking a difference-in-differences approach as in Eq. (2) below:

$$Innovation_{i,j,t} = \alpha + \beta Lib_{i,t-3} \times Intensity_{j,t-1} + \theta Lib_{i,t-3} + \gamma' X_{i,j,t-1} + Industry_j \times Country_i + Year_t + \varepsilon_{i,j,t} \quad (2),$$

where we include the interaction term of the stock market liberalization indicator and innovation intensity (*Lib*×*Intensity*). All other variables are defined in the same way as in Eq. (1).

Our key variable of interest is the coefficient estimate of *Lib*×*Intensity*, β, which captures the change in innovation output before and after liberalization between more innovative and less innovative industries. If the liberalization effect is more pronounced for more innovative industries, we expect β to be positive and significant.

[Insert Table 4 about here]

We present the results from estimating Eq. (2) in columns (1)-(3) of Table 4. In columns (4)-(6), we present our baseline results by further including interaction terms of control variables and industry innovation intensity to account for the potential correlation between industry and country characteristics and stock market liberalization across industries with different levels of industrial patenting propensity as pointed out by Acharya and Subramanian (2009). The coefficient estimates of *Lib*×*Intensity* remain positive and significant at the 1% level in all regressions. This finding suggests that, compared with that of less innovative industries, the innovation output of more innovative industries increases more substantially after the country opens its equity market to foreign investors. Our results are also economically sizable. Specifically, in columns (4)-(6) in which we include a full set of interactions of control variables and industry innovation intensity (*Intensity*), an increase in *Intensity* from the 25th percentile to the 75th percentile is associated with an increase in the number of patents, the number of citations, and the number of innovative firms by 26%, 29%, and 21%, respectively, after stock market liberalization. These results indicate that it is the more innovative industries that drive the results, suggesting that equity market liberalization promotes innovation by enhancing it in more innovative industries.

3.4. Robustness checks

We conduct an array of additional tests to check the robustness of our baseline results in Section 3.3. For brevity, we report the results of the following five sets of robustness checks in Tables IA1 to IA5 of the Internet Appendix, respectively. All regressions include interaction terms of control variables and industrial patenting intensity.

First, we exclude Japan from our sample. Given that Japan has the largest number of patents, patent citations, and innovative firms among all countries in our sample, it is plausible that our inferences from the main analysis are driven by Japan. Our findings show that the results are robust to the exclusion of Japan from our sample.

Second, following Hsu, Tian, and Xu (2014), we conduct an analysis at the technology-class level. Specifically, we aggregate all variables at the three-digit International Patent Classification (IPC) class and re-estimate Eq. (2). We find that our results do not change qualitatively.

Third, to further mitigate the concern regarding the presence of residual correlation in both country and year dimensions, we employ a two-way clustering by clustering standard errors at both country-industry and year following the suggestion of Petersen (2009). Our baseline results are robust to the two-way clustering.

Fourth, similar to Acharya and Subramanian (2009), we replace dependent variables with the average number of patents and the average number of patent citations as proxies for the innovation output of a typical firm in an industry. We find that the results remain.

Last, to further capture the long-term nature of the innovation process (Manso, 2011), we measure the liberalization indicator in year *t*-5 (*Lib_lag5*) instead of year *t*-3 in Eq. (2). Hence, we are estimating the effect of stock market liberalization on a country's 5-year-ahead innovation output. We then re-estimate the regressions and find that the results are robust to this model specification that takes into account the delayed effect of innovation output.

3.5. Further tests on identification

To ensure that the effect of stock market liberalization is causal, we conduct five additional tests. First, we directly control for potential omitted variables that may be correlated with both stock market liberalization and innovation but are not included in the baseline regressions. Second, we examine the dynamics of innovation output surrounding liberalization years to address the reverse causality concern. Third, we focus directly on the changes in innovation output surrounding liberalization years using a short-event window. Fourth, we include both liberalized economies and non-liberalized economies in our analysis. Finally, we perform a placebo tests by using a sample of private firms and examine the effect of stock market liberalization on the innovation output of these private firms across more innovative versus less innovative industries.

3.5.1. Controlling for potential omitted variables

We first directly include a few variables omitted from the baseline regressions. The first variable we consider is foreign direct investment (FDI). Previous literature documents that through inflows of FDI, foreign acquirers encourage local firms to innovate by facilitating technology transfer to local markets (Guadalupe, Kuzmina, and Thomas, 2012) and allowing these firms to hire and utilize high quality employees (Javorcik, 2015), who are essential to innovative firms. If stock market liberalization, which attracts equity inflows, is correlated with a country's pro-FDI policies, then the positive correlation between stock market liberalization and innovation can be spurious. We hence include the ratio of net FDI inflows over GDP (*FDI*) for each country and year into the regressions. The information on net FDI inflows is retrieved from the World Development Indicator (WDI) database compiled by the World Bank.

Second, financial market development is another variable that can be related to both equity market liberalization and innovation. Hsu, Tian, and Xu (2014) document that equity market development is positively associated with innovation in industries more dependent on external finance because of the convex payoff structure of equity encouraging risk-taking, the information generating function of equity markets, and the feedback effects of equity prices, whereas credit market development is negatively associated with innovation in industries more dependent on external finance because of the concave payoff structure of debt, discouraging risk-taking and the lack of price signals. Given the possibility that stock market liberalization may coincide with local financial market development, we include the ratio of total market capitalization of all public firms in a country to its GDP (*Stock Market*) as a proxy for equity market development and the ratio of domestic credit provided by the banking sector over GDP (*Credit Market*) as a proxy for credit market development in the regressions.

Last, we add a set of institutional characteristics into the baseline regression in Eq. (2). These characteristics include the intellectual property protection index (*IP Protection*) created by Park (2008), an indicator denoting the enforcement of insider trading laws in a country (*Insider Trade*) compiled by Bhattacharya and Daouk (2002), Quinn's (1997) capital account openness (*Quinn*) in Bekaert, Harvey, and Lundblad (2005), and the legal origin of a country, i.e., whether a country is a common law country (*English Law*) in La Porta et al. (1998) to account for the possibility that a country's equity market liberalization may coincide with the change in its laws and regulatory environment.[27]

[Insert Table 5 about here]

We control for all aforementioned variables and their interactions with *Intensity* in the regression model in Eq. (2) and present the results in columns (1)-(3) of Table 5 Panel A. We find that the coefficient estimates of *Lib×Intensity* are all positive and significant at the 5% or the 1% level in the three columns.[28]

We further include country-year and industry-year fixed effects in columns (4)-(6) to account for the potential effects of time-varying country and industry characteristics.[29] The coefficient estimates of *Lib×Intensity* are all positive and significant at the 5% or the 1% level, suggesting that the positive effect of stock market liberalization on the innovation output of more innovative industries continues to hold after controlling for these important variables omitted from the baseline regressions. In addition, these additional control variables exhibit signs that are generally consistent with the findings of previous studies.

Overall, the evidence in this subsection suggests that our baseline results are not likely to be driven by these potential omitted variables.

3.5.2. Test on reverse causality

[27] The intellectual property protection index and the property protection index are both on a scale of 1 to 5 with 5 representing the strongest intellectual property or property protection. The insider trading enforcement indicator takes the value of one in the year of a country's first insider trading enforcement case and thereafter, and zero otherwise. Quinn's (1997) capital account openness is on a scale of 0 to 1 with 1 representing a fully open economy. See Park (2008), Bhattacharya and Daouk (2002), Bekaert, Harvey, and Lundblad (2005) and La Porta et al. (1998) for more details on the construction of these measures.

[28] Time-invariant country-level variables such as *Quinn* and *English Law* are subsumed by country-industry fixed effects and hence are removed from the regressions.

[29] Country-year variables such as *Lib*, *Ln*(*GDP*), *Exports*, *Imports*, *FDI*, *Stock Market*, *Credit Market*, and *Insider Trade* are subsumed by the country-year fixed effects and industry-year variables such as *Intensity*, *Quinn×Intensity*, and *English Law×Intensity* are subsumed by industry-year fixed effects, and hence these variables are removed from the regressions.

To further address the reverse causality concern, we conduct a test to examine the dynamics of innovation output surrounding stock market liberalization. If it is the reverse causality that drives the results, i.e., a country liberalizes its equity market to facilitate innovative firms' financing needs, we should observe an increase in innovation output prior to the liberalization year. To rule out this possibility, we follow Bertrand and Mullainathan (2003) and create 6 indicators, i.e., Lib_{t-2}, Lib_{t-1}, Lib_t, Lib_{t+1}, Lib_{t+2}, and $Lib_{\geq t+3}$, which denote relative years around liberalization with t referring to the liberalization years. Specifically, Lib_{t-2} (Lib_{t-1}) takes the value of one in a two-year window (one year) before the liberalization year, and zero otherwise. Lib_t takes the value of one in the liberalization year, and zero otherwise. Lib_{t+1} (Lib_{t+2}) takes the value of one in the one year (two-year) window after the liberalization year, and zero otherwise. $Lib_{\geq t+3}$ takes the value of one three years after the liberalization year and onwards, and zero otherwise. We then re-estimate the baseline regression in Eq. (2) by replacing $Lib \times Intensity$ with the interactions of *Intensity* and these 6 indicators.

We present the results in Table 5 Panel B. We find that the coefficient estimates of $Lib_{t-2} \times Intensity$ and $Lib_{t-1} \times Intensity$ are statistically insignificant, suggesting that there is no significant increase in innovation output prior to equity market liberalization. More importantly, the coefficient estimate of $Lib_{t+1} \times Intensity$ starts to become marginally significant and those of $Lib_{t+2} \times Intensity$ and $Lib_{\geq t+3} \times Intensity$ are positive and significant at the 5% level.[30] This result suggests that firms' innovation output increases from the liberalization year onwards. Interestingly, the magnitudes of the coefficients of $Lib_{t+1} \times Intensity$, $Lib_{t+2} \times Intensity$, and $Lib_{\geq t+3} \times Intensity$ increase dramatically, suggesting that the impact of stock market liberalization on the innovation output of more innovative industries is long lasting. The result is also consistent with the patterns observed in Figure 1.

Overall, the analysis suggests that it is the opening of a country's equity market that leads to an enhancement of innovation output in the country, not *vice versa*.

3.5.3. Event study

While the baseline regression analysis shows that innovation output becomes significantly higher after a country opens its equity market to foreign investors, these regressions

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[30] The coefficient estimates of $Lib_t \times Intensity$ and $Lib_{t+2} \times Intensity$ are significant at the 10% level when the dependent variable is $Ln(1+Tcite)$ and $Ln(1+Nfirm)$, respectively. The coefficient estimate of $Lib_{t+1} \times Intensity$ is insignificant when the dependent variable is $Ln(1+Tcite)$.

examine the changes in innovation output before and after liberalization events instead of the changes surrounding these events. In this section, we conduct an analysis to examine the change in average levels of innovation output surrounding liberalization events using short event windows. Using a short event window also alleviates the concern that our results capture the upward time trend in industrial innovation output.

Specifically, we perform a regression analysis in the liberalizing sample for a 7-year event window, i.e., three years before and three years after the liberalization events, and an 11-year event window, i.e., five years before and five years after the liberalization events. Table 5 Panel C presents the event study results. We find that the coefficient estimates of *Lib*×*Intensity* are positive and significant at the 1% level across all the six columns. Collectively, the results of the event analysis lends further support to our conjecture that more innovative industries are more likely to experience an increase in innovation output after a country opens its stock market to foreign investors.

3.5.4. Including liberalized and non-liberalized countries

As documented by Lerner and Seru (2017), industrial patenting activities increase over time in response to strengthened patent rights and national policies that encourage patenting activities. Thus, it is possible that our results merely reflect such an upward time trend in certain countries. In this section, we control for the upward time trend by including both the liberalized sample and the non-liberalized sample, and re-estimate the regressions in Eq. (2).

We report the results in Panel D of Table 5. The results show that including non-liberalized countries in our sample does not alter the positive effect of stock market liberalization on innovation output. For example, the coefficient estimates of *Lib*×*Intensity* are significant at the 1% level in all the three columns, which suggests that the upward time trend is unlikely to drive our results.

3.5.5 Using private firms as a placebo group

According to previous literature (e.g., Chari and Henry, 2004, 2008), equity market liberalization has a more direct impact on publicly traded firms because these firms become investible to foreign investors after liberalization. If our results just capture the possibility that the equity market liberalization of a country coincides with the technological advancement of more innovative industries in the country, we should observe that private firms in more innovative industries also exhibit an increase in innovation output. In contrast, if liberalization promotes firms' innovation output by attracting foreign investment, we should expect that the positive effect of equity market liberalization is primarily on public firms in more innovative industries.

To examine this conjecture, we conduct a placebo test by re-estimating Eq. (2) using a sample of private firms. The results, reported in Panel E of Table 5, show that the innovation output of private firms in more innovative industries does not experience a significant increase after a country opens up its equity market to foreign investors. These findings suggest that the coincidence of equity market liberalization with the technological advancement of more innovative industries in a country is unlikely to be a plausible explanation for our findings.

3.6. Patent originality and generality

While previous studies argue that patent counts and patent citations capture the quantity and quality of a country's innovation output, to further capture the fundamental nature and importance of innovation, we follow Hsu, Tian, and Xu (2014) by computing two additional patent citation-based innovation measures, namely, industrial patent originality and generality (*Originality* and *Generality*). According to Hall, Jaffe, and Trajtenberg (2001), a patent's originality score is calculated as one minus the Herfindahl concentration index of technological classes for all prior patents that it cites. Therefore, a patent with a high originality score is inspired by prior inventions from a wide range of technological classes instead of only closely related technological classes. Likewise, a patent's generality score is calculated as one minus the Herfindahl concentration index of technological classes for all the citations it receives.[31] In other words, a patent with a high generality score has widespread impact on future patents from various technological classes.

Similar to citations, an improvement in patent originality and generality is particularly meaningful for emerging economies because it not only reflects the intricate novelty of inventions but also indicates the profound influence of inventions on innovations in other scientific areas. We aggregate individual patents' originality and generality scores to the industry level and compute *Originality* and *Generality* in each 2-digit SIC industry for each country each year. To reduce the skewness of these measures, we also use the logarithm of one plus the

[31] We use the 3-digit IPC class to define originality and generality scores, but our results are robust to 1-digit or 2-digit IPC class.

industrial originality and generality scores, i.e., *Ln*(1+*Originality*) and *Ln*(1+*Generality*), in regressions.

[Insert Table 6 about here]

We regress *Ln*(1+*Originality*) and *Ln*(1+*Generality*) on *Lib×Intensity* together with control variables described in Section 2.3 and report the results in Table 6. The results show that the coefficients on *Lib×Intensity* are positive and significant at the 1% level, which suggests that the openness of a country's equity market not only improves industrial innovativeness in this country but also enhances the originality and generality of innovation particularly in more innovative industries.

4. Economic channels

The baseline regression results show that the liberalization of equity markets in a country enhances innovation output in more innovative industries. In this section, we explore three plausible underlying economic channels through which stock market liberalization affects innovation output. The three plausible economic channels are built upon existing theories of how stock market liberalization could benefit local firms, paying special attention to financing, risk-sharing, and corporate governance as factors that promote innovation (Holmstrom 1989, Manso, 2011).

4.1. The financing channel

Gupta and Yuan (2009) show that stock market liberalization allows foreign investors to purchase shares of public firms listed on domestic stock exchanges and thus attracts more foreign capital inflows, meeting firms' investment needs. Furthermore, Hsu, Tian, and Xu (2014) document that equity financing is an important financing channel for innovative firms because higher risk and information asymmetry lead to a greater reliance of these firms on equity financing. Thus, we expect the effect of stock market liberalization on innovation output of more innovative industries to be stronger in countries that have a less developed equity market.

To examine this conjecture, we explore how stock market development alters our baseline results. Specifically, we partition the sample into countries with more developed and less developed equity markets according to a country's level of equity market development, measured by the ratio of total market capitalization of all public firms in a country to its GDP. To show different effects of stock market liberalization on innovation across more innovative and less innovative industries along the partitioning variable, we use the top and bottom terciles of the partitioning variable as the cut-off points to split the sample. We classify countries with the equity market development ratio higher than the top tercile of the sample as those having a more developed stock market and countries with the equity market development ratio lower than the bottom tercile of the sample as those having a less developed stock market. Following existing literature (e.g., Low, 2009), we use the equity market development ratio measured at one year prior to the liberalization year to partition the sample. We estimate the regression in Eq. (2) for the subsamples of countries with less developed and more developed stock markets separately.

[Insert Table 7 about here]

We present the results in Table 7. We observe that the coefficient estimates of *Lib×Intensity* are positive and significant at the 5% or the 1% level in countries with a less developed equity market, while those are insignificant in countries with a more developed equity market. We also compare the coefficient estimates of *Lib×Intensity* between the two subsamples with high and low levels of equity market development by conducting the *F*-test. We find that the coefficient estimates between the two groups are significantly different with *p*-values of less than 0.01. The results suggest that stock market liberalization encourages innovation by alleviating firms' financing difficulties.

4.2. The risk-sharing channel

Prior literature (e.g., Henry, 2000; Chari and Henry, 2004; Bekaert, Harvey, and Lundblad, 2005) shows that foreign portfolio holdings induced by equity market liberalization enhance risk sharing between domestic and foreign investors. Moreover, recent studies find that foreign investors can better achieve diversification through their international portfolio investment, which encourages the risk-taking of firms they hold (Faccio, Marchica, and Mura, 2011, Boubakri, Cosset, and Saffar, 2013). To the extent that stock market liberalization lifts the restrictions on foreign investors purchasing shares of domestic listed firms, these firms are better able to tolerate the potential failure involved in innovative activities, and hence should undertake more innovative projects after liberalization.

Acharya and Subramanian (2009) show that a creditor-friendly bankruptcy code impedes innovation by exacerbating intolerance for failure and discouraging risk taking in innovation as a result of potential deadweight costs arising from liquidation. Therefore, we expect the effect of stock market liberalization on innovation output of more innovative industries to be more pronounced in economies with a creditor-friendly bankruptcy code where firms are more risk averse.

To test this conjecture, we divide the sample into subsamples of economies with stronger and weaker creditor rights according to the creditor rights index created by Djankov, McLiesh, and Shleifer (2007). Specifically, we classify countries as those with stronger creditor rights if their creditor rights index is above the top tercile of the sample and as those with weaker creditor rights if their creditor rights index is below the bottom tercile of the sample. We then estimate the regression in Eq. (2) for the two subsamples separately and report the results in Table 8.

[Insert Table 8 about here]

The coefficient estimates of *Lib*×*Intensity* are positive and significant at the 1% level for economies with stronger creditor rights but are insignificant for economies with weaker creditor rights except for the regression where the dependent variable is *Ln*(1+*Tcite*). Furthermore, the coefficient estimates of *Lib*×*Intensity* between the two subsamples are statistically different at the 1% level, suggesting that the positive effect of stock market liberalization on innovation in more innovative industries is more pronounced in economies with stronger creditor rights. Hence, risk-sharing appears to be an underlying economic channel through which stock market liberalization affects innovation.

4.3. The corporate governance channel

Previous studies (e.g., Mitton, 2006; Bekaert, Harvey, and Lundblad, 2011) argue that the liberalization of equity markets attracts more foreign investors who require better corporate governance, which effectively disciplines managers' opportunistic behaviors and promotes firms' investment efficiency. Furthermore, recent literature highlights the important role of good corporate governance in innovation. For example, Brown, Martinsson, and Peterson (2013) find that strong shareholder protection promotes innovation because innovative projects, compared with conventional investment, are highly risky and have greater information asymmetry. Atanassov (2013) points out the moral hazard problems in innovative projects by showing that firms' innovation output declines after the states where these firms are incorporated pass the anti-takeover laws, which leads to a weakened disciplinary effect of the takeover market on managers. Thus, if improving corporate governance is an underlying economic channel that allows stock market liberalization to promote innovation, we expect to observe the positive effect of stock market liberalization on innovation output of more innovative industries to be more pronounced in economies with stronger investor protection.

To examine this conjecture, we partition the sample according to the country level investor protection index compiled by La Porta et al. (2000). Specifically, we classify a country as the one with stronger shareholder protection if its investor protection index is above the top tercile of the sample and a country with weaker shareholder protection if its investor protection index is below the bottom tercile of the sample. We then estimate the regression model in Eq. (2) for the strong and weak shareholder protection groups separately and report the results in Table 9.

[Insert Table 9 about here]

We find that the coefficient estimates of *Lib*×*Intensity* are positive and significant in both subsamples. Comparing the coefficients of *Lib*×*Intensity* in subsamples with strong and weak shareholder protection, we find an insignificant difference. The findings in this table suggest that improving local firms' corporate governance is less likely to be the channel through which stock market liberalization affects innovation output in innovative industries. A plausible explanation is that strong shareholder governance such as shareholder protection can also weaken managers' risk-taking incentives and induce managerial short-termism by exerting too much external pressure on managers, which in turn hinders innovation (e.g., Belloc, 2013; Lin, Liu, and Manso, 2017).

5. Innovation, stock market liberalization, and economic growth

Thus far our findings show that the innovation output of more innovative industries improves after a country liberalizes its equity market. It is, however, not clear whether liberalization affects economic growth through promoting technological innovation. In this section, we examine the effect of liberalization on the growth of value-added across industries with different degrees of innovativeness. If liberalization promotes economic growth mainly through enhancing technological innovation, we should observe a significant and positive effect of liberalization on the growth of value-added in more innovative industries.

To test our conjecture, we first regress the growth of industry value-added ($\Delta Ln(VA)$) from year *t*-1 to *t* on *Lib* measured in year *t*-1, and include the same set of control variables in Eq. (2), measured in year *t*-1, and industry-country and year fixed effects in the regression. The results are reported in column (1) of Table 10. We find that the coefficient estimate of *Lib* is positive and significant at the 1% level, confirming the findings of Gupta and Yuan (2009) in a sample of liberalizing countries.

[Insert Table 10 about here]

Next, we further include the interaction of *Lib* and *Intensity* in the regression. The results are presented in column (2) of Table 10. We find that the coefficient estimate of *Lib*×*Intensity* is positive and significant at the 5% level. The result provides supportive evidence to the premise that stock market liberalization promotes the growth of value-added more through fostering innovation in innovative industries.

Finally, in columns (3) and (4) of Table 10, we follow Bekaert, Harvey, and Lundblad (2011) and examine the temporary and permanent effects of liberalization. In doing so, we construct two indicators to denote the temporary and permanent effects of stock market liberalization. The first dummy variable, Lib_{temp}, which captures the temporary effect equals one for observations in the first 3 years after a country liberalizes its equity market and zero otherwise. The second dummy variable, Lib_{perm}, which captures the permanent effect equals one for observations in more than 3 years after a country liberalizes its equity market and zero otherwise. In column (3), we replace *Lib* with Lib_{temp} and Lib_{perm}, and re-estimate the regression. We find that the positive effect of liberalization on economic growth is not only temporary but also permanent because the coefficient estimates of Lib_{temp} and Lib_{perm} are both positive and significant at the 1% level. In column (4), we further include $Lib_{temp} \times Intensity$ and $Lib_{perm} \times Intensity$ in the regression. The results show that the coefficient estimate of $Lib_{temp} \times Intensity$ is insignificant despite being positive, while the coefficient estimate of $Lib_{perm} \times Intensity$ is positive and significant at the 5% level. These findings suggest that equity market liberalization is beneficial to the economy in both the short run and the long run. However, the enhancement of innovation output as a result of liberalization is likely to be the driver of the economic growth in the long run.

6. Conclusion

In this paper, we have investigated the impact of stock market liberalization on technological innovation. Using a fixed effects identification strategy and a sample of 20 developed and emerging economies between 1981 and 2008, we find that stock market liberalization promotes industry innovation output and the effect is disproportionately stronger in more innovative industries. We find support for two economic mechanisms underlying the positive impact of stock market liberalization on innovation: the financing channel and the risk-sharing channel. We further show that innovation is a mechanism that links stock market liberalization with economic growth.

While we show that stock market liberalization appears to have a positive, causal effect on innovation, there are two important caveats when interpreting or generalizing our findings. First, even though we explore various model specifications and conduct different tests to address the endogeneity issue, there are still possible unobservable missing time-varying country-industry factors that could drive the positive relation between stock market liberalization and innovation in more innovative industries. Second, although our economic channels are based on economic theory, our tests are unable to perfectly identify these channels without suffering potential endogeneity biases. Importantly, these channels are not necessarily mutually exclusive and could jointly contribute to the positive effect of equity market liberalization on innovation.

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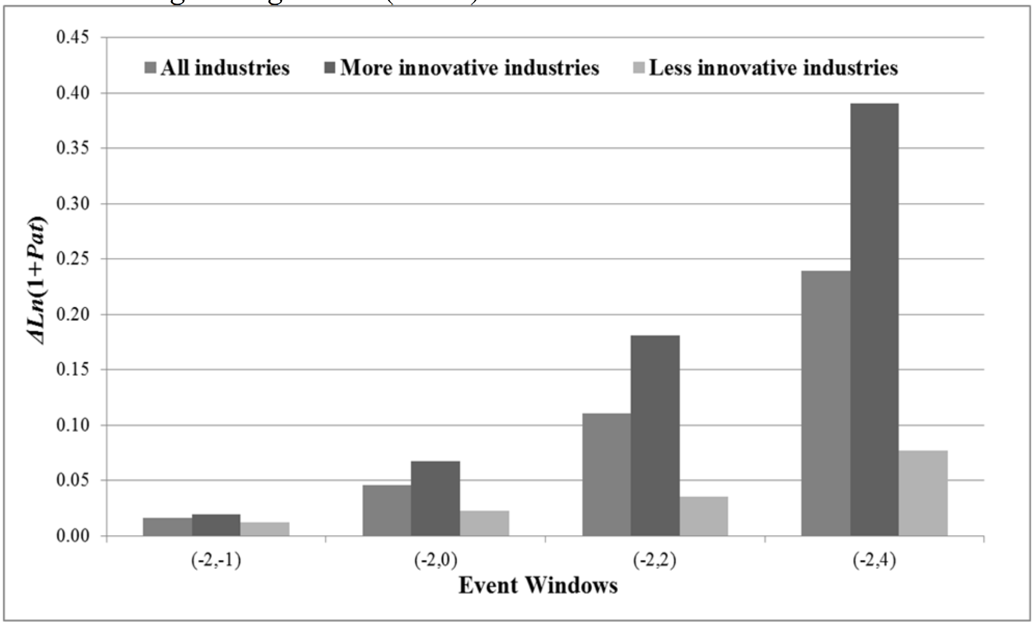
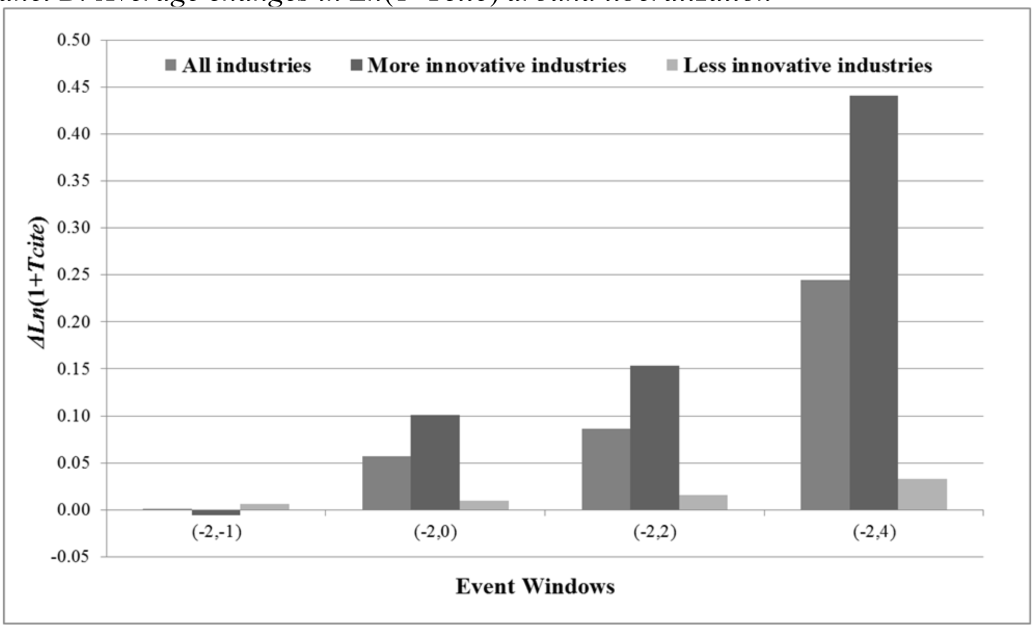
Figure 1: Average changes in innovation output around liberalization

This figure plots the average changes in innovation output for all industries and for more-innovative and less-innovative industries during 1981 to 2008. *Ln*(1+*Pat*), *Ln*(1+*Tcite*), and *Ln*(1+*Nfirm*) are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in an industry for each country each year, respectively. More (less) innovative industries are defined as industries of which the industry innovation intensity is above (below) the sample median. The changes in *Ln*(1+*Pat*), *Ln*(1+*Tcite*), and *Ln*(1+*Nfirm*) are computed from two years before liberalization (i.e., year -2) to one year before liberalization (i.e., year -1) and to *t* years (*t* = 0, 2, and 4) after liberalization.

Panel A: Average changes in Ln(1+*Pat*) *around liberalization*



Panel B: Average changes in Ln(1+*Tcite*) *around liberalization*



Panel C: Average changes in Ln(1+*Nfirm*) *around liberalization*

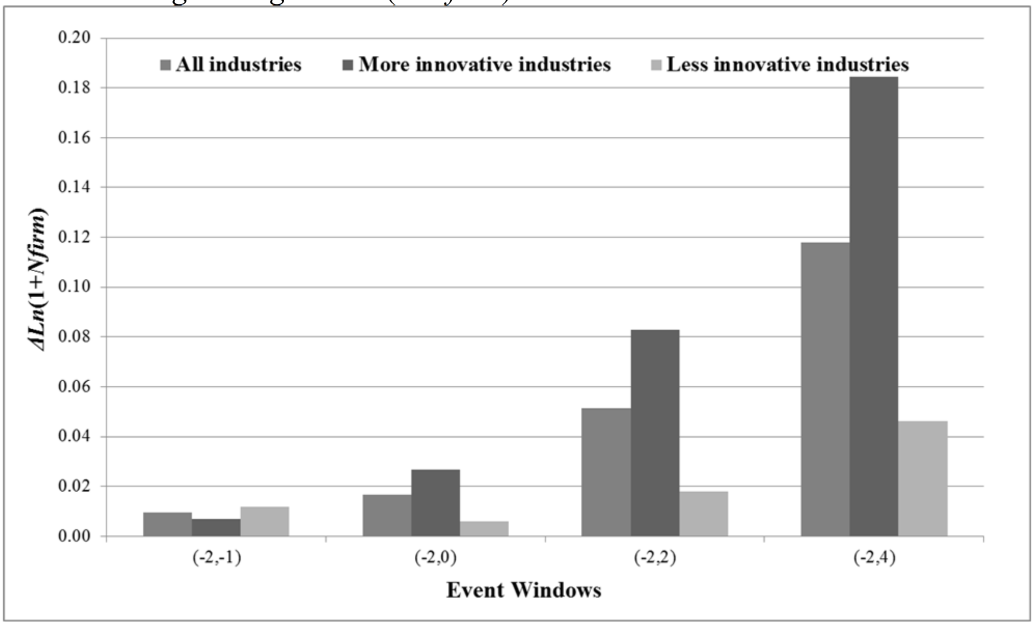


Table 1: Sample distribution

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. In Panel A, stock market liberalization years are from Bekaert, Harvey, and Lundblad (2005). N denotes the number of industry-year observations. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in a country across all industries and years, respectively. In Panel B, N denotes the number of country-year observations. *Pat*, *Tcite*, and *Nfirm* are the average number of patents, the average number of citations adjusted for time-technology class fixed effects, and the average number of innovative firms in an industry, respectively. *VA* is the average ratio of value-added in a two-digit SIC over the total value-added for each country each year. *Intensity* is the average number of patents held by a U.S. firm in a two-digit SIC industry in each year.

Panel A: Sample distribution by country

Country	Liberalization year	N	*Pat*	*Tcite*	*Nfirm*
	(1)	(2)	(3)	(4)	(5)
Argentina	1989	380	7	7	3
Brazil	1991	348	67	153	27
Chile	1992	387	7	12	2
Greece	1987	400	26	87	15
India	1992	560	2,149	4,010	345
Indonesia	1989	360	5	3	4
Israel	1993	546	1,726	3,341	217
Japan	1983	555	521,107	1,070,883	15,476
Korea	1992	558	130,871	202,899	2,505
Malaysia	1988	560	14	2	13
Mexico	1989	480	18	45	12
New Zealand	1987	396	79	352	43
Philippines	1991	557	7	7	4
Portugal	1986	400	26	47	14
Saudi Arabia	1999	280	155	305	5
South Africa	1996	544	187	443	30
Spain	1985	560	484	1,812	181
Taiwan	1991	400	80,009	140,031	3,974
Thailand	1987	400	30	76	12
Turkey	1989	400	963	1,936	93

Panel B: Sample distribution by industry

SIC	SIC description	(1)	(2)	(3)	(4)	(5)	(6)
		N	*Pat*	*Tcite*	*Nfirm*	*VA*	*Intensity*
20	Food and kindred products	459	15.55	28.38	2.16	0.16	2.22
21	Tobacco products	389	3.57	5.66	0.07	0.02	0.18
22	Textile mill products	459	7.10	14.30	0.90	0.05	2.03
23	Apparel and other finished products made from fabrics and similar materials	459	1.35	3.66	0.29	0.03	2.23
24	Lumber and wood products, except furniture	459	1.10	1.99	0.23	0.02	2.60
25	Furniture and fixtures	453	0.77	1.66	0.23	0.02	1.78
26	Paper and allied products	459	9.55	20.52	0.78	0.03	2.87
27	Printing, publishing, and allied industries	459	7.82	14.09	0.36	0.03	1.35
28	Chemicals and allied products	458	237.04	396.62	9.07	0.11	3.97

29	Petroleum refining and related industries	459	2.48	5.40	0.38	0.06	3.23
30	Rubber and miscellaneous plastics products	459	32.87	86.41	1.71	0.04	3.05
31	Leather and leather products	459	0.26	0.05	0.07	0.03	1.21
32	Stone, clay, glass, and concrete products	459	27.54	61.63	1.42	0.05	3.77
33	Primary metal industries	459	70.83	111.43	2.65	0.07	2.40
34	Fabricated metal products, except machinery and transportation equipment	458	12.07	22.43	1.38	0.05	2.18
35	Industrial and commercial machinery and computer equipment	458	312.50	600.99	9.00	0.05	3.74
36	Electronic and other electrical equipment and components, except computer equipment	459	544.94	1,028.36	12.43	0.07	3.79
37	Transportation equipment	459	185.47	390.97	3.70	0.05	3.55
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks	435	127.87	293.74	2.62	0.01	3.07
39	Miscellaneous manufacturing industries	453	15.70	38.42	0.82	0.02	2.10

Table 2: Summary statistics

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in an industry for each country each year, respectively. *VA* is the percentage of value-added in a two-digit SIC over the total value-added for each country each year, measured in year *t*-1. *Ln*(*GDP*) is the log of GDP per capita for each country each year. Variables in dollars are computed in real terms at constant national prices in 2005 U.S. dollars. *Export* and *Import* are a country's exports and imports as a fraction of GDP, respectively. *Intensity* is the log of one plus the average number of patents held by a U.S. firm in a two-digit SIC industry each year.

Variables	Mean	SD	Min	Q1	Median	Q3	Max
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pat	81.35	507.87	0.00	0.00	0.00	0.00	4,475.00
Ln(1+*Pat*)	0.58	1.64	0.00	0.00	0.00	0.00	8.41
Tcite	157.25	975.68	0.00	0.00	0.00	0.00	8,454.12
Ln(1+*Tcite*)	0.61	1.81	0.00	0.00	0.00	0.00	9.04
Nfirm	2.53	14.27	0.00	0.00	0.00	0.00	290.00
Ln(1+*Nfirm*)	0.30	0.83	0.00	0.00	0.00	0.00	4.65
VA	5.02	4.55	0.12	2.10	3.72	6.42	27.26
Ln(*GDP*)	3.18	0.80	1.04	2.73	3.32	3.83	4.37
Export	0.21	0.14	0.03	0.10	0.18	0.25	0.79
Import	0.22	0.13	0.03	0.11	0.21	0.29	0.68
Intensity	2.58	1.13	0.00	1.84	2.64	3.43	5.07

Table 3: The effect of stock market liberalization on innovation

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each two-digit SIC industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. *VA* is the ratio of value-added in a two-digit SIC over the total value-added for each country each year, measured in year *t*-1. *Ln*(*GDP*) is the log of GDP per capita for each country each year, measured in year *t*-1. Variables in dollars are computed in real terms at constant national prices in 2005 U.S. dollars. *Export* and *Import* are a country's exports and imports as a fraction of GDP, respectively, measured in year *t*-1. *Intensity* is the log of one plus the average number of patents held by a U.S. firm in a two-digit SIC industry each year, measured in year *t*-1. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib	0.153***	0.176***	0.100***
	(0.05)	(0.05)	(0.02)
VA	3.090*	3.652*	1.660*
	(1.59)	(1.89)	(0.86)
Ln(*GDP*)	1.516***	1.430***	0.871***
	(0.19)	(0.21)	(0.11)
Export	-0.470	-0.037	-0.245
	(0.34)	(0.36)	(0.17)
Import	-2.716***	-2.708***	-1.537***
	(0.43)	(0.49)	(0.23)
Intensity	-0.020	-0.015	-0.014
	(0.02)	(0.02)	(0.01)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	9,071	9,071	9,071
R-squared	0.25	0.16	0.28

Table 4: The effect of stock market liberalization on innovation across different industries

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)	*Ln*(1+*Pat*) (4)	*Ln*(1+*Tcite*) (5)	*Ln*(1+*Nfirm*) (6)
Lib×Intensity	0.167***	0.182***	0.101***	0.161***	0.182***	0.095***
	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)
Lib	-0.279***	-0.295***	-0.161***	-0.265***	-0.296***	-0.148***
	(0.09)	(0.10)	(0.05)	(0.09)	(0.10)	(0.04)
VA	2.717*	3.246*	1.434*	1.792	1.013	0.780
	(1.50)	(1.80)	(0.80)	(1.69)	(1.80)	(0.88)
Ln(*GDP*)	1.524***	1.439***	0.876***	1.295***	1.231***	0.719***
	(0.18)	(0.20)	(0.10)	(0.17)	(0.17)	(0.09)
Export	-0.456	-0.021	-0.236	-1.106**	-0.924*	-0.564*
	(0.33)	(0.36)	(0.16)	(0.55)	(0.54)	(0.29)
Import	-2.708***	-2.699***	-1.532***	-1.492***	-1.203**	-0.849***
	(0.42)	(0.48)	(0.22)	(0.55)	(0.58)	(0.29)
Intensity	-0.110***	-0.113***	-0.068***	-0.349***	-0.340**	-0.235***
	(0.03)	(0.03)	(0.02)	(0.13)	(0.13)	(0.08)
VA×Intensity				0.319	0.795	0.228
				(0.72)	(0.80)	(0.38)
Ln(*GDP*)*×Intensity*				0.088**	0.077*	0.060***
				(0.04)	(0.04)	(0.02)
Export×Intensity				0.244	0.339*	0.122
				(0.20)	(0.19)	(0.11)
Import×Intensity				-0.461**	-0.568**	-0.259**
				(0.20)	(0.23)	(0.11)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,071	9,071	9,071	9,071	9,071	9,071
R-squared	0.26	0.18	0.30	0.26	0.18	0.31

Table 5: Test on endogeneity

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. In Panel A, *FDI* is a country's foreign direct investment over GDP, measured in year *t*-1. *Stock Market* is the ratio of stock market capitalization over GDP, measured in year *t*-1. *Credit Market* is the ratio of domestic credit provided by the banking sector over GDP, measured in year t-1. *IP Protection* is the intellectual property protection index of a country from Park (2005), measured in year *t*-1. *Insider Trade* is a dummy variable that takes the value of one in the year of a country's first insider trading enforcement case and thereafter, and zero otherwise from Denis and Xu (2013), measured in year *t*. *Quinn* is the capital account openness in Quinn (1997). *English Law* is a dummy variable that takes the value of one if a country is a common law country, and zero otherwise. In Panel B, Lib_{t-2} (Lib_{t-1}) is a binary variable that takes the value of one if a country liberalizes its equity market two years (one year) ago, and zero otherwise. Lib_{t+1} (Lib_{t+2}) is a binary variable that takes the value of one if a country liberalizes its equity market in one year (two years), and zero otherwise. $Lib_{\geq t+3}$ is a binary variable that takes the value of one if a country liberalizes its equity market in three years and thereafter, and zero otherwise. In Panel C, the event window in columns (1)-(3) (columns (4)-(6)) is 7 (11) years with 3 (5) years before and 3 (5) years after the liberalization effect starting year, which is three years since a country liberalizes its equity market. In Panel D, we include both liberalized and non-liberalized economies. In Panel E, we employ a sample of private firms as the placebo group. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Controlling for omitted variables

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)	*Ln*(1+*Pat*) (4)	*Ln*(1+*Tcite*) (5)	*Ln*(1+*Nfirm*) (6)
Lib×Intensity	0.083**	0.120***	0.058***	0.090**	0.109**	0.043***
	(0.03)	(0.04)	(0.02)	(0.04)	(0.05)	(0.01)
Lib	-0.162*	-0.234**	-0.091*			
	(0.09)	(0.10)	(0.05)			
VA	1.670	0.383	0.924	1.527	0.667	0.273
	(1.45)	(1.52)	(0.77)	(1.62)	(1.83)	(0.76)
Ln(*GDP*)	1.205***	1.132***	0.720***			
	(0.19)	(0.20)	(0.12)			
Export	-1.451**	-1.377**	-0.675**			
	(0.57)	(0.68)	(0.34)			
Import	-0.255	0.225	-0.418			
	(0.70)	(0.79)	(0.37)			
Intensity	-0.373***	-0.362***	-0.231***			
	(0.11)	(0.13)	(0.07)			
FDI	-1.722	-1.413	-1.227**			
	(1.22)	(1.29)	(0.61)			
Stock Market	-0.167	-0.226*	-0.020			
	(0.11)	(0.13)	(0.03)			

Credit Market	0.382***	0.375***	0.165***			
	(0.10)	(0.10)	(0.04)			
IP Protection	-0.190***	-0.143**	-0.123***			
	(0.07)	(0.07)	(0.03)			
Insider Trade	-0.120	-0.100	-0.129***			
	(0.11)	(0.13)	(0.04)			
VA×Intensity	0.167	0.702	0.059	0.314	0.763	0.310
	(0.64)	(0.71)	(0.36)	(0.74)	(0.87)	(0.39)
Ln(GDP)×Intensity	0.094**	0.107**	0.067**	0.061	0.076	0.056**
	(0.04)	(0.05)	(0.03)	(0.04)	(0.05)	(0.02)
Export×Intensity	0.441*	0.521*	0.243*	0.339*	0.404*	0.172
	(0.23)	(0.27)	(0.14)	(0.20)	(0.24)	(0.11)
Import×Intensity	-0.950***	-1.109***	-0.489***	-0.773***	-0.948***	-0.462***
	(0.30)	(0.35)	(0.16)	(0.29)	(0.33)	(0.14)
FDI×Intensity	0.537	0.161	0.368	0.622	0.305	0.386
	(0.52)	(0.54)	(0.26)	(0.56)	(0.63)	(0.26)
Stock Market×Intensity	0.065*	0.101**	0.019	0.060	0.108**	0.026**
	(0.04)	(0.04)	(0.01)	(0.04)	(0.05)	(0.01)
Credit Market×Intensity	-0.123***	-0.164***	-0.035*	-0.122***	-0.152***	-0.034**
	(0.04)	(0.05)	(0.02)	(0.04)	(0.05)	(0.02)
IP Protection×Intensity	0.062***	0.052**	0.025**	0.065**	0.036	0.007
	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)
Insider Trade×Intensity	0.006	-0.014	0.015	0.013	-0.017	0.006
	(0.04)	(0.04)	(0.01)	(0.03)	(0.04)	(0.01)
Quinn×Intensity	-0.006	-0.055	-0.078			
	(0.14)	(0.16)	(0.08)			
English Law×Intensity	0.064	0.093*	0.034			
	(0.05)	(0.05)	(0.02)			
Year FE	Yes	Yes	Yes	No	No	No
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FE	No	No	No	Yes	Yes	Yes
Industry-year FE	No	No	No	Yes	Yes	Yes
Observations	7,991	7,991	7,991	7,991	7,991	7,991
R-squared	0.29	0.19	0.35	0.93	0.91	0.94

Panel B: Test on reverse causality

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib_{t-2}×*Intensity*	0.050	0.060	0.013
	(0.04)	(0.04)	(0.02)
Lib_{t-1}×*Intensity*	0.036	0.036	0.007
	(0.04)	(0.05)	(0.02)
Lib_{t}×*Intensity*	0.060	0.088*	0.019
	(0.04)	(0.05)	(0.02)
Lib_{t+1}×*Intensity*	0.082*	0.084	0.036*
	(0.04)	(0.05)	(0.02)
Lib_{t+2}×*Intensity*	0.092**	0.109**	0.037*
	(0.04)	(0.05)	(0.02)
$Lib_{\geq t+3}$×*Intensity*	0.198***	0.226***	0.109***
	(0.05)	(0.05)	(0.02)
Lib_{t-2}	-0.217**	-0.198*	-0.117**
	(0.11)	(0.11)	(0.05)
Lib_{t-1}	-0.218**	-0.178*	-0.115**
	(0.10)	(0.10)	(0.05)
Lib_{t}	-0.221**	-0.229**	-0.113**
	(0.11)	(0.11)	(0.05)
Lib_{t+1}	-0.204*	-0.166	-0.110**
	(0.11)	(0.12)	(0.05)
Lib_{t+2}	-0.187*	-0.194	-0.083
	(0.11)	(0.12)	(0.06)
$Lib_{\geq t+3}$	-0.381***	-0.385***	-0.216***
	(0.11)	(0.12)	(0.06)
Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	9,071	9,071	9,071
R-squared	0.27	0.18	0.31

Panel C: Event study

Dependent variables	*Ln*(1+*Pat*)	*Ln*(1+*Tcite*)	*Ln*(1+*Nfirm*)	*Ln*(1+*Pat*)	*Ln*(1+*Tcite*)	*Ln*(1+*Nfirm*)
Event window	Window (-3yr, +3yr)			Window (-5yr, +5yr)		
	(1)	(2)	(3)	(4)	(5)	(6)
Lib×Intensity	0.087***	0.097***	0.041***	0.113***	0.126***	0.057***
	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)
Lib	-0.220***	-0.209***	-0.098***	-0.248***	-0.284***	-0.124***
	(0.06)	(0.06)	(0.02)	(0.07)	(0.08)	(0.03)
VA	0.709	1.161	0.051	-0.088	-0.282	-0.156
	(1.35)	(1.57)	(0.60)	(1.64)	(1.82)	(0.67)
Ln(*GDP*)	0.745***	0.603**	0.347***	1.019***	0.963***	0.559***
	(0.21)	(0.25)	(0.09)	(0.23)	(0.28)	(0.11)
Export	1.491**	1.098	0.909***	0.218	0.226	0.722**
	(0.72)	(0.82)	(0.32)	(0.70)	(0.74)	(0.31)
Import	-0.559	-0.658	-0.363	-1.564**	-1.836**	-1.250***
	(0.61)	(0.66)	(0.27)	(0.71)	(0.75)	(0.31)
Intensity	0.084	0.240	-0.004	-0.069	0.021	-0.092
	(0.16)	(0.21)	(0.06)	(0.15)	(0.20)	(0.06)
VA×Intensity	-0.416	-0.813	-0.025	0.426	0.611	0.339
	(0.72)	(0.95)	(0.31)	(0.89)	(1.08)	(0.36)
Ln(*GDP*)*×Intensity*	-0.031	-0.086	-0.001	0.008	-0.033	0.025
	(0.05)	(0.06)	(0.02)	(0.05)	(0.06)	(0.02)
Export×Intensity	-0.369*	-0.235	-0.253***	-0.235	-0.199	-0.206**
	(0.21)	(0.24)	(0.09)	(0.21)	(0.24)	(0.10)
Import×Intensity	0.103	0.158	0.108	0.033	0.151	0.047
	(0.24)	(0.28)	(0.10)	(0.22)	(0.27)	(0.10)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,596	2,596	2,596	3,902	3,902	3,902
R-squared	0.15	0.09	0.19	0.19	0.12	0.28

Panel D: Including liberalized and non-liberalized countries

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib×Intensity	0.092***	0.139***	0.053***
	(0.03)	(0.04)	(0.02)
Lib	-0.153**	-0.187**	-0.080**
	(0.07)	(0.08)	(0.04)
VA	0.542	-0.707	0.482
	(1.19)	(1.40)	(0.60)
Ln(*GDP*)	1.338***	1.214***	0.750***
	(0.17)	(0.17)	(0.09)
Export	-2.192***	-1.987***	-1.161***
	(0.34)	(0.41)	(0.16)
Import	0.927***	1.002***	0.430***
	(0.29)	(0.32)	(0.15)
Intensity	-0.347***	-0.371***	-0.238***
	(0.11)	(0.11)	(0.07)
VA×Intensity	0.281	0.704	0.162
	(0.48)	(0.58)	(0.25)
Ln(*GDP*)*×Intensity*	0.069**	0.075**	0.050***
	(0.03)	(0.03)	(0.02)
Export×Intensity	0.366***	0.446***	0.148**
	(0.14)	(0.17)	(0.06)
Import×Intensity	-0.295**	-0.387***	-0.117**
	(0.12)	(0.14)	(0.06)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	20,465	20,465	20,465
R-squared	0.17	0.09	0.22

Panel E: Using private firms as the placebo group

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib×Intensity	-0.003	0.026	-0.035
	(0.07)	(0.07)	(0.05)
Lib	0.044	0.106	0.071
	(0.11)	(0.13)	(0.08)
VA	-1.632	-2.530	-1.424
	(2.16)	(2.31)	(1.74)
Ln(*GDP*)	0.884***	1.256***	0.744***
	(0.17)	(0.21)	(0.13)
Export	-0.917	0.487	-0.592
	(0.83)	(0.92)	(0.64)
Import	-1.176	-2.396**	-1.268**
	(0.83)	(1.11)	(0.58)
Intensity	-0.005	-0.023	-0.005
	(0.25)	(0.26)	(0.19)
VA×Intensity	2.143*	2.039	1.939*
	(1.29)	(1.35)	(0.99)
Ln(*GDP*)*×Intensity*	-0.016	-0.008	-0.013
	(0.08)	(0.09)	(0.06)
Export×Intensity	0.323	0.006	0.310
	(0.47)	(0.52)	(0.37)
Import×Intensity	0.353	0.472	0.372
	(0.50)	(0.65)	(0.34)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	9,071	9,071	9,071
R-squared	0.19	0.11	0.25

Table 6: Stock market liberalization and patent originality and generality

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Originality* (*Generality*) is defined as the total originality (generality) score of all patents in an industry for each country in each year, measured in year *t*. The originality (generality) score of a patent is calculated as one minus the Herfindahl index of the technology class distribution of all the patents that this patent cites (that cite this patent), measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Originality*) (1)	*Ln*(1+*Generality*) (2)
Lib×Intensity	0.120***	0.096***
	(0.03)	(0.02)
Lib	-0.289***	-0.205***
	(0.07)	(0.05)
VA	1.588	0.431
	(1.11)	(0.76)
Ln(*GDP*)	0.493***	0.383***
	(0.11)	(0.08)
Export	-0.525*	-0.293
	(0.29)	(0.21)
Import	-1.432**	-0.768**
	(0.56)	(0.33)
Intensity	-0.186**	-0.132**
	(0.08)	(0.06)
VA×Intensity	0.145	0.312
	(0.45)	(0.33)
Ln(*GDP*)*×Intensity*	0.035	0.023
	(0.03)	(0.02)
Export×Intensity	0.208*	0.107
	(0.11)	(0.07)
Import×Intensity	-0.294	-0.218*
	(0.19)	(0.13)
Year FE	Yes	Yes
Country-industry FE	Yes	Yes
Observations	9,071	9,071
R-squared	0.23	0.18

Table 7: The effect of liberalization on innovation in different industries depending on equity market development

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. An equity market is defined as less developed if the ratio of market capitalization over GDP of an economy is below the bottom tercile of the sample, and as developed if the ratio is above the top tercile of the sample. The ratio is measured one year prior to the liberalization year. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*)		*Ln*(1+*Tcite*)		*Ln*(1+*Nfirm*)	
	(1)	(2)	(3)	(4)	(5)	(6)
	Partitioning variable: Equity market development					
	Less developed	Developed	Less developed	Developed	Less developed	Developed
Lib×Intensity	0.075**	-0.032	0.104***	-0.019	0.046***	-0.015
	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.01)
Lib	-0.209**	0.042	-0.239**	-0.014	-0.142***	0.015
	(0.08)	(0.07)	(0.11)	(0.05)	(0.05)	(0.04)
VA	1.096	0.494	-1.446	-1.930	0.298	0.532
	(1.41)	(1.24)	(1.64)	(1.42)	(0.86)	(0.65)
Ln(*GDP*)	0.762**	0.126	0.865**	0.393*	0.381**	0.038
	(0.37)	(0.18)	(0.39)	(0.21)	(0.18)	(0.09)
Export	-0.415	-0.417	0.153	-0.404	-0.253	-0.195
	(0.85)	(0.26)	(1.19)	(0.26)	(0.46)	(0.17)
Import	0.118	-0.273	-0.085	-0.570	0.208	-0.167
	(0.82)	(0.30)	(0.89)	(0.35)	(0.42)	(0.24)
Intensity	-0.501*	-0.105	-0.337	0.003	-0.312**	-0.069
	(0.27)	(0.09)	(0.30)	(0.12)	(0.14)	(0.06)
VA×Intensity	-0.603	0.096	0.062	0.856	-0.140	-0.113
	(0.57)	(0.48)	(0.63)	(0.68)	(0.33)	(0.18)
Ln(*GDP*)*×Intensity*	0.130	0.032	0.074	-0.007	0.081*	0.018
	(0.09)	(0.03)	(0.10)	(0.05)	(0.04)	(0.02)
Export×Intensity	0.849**	-0.010	1.027**	0.008	0.465**	-0.028
	(0.41)	(0.12)	(0.47)	(0.14)	(0.20)	(0.10)
Import×Intensity	-0.416	0.038	-0.620	-0.035	-0.246	0.074
	(0.53)	(0.18)	(0.57)	(0.21)	(0.25)	(0.12)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,168	1,887	2,168	1,887	2,168	1,887
R-squared	0.12	0.03	0.05	0.02	0.14	0.04

Table 8: The effect of liberalization on innovation in different industries depending on creditor rights

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. An economy is defined as having stronger creditor rights if its creditor rights index, compiled by Djankov, McLiesh, and Shleifer (2007), is above the top tercile of the sample, and as having weaker creditor rights if the index is below the bottom tercile of the sample. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*)		*Ln*(1+*Tcite*)		*Ln*(1+*Nfirm*)	
	(1)	(2)	(3)	(4)	(5)	(6)
	Partitioning variable: Creditor rights index					
	Strong	Weak	Strong	Weak	Strong	Weak
Lib×Intensity	0.228***	0.006	0.269***	0.030**	0.106***	0.004
	(0.07)	(0.01)	(0.08)	(0.01)	(0.04)	(0.01)
Lib	-0.445**	-0.020	-0.527**	-0.079**	-0.205**	-0.021
	(0.17)	(0.03)	(0.20)	(0.03)	(0.09)	(0.02)
VA	6.284	0.114	6.436	-0.761*	2.873	-0.033
	(4.85)	(0.57)	(5.18)	(0.43)	(1.98)	(0.30)
Ln(*GDP*)	1.308***	-0.076	1.351***	-0.076	0.687***	-0.037
	(0.27)	(0.09)	(0.28)	(0.12)	(0.14)	(0.06)
Export	-1.288**	-0.240	-1.065*	-0.865	-0.921***	-0.119
	(0.60)	(0.34)	(0.61)	(0.61)	(0.31)	(0.23)
Import	-1.815**	-0.065	-1.650*	0.750	-1.063***	-0.021
	(0.79)	(0.33)	(0.84)	(0.47)	(0.41)	(0.19)
Intensity	-0.384	0.008	-0.331	0.005	-0.381**	0.007
	(0.27)	(0.02)	(0.31)	(0.02)	(0.15)	(0.01)
VA×Intensity	-0.775	-0.128	-0.599	0.141	-0.309	-0.009
	(1.48)	(0.33)	(1.62)	(0.23)	(0.65)	(0.18)
Ln(*GDP*)*×Intensity*	0.147*	-0.007	0.131	-0.004	0.120***	-0.007*
	(0.08)	(0.01)	(0.10)	(0.01)	(0.04)	(0.00)
Export×Intensity	0.149	0.048	0.125	0.267	0.064	0.010
	(0.22)	(0.13)	(0.22)	(0.22)	(0.11)	(0.08)
Import×Intensity	-0.840***	0.022	-0.937***	-0.247*	-0.324**	0.031
	(0.29)	(0.09)	(0.34)	(0.15)	(0.14)	(0.05)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,884	2,565	2,884	2,565	2,884	2,565
R-squared	0.36	0.02	0.30	0.02	0.46	0.02

Table 9: The effect of liberalization on innovation in different industries depending on shareholder rights

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. An economy is defined as having stronger shareholder protection if its investor protection index, created by La Porta et al. (2000), is above the top tercile of the sample, and as having weaker shareholder protection if the index is below the bottom tercile of the sample. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*)		*Ln*(1+*Tcite*)		*Ln*(1+*Nfirm*)	
	(1)	(2)	(3)	(4)	(5)	(6)
	Partitioning variable: Investor protection index					
	Weak	Strong	Weak	Strong	Weak	Strong
Lib×Intensity	0.105*	0.085**	0.131**	0.097*	0.087***	0.052**
	(0.06)	(0.04)	(0.06)	(0.06)	(0.03)	(0.02)
Lib	-0.187	-0.228*	-0.233	-0.265*	-0.010	-0.151**
	(0.21)	(0.12)	(0.22)	(0.15)	(0.09)	(0.07)
VA	-0.135	3.030	-0.887	1.169	-0.274	2.169
	(2.51)	(3.45)	(2.71)	(3.60)	(1.33)	(2.09)
Ln(*GDP*)	0.728**	0.211*	1.216***	0.202	0.265*	0.152*
	(0.31)	(0.13)	(0.32)	(0.13)	(0.16)	(0.08)
Export	-1.799	-0.729*	-1.620	-0.700	-0.765	-0.477*
	(1.25)	(0.41)	(1.57)	(0.43)	(0.85)	(0.27)
Import	-0.989	0.373	0.780	0.600	-1.418**	0.173
	(1.35)	(0.48)	(1.47)	(0.53)	(0.70)	(0.30)
Intensity	-0.826***	-0.302	-0.722**	-0.352*	-0.570***	-0.173
	(0.31)	(0.18)	(0.31)	(0.21)	(0.21)	(0.11)
VA×Intensity	1.026	-0.267	1.440	0.587	0.903	-0.358
	(1.14)	(0.76)	(1.24)	(0.80)	(0.67)	(0.44)
Ln(*GDP*)*×Intensity*	0.202**	0.146*	0.167**	0.162*	0.130**	0.083*
	(0.08)	(0.08)	(0.08)	(0.10)	(0.05)	(0.05)
Export×Intensity	0.597	-0.037	0.599	-0.023	0.634*	-0.036
	(0.42)	(0.17)	(0.58)	(0.17)	(0.33)	(0.11)
Import×Intensity	-0.431	-0.463**	-0.628	-0.566*	-0.453*	-0.235**
	(0.43)	(0.21)	(0.50)	(0.29)	(0.26)	(0.11)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,793	2,608	2,793	2,608	2,793	2,608
R-squared	0.40	0.18	0.28	0.13	0.50	0.21

Table 10: Innovation, stock market liberalization, and economic growth

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *ΔLn*(*VA*) the annual growth rate of industry value-added in each two-digit SIC industry for each country each year. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-1. Lib_{temp} is a binary variable that takes the value of one for the first three years after a country liberalizes its equity market, and zero otherwise. Lib_{perm} is a binary variable that takes the value of one from the fourth year after a country liberalizes its equity market and thereafter, and zero otherwise. Variables in dollars are computed in real terms at constant national prices in 2005 U.S. dollars. The definitions of other variables are in the legend of Table 3. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*ΔLn*(*VA*)			
	(1)	(2)	(3)	(4)
Lib×Intensity		0.010**		
		(0.01)		
Lib	0.074***	0.047***		
	(0.01)	(0.02)		
Lib_{temp}×*Intensity*				0.006
				(0.01)
Lib_{perm}×*Intensity*				0.012**
				(0.01)
Lib_{temp}			0.085***	0.070***
			(0.01)	(0.02)
Lib_{perm}			0.040***	0.009
			(0.01)	(0.02)
VA	-2.445***	-2.468***	-2.450***	-2.475***
	(0.25)	(0.25)	(0.25)	(0.25)
Ln(*GDP*)	-0.138***	-0.138***	-0.129***	-0.128***
	(0.02)	(0.02)	(0.02)	(0.02)
Export	-0.102	-0.101	-0.080	-0.079
	(0.10)	(0.10)	(0.10)	(0.10)
Import	0.033	0.033	0.043	0.044
	(0.10)	(0.10)	(0.10)	(0.10)
Intensity	-0.009**	-0.016***	-0.009**	-0.016***
	(0.00)	(0.00)	(0.00)	(0.00)
Year FE	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes
Observations	8,960	8,960	8,960	8,960
R-squared	0.13	0.13	0.13	0.13

Internet Appendix for

"Stock Market Liberalization and Innovation"

(Not to be Published)

This Internet Appendix provides supplemental analyses and robustness tests to the main results presented in "Stock Market Liberalization and Innovation". Section A provides a comparison of the Orbis database with the NBER Patent and Citation database. Section B presents the results of numerous robustness checks conducted using different samples, alternative model specifications, and alternative variable definitions. The tables are organized as follows:

Section A: A comparison of the Orbis database and the NBER database

To obtain further insights into the quality of the Orbis database, we compare the number of U.S. patents owned by publicly-traded firms included in the Orbis database with that included in the NBER Patent and Citation database. Given that the coverage of the NBER database extends until 2006, we plot the number of U.S. patents between 1980 and 2006 in Figure IA1. The number of U.S. patents for the two databases are comparable. The only noticeable difference is the large decline in the number of U.S. patents in the NBER database over the 2002-2006 period. This difference exists because the lag between a patent's application year and its grant year is significant (about two years on average) and many patent applications filed during these years were still under review and had not been granted by 2006, at which point the NBER database ends. However, the Orbis database does not suffer from this problem as of 2006 because it continues to include granted patents after 2006 and has coverage up until 2013. Apart from this difference, the two lines in Figure IA1 are very close to each other and exhibit an identical time trend. Therefore, the quality of the Orbis database for U.S. patents is at least as good as that of the NBER database.

Section B: Robustness checks

In this section, we run several tests to check the robustness of baseline results. First, we exclude Japan from our sample. Given that Japan has the largest number of patents, patent citations, and innovative firms among all countries in the entire sample, it is possible that our inferences from the main analysis are driven by Japan. We then estimate Eq. (2) without Japan and report the regression results in Table IA1. The coefficient estimates of *Lib*×*Intensity* in all columns are all significant at the 1% level, suggesting that our baseline results are not driven by the inclusion of Japan. In an untabulated test, we further exclude Korea and Taiwan, which have the second and third largest number of patents, and find similar results.

Second, following Hsu, Tian, and Xu (2014), we conduct an analysis at the technology-class level. Specifically, we aggregate all variables at the three-digit International Patent Classification (IPC) class and re-estimate Eq. (2). We present the regression results in Table IA2 and find that our results do not change qualitatively.

Third, to further mitigate the concern on the presence of residual correlation in both country-industry and year dimensions, we employ a two-way clustering by clustering standard errors at both country-year and year following the suggestion of Petersen (2009). We present the regression results in Table IA3 and find that our baseline results are robust to the two-way clustering as the coefficient estimates of *Lib×Intensity* are all positive and significant at the 1% level.

Fourth, similar to Acharya and Subramanian (2009), we replace the dependent variables in Eq. (2) with the logarithm of one plus average number of patents (*Ln*(1+*Pat_mean*)) and the logarithm of one plus average number of patent citations (*Ln*(1+*Tcite_mean*)) as proxies for the innovation output of a typical firm in an industry. We then estimate Eq. (2) with these two dependent variables and report the regression results in Table IA4. We find that the results remain because the coefficient estimates of *Lib×Intensity* are all positive and significant at the 1% level. In an untabulated test, we use the median rather than average number of patents and patent citations and find qualitatively similar results.

Last, to further capture the long-term nature of innovation process (Manso, 2011), we measure the liberalization indicator in year *t*-5 (*Lib_lag5*) instead of year *t*-3 in Eq. (2). Hence, we are essentially estimating the effect of stock market liberalization on a country's 5-year-ahead innovation output. We then re-estimate the regressions and present the results in Table IA5. We find that the results are robust to this model specification that takes into account the delayed effect of innovation output to liberalization events. The coefficient estimates of *Lib_lag5×Intensity* are all positive and significant at the 1% level, suggesting that the effect of equity market liberalization is long lasting.

References

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Hsu, P.-H., X. Tian, and Y. Xu. 2014. Financial Development and Innovation: Cross-Country Evidence. *Journal of Financial Economics* 112, 116-135.

Manso, G. 2011. Motivating Innovation. *Journal of Finance* 66, 1823-60.

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Figure IA1: The number of patents in the Orbis database vs. that in the NBER database
This figure compares the number of U.S. patents produced by publicly-traded firms included in the Orbis database with that included in the NBER Patent and Citation database between 1980 and 2006. The solid line depicts the number of patents recorded in the Orbis database and the dashed line depicts the number of patents recorded in the NBER patent database.

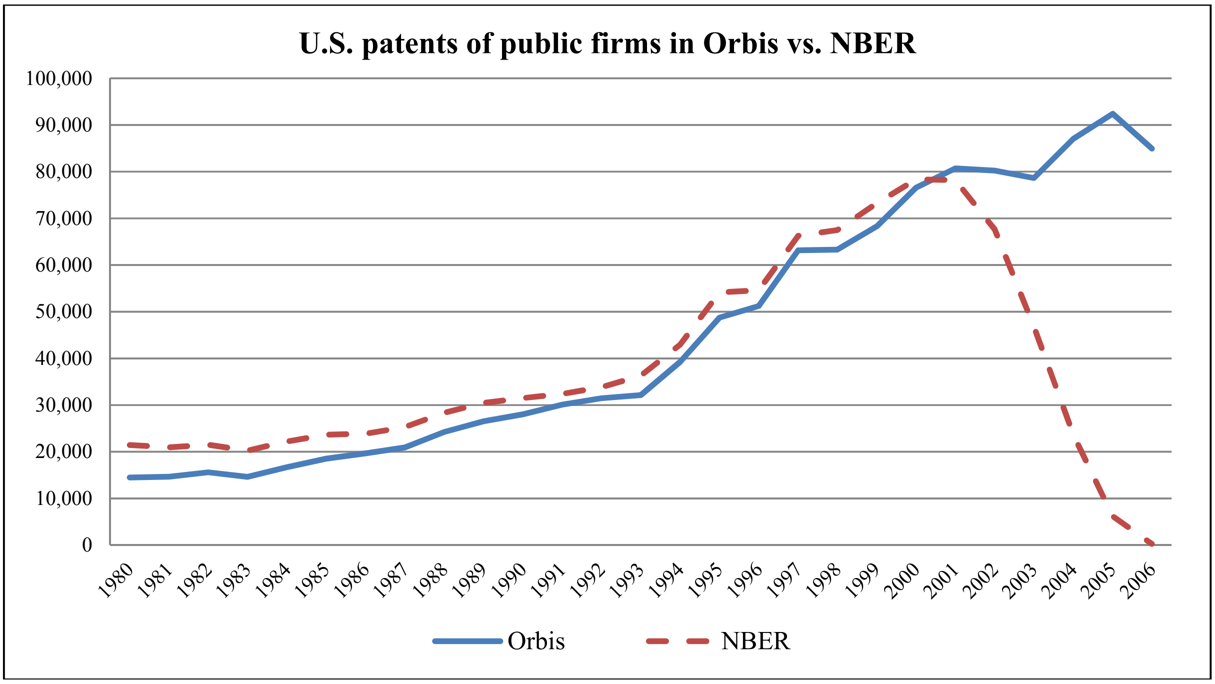

Table IA1: Excluding Japan from the sample

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each two-digit industry for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. *VA* is the ratio of value-added in a two-digit SIC over the total value-added for each country each year, measured in year *t*-1. *Ln*(*GDP*) is the log of GDP per capita for each country each year, measured in year *t*-1. Variables in dollars are computed in real terms at constant national prices in 2005 U.S. dollars. *Export* and *Import* are a country's exports and imports as a fraction of GDP, respectively, measured in year *t*-1. *Intensity* is the log of one plus the average number of patents held by a U.S. firm in a two-digit SIC industry each year, measured in year *t*-1. Robust standard errors in parentheses are clustered by country-industry. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib×*Intensity*	0.184***	0.212***	0.102***
	(0.04)	(0.04)	(0.02)
Lib	-0.331***	-0.397***	-0.175***
	(0.09)	(0.10)	(0.05)
VA	1.525	1.056	0.667
	(1.73)	(1.84)	(0.90)
Ln(*GDP*)	1.212***	1.131***	0.674***
	(0.17)	(0.17)	(0.09)
Export	-1.315**	-1.262**	-0.683**
	(0.58)	(0.58)	(0.31)
Import	-0.712	-0.466	-0.416
	(0.55)	(0.60)	(0.30)
Intensity	-0.391***	-0.398***	-0.249***
	(0.13)	(0.14)	(0.08)
VA×*Intensity*	0.383	0.770	0.275
	(0.75)	(0.83)	(0.39)
Ln(*GDP*)×*Intensity*	0.107***	0.106**	0.067***
	(0.04)	(0.04)	(0.02)
Export×*Intensity*	0.306	0.426**	0.151
	(0.21)	(0.20)	(0.11)
Import×*Intensity*	-0.640***	-0.840***	-0.334***
	(0.22)	(0.26)	(0.13)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	8,516	8,516	8,516
R-squared	0.25	0.19	0.28

Table IA2: Technology-class level analysis

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat*, *Tcite*, and *Nfirm* are the total number of patents, the total number of citations adjusted for time-technology class fixed effects, and the total number of innovative firms in each three-digit IPC class for each country each year, respectively, which are measured in year *t*. *Lib* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-3. *VA* is the ratio of value-added in a three-digit IPC class over the total value-added for each country each year, measured in year *t*-1. *Ln*(*GDP*) is the log of GDP per capita for each country each year, measured in year *t*-1. Variables in dollars are computed in real terms at constant national prices in 2005 U.S. dollars. *Export* and *Import* are a country's exports and imports as a fraction of GDP, respectively, measured in year *t*-1. *Intensity* is the log of one plus the average number of patents held by a U.S. firm in a three-digit IPC class each year, measured in year *t*-1. Robust standard errors in parentheses are clustered by country-tech-class. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib×Intensity	0.165***	0.193***	0.117***
	(0.04)	(0.04)	(0.02)
Lib	-0.094*	-0.185***	-0.038
	(0.05)	(0.05)	(0.03)
VA	-0.945	-1.895	-2.249
	(1.93)	(2.06)	(1.49)
Ln(*GDP*)	0.867***	0.838***	0.768***
	(0.08)	(0.08)	(0.06)
Export	-0.947***	-0.862***	-0.601***
	(0.24)	(0.26)	(0.16)
Import	-0.729***	-1.038***	-0.871***
	(0.28)	(0.31)	(0.19)
Intensity	-0.514***	-0.589***	-0.381***
	(0.15)	(0.17)	(0.10)
VA×Intensity	-1.693	-1.202	-0.206
	(1.08)	(1.08)	(0.79)
Ln(*GDP*)*×Intensity*	0.147***	0.176***	0.100***
	(0.05)	(0.06)	(0.03)
Export×Intensity	0.282	0.187	0.206
	(0.22)	(0.23)	(0.13)
Import×Intensity	-0.641***	-0.618**	-0.406***
	(0.24)	(0.27)	(0.14)
Year FE	Yes	Yes	Yes
Country-tech class FE	Yes	Yes	Yes
Observations	31,123	31,123	31,123
R-squared	0.19	0.14	0.25

Table IA3: Clustering standard errors in two dimensions

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. The definitions of all variables are in the legend of Table IA1. Robust standard errors in parentheses are clustered by country-industry and year. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib×Intensity	0.161***	0.182***	0.095***
	(4.32)	(4.23)	(4.69)
Lib	-0.265***	-0.296***	-0.148***
	(-2.67)	(-2.75)	(-2.85)
VA	1.792	1.013	0.780
	(1.05)	(0.55)	(0.89)
Ln(*GDP*)	1.295***	1.231***	0.719***
	(6.79)	(6.55)	(6.46)
Export	-1.106*	-0.924	-0.564*
	(-1.80)	(-1.49)	(-1.77)
Import	-1.492**	-1.203*	-0.849**
	(-2.24)	(-1.72)	(-2.40)
Intensity	-0.349***	-0.340**	-0.235***
	(-2.65)	(-2.56)	(-3.00)
VA×Intensity	0.319	0.795	0.228
	(0.44)	(0.96)	(0.60)
Ln(*GDP*)*×Intensity*	0.088**	0.077*	0.060***
	(2.24)	(1.87)	(2.71)
Export×Intensity	0.244	0.339*	0.122
	(1.27)	(1.85)	(1.18)
Import×Intensity	-0.461**	-0.568**	-0.259**
	(-2.22)	(-2.39)	(-2.22)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	9,071	9,071	9,071
R-squared	0.88	0.86	0.87

Table IA4: Using average patent/citations as dependent variables

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Pat_mean* and *Tcite_mean* are the average number of patents and the average number of citations adjusted for time-technology class fixed effects of innovative firms in an industry for each country each year, respectively, which are measured in year *t*. The definitions of other variables are in the legend of Table IA1. Robust standard errors in parentheses are clustered by country-industry and year. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat_mean*) (1)	*Ln*(1+*Tcite_mean*) (2)
Lib×Intensity	0.083***	0.103***
	(3.61)	(3.71)
Lib	-0.146**	-0.177***
	(-2.38)	(-2.59)
VA	0.682	0.010
	(0.60)	(0.01)
Ln(*GDP*)	0.728***	0.692***
	(7.34)	(6.93)
Export	-0.682**	-0.522
	(-1.98)	(-1.46)
Import	-0.796**	-0.516
	(-2.20)	(-1.25)
Intensity	-0.142**	-0.129**
	(-2.20)	(-1.98)
VA×Intensity	0.180	0.540
	(0.40)	(1.01)
Ln(*GDP*)*×Intensity*	0.032	0.023
	(1.57)	(1.07)
Export×Intensity	0.127	0.204*
	(1.00)	(1.67)
Import×Intensity	-0.205	-0.316**
	(-1.55)	(-2.08)
Year FE	Yes	Yes
Country-industry FE	Yes	Yes
Observations	9,071	9,071
R-squared	0.18	0.09

Table IA5: Lagging liberalization year for five years

The sample includes manufacturing industries in countries experiencing stock market liberalization, which are jointly covered by the Orbis, the UNIDO, and the PWT 8.0 databases from 1981-2008. *Lib_lag5* is a binary variable that takes the value of one if the observation is in the year since a country's official liberalization, and zero otherwise, measured in year *t*-5. The definitions of other variables are in the legend of Table IA1. Robust standard errors in parentheses are clustered by country-industry and year. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(1+*Pat*) (1)	*Ln*(1+*Tcite*) (2)	*Ln*(1+*Nfirm*) (3)
Lib_lag5×Intensity	0.142***	0.153***	0.096***
	(3.79)	(3.76)	(4.84)
Lib_lag5	-0.261***	-0.256**	-0.170***
	(-2.68)	(-2.30)	(-3.36)
VA	1.830	1.068	0.758
	(1.08)	(0.59)	(0.86)
Ln(*GDP*)	1.286***	1.215***	0.716***
	(7.47)	(6.99)	(7.75)
Export	-1.000*	-0.820	-0.516*
	(-1.83)	(-1.54)	(-1.77)
Import	-1.564***	-1.321**	-0.818***
	(-2.87)	(-2.25)	(-2.85)
Intensity	-0.336**	-0.328**	-0.223***
	(-2.53)	(-2.47)	(-2.89)
VA×Intensity	0.347	0.826	0.257
	(0.48)	(1.01)	(0.66)
Ln(*GDP*)*×Intensity*	0.091**	0.081**	0.060***
	(2.31)	(2.00)	(2.74)
Export×Intensity	0.187	0.272	0.090
	(0.97)	(1.52)	(0.88)
Import×Intensity	-0.405**	-0.489**	-0.251**
	(-2.12)	(-2.25)	(-2.35)
Year FE	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes
Observations	9,071	9,071	9,071
R-squared	0.26	0.17	0.31