Secondary Stock Exchanges and Growth of High-Tech Entrepreneurs*

Huasheng Gao
Fanhai International School of Finance, Fudan University
huashenggao@fudan.edu.cn
Po-Hsuan Hsu
College of Technology Management, National Tsing Hua University
pohsuanhsu@mx.nthu.edu.tw
Yuxi Wang
Antai College of Economics and Finance, Shanghai Jiao Tong University
yuxiwang@sjtu.edu.cn

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Abstract

We present empirical evidence that the establishment of secondary stock exchanges spurs local high-tech entrepreneurship. We find a significant increase in high-tech entrepreneurial activities following the staggered launches of such stock exchanges, and this increase is disproportionally higher in industries that are more dependent on secondary stock exchanges *ex ante*. We further show that secondary stock exchanges promote entrepreneurial growth by encouraging talent to become entrepreneurs, by promoting venture investment, and by enhancing transactions of intellectual property. More experienced inventors and inventors who have worked for big companies are all more likely to become entrepreneurs after the launch of secondary stock exchanges.

Keywords: entrepreneurship, secondary stock exchanges, inventors, innovation, intellectual property

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1. Introduction

High-tech entrepreneurial activities are at the core of modern economic growth and work as the driving force for innovation: typical entrepreneurs invest an extremely high portion of their time and money in innovative projects that are subject to great uncertainty yet carry high upside option values.[1] Acs and Audretsch (1987) find that a disproportionate share of innovation is created by small firms. It is also documented that start-ups produce more new drugs and that their R&D activities are more efficient than those of big firms in the pharmaceutical industry (Munos, 2009).[2]

There is growing consensus that active stock markets play a central role in driving economic growth by spurring innovation and entrepreneurial activities (King and Levine, 1993; Brown, Fazzari and Petersen, 2009; Kerr and Nanda, 2015; Mace, forthcoming). Over the last three decades, financial policy makers around the world have strived to create secondary stock exchanges (also called secondary boards) targeting young and entrepreneurial firms to promote domestic entrepreneurship in high-tech industries. However, there is limited research that investigates how effective these secondary stock exchanges are in achieving that goal. In this paper, we fill this gap and provide empirical evidence on whether (and through which channels) secondary stock exchanges influence entrepreneurship from a global perspective.

We propose that the establishment of secondary stock exchanges promotes a country's high-tech entrepreneurship through the following three channels. First, from the perspective of human capital, these secondary stock exchanges increase likely success rates of entrepreneurs and the expected payoffs from their businesses, which thus encourage talented scientists and engineers to become entrepreneurs themselves (rather than work for large, mature firms) (Puri and Robinson, 2013). Moreover, since stock prices offer

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[1] See, for example, Adam Smith (1776), Schumpeter (1976), and Baumol, Litan, and Schramm (2007) on the importance of entrepreneurship for economic growth. Klepper (2001), Gompers, Lerner, and Scharfstein (2005) and Puri and Robinson (2013) provide reviews of incentives and motivations associated with entrepreneurial activities.

[2] https://www.baybridgebio.com/blog/rd_bigpharma_startup.html and https://www.hbmpartners.com/media/docs/industry-reports/Analysis-of-FDA-Approvals-2018-and-Previous-Years.pdf

important information about investment opportunities and technology prospects (Bond, Edmans, and Goldstein, 2012), available secondary stock exchanges offer valuable signals for venture capitalists (VCs) and entrepreneurs and reduces their learning costs, which likely results in more active entrepreneurial activities (Kerr, Nanda, and Rhodes-Kropf, 2014; Ewens, Nanda, and Rhodes-Kropf, 2018). Second, from the perspective of capital, the establishment of secondary stock exchanges increases VCs' exit opportunities by increasing the likelihood of initial public offerings (IPOs) (and reducing the requirements for public listing) for the startups in which they invest. Such an increase in IPO likelihood will encourage VCs (and their investors) to provide more funding for entrepreneurial firms (Gompers, Kovner, Lerner, and Scharfstein, 2008; Ozmel, Robinson, and Stuart, 2013). Finally, from the perspective of the market for intellectual properties (IPs), public listing facilitates the acquisition of external innovation (Bernstein, 2015), which fosters the commercialization and transactions of innovative ideas and intellectual property and, in so doing, encourages high-tech entrepreneurship (Hochberg, Serrano, and Ziedonis, 2018; Serrano and Ziedonis, 2019).

Using the data of Bernstein, Dev, and Lerner (2020),[3] we collect and update the information of stock exchanges in 217 countries covered in World Bank datasets from 1990 to 2018; during this period, 100 new secondary stock exchanges in 55 countries were created, and 17 unique secondary boards were closed. We then collect all patent filings in the PatentsView database of the US Patent and Trademark Office (USPTO) and use the number of first-time patent-filing assignees to measure a country's (and a country-industry's) high-tech entrepreneurial activities, following Farre-Mensa, Hegde, and Ljungqvist (2020).[4] We do not include the U.S. in our main sample to prevent reporting

[3] Our dataset of stock exchanges is based on Bernstein, Dev, and Lerner (2020), which covers 45 countries and 91 unique secondary stock exchanges in the period 1990 to 2013.

[4] It is common in the literature to use US patents to measure cross-country innovation activities (Griffith, Harrison, and Van Reenen, 2006; Hsu, Tian, and Xu, 2014; Bhattacharya et al., 2017) for several reasons. First, it ensures the consistency and comparability of the quality, examination procedure, and legal protection of different countries' patent outputs (e.g., Jaffe and Trajtenberg, 2002; Lerner, 2009). Second, it is reasonable for us to assume that all important inventions from other countries have been filed with the USPTO in the past few decades due to the territorial principle in patent laws. In our robustness checks, we examine the potential underreporting bias in our results.

bias and to enable further identification (which we discuss later). More importantly, the inventor information provided in the PatentsView database allows us to track the career path of each startup's founding team by analyzing inventors' prior patent records.

The staggered country-level establishment of secondary stock exchanges allows us to implement a difference-in-differences (DiD) analysis by creating a group of counterfactuals to determine how entrepreneurship would have been without such changes.[5] Our DiD analysis shows a significant increase in local entrepreneurial activities after the launch of secondary stock exchanges. On average, countries that establish secondary stock exchanges experience a 29.3% increase in the number of startups, relative to that of other countries. In a country-industry-year panel, we find that the establishment of secondary stock exchanges is associated with a 7.3% increase in the number of startups in each industry.

An important assumption regarding DiD estimation is that treated and control groups share parallel trends before events. We show that treated countries' entrepreneurial activities are indeed similar to those of control countries prior to the treatments, and that most increases in entrepreneurial activities happen two years after the launch of secondary stock exchanges, all supporting a causal interpretation of our baseline results.

Moreover, we adopt the identification strategy of Rajan and Zingales (1998) by estimating each industry's dependence on secondary boards based on NASDAQ-listed IPOs' patent records in the 1980s. Since the dependence on secondary boards is measured by exogenously determined industry properties, significant coefficient estimates for the interaction between this dependence and the launch of secondary boards would support a causal impact of the latter on high-tech startups. We show that entrepreneurial growth is disproportionally higher in industries that are more dependent on secondary stock

[5] In our robustness checks, we also consider (i) the stacked DiD method proposed by Cengiz et al. (2019); (ii) the method proposed by Sun and Abraham (2021); and (iii) the imputation strategy proposed by Borusyak, Jaravel, and Spiess (2021).

exchanges *ex ante*, providing additional evidence for a causal effect.

We further consider several additional tests to strengthen our identification and ensure the robustness of our main results. First, to rule out the concern that our results may simply reflect an overall economic boom period rather than a surge of high-tech startups, we implement a placebo test using trademark data from the USPTO to measure local entrepreneurial activities. That said, as we do not find a significant relation using this trademark-based measure, we suggest that our baseline results are more specific to high-tech industries rather than general businesses. Second, we find consistent results using alternative DiD specifications following Cengiz et al. (2019), Sun and Abraham (2021), and Borusyak, Jaravel, and Spiess (2021). Third, we find consistent results when we consider different definitions of high-tech startups. Finally, we address an underreporting bias that may occur when many startups outside the U.S. choose not to file patents to the USPTO. We find that such a bias makes us underestimate the effect of secondary stock exchanges.

We examine three possible channels underlying the effect of establishing secondary boards. First, we present supportive evidence for the channel of attracting more talent to establish high-tech startups. We also show that the establishment of a country's secondary stock exchange is associated with an increase in entrepreneurs' qualifications: entrepreneurs not only have stronger technological expertise, but also have work experience in mature, big companies. These results complement the findings in Azoulay et al. (2020) that successful entrepreneurs tend to be middle-aged and have prior experience. Moreover, we find that the treatment effect is stronger when a country has a larger amount of human capital, as measured by the country's literacy rate, education expense, and similar factors. Overall, these results support the view that secondary stock exchanges spur high-tech startups by inducing more high-quality scientists and engineers to become entrepreneurs.

We then examine the second channel for attracting more VC capital. We show that the establishment of secondary boards leads to a significant increase in the amount of VC investment in a given country. We also show that our treatment effect is more pronounced when secondary boards better protect investors or have a larger number of IPOs. These results are consistent with the view that secondary stock exchanges' promotion of high-tech startups attracts more VC investment in these countries.

Third, we show that the establishment of secondary boards leads to more frequent trading of patents—either through purchases or sales in the secondary patent market or through corporate acquisitions. We further show that an increase in patent transactions is positively related to entrepreneurship. These results confirm that the establishment of secondary boards promotes high-tech entrepreneurship by enhancing the demand and liquidity for patents and intellectual property.

Our paper contributes to several strands of the literature. First, it adds to prior studies that examine the real effects of secondary stock exchanges. Bernstein, Dev, and Lerner (2020) show that newly-created secondary boards attract a significant share of the global IPO market activity during their sample period of 1990 to 2013, and that these IPOs tend to be more successful (i.e., capital raised through IPOs and higher growth subsequent to IPOs) in countries with stronger shareholder protection. To complement these findings, we examine the role that secondary boards play in promoting high-tech entrepreneurship. To the best of our knowledge, our study builds the first large-scale cross-country empirical measure for high-tech startups. Moreover, we analyze patent inventor data to provide micro-evidence for the channel that encourages talented technicians to become entrepreneurs, which echoes the prior finding of prospective entrepreneurs' patenting strategies in Akcigit and Kerr (2018). Our analyses of entrepreneurs' backgrounds also support the argument of Hellmann (2007): we find that experienced inventors are more likely to become entrepreneurs because they brew ideas and acquire related knowledge when they work for related companies.[6]

This paper also adds to the research on the driving forces of regional entrepreneurial activities. Prior studies have examined the roles of VCs, angel investors, crowdfunding, and government funding, as well as incubators and accelerators.[7] In this paper, we offer abundant evidence that secondary boards play an important role with respect to local high-tech entrepreneurship, which supports related policy initiatives of many governments (especially those in emerging economies). Moreover, our channel tests based on human capital stock and degrees of shareholder protection also reveal necessary institutional conditions for secondary boards to succeed.

Finally, this paper offers unique and timely evidence to support earlier findings on the interaction between financial markets and entrepreneurial activities (King and Levine, 1993; Brown, Fazzari, and Petersen, 2009) and, more broadly, to extend the literature on the real effects of financial development (Rajan and Zingales, 1998). Different from prior studies that consider aggregate financial development (e.g., Rajan and Zingales, 1998) or the contrast between equity and debt financing (e.g., Hsu, Tian, and Xu, 2014), we focus on a specific financing mechanism—the secondary stock exchange—that prevails in modern equity markets and which therefore calls for large-scale analysis. On the other hand, our investigation of innovative, small startups (and their founding teams) also deviates from prior research on how aggregate innovation is influenced by financial markets (Hall and Lerner, 2010; Kerr and Nanda, 2015). As a result, our empirical analyses highlight how

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[6] Cooper (1985) and Bhidé (1994, p. 151) suggest that a majority of entrepreneurs' ideas and target markets are closely related to their prior employment experience. On the other hand, Ouimet and Zarutskie (2014) show that startups tend to attract young employees, and Akcigit, Grigsby, and Nicholas (2017) find that inventors produced their highest quality inventions early in their careers.

[7] The role of VCs on entrepreneurial activities has been extensively studied (e.g., Lerner, 1995; Chemmanur, Krishnan, and Nandy, 2011; Bernstein, Giroud, and Townsend, 2016; Janeway, Nanda, and Rhodes-Kropf, 2021). Some studies have examined the role that angel investors play with respect to entrepreneurship (Kerr, Lerner, and Schoar, 2014). Also, the role of government funding has been discussed in Lerner (1999) and Howell (2017). In addition, other researchers have examined how entrepreneurial performance is affected by local incubators and accelerators (Cohen, Fehder, Hochberg, and Murray, 2019; Yu, 2020), by local crowdfunding activities (Yu and Fleming, 2022), by banking activities (Black and Strahan, 2002; Kerr and Nanda, 2009; Robb and Robinson, 2014), and by patent infringement threats (Appel, Farre-Mensa, and Simintzi, 2019).

financial markets contribute to economic growth by promoting entrepreneurship.

2. Institutional Background and Hypothesis Development

2.1. Firms' access to public equity markets

It is well-documented that access to public equity markets plays a critical role with respect to innovation and entrepreneurial activities, as it allows investors to diversify their risk and price growth options (Pagano, Panetta and Zingales, 1998; Brown, Fazzari, and Petersen, 2009; Hsu, Tian and Xu, 2014).[8] In addition, the model of Allen and Gale (1999) implies that, since young industries feature heterogeneous technologies, public equity markets consisting of investors with heterogeneous beliefs can fund more different technologies in these industries.

With the development of public equity markets, a country's first stock exchange (or main board) usually becomes more acceptable of firms with a sufficient track record of operations, profitability, and a minimum of accounting-based assets. Although such restrictive listing requirements help to protect outside investors in the stock market, they are unfriendly to high-growth, entrepreneurial companies, because these firms are typically unprofitable at the time of IPOs and because a sizable part of these firms' assets have not been formed (e.g., R&D) and/or are more intangible (e.g., patents, intellectual property). The creation of secondary stock exchanges is often characterized by less-restrictive listing requirements[9], and is aimed to help young and small companies raise financing from stock investors.

The literature that studies the impact of secondary stock exchanges mainly centers on

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[8] Debt financing is also important for entrepreneurial activities (Black and Strahan, 2002; Kerr and Nanda, 2009; Robb and Robinson, 2014). On the other hand, debt and credit financing is often less effective in promoting entrepreneurial activities due to concentrated risk, information asymmetry, and adverse selection. Brown, Fazzari, and Petersen (2009) show that debt serves as much less desirable equity for financing high-tech firms due to adverse selection and moral hazard issues that result from the inherent riskiness of R&D investment. They also find that young, high-tech public firms finance R&D investment almost entirely with equity. Chava et al. (2013) show that banks often have greater bargaining power over entrepreneurs and suppress ex-post rents from entrepreneurs, which reduces entrepreneurs' incentives to establish startups ex ante.

[9] Studies have shown that local entrepreneurship increases with reduced regulatory barriers (Klapper, Laeven, and Rajan, 2006) and financial development (Iwasaki, Kocenda, and Shida, 2022).

specific economies and maintains a focus on stock returns or profitability; however, these studies seem to provide mixed results. For instance, Vismara, Paleari, and Ritter (2012) find that in the European market, firms listed on secondary boards significantly underperform firms listed on main boards on average in terms of long-run stock performance. Jenkinson and Ramadorai (2013) examine the consequences for small firms that switched from the London main board to the Alternative Investment Market (AIM) and find that despite experiencing a negative announcement return, these firms exhibit longer-term upward drift in stock returns due to improved operating performance after the switch. Harwood and Konidaris (2015) review the current states of small- and medium-sized enterprise (SME) exchanges in seven emerging market economics and provide recommendations on policy design. Choi and Lee (2021) document a positive impact of Korean secondary stock exchanges on the valuation of growth firms.

Further, Bernstein, Dev, and Lerner (2020) examine the determinants of the creation and success of new secondary boards from a global perspective, by focusing on the role of countries' legal provisions with respect to shareholder protection. They show that newly-created secondary stock exchanges attract IPOs and that stronger shareholder protection increases the likelihood of market introduction and ultimate success.

In sum, our literature review suggests the following. First, prior studies that focus on one or few economies unavoidably miss potentially important institutional factors, such as shareholder protection and human capital. Second, cross-country analyses of the effects of secondary boards, especially from the perspective of start-up activities, are underexplored in prior research. Third, it is challenging to design identification tests to draw a causal inference on the effect of secondary boards.

2.2. The role of secondary stock exchanges in entrepreneurship

We propose that the creation of secondary stock exchanges promotes high-tech entrepreneurship by encouraging more talented technicians to become entrepreneurs, by attracting more VC capital to finance entrepreneurship, and by enhancing demand and liquidity for patents and intellectual property.

First, from the perspective of the supply of entrepreneurs, the creation of secondary boards also induces talented scientists and engineers to become entrepreneurs. For example, suppose a technician has two alternative career choices: working as an employee in a mature firm or becoming an entrepreneur. In the former case, the technician usually has stable compensation; in the latter case, the payoff to the technician is much more uncertain, but the technician may receive a very high payoff at the event of an exit (Gentry and Hubbard, 2000), especially in an IPO. The technician more likely chooses to be an entrepreneur if the corresponding payoff is larger and vice versa (Kerr, Nanda, and Rhodes-Kropf, 2014; Manso, 2016). The creation of secondary boards increases the possibility that a startup will be publicly listed, which enhances the upside payoff for being an entrepreneur (Puri and Robinson, 2013). Thus, in this case, a technician on the margin is more likely to become an entrepreneur, rather than maintain employment in a mature organization. Broadly consistent with this view, Babina, Ouimet, and Zarutskie (2017) document a positive relationship between IPO activity and entrepreneurship in the U.S. Further, Gottlieb, Townsend, and Xu (2016) and Benzarti, Harju, and Matikka (2020) show that policies that lower the cost of entry stimulate entrepreneurship, given that entrepreneurship is a highly risky decision (Hall and Woodward, 2010).

The establishment of secondary stock exchanges also facilitates entrepreneurs' learning of the prospects and success likelihood of their projects that are revealed in stock prices (Bond, Edmans, and Goldstein, 2012). Such learning reduces prospective entrepreneurs' costs of experimentation and thus encourages local entrepreneurial activities (Ewens, Nanda, and Rhodes-Kropf, 2018).

Second, from the perspective of VC investment, the creation of secondary boards increases the likelihood that venture-back firms will pursue IPOs, thus raising potential returns that encourage VC investors to invest in start-ups. Consistent with this view, Gompers, Kovner, Lerner, and Scharfstein (2008) and Ozmel, Robinson, and Stuart (2013) show that a higher chance of successful IPO exit is associated with a stronger incentive for PE/VC investment in start-ups. In addition, when start-up firms are more able to raise initial capital from VCs, they may create more radical innovations (Nanda and Rhodes-Kropf, 2013), which could, in turn, fuel IPO markets and thus encourage more VC investment and entrepreneurial activities.

In addition, the establishment of secondary stock exchanges also enhances VCs' learning and experimentation. Stock prices offer important information about investment opportunities and technology prospects (Bond, Edmans, and Goldstein, 2012). Allen and Gale (1999) argue that innovative projects are difficult to evaluate, as information about their likely success and potential profits is hard to collect or process. Since secondary stock exchanges facilitate the feedback effects derived from market equilibrium security prices, VCs can then more easily obtain valuable information about prospects of new investment opportunities. Such a reduction in information costs encourages venture capital providers (Kerr, Nanda, and Rhodes-Kropf, 2014), which should lead to more entrepreneurial financing. As further evidence with respect to the informativeness of listed stock prices, Bernstein (2015) shows that firms that file for IPOs are more likely to withdraw their planned initial offering when there are market downturns during their bookbuilding phase.

Third, the creation of secondary stock exchanges could spur the commercialization and transactions of entrepreneurs' intellectual property in the form of patent trades or corporate acquisitions. Bena and Li (2014) demonstrate that pursuing technological innovation is a key driver for corporate acquisitions, and Bernstein (2015) shows that the availability of public equity markets facilitates the acquisition of innovation externally, especially for public firms. Before filing IPOs, some private firms may actively purchase patent assets to facilitate their IPO process (Caskurlu, 2020). An active market for patent transactions could increase the payoffs for entrepreneurs and thus spur entrepreneurship.

Hochberg, Serrano, and Ziedonis (2018) find that thicker trading in the secondary patent market expands entrepreneurial financing opportunities. Serrano and Ziedonis (2019) meanwhile find that active markets for buying and selling patents help start-ups redeploy their patent assets. In sum, we expect the increased demand and liquidity of entrepreneurs' patents to be the third channel that secondary boards use to foster entrepreneurship.

In closing, our review of the literature thus suggests three possible mechanisms underlying such a positive relation: (i) encouraging prospective entrepreneurs, (ii) promoting VC financing, and (iii) enhancing the demand and liquidity of entrepreneurs' patents.

3. Data

To examine the relation between the introduction of secondary stock exchanges and entrepreneurial activities from a global perspective, we gather data on the detailed timing of the launch (and closure) of new secondary stock exchanges, the number of high-tech startups for each country in a given year, and other country-level covariates that may contribute to entrepreneurship. In this section, we describe the data sources that we use to construct our country-year panel and country-industry-year panel.

3.1 Stock exchanges

Our sample for our empirical analysis starts with a country-year panel in 1990-2018, which include 217 countries for which we can find relevant country characteristics in the World Bank World Development Index dataset. Our list of the entry and exit years of secondary stock exchanges in these countries starts with the exchange-level data set compiled in Bernstein, Dev, and Lerner (2020), which covers newly introduced stock exchanges (both primary and secondary) around the world between 1990 and 2013. We manually check each exchange and update the closure time, as well as include newly-opened exchanges after 2013. In comparison with the sample of Bernstein, Dev, and Lerner (2020), we include 100 unique new secondary markets (8 of which are in countries that are not in their list) in 55 countries to the end of 2018.[10] Table A2 in the Appendix lists the details of all newly-introduced secondary stock exchanges in our sample.

A main explanatory variable in our regression analysis is an indicator variable *Secondary Board*, which captures the timing of the secondary stock exchanges. Specifically, for countries that introduce the secondary stock exchange, *Secondary Board* takes the value of 1 for the period after the entry year and before the exit year (if any), and 0 for the period prior to the introduction (and after the closure, if any). For countries that never introduce such boards in our sample period, *Secondary Board* always takes the value of 0. For countries that have more than one active secondary board in overlapping time periods, we take the entry year of the earliest one as the entry year for a given country.[11] For instance, China launched two secondary boards in our sample period: the Shenzhen Small & Medium Enterprise Board in 2004 and the Shenzhen ChiNext Board in 2009. Both of them have been in operation ever since, so we treat year 2004 as the entry year for the secondary board in China in our sample and ignore the other event in 2009.

3.2 High-tech startups

The second important task of our empirical analysis is to identify local high-tech entrepreneurial activities in each sample country. We measure each country's high-tech entrepreneurial activities in a year using the number of first-time patent applicants that reside in that country, following Farre-Mensa, Hegde, and Ljungqvist (2020). We use patent records in the PatentsView database that includes all patents filed to and granted by the U.S. Patent and Trademark Office (USPTO). It is common in the literature to use patent applications to the USPTO to measure country-specific innovation activities (e.g., Griffith,

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[10] These newly covered markets include the following: the Tshipidi SME Board in Botswana, the Pyme Board in Argentina, the Santiago Stock Exchange Venture in Chile, the SME Growth Market Beam in Bulgaria, the Progress Market in Croatia, Euronext Growth in Netherlands, and the New Zealand Alternative Market, NXT Market in New Zealand.

[11] For countries that experience both a closure and opening of a secondary market, we treat the window when the secondary board exists as *Secondary Board* =1. For instance, Saadiyat Market was launched in United Arab Emirates (UAE) in 1996 and closed in 1999 and NASDAQ Dubai Limited was later launched in 2005. Thus, the variable *Secondary Board* for UAE equals 1 for years 1996 to 1998, as well as for years 2005 to 2018, and is 0 for all other years.

Harrison, and Van Reenen, 2006; Acharya, Baghai, and Subramanian, 2013) for several reasons. First, the use of U.S. patents ensures the consistency and comparability of the quality, examination procedure, and legal protection in patents across different countries (e.g., Jaffe and Trajtenberg, 2002; Lerner, 2009). Second, the territorial principle in U.S. patent laws requires anyone intending to protect their intellectual property in the U.S. to file U.S. patents. As the U.S. has been the largest technology consumption market in the world over the past few decades, it is reasonable for us to assume that all important inventions from other countries have been filed with the USPTO.

To ensure that a first-time patent applicant is likely to be a high-tech startup, we exclude large and mature corporations by requiring that an applicant apply for fewer than 5 patents in the year of its first application.[12] We exclude the U.S. from our sample to prevent the situation in which our baseline results are driven by U.S. startups, as well as to prevent the potential reporting bias that U.S. startups have a higher incentive to file for U.S. patents to protect their intellectual property.

We also measure high-tech entrepreneurial activities at the country-industry level. In particular, we calculate the number of first-time patent applicants in each technology subsection (1- or 3-digit) in a country in a year to measure entrepreneurial activities in the industry reflecting technology subsection (Bhattacharya et al., 2017). We assign a value of 0 if the number of startups is missing for a given observation unit.

3.3 Country-level variables

Most of our country-level characteristics are collected from the World Bank. We gather country basics such as GDP, population, and labor from the World Bank's World Development Index, and gather region and income groupings from the November 2021

[12] The mean number of patents filed by an applicant (excluding US ones) in its first application year is 1.543 (median=1). In addition, 77.4% of the applicants file for only 1 patent in its first application year, 90.9% file for <=2 patents in their first application year and 95.2% file for <=3 patents in their first application year. We show in robustness tests (Panel A of Table 10) that our empirical results are robust to other filters (<3, <10) and also to no filter.

version of the World Bank's Global Financial Development Database.

In addition, we obtain country-level VC investment data from the Refinitiv Eikon Private Equity Screener (powered by VentureXpert). These data reflect a global coverage of over 22,000 PE or VC firms, over 51,000 funds, and over 292,000 investments since the 1970s; the data include fund company, fund, and portfolio company-level statistics, as well as investment deal-level statistics. We download all the VC investment data from the Private Equity Screener in Eikon at the fund level, giving us 11,788 funds initiated during the sample period 1990-2018. We then aggregate the information at the country-year level to facilitate our analysis in Section 5.

We also explore how the relation between secondary boards and entrepreneurial activities varies with the quality of a country's secondary boards. The first metric we adopt is the strength of legal shareholder protection, since Bernstein, Dev, and Lerner (2020) have documented that shareholder protection strength is closely related with the success of secondary boards. We quantify such strength using the shareholder protection index obtained from the World Bank's Doing Business – Protecting Minority Investors database. Moreover, we also exploit the characteristics of respective secondary boards to directly measure the success of a secondary board. That is, we take the IPO dollar proceeds and IPO quantity in a given year to proxy for the success of a secondary board in a particular country. We obtain the IPO-related data from the SDC Platinum New Issue database.

Further, we examine if secondary stock exchanges promote local entrepreneurial activities by encouraging technicians to become entrepreneurs. We use the inventor information provided in the PatentsView database that allows us to track the career path of each inventor as an entrepreneur (i.e., being listed as an inventor in the first few patents filed by a startup).[13]

[13] We acknowledge that our inventor data hinge on the quality of inventor disambiguation and harmonization of the PatentsView database. This data source is unavoidably subject to potential errors acknowledged in Bernstein (2015), such as inventors' first names often being abbreviated, and some last names being common among inventors.

Finally, we also collect human capital data from World Bank Education Statistics to explore how the relation between secondary boards and entrepreneurial activities varies with the stock of human capital cross-sectionally.

3.4 Sample construction

We elaborate our sample construction as follows. We start with all 217 countries in the World Bank World Development Index database during our sample period of 1990 to 2018 and merge them with the exchange-level data to obtain the respective entry and exit years of new secondary stock exchanges. We then calculate the number of each sample country's startups in each technology subsection in a year. Our final sample consists of 4,307 country–year level observations, 38,763 country–industry (1-digit technology subsection)–year level observations, and 551,269 country–industry (3-digit technology subsection)–year level observations with non-missing country characteristics (e.g., GDP).

Panels A to C of Table 1 provide our summary statistics at the country-year level and the country-industry-year level (both 1-digit and 3-digit technology subsections, respectively). An average country has 32 high-tech startups in a given year. This annual statistic reduces to 3.748 if we narrow our view to a typical country-industry observation unit in which the industry is defined by the 1-digit technology subsection, and 0.269 if we further narrow our view to a country-industry unit defined by the 3-digit technology subsection.

4. Main Results

4.1 Visual illustration

We first attempt to visualize the relation between the establishment of secondary stock markets and high-tech entrepreneurial activities by estimating the following regressions using a country-year panel or a country-industry-year panel:

$Ln(\#of\ Startups + 1)_{i,(j,)t} = \alpha + \sum_{\tau=-3}^{4+} \beta_\tau\ EntryYear_{i,t}^{\tau} + (Contry\ Controls_{it}) +$

$$Country\ (\times\ Industry)\ FE_{i(,j)} + Year\ FE_t (Industry \times Year\ FE_{jt}) + \varepsilon_{i,(j,)t}, \quad (1)$$

in which i indexes country, j indexes industry, and t indexes year. The dependent variable $Ln(\#of\ Startups + 1)_{i,(j,)t}$ is the natural logarithm of the number of startups[14] in (industry j of) country i and year t plus one, as discussed in Section 3.2. $EntryYear_{i,t}^{\tau}$ is a variable indicating the year relative to the introduction of the secondary stock exchange in country i and year t. For example, $EntryYear_{i,t}^{0}$ equals 1 in the exact year of the introduction of a new secondary board in country i and year t, and 0 otherwise; $EntryYear_{i,t}^{4+}$ equals 1 for years from the fourth year (since the introduction of a secondary stock exchange) onwards in country i and year t, and 0 otherwise. We use industry × year fixed effects when we consider a country-industry-year panel as they allow us to control for intertemporal trends of entrepreneurial activities within a particular industry (e.g., Internet bubbles, social media).

Figure 1 plots the point estimates and 90% confidence interval of the coefficients on $EntryYear_{i,t}^{\tau}$ (based on the standard errors clustered by country of location of the patent assignee) from our estimations when we use a country-year panel in Panels A and B. Panel A does not include any controls, while Panel B controls for country-level characteristics including GDP and the size of the labor force. We then consider a country-industry-year panel in Panels C and D based on 1- and 3-digit technology subsections, respectively. The regressions underlying Panels A and B of Figure 1 control for year and country fixed effects; the regressions underlying Panel C and D control for year and country-industry fixed effects. The time span underlying the regressions is 1990–2018.

Panels A to D of Figure 1 present a consistent pattern that high-tech entrepreneurial

[14] We define "*startups*" as organizations that are first-time applicants and have applied for fewer than 5 patents in each country-year or in each country-industry-year hereafter. We provide robustness checks on this definition in Section 6.3. For firms that apply for patents in multiple industries, we treat them as big firms as long as they has applied for no fewer than 5 patents in any industry; for those firms that apply for fewer than 5 patents in each industry, we only count the industry with more patents to avoid double-counting (if they apply for equal number of patents in multiple industries, we randomly pick one industry to avoid double-counting).

activities increase significantly after the introduction of secondary stock exchanges. For instance, in Panel A, for 3 years prior to the introduction, the β_{-3} coefficient is approximately 0.06, while 4 years after the introduction, the corresponding β_{4+} coefficient is more than 4 times as large (0.26). Moreover, we observe that the greatest increase in high-tech entrepreneurial activities appears several years after the introduction of secondary boards, which supports our primary hypothesis and suggests that the introduction of such exchanges generally has a persistent long-run effect.

4.2 Baseline regression

In this section, we implement a formal difference-in-differences (DiD) analysis to compare the before-after change of high-tech entrepreneurial activities in countries launching secondary boards (as the treatment group) to the before-after change of high-tech entrepreneurial activities in countries in which no secondary board is launched (as the control group). As 55 out of 217 countries launched secondary boards in different years, our research design features a staggered DiD test design with multiple treatment groups and multiple time periods, as employed by Bertrand and Mullainathan (2003), Imbens and Wooldridge (2009), and Atanassov (2013). We estimate the following regressions for both a country-year panel and a country-industry-year panel:

$$Ln(\#\ Startups + 1)_{i,(j,)t} = \alpha + \beta_1 Secondary\ Board_{i,t} + \beta_2 Country\ characteristics_{i,t-1} + Country\ (\times\ Industry\ FE)_{i(,j)} + Year\ FE_t (+Industry\ \times Year\ FE_{j,t}) + \varepsilon_{i,(j,)t},$$

(2)

in which i indexes the country, j indexes the industry (i.e., technology subsection), and t indexes the year. The dependent variable is the natural logarithm of the number of startups (first-time applicants who also have applied for fewer than 5 patents) plus one (in industry j) in country i in year t. The variable *Secondary Board* is an indicator variable that takes the value of 1 if there is a secondary stock exchange in country i in a given year t, and 0 otherwise. This variable can change either from 0 to 1 (i.e., the secondary stock exchange is newly opened in a country) or from 1 to 0 (i.e., the secondary stock exchange is closed in a country).[15] We also control for country characteristics such as *Ln(GDP)* and *Ln(Labor),* which may affect local entrepreneurial activities. As we do in Equation (1), we consider country and year fixed effects when our sample is a country-year panel, and we consider country × industry fixed effects and industry × year fixed effects when we consider a country-industry-year panel. Given that our treatment is defined at the country level, we cluster standard errors by country.

The coefficient of interest in Equation (2) is β_1. As pointed out by Imbens and Wooldridge (2009), after we control for country fixed effects, β_1 is the estimate of *within-country* differences between the periods before and after the introduction of a secondary board relative to a similar before-after difference in countries without such a board.

It is helpful to consider an example. Suppose we wish to estimate the effect of Shenzhen Small & Medium Enterprise Board, which was launched in China in 2004, on entrepreneurial activities in China. We can subtract the number of startups before the board's launch from the number of startups after the launch in China. However, worldwide economic shocks may occur concurrently and therefore affect entrepreneurial activities in 2004. To difference away such influences, we calculate the same difference in the number of high-tech startups in a control country that does not launch a secondary board. Finally, we compute the difference between these two differences, which captures the incremental effect of introducing secondary boards on startup activities in China compared to that in control countries without such exchanges.

Table 2 column (1) presents our results, which are based on a simplified version of Equation (2), in which we include only the *Secondary Board* indicator, country fixed effects, and year fixed effects as independent variables. The coefficient on *Secondary Board* is positive and significant at the 5% level, suggesting that a country's high-tech

[15] For countries whose secondary boards exist throughout our sample period, the *Post* variables always assume the value of 1.

entrepreneurial activities increase after the launch of secondary stock exchanges.

In column (2), we extend the regression specification by also controlling for country characteristics. The coefficient on *Secondary Board* is 0.257 and significant at the 1% level, which translates to a 29.3% ($= e^{0.257} - 1$) increase in the number of high-tech startups for an average sample country after the launch of secondary stock exchanges. Given that the sample average number of high-tech startups is 32 per country in a given year, the introduction of secondary stock exchanges is associated with an increase in the number of high-tech startups by 9.4 ($= 32 \times (e^{0.257} - 1)$).

In columns (3) and (4) of Table 2, we present our results when we use a country–industry–year panel based on 1- and 3-digit technology subsection codes, respectively. We additionally control for country characteristics, country × industry fixed effects, and industry × year fixed effects. The coefficients on *Secondary Board* are both positive and significant at the 5% level in both columns. Since column (4) gives the finest observation unit and the most stringent control of fixed effects, we use column (4) of Table 2 as our baseline regression hereafter.

Taken together, our results in Table 2 present a consistent pattern supporting our proposition that the introduction of secondary boards leads to an increase in entrepreneurial activities locally.

4.3 The pre-treatment trends

The validity of our difference-in-differences estimation rests on a parallel trends assumption: absent the introduction of secondary boards, high-tech entrepreneurial activities would have evolved in the same way in both treatment and control countries. Table 3 displays our results when we examine the pre-trend between the treated and control groups. The regression specifications in columns (1) to (4) follow those in Table 2, except that we replace the indicator *Secondary Board* with eight new indicator variables: $Year^{3}$, $Year^{2}$, $Year^{-1}$, $Year^{0}$, $Year^{1}$, $Year^{2}$, $Year^{3}$, and $Year^{4+}$. These variables indicate years relative to the introduction year of the secondary board. For instance, $Year^{3}$ indicates 3 years before the introduction, while $Year^{4+}$ indicates 4 or more years after the introduction. Other indicator variables are defined likewise. We take all other years that are not covered by *Secondary Board* as the benchmark group in our regression. The coefficients on $Year^{3}$, $Year^{2}$ and $Year^{-1}$ are of particular interest because their significance and magnitude indicate whether there is any significant difference in high-tech entrepreneurial activities between treatment and control countries prior to the introduction of secondary boards.

The coefficients on $Year^{3}$, $Year^{2}$, and $Year^{-1}$ throughout all specifications in Table 3 are insignificant and close to 0, suggesting that treated and control countries share a similar trend in high-tech entrepreneurial activities prior to the introduction of secondary boards. These results support the parallel trends assumption necessary for our DiD test. Furthermore, the lack of significant lead effects implies that the introduction of secondary boards is unlikely to be anticipated by prospective entrepreneurs in treated countries. More importantly, we find that coefficients on $Year^{0}$ and $Year^{1}$ are insignificant in all cases (except for $Year^{1}$ in column (4)), which suggests that the effect of secondary boards on local high-tech entrepreneurial activities occurs, if at all, several years *after* the launch of such exchanges. This finding supports the long-term effect of secondary boards in our investigation.

4.4 Reverse causality

We acknowledge that a country's introduction of secondary stock exchanges could be driven by the aggregate level of high-tech entrepreneurial activities in that country. To check this reverse causality concern, we follow Acharya, Baghai, and Subramanian (2014) and employ a Weibull hazard model in which the "failure event" is the introduction of a secondary stock exchange in a country (as the dependent variable). Our sample consists of 55 treated countries over our sample period, with countries dropped from the sample once they have launched secondary stock exchanges. We consider the following explanatory variables that are at the country level and lagged by one year. *Ln(# Startups* + 1*)* is the natural logarithm of the number of high-tech startups plus 1 in a country in a given year. The variable *Δ in # Startups* is the change in the number of high-tech startups from year *t*-2 to year *t-1*. We also control for a number of country-level variables, including GDP, the labor force size, stock market size, and the amount of foreign direct investment.

Table 4 presents our estimation results. We use *Ln*(# *Startups* + 1) as the main explanatory variable in columns (1) and (2), and use *Δ in # Startups* as the main explanatory variable in columns (3) and (4). Columns (2) and (4) additionally control for income group and region fixed effects.[16] We show that the coefficients on *Ln (# Startups+1)* and *Δ in # Startups* are insignificant across all 4 columns. Taking column (2) as an example, the coefficient on *Ln(# Startups*+1*)* is small in magnitude (0.023) and is statistically insignificant. These results indicate that the introduction of secondary boards in a country is not related to the contemporaneous level and trend of entrepreneurial activities, suggesting that the introduction of secondary boards is not mainly driven by existing local high-tech entrepreneurship.

4.5 Additional identification strategy

Establishing the causal link between secondary stock exchanges and high-tech entrepreneurship is a challenging task. In an influential study, Rajan and Zingales (1998) establish causality between financial market development and economic growth by pinning down one specific mechanism: that financial development spurs growth by reducing the cost of external financing. They also address reverse causality and omitted variable problems by documenting disproportionate growth in countries that are more dependent on external financing.

Specifically, we first separate all industries into high-secondary board-dependent and

[16] The income group and region information are obtained from the World Bank Global Financial Development Database (November 2021 version). Detailed definitions can be found in Table A1 of the Appendix.

low-secondary board-dependent groups by using each industry's IPO-related appearance in NASDAQ over the period 1980-1989[17]. We implicitly assume that differential degrees of dependence on secondary boards persist across countries, so that we can exploit an industry's dependence on secondary boards identified in the U.S. as a measure of its dependence in other countries. We note that this instrument is valid because the U.S. is not in our sample, and our sample period is 1990-2018. We then interact the *Secondary Board* dummy with the dummy for high-secondary board-dependent industries (*HighSecondaryDependent*) and estimate the following regressions in a country-industry-year panel:

$$Ln(\#\ Startups + 1)_{i,j,t} = \alpha + \beta_1 Secondary\ Board_{i,t} + \beta_2 Secondary\ Board_{i,t} \times HighSecondaryDependent_j + \beta_3 Country\ characteristics_{i,t-1} + Country \times Industry\ FE_{i,j} + Industry \times Year\ FE_{j,t} + \varepsilon_{i,j,t}, \tag{3}$$

in which $HighSecondaryDependent_j$ is either *HighSecondaryDependent1* or *HighSecondaryDependent2*, which captures the dependence of industry *j* on secondary stock exchanges *ex ante* and helps with identification. The coefficient of interest in Equation (3) is β_2. If this coefficient is positive and significant, it implies that there is a disproportionately higher growth of high-tech entrepreneurial activities in industries that are more dependent on secondary boards.

In Table 5 columns (1) and (3), we present our results based on a simplified version of Equation (3), in which we include only the *Secondary Board* indicator, country × industry fixed effects, and industry-year fixed effects as the independent variables. In columns (2) and (4), we additionally control for country characteristics in Equation (3). The coefficient

[17] To construct the dummy variable, *HighSecondaryDependent*, we first make use of the patent-CRSP link file in Kelly et. al. (2021) (KPST(2021) hereafter) to obtain patent numbers of listed firms and merge them with our USPTO data to obtain the industry code (CPC code) for patents. We then merge the resultant data with the SDC New Issues database to screen IPO firms and then merge the resultant data with CRSP data to screen firms that are listed in NASDAQ. Finally, we sort all industries into two groups (three groups) based on the number of occurrences of patents in these classifications over the period 1980-1989. The dummy variable *HighSecondaryDependent1* (*HighSecondaryDependent2*) takes the value of 1 if industry *j* belongs to the top half (tercile), and 0 otherwise.

estimates of the interaction terms between the *Secondary Board* dummy and the *HighSecondaryDependent* dummy, β_2's, report the difference in high-tech entrepreneurial activities among industries that are more dependent on secondary stock exchanges compared to those that are less dependent. They are positive and significant at the 1% level across all four columns. For example, in column (2), the coefficient estimate of β_2 is 0.060 and is significant at the 5% level. This translates to a 6.2% ($= e^{0.060} - 1$) differential increase in the number of high-tech startups for an average high-secondary board-dependent industry versus that for a low-dependent industry.

Overall, our tests in Table 5 imply that the association between secondary boards and high-tech entrepreneurial growth shown in our baseline regression is likely to be causal because our instrument only reflects pre-existing industry-specific dependence and is unrelated to any industry characteristics or economic variables in our sample.

5. Channel Tests

In this section, we conduct further analyses to understand possible channels through which the launch of secondary stock exchanges fosters high-tech entrepreneurial activities.

5.1 Attracting talents

The introduction of secondary stock exchanges creates more IPO opportunities, which in turn offer potential financial rewards and enhanced reputations for entrepreneurs. All these would encourage talented and ambitious talent to start new ventures or incentivize experienced entrepreneurs to become serial entrepreneurs. To investigate this channel, we examine the composition of inventors of startups as well as the heterogeneous treatment effects related to country-specific human capital conditions.

To test this channel, we first examine the characteristics of the individuals who become high-tech entrepreneurs when IPOs become more feasible. In particular, we define a series of 5 variables to capture the demographic change of local high-tech entrepreneurs after the launch of secondary boards: *Experienced*, *LessExperienced*, *MoreExperienced*, *FromCorp*, and *BigToSmall*. These variables are defined at the country-industry-year-level. Specifically, the variable *Experienced* (*LessExperienced* / *MoreExperienced*) is the fraction of inventors who have applied for (1 to 5 / greater than or equal to 5) patents prior to the application of the current one in the sample of inventors. We report inventor characteristics at the country-industry-year level in Panel C of Table 1, which shows that 40.8% of our sample inventors are experienced patent inventors. The variable *FromCorp* is the fraction of inventors who work in corporations before working for high-tech startups, and Panel C of Table 1 demonstrates that the majority of our sample inventors (99.7%) work in for-profit corporations. The variable *BigToSmall* is the fraction of inventors who used to work for big firms (firms that have applied for more than 5 patents) before joining a high-tech startup, and Panel C of Table 1 demonstrates that 7.6% of our sample inventors switched from big to small firms.

We then estimate the following regression:

$$Entrepreneur\ Composistion_{i,j,t} = \alpha + \beta_1 Secondary\ Board_{i,t} + \beta_2 Country\ characteristics_{i,\ t-1} + Country\ \times Industry\ FE_{i,j} + Industry\ \times Year\ FE_{j,t} + \varepsilon_{i,j,t}, \quad (4)$$

The regression specification in Equation (4) is the same as our baseline specification in which we use a country-industry-year panel, except that we replace the dependent variable by the aforementioned 6 variables to capture the change in entrepreneurs' composition. Panel A of Table 6 presents our results. The coefficients on *Secondary Board* are significant in 4 out of the 5 specifications at or below the 10% level, which offers the following implications: (1) the fraction of experienced inventors increases significantly, both for the less experienced and more experienced groups, suggesting that both junior and senior talent are more likely to become entrepreneurs; and (2) the fraction of inventors who switch from big to small firms increases significantly, suggesting that small firms are becoming more attractive to talent (because of their IPO opportunities or their venture atmosphere).

Taken together, our evidence in Panel A of Table 6 suggests that more experienced are more responsive to changes in the capital market and thus seize opportunities to start new firms; this finding complements the findings in Azoulay et al. (2020) that successful entrepreneurs tend to be middle-aged and have prior experience.

Further, if the effect of secondary boards on high-tech entrepreneurship indeed takes place through the human capital channel, we would expect to find a more pronounced treatment effect in economies with more high-quality human capital endowment *ex ante*. To explore this prediction, we employ 4 indicator variables to characterize the local quality of human capital, so we may examine the heterogeneous treatment effects. These variables are constructed based on commonly used measures for the stock of human capital in the literature. We follow prior studies such as Azariadis and Drazen (1990) and Romer (1989) to use the adult literacy rate, follow Weisbrod (1962) to use the investment on formal education, follow Barro (2001) to use the pupil-teacher ratio, and follow Barro (1991) and Mankiw, Romer, and Weil (1992) to use intake ratio as proxies for human capital. Specifically, *HighLiteracyRate* (*HighEduExpense/ HighTeacherPupilRatio/ HighIntakeRatio*) is a dummy variable that equals 1 if the adult literacy rate (government expenses on tertiary education/ tertiary teacher-pupil ratio/ tertiary intake ratio) measured at the beginning of the sample period (year 1990 or the earliest available year) is above the sample median and 0 otherwise.

Equation (5) expands our baseline regression (column (4) of Table 2) by including the interaction terms *Secondary Board* × *HighLiteracyRate*, *Secondary Board* × *HighEduExpense*, *Secondary Board* × *HighTeacherPupilRatio*, or *Secondary Board* × *HighIntakeRatio*:

$Ln(\# \, Startups + 1)_{i,j,t} = \alpha + \beta_1 Secondary \, Board_{i,t} + \beta_2 Secondary \, Board_{i,t} \times$
$HighLiteracyRate_i (HighEduExpense_i / HighTeacherPupilRatio_i / HighIntakeRatio_i) +$

$$\beta_3 Country\ characteristics_{i,t-1} + Country\ \times Industry\ FE_{i,j} + Industry\ \times Year\ FE_{j,t} + \varepsilon_{i,j,t}, (5)$$

Panel B of Table 6 presents our results. The coefficients on all 4 interaction terms are positive and significant at or below the 10% level, indicating that the effect of secondary boards' encouraging high-tech entrepreneurship is more pronounced among countries with a larger stock of high-quality human capital. The cross-sectional variations in the treatment effect shown in Panel B of Table 6 thus support our proposition that secondary boards promote startups by attracting talent.

5.2 Promoting VC financing

Vibrant public stock markets provide liquidity for private equity investors, enabling them to channel additional investment to new innovative projects (Gompers et al. (2008), Phillips and Zhdanov (2017), Bernstein (2022)), which are long recognized as difficult to finance (Arrow (1962)). In fact, international evidence in Jeng and Wells (2000) demonstrates that the vibrancy of IPO markets is the main driver for VC investment.

If the introduction of secondary boards indeed facilitates VCs' exit based on this discussion, we would expect an increase in VC activities following the launch of a secondary board. To explore this prediction, we employ four aggregate proxies for the intensity of local VC activities: VC fund raising activity captured by *Ln(Amount Raised)* and *Ln(Fund Size)*, and investment activity captured by *Ln(Equity Invested)* and *Ln(# Firm Invested)*. Our detailed variable definitions are provided in the Appendix. Panel A of Table 7 presents our results when we estimate the following regression using a country-year panel.

We find that the coefficients on *Secondary Board* are positive and significant at or below the 5% level for all 4 VC activity proxies. This implies that for countries that introduce secondary boards, the likelihood of VCs' exit from the capital market through an IPO increases and VCs, in response, engage more actively in fundraising and subsequent investing activities.

We also consider another set of tests based on heterogeneous treatment effects: if the launch of secondary boards fosters entrepreneurial activities by channeling resources to innovative projects that lack funding, we would expect the effect to be more pronounced in countries where capital markets are healthier and where secondary boards are more successful. To explore this prediction, we follow Bernstein, Dev, and Lerner (2020) and employ 3 variables to capture the overall development of the financial infrastructure and the success of secondary boards. Specifically, we define the indicator variable, *HighShareholderProtection* (*HighIPOProceeds/ HighIPONumber*), to take the value of 1 if the shareholder protection index in the first sample year (if the country's total IPO proceeds in the first year of secondary boards/if the country's total number of IPOs in the first year of secondary boards) exceeds the sample median and 0 otherwise. We provide detailed definitions of these 3 variables in the Appendix.

We estimate our baseline regression (column (4) of Table 2) by additionally including the interaction terms *Secondary Board* × *HighShareholderProtection*, *Secondary Board* × *HighIPOProceeds,* or *Secondary Board* × *HighIPONumber*. Panel B of Table 7 presents the results. The coefficients on all 3 interaction terms are positive and significant at or below the 5% level, indicating that the effect of secondary boards' encouraging high-tech entrepreneurship is more pronounced when there is stronger shareholder protection and when the secondary stock exchange is more successful. All results presented in Table 7 thus collectively support the channel of promoting VC investment through which the creation of secondary boards fosters local entrepreneurship.

5.3 Increasing demand and liquidity of patents

As we detailed in Section 2.2, we expect the increased demand and liquidity of patents and intellectual property to be the third channel through which secondary boards foster high-tech entrepreneurship. To test this prediction, we measure patent transaction and

M&A frequency with data obtained from the USPTO Patent Assignment Dataset (UPAD)[18] and from SDC Platinum, respectively. Specifically, we measure patent transaction as the natural logarithm of the total number of patent assignments plus one in country *i* and year *t* after excluding employer assignments[19]and use it as the dependent variable in column (1) of Panel A of Table 8 (*Ln(#Assign_Trans+1)*). To measure the number of high-tech M&A events, we require the acquirer to be in a high-tech industry as defined by Brown, Fazzari, and Petersen (2009)[20] and compute the natural logarithm of 1 plus the number of such high-tech M&A deals in country *i* and year *t* as the dependent variable in column (1) of Panel A of Table 8 (*Ln(#Deal+1*)). In column (3), we additionally require the acquirer to be a public firm, so we may validate the hypothesis that public listing encourages the acquisition of external innovation.

The regression specification is identical to our baseline specification that uses a country-year panel, except that we replace the dependent variable by the aforementioned 3 variables. Panel A of Table 8 presents our results. The coefficients on *Secondary Board* are significant in all regressions at or below the 5% level, suggesting that there is a significant increase in patent transactions and M&A activities subsequent to the introduction of secondary boards.

Further, if secondary boards indeed promote high-tech entrepreneurship by increasing IP liquidity, we expect such a treatment effect to be more pronounced for countries that experience a greater increase in IP liquidity after the introduction of secondary boards. We measure the increase in IP liquidity and demand as the percentage change from the five-year-average of the number of patent assignments (high-tech M&A deals/public high-tech

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[18] UPAD is a relational database containing over 6 million patent assignments and other transactions registered with the USPTO since 1970. Graham, Marco, and Myers (2018) provide a detailed description of this dataset for academic uses.

[19] Graham, Marco, and Myers (2018) note that the majority of assignment records are "employer assignments"—within firm transfers from employee inventors to their employers. To capture external patent transactions, we therefore exclude employer assignments.

[20] Consistent with Brown, Fazzari, and Petersen (2009), we define high-tech industries to be industries with two-digit SIC codes of 28 (chemicals, biotech, and drugs), 35 (computer hardware and machinery), 36 (electrical and electronics), 37 (transportation equipment), 38 (instruments), and 73 (software and data services).

M&A deals) before the launch of secondary boards to the corresponding five-year-average after the launch. The interaction term *MorePatentTrans* (*LessPatentTrans*) is an indicator variable that equals 1 if a country's percentage change in the number of patent assignments is in the top (bottom) half, and 0 otherwise.

The regression specification is identical to our baseline regression that uses a country-industry-year panel (column (4) of Table 2). Panel B of Table 8 presents our results. We show that across all 3 columns, the coefficients on *Secondary Board* × *MorePatentTrans* (*MoreHighTechDeals* / *MorePublicDeals*) are positive and significant, whereas the coefficients on *Secondary Board* × *LessPatentTrans* (*(LessHighTechDeals* / *LessPublicDeals*)*)* are much weaker in terms of both economic and statistical significance. Take column 1, for example, for which the dependent variable is *Ln(# Startups+1)*: We show that the coefficient on *Secondary Boards* × *MorePatentTrans* is 0.164 and significant at the 5% level, whereas the coefficient on *Secondary Boards* × *LessPatentTrans* is much smaller in magnitude (only 0.007) and is insignificant. The F-test to measure the equality of these two coefficients indicates that they are significantly different at the 1% level. This result suggests that the treatment effect is more pronounced for countries with a larger percentage increase in IP liquidity and is much weaker for firms in countries with a smaller percentage increase in IP liquidity.

Overall, Section 5 presents supportive evidence that the launch of secondary stock exchanges fosters high-tech entrepreneurial activities by enhancing the supply of entrepreneurs, by filling the financing gap of innovative startups, and by increasing the liquidity of the patent market.

6. Robustness Checks and Additional Tests

In this section, we conduct a number of robustness checks and additional tests; our results are reported in Tables 9 to 11.

6.1 Placebo tests: Evidence on trademarks

First, we acknowledge that our baseline results may simply reflect overall economic boom periods rather than a surge of high-tech startups. To examine this alternative explanation, we implement a placebo test by using trademark data from the USPTO to measure local business activities. We construct our dependent variables in the same manner as in our baseline regression except that we replace the number of firms that file for patents for the first time by the number of firms that file for trademarks for the first time (i.e., we define the variable *Ln (# Startups* + 1*)_TM* to be the natural logarithm of 1 plus the number of firms that are first-time trademark applicants and apply for fewer than 5 trademarks in year *t*).

Given that there is no technology subsection information associated with trademarks, we estimate our regression in Table 9 at the country-year level and control for country fixed effects and year fixed effects. Our results in Table 9 show that the coefficients on the key variable of interest, *Secondary Board*, are insignificant both with and without country-level control variables. The fact that we do not find a significant effect on trademark-based entrepreneurial activities supports our hypothesis that second-tier exchanges promote innovative and high-tech firms rather than general businesses.

6.2 Alternative difference-in-differences specifications

Second, Goodman-Bacon (2021) points out that staggered DiD estimates can be biased when multiple treatments take place at various points in time. This is in part because earlier treatment groups serve as controls for later treatment groups, and problem arises when there are heterogenous treatment effects. To address the issues of possible heterogenous treatment effects, we employ three alternative methods suggested in the literature. They include (1) the stacked DiD method proposed by Cengiz et al. (2019); (2) the method proposed by Sun and Abraham (2021); and (3) the imputation strategy proposed by Borusyak, Jaravel, and Spiess (2021).

For the first estimator developed by Cengiz et al. (2019), stacked DiD is used to create "clean" event-specific 2×2 datasets for treatment groups and create "clean" control groups inside the treatment window. We then stack all of these datasets together and estimate a two-way fixed-effects DiD specification with dataset-specific unit- and time-fixed effects. For the second estimator proposed in Sun and Abraham (2021), we first estimate the individual cohort-time-specific treatment effects, allowing for heterogeneity in treatment effects; we then aggregate these treatment effects to produce the average treatment effects. For the third estimator proposed in Borusyak et al. (2021), we run a regression of the outcome on individual cohort and time fixed effects in the sample of untreated observations, so we may predict the counterfactual outcome of our treated observations. Based on our predicted results, we may obtain an estimated treatment effect for each treated observation and a weighted average of these treatment effect estimates in the end.[21]

Table 10 presents the estimates from our three alternative DiD methods, so we may examine the impact of secondary stock exchanges on high-tech entrepreneurial activities by using our baseline specification in the country-industry-year panel. The sample includes countries that are treated (i.e., introducing secondary stock exchanges) during the sample period and clean controls (i.e., never launched secondary stock exchanges during the sample period). The coefficient on *Secondary Board* is 0.064 based on the method of Cengiz et al. (2019), 0.049 based on the method of Sun and Abraham (2021), and 0.051 based on the method of Borusyak et al. (2021), respectively. All of the coefficients are significant at the 1% level. In addition, the economic magnitude of these coefficients is comparable to that of our baseline regression in column (4) of Table 3 (0.070). Our results in Table 10 thus suggest that our main inference is fairly robust under alternative DiD specifications.

[21] The STATA commands for the three estimation methods are eventstudyinteract, stackedev, and did_imputation, respectively.

6.3 Alternative definitions of high-tech entrepreneurial activities

Third, our results could be driven by an inaccurate definition of high-tech startups. Panel A of Table 11 tests the robustness of our definition for startups. Specifically, the definition of startups refers to patent applicants that are first-time applicants in column (1); first-time applicants that have applied for fewer than 3 patents in year *t* in column (2); and first-time applicants that have applied for fewer than 10 patents in year *t* in column (3).

As shown in Panel A of Table 11, the coefficients on *Secondary Board* are positive and significant at the 5% level in all 3 specifications, indicating that our definition of high-tech startups is robust to alternative specifications.

6.4 Addressing an under-reporting bias

Fourth, to the extent that patents filed in the U.S. only partially capture the universe of innovative projects, we expect our definition of startups to be subject to an under-reporting bias. Although this will bias us from finding any significant results, we are nevertheless still able to present a positive relation between the creation of secondary stock exchanges and high-tech entrepreneurial activities. We also perform a robustness check to assess the bias in the positive relation due to the degree of such under-reporting bias in U.S. patents. Specifically, we use the ratio of the total number of patents filed domestically as obtained from the World Bank divided by those filed in the U.S. as obtained from the USPTO, so we may measure the degree of under-reporting (i.e., a higher value of the ratio implies a higher likelihood of underreporting). After we sort the ratio into terciles (quintiles) to form a rank variable *UnderReporting1* (*UnderReporting2*), we then re-estimate our baseline regression (column (4) of Table 3) by including the interaction terms *Secondary Board* × *UnderReporting1* and *Secondary Board* × *UnderReporting2*. Panel B of Table 11 presents our results. We first note that the coefficients on *Secondary Boards* are significant in both columns. In addition, the coefficients on the interaction terms are negative and significant at or below the 5% level for both columns. Taking column (1) as an example, the coefficient on *Secondary Board* is 0.105, and the coefficient on *Secondary Board* × *UnderReporting1* is -0.0207. These estimates imply that for the least under-reported countries (where *UnderReporting1* = 0), our treatment effect is 0.105. As the degree of under-reporting increases by 1 unit, the treatment effect is 0.027 smaller.

Overall, our evidence suggests that under-reporting bias with respect to U.S. patents does exist and that our main effect is indeed weaker in countries that are more prone to this under-reporting bias. It also implies that our estimates, despite their economic and statistical significance, may be a lower bound of the real effect of secondary boards on high-tech entrepreneurship. In other words, high-tech startups may be influenced by the establishment of secondary stock exchanges to a greater extent than what we have quantified.

6.5 Alternative regression specifications

Fifth and finally, we address the concern raised in Cohn et al. (2022) that linear "log1plus" regressions may yield biased estimates that lack meaningful interpretations. To examine whether our main findings are driven by such biases, we follow their recommendation and estimate fixed-effect Poisson models with our baseline regression samples. Panel C of Table 11 presents our results.

Panel C shows that all 4 regression coefficients on *Secondary Boards* are positive and significant at or below the 10% significance level, indicating that the launch of secondary boards significantly increases the number of startups in treatment countries. Taking column (4) as an example, the coefficient on *Secondary Boards* is 0.100 and is significant at the 1% level, suggesting that compared to countries that have not introduced secondary boards, countries that do so experience a 10.5% ($= e^{0.100} - 1$) increase in the number of startups.

Overall, our evidence in Table 11 implies that our results concentrate only in high-tech startups and are robust to various model specifications; also, we note that what we are quantifying may only reflect a lower bound of the impact of secondary stock exchanges on entrepreneurial activities.

7. Conclusion

In this paper, we investigate the effect of secondary stock exchanges on high-tech entrepreneurial activities in a cross-country setting. We expect the establishment of secondary stock exchanges to spur entrepreneurship by i) encouraging talent to become entrepreneurs, ii) promoting venture investment, and iii) enhancing the demand and liquidity of entrepreneurs' patents.

Using a staggered DiD approach, we find a significant increase in a country's number of high-tech startups following the launch of such exchanges, relative to countries that have not introduced such exchanges. Moreover, we show that such growth in high-tech startups is disproportionally stronger in industries that are more dependent on secondary boards *ex ante*, thus providing support for a causal interpretation.

We further provide supporting evidence for our three channels: i) that secondary boards encourage more scientists and engineers to become entrepreneurs, ii) that the establishment of secondary boards is associated with greater VC investment, and iii) that the establishment of secondary boards is associated with greater demand and liquidity for patents and intellectual property.

Our paper offers important implications for public policy aimed at fostering innovation and entrepreneurship. Our results suggest that the creation of new stock exchanges characterized by more lenient listing requirements and targeting small and medium-sized firms, can have real economic effects in terms of improving domestic entrepreneurship and innovation. This finding is particularly timely and relevant in light of the accelerating competition in technologies in today's intellectual property-based economy.

References

Acharya, V. V., Baghai, R. P., & Subramanian, K. V., 2013. Labor laws and innovation. *Journal of Law and Economics*, 56(4), 997-1037.

Acs, Zoltan J, and David B Audretsch, 1987, An empirical examination of small firm growth, *Economics Letters* 25, 363-366.

Akcigit, Ufuk, John Grigsby, and Tom Nicholas, 2017, The rise of american ingenuity: Innovation and inventors of the golden age, NBER working paper.

Akcigit, Ufuk, and William R Kerr, 2018, Growth through heterogeneous innovations, *Journal of Political Economy* 126, 1374-1443.

Appel, Ian, Joan Farre-Mensa, and Elena Simintzi, 2019, Patent trolls and startup employment, *Journal of Financial Economics* 133, 708-725.

Arrow, Kenneth, 1962, Economic welfare and the allocation of resources for invention, in *The rate and direction of inventive activity: Economic and social factors* (Princeton University Press).

Azariadis, Costas, and Allan Drazen, 1990, Threshold externalities in economic development, *The Quarterly Journal of Economics* 105, 501-526.

Azoulay, Pierre, Benjamin F Jones, J Daniel Kim, and Javier Miranda, 2020, Age and high-growth entrepreneurship, *American Economic Review: Insights* 2, 65-82.

Babina, Tania, Paige Ouimet, and Rebecca Zarutskie, 2017, Going entrepreneurial? Ipos and new firm creation.

Barro, Robert J, 1991, Economic growth in a cross section of countries, *The Quarterly Journal of Economics* 106, 407-443.

Barro, Robert J, 2001, Human capital and growth, *American Economic Review* 91, 12-17.

Baumol, William J, Robert E Litan, and Carl J Schramm, 2007. *Good capitalism, bad capitalism, and the economics of growth and prosperity* (Yale University Press).

Beck, Thorsten, and Ross Levine, 2002, Industry growth and capital allocation:: Does having a market-or bank-based system matter?, *Journal of Financial Economics* 64, 147-180.

Benzarti, Youssef, Jarkko Harju, and Tuomas Matikka, 2020, Does mandating social insurance affect entrepreneurial activity?, *American Economic Review: Insights* 2, 255-68.

Bernstein, Shai, 2015, Does going public affect innovation?, *The Journal of Finance* 70, 1365-1403.

Bernstein, Shai, 2022, The effects of public and private equity markets on firm behavior, *Annual Review of Financial Economics* 14, 295-318.

Bernstein, Shai, Abhishek Dev, and Josh Lerner, 2020, The creation and evolution of entrepreneurial public markets, *Journal of Financial Economics* 136, 307-329.

Bernstein, Shai, Xavier Giroud, and Richard R Townsend, 2016, The impact of venture capital monitoring, *The Journal of Finance* 71, 1591-1622.

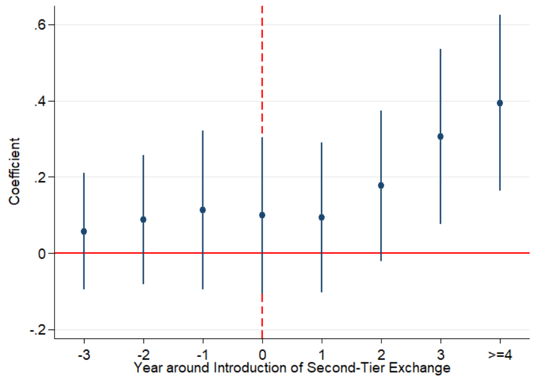
Bhattacharya, Utpal, Po-Hsuan Hsu, Xuan Tian, and Yan Xu, 2017, What affects innovation more: Policy or policy uncertainty?, *Journal of Financial and*

Quantitative Analysis 52, 1869-1901.
Bhide, Amar, 1994, How entrepreneurs craft strategies that work, *Harvard Business Review* 72, 150-161.
Black, Sandra E, and Philip E Strahan, 2002, Entrepreneurship and bank credit availability, *The Journal of Finance* 57, 2807-2833.
Bond, Philip, Alex Edmans, and Itay Goldstein, 2012, The real effects of financial markets, *Annu. Rev. Financ. Econ.* 4, 339-360.
Borusyak, Kirill, Xavier Jaravel, and Jann Spiess, 2021, Revisiting event study designs: Robust and efficient estimation, *arXiv preprint arXiv:2108.12419*.
Brown, James R, Steven M Fazzari, and Bruce C Petersen, 2009, Financing innovation and growth: Cash flow, external equity, and the 1990s r&d boom, *The Journal of Finance* 64, 151-185.
Caskurlu, Tolga, 2020, An IPO Pitfall: Patent lawsuits, working paper.
Cengiz, Doruk, Arindrajit Dube, Attila Lindner, and Ben Zipperer, 2019, The effect of minimum wages on low-wage jobs, *The Quarterly Journal of Economics* 134, 1405-1454.
Chava, Sudheer, Alexander Oettl, Ajay Subramanian, and Krishnamurthy V Subramanian, 2013, Banking deregulation and innovation, *Journal of Financial Economics* 109, 759-774.
Chemmanur, Thomas J, Karthik Krishnan, and Debarshi K Nandy, 2011, How does venture capital financing improve efficiency in private firms? A look beneath the surface, *The Review of Financial Studies* 24, 4037-4090.
Cohen, Susan, Daniel C Fehder, Yael V Hochberg, and Fiona Murray, 2019, The design of startup accelerators, *Research Policy* 48, 1781-1797.
Cohn, Jonathan B, Zack Liu, and Malcolm I Wardlaw, 2022, Count (and count-like) data in finance, *Journal of Financial Economics* 146, 529-551.
Cooper, Arnold C, 1985, The role of incubator organizations in the founding of growth-oriented firms, *Journal of Business Venturing* 1, 75-86.
Eberhart, Robert Neal, Kathleen M Eisenhardt, and Chuck Eesley, 2013, Too much of a good thing? Equity market reform, investment, and new venture performance, Academy of Management Proceedings (Academy of Management Briarcliff Manor, NY 10510).
Ewens, Michael, Ramana Nanda, and Matthew Rhodes-Kropf, 2018, Cost of experimentation and the evolution of venture capital, *Journal of Financial Economics* 128, 422-442.
Farre-Mensa, Joan, Deepak Hegde, and Alexander Ljungqvist, 2020, What is a patent worth? Evidence from the us patent “lottery”, *The Journal of Finance* 75, 639-682.
Gentry, William M, and R Glenn Hubbard, 2000, Tax policy and entrepreneurial entry, *American Economic Review* 90, 283-287.
Gompers, Paul, Anna Kovner, Josh Lerner, and David Scharfstein, 2008, Venture capital

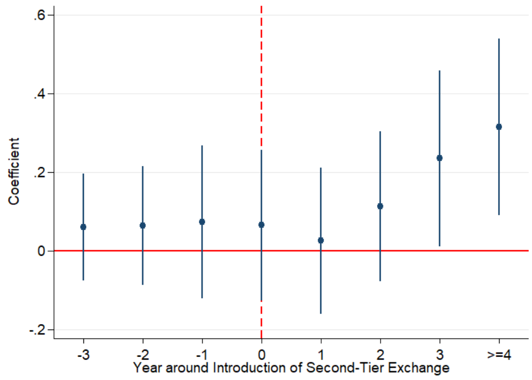
investment cycles: The impact of public markets, *Journal of Financial Economics* 87, 1-23.
Gompers, Paul, Josh Lerner, and David Scharfstein, 2005, Entrepreneurial spawning: Public corporations and the genesis of new ventures, 1986 to 1999, *The Journal of Finance* 60, 577-614.
Goodman-Bacon, Andrew, 2021, Difference-in-differences with variation in treatment timing, *Journal of Econometrics* 225, 254-277.
Gottlieb, Joshua, Richard Townsend, and Ting Xu, 2016, Experimenting with entrepreneurship: The effect of job-protected leave.
Graham, Stuart JH, Alan C Marco, and Amanda F Myers, 2018, Patent transactions in the marketplace: Lessons from the uspto patent assignment dataset, *Journal of Economics & Management Strategy* 27, 343-371.
Griffith, Rachel, Rupert Harrison, and John Van Reenen, 2006, How special is the special relationship? Using the impact of us r&d spillovers on uk firms as a test of technology sourcing, *American Economic Review* 96, 1859-1875.
Hall, Bronwyn H, and Josh Lerner, 2010, The financing of r&d and innovation, in *Handbook of the economics of innovation* (Elsevier).
Hall, Robert E, and Susan E Woodward, 2010, The burden of the nondiversifiable risk of entrepreneurship, *American Economic Review* 100, 1163-94.
Harwood, Alison, and Tanya Konidaris, 2015, Sme exchanges in emerging market economies: A stocktaking of development practices, *World Bank Policy Research Working Paper*.
Hellmann, Thomas, 2007, When do employees become entrepreneurs?, *Management Science* 53, 919-933.
Hochberg, Yael V, Carlos J Serrano, and Rosemarie H Ziedonis, 2018, Patent collateral, investor commitment, and the market for venture lending, *Journal of Financial Economics* 130, 74-94.
Howell, Sabrina T, 2017, Financing innovation: Evidence from r&d grants, *American Economic Review* 107, 1136-64.
Hsu, Po-Hsuan, Xuan Tian, and Yan Xu, 2014, Financial development and innovation: Cross-country evidence, *Journal of Financial Economics* 112, 116-135.
Iwasaki, Ichiro, Evžen Kočenda, and Yoshisada Shida, 2021, Institutions, financial development, and small business survival: Evidence from european emerging markets, *Small Business Economics* 1-23.
Jaffe, Adam B, and Manuel Trajtenberg, 2002. *Patents, citations, and innovations: A window on the knowledge economy* (MIT press).
Janeway, William H, Ramana Nanda, and Matthew Rhodes-Kropf, 2021, Venture capital booms and start-up financing, *Annual Review of Financial Economics* 13, 111-127.
Jeng, Leslie A, and Philippe C Wells, 2000, The determinants of venture capital funding: Evidence across countries, *Journal of Corporate Finance* 6, 241-289.

Jenkinson, Tim, and Tarun Ramadorai, 2013, Does one size fit all? The consequences of switching markets with different regulatory standards, *European Financial Management* 19, 852-886.
Kahn, Shulamit, Giulia La Mattina, and Megan J MacGarvie, 2017, "Misfits,""stars," and immigrant entrepreneurship, *Small Business Economics* 49, 533-557.
Kelly, Bryan, Dimitris Papanikolaou, Amit Seru, and Matt Taddy, 2021, Measuring technological innovation over the long run, *American Economic Review: Insights* 3, 303-320.
Kerr, William R, Josh Lerner, and Antoinette Schoar, 2014, The consequences of entrepreneurial finance: Evidence from angel financings, *The Review of Financial Studies* 27, 20-55.
Kerr, William R, and Ramana Nanda, 2009, Democratizing entry: Banking deregulations, financing constraints, and entrepreneurship, *Journal of Financial Economics* 94, 124-149.
Kerr, William R, and Ramana Nanda, 2015, Financing innovation, *Annual Review of Financial Economics* 7, 445-462.
Kerr, William R, Ramana Nanda, and Matthew Rhodes-Kropf, 2014, Entrepreneurship as experimentation, *Journal of Economic Perspectives* 28, 25-48.
King, Robert G, and Ross Levine, 1993, Finance, entrepreneurship and growth, *Journal of Monetary economics* 32, 513-542.
Klapper, Leora, Luc Laeven, and Raghuram Rajan, 2006, Entry regulation as a barrier to entrepreneurship, *Journal of financial economics* 82, 591-629.
Klepper, Steven, 2001, Employee startups in high-tech industries, *Industrial and Corporate Change* 10, 639-674.
Lerner, Josh, 2000, The government as venture capitalist: The long-run impact of the sbir program, *The Journal of Private Equity* 3, 55-78.
Lerner, Josh, 2009, The empirical impact of intellectual property rights on innovation: Puzzles and clues, *American Economic Review* 99, 343-48.
Lerner, Josh, 2022, Venture capitalists and the oversight of private firms, in *Venture capital* (Routledge).
Mace, Chris, The real effects of equity markets on innovation, *Journal of Financial and Quantitative Analysis* 1-53.
Mankiw, N Gregory, David Romer, and David N Weil, 1992, A contribution to the empirics of economic growth, *The Quarterly Journal of Economics* 107, 407-437.
Manso, G., 2016. Experimentation and the Returns to Entrepreneurship. *Review of Financial Studies*, 29(9), 2319-2340.
Munos, Bernard, 2009, Lessons from 60 years of pharmaceutical innovation, *Nature Reviews Drug Discovery* 8, 959-968.
Nanda, Ramana, and Matthew Rhodes-Kropf, 2013, Investment cycles and startup innovation, *Journal of Financial Economics* 110, 403-418.
Ouimet, Paige, and Rebecca Zarutskie, 2014, Who works for startups? The relation

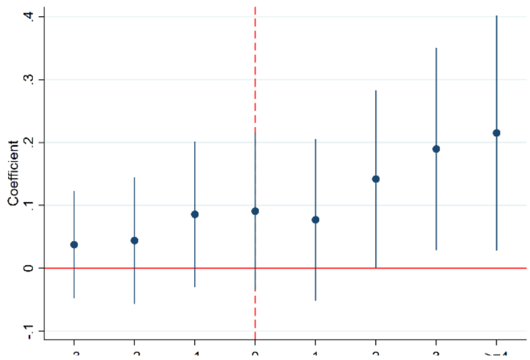
between firm age, employee age, and growth, *Journal of Financial Economics* 112, 386-407.
Ozmel, Umit, David T Robinson, and Toby E Stuart, 2013, Strategic alliances, venture capital, and exit decisions in early stage high-tech firms, *Journal of Financial Economics* 107, 655-670.
Pagano, Marco, Fabio Panetta, and Luigi Zingales, 1998, Why do companies go public? An empirical analysis. *Journal of Finance* 53, 27-64.
Phillips, Gordon M, and Alexei Zhdanov, 2017, Venture capital investments and merger and acquisition activity around the world, NBER working paper.
Puri, Manju, and David T Robinson, 2013, The economic psychology of entrepreneurship and family business, *Journal of Economics & Management Strategy* 22, 423-444.
Rajan, Raghuram, and Luigi Zingales, 1998, Financial development and growth, *American Economic Review* 88, 559-586.
Robb, Alicia M, and David T Robinson, 2014, The capital structure decisions of new firms, *The Review of Financial Studies* 27, 153-179.
Roberts, Michael R, and Toni M Whited, 2013, Endogeneity in empirical corporate finance1, in *Handbook of the economics of finance* (Elsevier).
Romer, Paul M, 1989, Human capital and growth: Theory and evidence, (National Bureau of Economic Research Cambridge, Mass., USA).
Schumpeter, Joseph A, 1911. *Theorie der wirtschaftlichen entwicklung* (Duncker & Humblot).
Serrano, Carlos Javier, and Rosemarie Ziedonis, 2019, How redeployable are patent assets? Evidence from failed startups, Academy of Management Proceedings (Academy of Management Briarcliff Manor, NY 10510).
Smith, Adam, 1776, An inquiry into the nature and causes of the wealth of nations, in (London: printed for W. Strahan; and T. Cadell, 1776.).
Sun, Liyang, and Sarah Abraham, 2021, Estimating dynamic treatment effects in event studies with heterogeneous treatment effects, *Journal of Econometrics* 225, 175-199.
Vismara, Silvio, Stefano Paleari, and Jay R Ritter, 2012, Europe's second markets for small companies, *European Financial Management* 18, 352-388.
Weisbrod, Burton A, 1962, Education and investment in human capital, *Journal of Political Economy* 70, 106-123.
Yu, Sandy, 2020, How do accelerators impact the performance of high-technology ventures?, *Management Science* 66, 530-552.
Yu, Sandy, and Lee Fleming, 2022, Regional crowdfunding and high tech entrepreneurship, *Research Policy* 51, 104348.



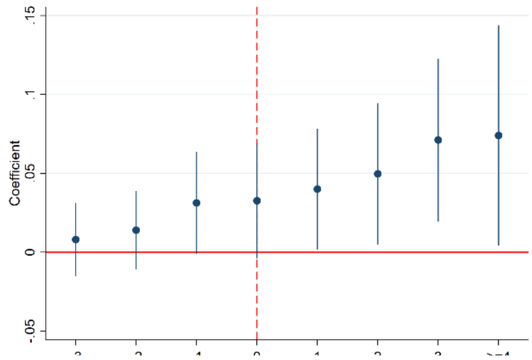
Panel A Country-Year Panel Without Controls



Panel B Country-Year Panel With Controls



Panel C Country-Industry (1-digit)-Year Panel With Controls



Panel D Country-Industry (3-digit)-Year Panel With Controls

Figure 1. Effects of the Introduction of Secondary Boards on Entrepreneurial Activity

Figure 1 plots the point estimates and 90% confidence interval of the coefficients on $EntryYear_{i,t}^{\tau}$ (based on standard errors clustered by country of location of the patent assignee) from our estimations using a country-year panel in Panels A and B. Panel A does not include any controls, while Panel B controls for country-level characteristics, including GDP and the size of the labor force. We then construct a country-industry-year panel in Panels C and D for 1- and 3-digit classifications, respectively. The time span underlying the regressions is 1990–2018.

Table 1. Summary Statistics

Our sample consists of 4,307 country-year-level observations, 38,772 country-industry (1-digit technology subsection)–year level observations, and 551,424 country–industry (3-digit technology subsection)–year level observations from 1990 to 2018. Panels A to C of this table present summary statistics of the full sample at respective observation units. All dollar values are converted to constant 2015 USD. Variable definitions are provided in the Appendix Table A1.

Panel A Country-year summary statistics

	Mean	Std. Dev	25th Percentile	Median	75th Percentile
# Startups	32.060	108.000	0.000	0.000	6.000
# Startups1	32.312	109.031	0.000	0.000	6.000
# Startups2	31.176	104.739	0.000	0.000	5.000
# Startups3	32.269	108.846	0.000	0.000	6.000
Secondary Board	0.179	0.383	0.000	0.000	0.000
GDP (in billions)	268.898	763.930	10.519	36.526	189.008
Labor (in millions)	17.675	7.037	1.323	3.829	10.745
Amount Raised (in millions)	194.151	1,267.733	0.000	0.000	40.000
Fund Size (in millions)	197.632	1,281.078	0.000	0.000	40.000
Equity Invested (in millions)	19.664	99.378	0.000	0.000	0.000
# Firm Invested	13.717	53.788	0.000	0.000	3.000

Panel B Country–industry (1-digit technology subsection)–year summary statistics

	Mean	Std. Dev	25th Percentile	Median	75th Percentile
# Startups	3.748	15.434	0.000	0.000	0.000
# Startups1	3.766	15.526	0.000	0.000	0.000
# Startups2	3.676	15.105	0.000	0.000	0.000
# Startups3	3.763	15.508	0.000	0.000	0.000
Secondary Board	0.179	0.383	0.000	0.000	0.000

Table 1. (continued)

Panel C Country-industry (3-digit technology subsection)–year summary statistics

	Mean	Std. Dev	25th Percentile	Median	75th Percentile
# Startups	0.269	2.189	0.000	0.000	0.000
# Startups1	0.270	2.201	0.000	0.000	0.000
# Startups2	0.265	2.147	0.000	0.000	0.000
# Startups3	0.270	2.199	0.000	0.000	0.000
Secondary Board	0.179	0.383	0.000	0.000	0.000
HighSecondaryDependent1	0.513	0.500	0.000	1.000	1.000
HighSecondaryDependent2	0.336	0.472	0.000	0.000	1.000
Experienced	0.408	0.339	0.000	0.400	0.625
LessExperienced	0.269	0.286	0.000	0.241	0.389
MoreExperienced	0.140	0.222	0.000	0.000	0.214
FromCorp	0.997	0.105	1.000	1.000	1.000
Serial	0.017	0.088	0.000	0.000	0.000
BigToSmall	0.076	0.177	0.000	0.000	0.079

Table 2. Secondary Stock Exchange and High-tech Entrepreneurial Activities

This table reports the DiD tests that examine the effect of the introduction of secondary board on local entrepreneurial activities. Over the sample period of 1990 to 2018, we exploit three different samples depending on the levels of aggregation: 4,307 country-year-level observations in columns (1) and (2); 38,763 country-1-digit technology subsection-year-level observations in column (3) and 551,296 country-3-digit technology subsection-year-level observations in column (4). The dependent variable is *Ln(# Startups+1)*, the natural logarithm of 1 plus the number of organizations that are first-time applicants and applied for fewer than 5 patents in year *t*. For countries that introduce the entrepreneurial board, the indicator variable *Secondary Boards* takes the value of 1 for the period after the introduction, and 0 for the period prior to the introduction. For countries that never introduce secondary boards in our sample period, *Secondary Boards* always takes the value of 0. In column (1), we include only the *Secondary Boards* dummy, country fixed effect, and year fixed effect. In column (2), we add country characteristics. In column (3), we expand the sample to the country-industry (defined by 1-digit technology subsection)-year level and control for country × industry fixed effects and industry × year fixed effects. In column (4), we further expand the sample to the country-industry (defined by 3-digit technology subsection)-year level with corresponding fixed effects. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Secondary Board	0.229**	0.257***	0.196**	0.070**
	(0.103)	(0.096)	(0.081)	(0.032)
Ln(GDP)		0.391**	0.328**	0.111*
		(0.172)	(0.145)	(0.056)
Ln(Labor)		-0.027	-0.073	-0.030
		(0.217)	(0.113)	(0.041)
Constant	1.183***	-0.252	-0.698	-0.306*
	(0.018)	(0.559)	(0.455)	(0.175)
Observations	4,307	4,307	38,763	551,296
Adjusted R-squared	0.937	0.938	0.893	0.738
Year FE	Yes	Yes	No	No
Country × Industry FE	Yes	Yes	Yes	Yes
Industry × Year FE	No	No	Yes	Yes
Obs unit	Country-Yr	Country-Yr	Country-1D Technology-Yr	Country-3D Technology-Yr

Table 3. Testing for Pre-treatment Trends

This table examines the pre-treatment trends between the treatment and control groups. The variables $Year^{-3}$, $Year^{-2}$, $Year^{-1}$, $Year^{0}$ (Event year), $Year^{1}$, $Year^{2}$, $Year^{3}$, and $Year^{4+}$ indicate the year relative to the introduction of a secondary board in country *i*. $Year^{0}$ is the event year. The regression specifications in column (1) through (4) are the same as those in columns (1) through (4) of Table 2, except that we replace the *Secondary Boards* indicator with the aforementioned 8 year indicator variables. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
$Year^{-3}$	0.055	0.060	0.037	0.008
	(0.090)	(0.082)	(0.052)	(0.014)
$Year^{-2}$	0.065	0.064	0.044	0.014
	(0.102)	(0.091)	(0.061)	(0.015)
$Year^{-1}$	0.069	0.073	0.086	0.031
	(0.125)	(0.117)	(0.070)	(0.020)
$Year^{0}$	0.055	0.066	0.091	0.033
	(0.125)	(0.116)	(0.075)	(0.022)
$Year^{1}$	0.019	0.026	0.077	0.040*
	(0.122)	(0.112)	(0.078)	(0.023)
$Year^{2}$	0.103	0.113	0.142*	0.050*
	(0.123)	(0.115)	(0.085)	(0.027)
$Year^{3}$	0.220	0.235*	0.190*	0.071**
	(0.144)	(0.135)	(0.097)	(0.031)
$Year^{4+}$	0.264*	0.314**	0.215*	0.074*
	(0.143)	(0.136)	(0.113)	(0.042)
Ln(GDP)		0.402**	0.332**	0.112*
		(0.172)	(0.146)	(0.057)
Ln(Labor)		0.003	-0.058	-0.025
		(0.212)	(0.106)	(0.038)
Constant	0.996***	-0.556	-0.883	-0.367*
	(0.126)	(0.643)	(0.539)	(0.212)
Observations	4,307	4,307	38,763	551,296
Adjusted R-squared	0.937	0.939	0.893	0.738
Year FE	Yes	Yes	No	No
Country × Industry FE	Yes	Yes	Yes	Yes
Industry × Year FE	No	No	Yes	Yes
Obs unit	Country-Yr	Country-Yr	Country-1D Technology-Yr	Country-3D Technology-Yr

Table 4. The Timing of the Introduction of Secondary Boards: The Duration Model

This table reports estimates from a Weibull hazard model in which the "failure event" is the introduction of a secondary board in a country. Countries are dropped from the sample once they introduce these boards, which happens to 55 countries before or during the period 1990–2018. All explanatory variables are at the country level and lagged by one year. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Ln(# Startups+1)	0.007	0.023		
	(0.119)	(0.384)		
Δ in # Startups			-0.036	-0.025
			(-0.735)	(-0.566)
Ln(GDP)	0.248**	0.341*	0.231**	0.267*
	(2.026)	(1.833)	(2.242)	(1.757)
Ln(Labor)	-0.097	-0.247	-0.087	-0.167
	(-1.101)	(-1.528)	(-1.017)	(-1.087)
MarketCapListed	0.234	0.310*	0.182	0.374**
	(1.250)	(1.895)	(0.938)	(1.986)
FDINetInflow	0.145*	0.138*	0.119	0.072
	(1.762)	(1.816)	(1.390)	(0.820)
Constant	-5.140***	-5.547***	-4.707***	-4.956***
	(-13.978)	(-7.701)	(-11.247)	(-7.024)
Observations	1,029	1,029	757	757
Country Controls	Yes	Yes	Yes	Yes
Income Group FE	No	Yes	No	Yes
Region FE	No	Yes	No	Yes

Table 5. Additional Identification Test

This table tests the differential effect of secondary boards on entrepreneurial activities in industries that are more second-tier exchange-dependent versus industries that are less dependent. The dummy variables *HighSecondaryDependent1* (*HighSecondaryDependent2*) equal 1 if the industry is in the top half (tercile) ranked by all industries associated with NASDAQ IPO firms over the period of 1980-1989, and 0 otherwise. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Secondary Board				
×HighSecondaryDependent1	0.060**	0.060**		
	(0.030)	(0.030)		
Secondary Board				
×HighSecondaryDependent2			0.076**	0.076**
			(0.036)	(0.036)
Secondary Board	0.034*	0.041**	0.039*	0.046**
	(0.020)	(0.018)	(0.023)	(0.022)
Ln(GDP)		0.111*		0.111*
		(0.056)		(0.056)
Ln(Labor)		-0.030		-0.030
		(0.041)		(0.041)
Constant	0.074***	-0.306*	0.074***	-0.306*
	(0.006)	(0.175)	(0.006)	(0.175)
Observations	551,296	551,296	551,424	551,296
Adjusted R-squared	0.735	0.738	0.441	0.738
Country × Industry FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 6. Channel Tests: Attracting Talent to Become Entrepreneurs

This table reports tests of the human capital channel through which the opening of secondary boards affects entrepreneurial activities. Panel A examines the effect of secondary boards on inventor demographic composition. The dependent variables are defined similarly at the country-year-industry (3-digit technology) level. Specifically, the dependent variable *Experienced* in column (1) (*LessExperienced* in column (2) / *MoreExperienced* in column (3)) is the fraction of investors who have applied for (1 to 5 / greater than or equal to 5) patents before. The dependent variable *FromCorp* in column (4) is the fraction of investors who used to work in corporations but do not any more. The dependent variable *BigToSmall* in column (5) is the fraction of inventors who used to work for big firms (firms that have applied for more than 5 patents before according to our definition) but do not any more. Panel B reports the heterogeneous treatment effects based on the quality of human capital. The dependent variable is *Ln(# Startups+1)*. The interacting variable in column (1) of Panel B is *HighLiteracyRate*, a dummy variable that equals 1 if the literacy rate measured at year 1990 or the earliest available year is above the sample median and 0 otherwise. The interacting variable in column (2) of Panel B is *HighEduExpense*, a dummy variable that equals 1 if the educational expenses measured at year 1990 or the earliest available year are above the sample median and 0 otherwise. The interacting variable in column (3) of Panel B is *HighTeacherPupilRatio*, a tertiary teacher-pupil ratio measured at year 1990 or the earliest available year that is above the sample median and 0 otherwise. The interacting variable in column (4) of Panel B is *HighIntakeRatio*, a dummy variable that equals 1 if the tertiary intake ratio measured at year 1990 or the earliest available year is above the sample median and 0 otherwise. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. (continued)

Panel A. Secondary boards and the characteristics of entrepreneurs

	(1) Experienced	(2) LessExperienced	(3) MoreExperienced	(4) FromCorp	(5) BigToSmall
Secondary Board	0.022***	0.010**	0.012*	-0.000	0.012***
	(0.008)	(0.004)	(0.006)	(0.001)	(0.003)
Ln(GDP)	0.173***	0.058***	0.115***	0.016***	0.063***
	(0.039)	(0.009)	(0.035)	(0.004)	(0.009)
Ln(Labor)	-0.094*	-0.001	-0.093**	0.005	-0.033**
	(0.052)	(0.028)	(0.045)	(0.012)	(0.016)
Constant	-0.488*	-0.114	-0.374	0.881***	-0.255***
	(0.286)	(0.079)	(0.265)	(0.035)	(0.057)
Observations	60,628	60,628	60,628	60,628	60,628
R-squared	0.198	0.076	0.240	0.089	0.069
Country × Industry FE	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes

Table 6. (continued)

Panel B. Cross-sectional variation in the treatment effect

	(1)	(2)	(3)	(4)
Secondary Board × HighLiteracyRate	0.714***			
	(0.106)			
Secondary Board × HighEduExpense		0.083*		
		(0.044)		
Secondary Board × HighTeacherPupilRatio			0.140**	
			(0.070)	
Secondary Board × HighIntakeRatio				0.112**
				(0.056)
Secondary Board	0.040**	0.014	0.018	0.010
	(0.019)	(0.010)	(0.012)	(0.010)
Ln(GDP)	0.066***	0.111**	0.103**	0.110**
	(0.022)	(0.055)	(0.048)	(0.053)
Ln(Labor)	-0.002	-0.019	-0.027	-0.035
	(0.019)	(0.036)	(0.037)	(0.042)
Constant	-0.175**	-0.320*	-0.281*	-0.296*
	(0.084)	(0.177)	(0.152)	(0.162)
Observations	551,296	551,296	551,296	551,296
Adjusted R-squared	0.745	0.738	0.740	0.739
Country × Industry FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 7. Channel Tests: Promoting VC Financing

This table reports tests of the financing channel through which the opening of secondary boards affects entrepreneurial activities. Panel A examines the effect of secondary boards on VC financing. The dependent variable *Ln(Amount Raised)* in column (1) of Panel A is the natural logarithm value of 1 plus the total amount of capital raised by all private equity funds in country *i* and year *t* , converted to constant 2015 US dollars. The dependent variable *Ln(Fund Size)* in column (2) of Panel A is the natural logarithm value of 1 plus the sum of net assets under management for all private equity funds in country *i* and year *t*, converted to constant 2015 US dollars. The dependent variable *Ln(Equity Invested)* in column (3) of Panel A is the natural logarithm value of 1 plus the total dollar amount of equity investment made by all private equity funds in country *i* and year *t* , converted to constant 2015 US dollars. The dependent variable *Ln(# Firm Invested)* in column (4) of Panel A is the natural logarithm value of 1 plus the total number of companies invested by all private equity funds in country *i* and year *t*. Panel B reports the heterogeneous treatment effects. The dependent variable in Panel B is *Ln(#Startups+1)*. The interacting variable in column (1) of Panel B is *HighShareholderProtection*, a dummy variable that equals 1 if the shareholder protection index is above the sample median and 0 otherwise. The interacting variable in column (2) of Panel B is *HighIPOProceeds*, a dummy variable that equals 1 if the total IPO proceeds in country *i* and year *t* is greater than the sample median and 0 otherwise. The interacting variable in column (3) of Panel B is *HighIPONumber*, a dummy variable that equals 1 if the total number of IPOs in country *i* and year *t* is greater than the sample median and 0 otherwise. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Secondary boards and VC investment

	(1)	(2)	(3)	(4)
	Ln(Amount Raised)	Ln(Fund Size)	Ln(Equity Invested)	Ln(# Firm Invested)
Secondary Board	0.626**	0.622**	0.460***	0.397**
	(0.255)	(0.255)	(0.172)	(0.160)
Ln(GDP)	0.922*	0.922*	0.892**	0.734**
	(0.502)	(0.503)	(0.392)	(0.354)
Ln(Labor)	-0.0848	-0.0785	-0.151	-0.130
	(0.431)	(0.431)	(0.275)	(0.256)
Constant	-2.657	-2.664	-3.296**	-2.455*
	(1.943)	(1.947)	(1.483)	(1.328)
Observations	2,697	2,697	2,697	2,697
R-squared	0.665	0.666	0.616	0.680
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 7. (continued)

Panel B. Cross-sectional variation in the treatment effect

	(1)	(2)	(3)
Secondary Board × HighShareholderProtection	0.082**		
	(0.041)		
Secondary Board × HighIPOProceeds		0.074***	
		(0.004)	
Secondary Board × HighIPONumber			0.174**
			(0.081)
Secondary Board	-0.005	0.057**	0.051**
	(0.019)	(0.025)	(0.022)
Ln(GDP)	0.112**	0.093**	0.098**
	(0.056)	(0.042)	(0.045)
Ln(Labor)	-0.031	-0.016	-0.017
	(0.041)	(0.032)	(0.032)
Constant	-0.309*	-0.255*	-0.277*
	(0.175)	(0.136)	(0.147)
Observations	551,296	551,296	551,296
Adjusted R-squared	0.738	0.742	0.741
Country × Industry FE	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes

Table 8. Channel Tests: Increasing IP Transactions

This table reports tests of the IP transaction channel through which the opening of secondary boards affects entrepreneurial activities. It examines the effect of secondary boards on the incidence of patent assignment transactions and M&A activities. The dependent variables are defined at the country-year level. Specifically, the dependent variable *Ln(#Assign_Trans+1)* in column (1) of Panel A is the natural logarithm of 1 plus the total number of patent assignment transactions after removing employer assignments for a particular country in a given year. The dependent variable in column (2) of Panel A, *Ln(#Deal+1)*, is the natural logarithm of 1 plus the total number of high-tech M&A events. The dependent variable in column (3) of Panel A, *Ln(#PublicDeal+1)*, is the natural logarithm of 1 plus the total number of high-tech M&A events, requiring the acquirer to be a public firm. Panel B reports the heterogenous treatment effect based on the percentage increase in patent liquidity. We quantify the increase in patent liquidity as the percentage increase in the five-year average of the number of patent transactions, the number of high-tech M&A deals, and the number of public high-tech M&A deals, respectively. The dependent variable in Panel B is *Ln(# Startups +1)*. Detailed variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Secondary boards and patent transactions

	(1) Ln(#Assign_Trans+1)	(2) Ln(#Deal+1)	(3) Ln(#PublicDeal+1)
Secondary Board	0.693***	0.461***	0.245*
	(0.161)	(0.141)	(0.133)
Ln(GDP)	0.103	0.456*	0.490*
	(0.254)	(0.235)	(0.253)
Ln(Labor)	-0.653*	-0.439	-0.330
	(0.377)	(0.336)	(0.208)
Constant	1.670**	0.126	-0.813
	(0.832)	(0.776)	(0.773)
Observations	4,307	4,307	4,307
Adjusted R-squared	0.922	0.914	0.889
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Table 8. (continued)

Panel B. Heterogenous treatment effects

	(1)	(2)	(3)
Secondary Board × MorePatentTrans (a)	0.164**		
	(0.063)		
Secondary Board × LessPatentTrans (b)	0.007		
	(0.013)		
Secondary Board × MoreHighTechDeals (a)		0.163**	
		(0.067)	
Secondary Board × LessHighTechDeals (b)		0.010	
		(0.012)	
Secondary Board × MorePublicDeals (a)			0.197**
			(0.086)
Secondary Board × LessPublicDeals (b)			0.017
			(0.014)
Ln(GDP)	0.101**	0.103**	0.098**
	(0.049)	(0.049)	(0.046)
Ln(Labor)	-0.018	-0.019	-0.014
	(0.035)	(0.035)	(0.032)
Constant	-0.284*	-0.294*	-0.277*
	(0.156)	(0.157)	(0.149)
Observations	551,296	551,296	551,296
Adjusted R-squared	0.740	0.740	0.741
Country × Industry FE	Yes	Yes	Yes
Technology × Year FE	Yes	Yes	Yes
F -statistic of the test: (a) =(b)	6.86***	5.56**	4.40**

Table 9. Placebo Test: Effect of Secondary Stock Exchange on Entrepreneurial Activity Measured by Trademarks

This table reports a placebo test: the impact of secondary boards on the number of startups constructed with trademarks. Columns (1) and (2) display results without and with country-level controls. The dependent variable is *Ln (# Startups+1)_TM,* the natural logarithm of 1 plus the number of firms that file for trademarks for the first time in year *t* and apply for fewer than 5 trademarks in year *t*. For countries that introduce entrepreneurial boards, the indicator variable *Secondary Boards* takes the value of 1 for the period after the introduction of such a board, and 0 for the period prior to the introduction. For countries that never introduce second-tier boards in our sample period, *Secondary Boards* always takes the value of 0. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Secondary Board	0.082	0.111
	(0.112)	(0.107)
Ln(GDP)		0.600**
		(0.247)
Ln(Labor)		-0.505
		(0.402)
Constant	3.156***	1.338
	(0.025)	(0.925)
Observations	3,385	3,385
Adjusted R-squared	0.944	0.946
Country FE	Yes	Yes
Year FE	Yes	Yes

Table 10. Alternative Difference-in-differences Methods

This table reports the static effect estimates from alternative DiD methods used to examine the impact of secondary boards on entrepreneurial activities. Columns (1)-(3) apply the approaches in Cengiz et al. (2019), Sun and Abraham (2021), and Borusyak et al. (2021), respectively. The dependent variable is *Ln (# Startups+1),* the natural logarithm of 1 plus the number of organizations that are first-time applicants and have applied for fewer than five patents in year t. For countries that introduce an entrepreneurial board, the indicator variable *Secondary Boards* takes the value of 1 for the period after the introduction of such a board, and 0 for the period prior to the introduction. For countries that never introduce a secondary board in our sample period, *Secondary Boards* always takes the value of 0. Variable definitions are provided in the Appendix Table A1. We report robust standard errors clustered at the country level in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) Cengiz et al. (2019)	(2) Sun and Abraham (2021)	(3) Borusyak et al. (2021)
Secondary Board	0.064***	0.049***	0.051***
	(0.004)	(0.004)	(0.004)

Table 11. Robustness Tests

Panel A tests the robustness of our baseline regression (column (4) of Table 3) with alternative definitions of the dependent variables *Ln(# Startups+1)*. The dependent variable in column (1) is *Ln(# Startups1+1)*, the natural logarithm of 1 plus the number of organizations that are first-time applicants in year *t*. The dependent variable in column (2) is *Ln(# Startups2+1)*, the natural logarithm of 1 plus the number of organizations that are first-time applicants and applied for fewer than 3 patents in year *t*. The dependent variable in column (3) is *Ln(# Startups3+1)*, the natural logarithm of 1 plus the number of organizations that are first-time applicants and applied for fewer than 10 patents in year *t*. Panel B addresses the underreporting bias. The dependent variable is *Ln(# Startups+1)*. The interacting variable in column (1) is *UnderReporting1*, an integer rank variable in the range of 0 to 3 indicating the degree of under-reporting bias. A higher value implies greater under-reporting. The interacting variable in column (2) is *UnderReporting2*, an integer rank variable in the range of 0 to 5 indicating the degree of under-reporting bias. A higher value implies greater under-reporting. Panel C addresses the potential bias caused by the liner "log1plus" regressions by exploiting fixed effect Poisson models, suggested by Cohn et al. (2022). The dependent variables are the number of startups (*# Startups*), and the rest of the specification is identical to Table 2. Variable definitions are provided in the Appendix Table A1. Robust standard errors clustered at the country level are reported in parentheses. The superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Alternative Definitions of Entrepreneurial Activities

	(1)	(2)	(3)
	Ln(# Startups1+1)	Ln(# Startups2+1)	Ln(# Startups3+1)
Secondary Board	0.070**	0.069**	0.070**
	(0.032)	(0.032)	(0.032)
Ln(GDP)	0.111*	0.110*	0.111*
	(0.056)	(0.056)	(0.056)
Ln(Labor)	-0.030	-0.029	-0.030
	(0.042)	(0.041)	(0.042)
Constant	-0.307*	-0.302*	-0.307*
	(0.176)	(0.173)	(0.176)
Observations	551,296	551,296	551,296
Adjusted R-squared	0.738	0.736	0.738
Country × Industry FE	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes

Table 11. (continued)

Panel B. Effects of Underreporting Problem

	(1)	(2)
Secondary Board	0.105**	0.099***
	(0.041)	(0.036)
Secondary Board × UnderReporting1	-0.027***	
	(0.010)	
Secondary Board × UnderReporting2		-0.012**
		(0.006)
Ln(GDP)	0.111*	0.111*
	(0.056)	(0.056)
Ln(Labor)	-0.025	-0.026
	(0.041)	(0.042)
Constant	-0.312*	-0.313*
	(0.176)	(0.175)
Observations	551,296	551,296
Adjusted R-squared	0.738	0.738
Country × Industry FE	Yes	Yes
Industry × Year FE	Yes	Yes

Table 11. (continued)

Panel C. Alternative Regression Specification

	(1)	(2)	(3)	(4)
Secondary Board	0.372*	0.093***	0.097***	0.102***
	(0.203)	(0.034)	(0.036)	(0.039)
Ln(GDP)		2.178***	2.193***	2.197***
		(0.175)	(0.189)	(0.199)
Ln(Labor)		-0.058	-0.124	-0.224
		(0.444)	(0.470)	(0.478)
Constant	5.223***	-10.040***	-11.850***	-13.390***
	(0.131)	(1.500)	(1.608)	(1.642)
Observations	4,191	4,191	23,533	139,278
Year FE	Yes	Yes	No	No
Country × Industry FE	Yes	Yes	Yes	Yes
Industry × Year FE	No	No	Yes	Yes
Obs unit	Country-Yr	Country-Yr	Country-1D Technology-Yr	Country-3D Technology-Yr

Appendix

Table A1. Variable Definitions

	Units	Description	Source
Firm Data			
Ln(# Startups+1)	Count	The natural logarithm of 1 plus the number of firms that are first-time applicants and apply for fewer than 5 patents in year *t*.	USPTO
Ln(# Startups1+1)	Count	The natural logarithm of 1 plus the number of organizations that are first-time applicants in year *t*.	USPTO
Ln(# Startups2+1)	Count	The natural logarithm of 1 plus the number of firms that are first-time applicants and applied for fewer than 3 patents in year *t*.	USPTO
Ln(# Startups3+1)	Count	The natural logarithm of 1 plus the number of firms that are first-time applicants and applied for fewer than 10 patents in year *t*.	USPTO
Ln (# Startups+1*)*_TM	Count	The natural logarithm of 1 plus the number of firms that are first-time trademark applicants and apply for fewer than 5 trademarks in year *t*.	USPTO
Exchange Data			
Entry Year	Year	The year in which a country introduced a new secondary board.	Bernstein, Dev, and Lerner (2020) and hand-collected
Exit Year	Year	The year in which a country closed an existing secondary board.	Bernstein, Dev, and Lerner (2020) and hand-collected
Secondary Board	Dummy	For countries that introduce the secondary board, the indicator variable *Secondary Board* takes the value of 1 for the period after the entry year and before the exit year (if any), and 0 for the period prior to the introduction. For countries that never introduce such boards in our sample period, *Secondary Board* always takes the value of 0.	-
Country Data			
GDP	Constant 2015 US$	The country-year-level sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Figures are converted to constant 2015 US dollars.	World Bank World Development Index
Labor	Count	Size of labor force. The country-year-level count of people ages 15 and older who supply labor for the production of goods and services during a given year.	World Bank World Development Index
MarketCapListed	Percent	Market capitalization of listed domestic companies measured as a percentage of GDP.	World Bank Financial Sector
FDINetInflow	Percent	Net inflows of investment, expressed as a percentage of GDP, for the purpose of acquiring a lasting management stake (10 percent or more of voting stock) in a company operating in an economy other than that of the investor,	World Bank Financial Sector
Income Group	Category	World Bank classifies each economy into 1 of these 4 categories: low, lower-middle, upper-	World Bank Global Financial

		middle, and high-income[22]. Countries with a GNI per capita (calculated using the World Bank Atlas method) of $1,085 or less in 2021 are classified as the low-income group; those with a GNI per capita between $1,086 and $4,255 are lower-middle income economies; those with a GNI per capita between $4,256 and $13,205 are upper-middle-income economies; and those with a GNI per capita of $13,205 or above are high-income economies.	Development Database November 2021 version
Region	Category	World Bank assigns each economy to 1 of the 7 groups according to its geographic location[23]: East Asia and Pacific, Europe and Central Asia, Latin America & the Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa.	World Bank Global Financial Development Database November 2021 version
Ln(Amount Raised)	Constant 2015 US$	The natural logarithm value of 1 plus the total dollar value of capital raised by all private equity funds in country *i* and year *t*. Figures are converted to constant 2015 US dollars.	Refinitiv Eikon Private Equity and Venture Capital
Ln(Fund Size)	Constant 2015 US$	The natural logarithm value of 1 plus the sum of assets under management for all private equity funds in country *i* and year *t*. Figures are converted to constant 2015 US dollars.	
Ln(Equity Invested)	Constant 2015 US$	The natural logarithm value of 1 plus the sum of equity investment made by all private equity funds in country *i* and year *t*. Figures are converted to constant 2015 US dollars.	
Ln(# Firm Invested)	Count	The natural logarithm value of 1 plus the sum of the number of companies invested by all private equity funds in country *i* and year *t*.	
HighShareholderPro-tection[24]	Dummy	A dummy variable that equals 1 if the shareholder protection index is above the sample median in year 2015, and 0 otherwise. Shareholder Protection is a score on a scale from 0 to 100, for which 0 denotes the worst performance.	The historical data of World Bank's Doing Business – Protecting Minority Investors database.
HighProceeds	Dummy	A dummy variable that equals 1 if the total IPO proceeds in country *i* and year *t* is greater than the sample median and 0 otherwise.	SDC Platinum
HighIPONumber	Dummy	A dummy variable that equals 1 if the number of IPOs in country *i* and year *t* is greater than the sample median and 0 otherwise.	SDC Platinum
HighLiteracyRate	Dummy	A dummy variable that equals 1 if the adult literacy rate measured at year 1990 or the earliest available year is above the sample median and 0 otherwise.	World Bank Education Statistics
HighEduExpense	Dummy	A dummy variable that equals 1 if the government expenses on tertiary education as a % of GDP measured at year 1990 or the earliest available year is above the sample median and 0 otherwise.	World Bank Education Statistics

[22] Detailed classifications are available at https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022

[23] Detailed grouping is available at https://datahelpdesk.worldbank.org/knowledgebase/articles/906519

[24] The index is available as part of the World Bank's Doing Business database since 2006. The coverage of all countries in our sample is incomplete until 2013. There was a change in the index construction methodology in 2014; therefore, we use the 2015 minority shareholder protection index to exploit the cross-sectional variation.

HighTeacherPupilRat-io	Dummy	A dummy variable that equals 1 if the tertiary teacher-pupil ratio measured at year 1990 or the earliest available year is above the sample median and 0 otherwise.	World Bank Education Statistics
HighIntakeRatio	Dummy	A dummy variable that equals 1 if the tertiary intake ratio measured at year 1990 or the earliest available year is above the sample median and 0 otherwise.	World Bank Education Statistics
Ln(#Assign_Trans+1)	Count	The natural logarithm of 1 plus the total number of patent assignments excluding employer assignments in country *i* and year *t*.	UPAD
Ln(#Deal+1)	Count	The natural logarithm of 1 plus the total number of high-tech M&A in country *i* and year *t*.	SDC Platinum
Ln(#PublicDeal+1)	Count	The natural logarithm of 1 plus the total number of high-tech M&A and requiring public acquirers in country *i* and year *t*.	SDC Platinum
UnderReporting1	Rank	An integer rank variable in the range of 0 to 3 indicating the degree of under-reporting bias. A higher value implies greater under-reporting. Specifically, we compute the ratio of the number of patents filed in the US to the total number of patents filed locally and sort this ratio to terciles. Note that we assume countries that file for 0 patents in the US exhibit the greatest degree of under-reporting and are therefore assigned a rank of 3.	World Bank World Development Index & USPTO
UnderReporting2	Rank	An integer rank variable in the range of 0 to 5 indicating the degree of under-reporting bias. A higher value implies greater under-reporting. Specifically, we compute the ratio of the number of patents filed in the US to the total number of patents filed locally and sort this ratio to quintiles. Note that we assume countries that file for 0 patents in the US exhibit the greatest degree of under-reporting and are therefore assigned a rank of 5.	World Bank World Development Index & USPTO
Industry Data			
HighSecondary-Dependent1	Dummy	To construct the dummy variable *HighSecondaryDependent1*, we first make use of the patent-CRSP link file in KPST (2021) to confirm patent numbers of listed firms and merge them with USPTO data to determine the industry code (CPC code) for patents. We then merge the resultant data with the SDC New Issues database to screen IPO firms and then with CRSP data to screen firms that are listed in NASDAQ. Finally, we sort all industries into two groups based on the number of occurrences of these industries over the period of 1980 to 1989. The dummy variable *HighSecondaryDependent1* takes the value of 1 if industry *j* belongs to the top half, and 0 otherwise.	USPTO, KPST (2021), CRSP and SDC Platinum
HighSecondary-Dependent2	Dummy	The construction of *HighSecondaryDependent2* is similar to that of *HighSecondaryDependent1* except that it takes the value of 1 if industry *j* belongs to the top tercile of all industries associated with NASDAQ IPO firms over 1980-1989, and 0 otherwise.	USPTO, KPST (2021), CRSP and SDC Platinum
Inventor Data			

Experienced	Percent	The number of inventors who have applied for patents before out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
LessExperienced	Percent	The number of inventors who have applied for 1 to 5 (1<n<5) patents before out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
MoreExperienced	Percent	The number of inventors who have applied for greater than or equal to 5 (n≥5) patents before out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
FromCorp	Percent	The number of inventors who work in for-profit corporations out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
BigToSmall	Percent	The number of inventors who used to work for big firms[25] (firms that have applied for more than 5 patents before) but not now out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
Old	Percent	The number of inventors whose career age (number of years since her first patent application) is above the sample median out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO
Young	Percent	The number of inventors whose career age (number of years since her first patent application) is below the sample median out of the total number of inventors in a particular country-3-digit technology subsection unit in a given year.	USPTO

[25] Alternative tests of "big firms" are available upon request.

Table A2. The List of New Secondary Boards

Country	Exchange	Entry Year	Exit Year
Argentina	Pyme Board	2005	
Armenia	NASDAQ OMX Armenia Second List	1997	
Australia	SIM VSE	2010	
Austria	Direct Market Plus	2019	
Barbados	Barbados Junior Market	1999	
Belgium	Euro Assoc of Sec Dealers Auto Quot	1996	2003
Belgium	Alternext Brussels	2005	
Botswana	Botswana Venture Capital Market	2001	
Botswana	Tshipidi SME Board	2017	
Brazil	Brazil OTC	1994	
Brazil	Sociedade Operadora Mercado Ativos	1996	
Brazil	Novo Mercado Brazil	1998	
Bulgaria	SME Growth Market beam	2018	
Canada	TSX Venture Exchange	1990	
Canada	NEX Board	2001	
Canada	Canadian National Stock Exchange	2003	
Chile	Santiago Stock Exchange Venture	2015	
China	Shenzhen Small & Medium Enterprise	2004	
China	Shenzhen ChiNext	2009	
Croatia	Progress Market	2018	
Cyprus	Cyprus Stock Exchange Emerging Companies Market	2000	
Cyprus	Emerging Companies Market	2000	
Czech Republic	START Market	2019	
Denmark	Copenhagen Share Market II	1990	
Denmark	GXG Markets	1998	2015
Denmark	First North Copenhagen	2006	
Egypt	Nile Stock	2010	
Estonia	First North Tallin	2007	
Finland	Finnish First North	2007	
France	Euronext Paris Marche Libre	1996	2000
France	Euronext Paris Nouveau Marche	1996	2000
France	Paris OTC	1996	2000
France	Paris Second Market	1996	2000
France	Alternext Paris	2005	
France	Euronext Paris Second Marche	2005	
Germany	Frankfurt Neuer Market	1996	2003
Germany	German NM	1997	2002
Germany	Smax	1999	2003
Greece	Athens Alt	2007	
Iceland	Irish Enterprise Securities Market	1995	

Iceland	First North Iceland	2006	
India	The OTC Exchange of India	1990	2015
Italy	Milan Star	1999	
Italy	Nuovo Mercato	1999	
Italy	Mercato Alternativo del Capitale	2012	
Jamaica	Jamaica Stock Exchange Junior Market		
Japan	TSE JASDAQ	1991	
Japan	NASDAQ Japan Standard	1996	
Japan	Osaka New Market Section	1996	
Japan	Mothers	1999	
Japan	Nagoya Stock Exchange Centrex	1999	
Japan	Sapporo Ambitious	1999	
Japan	Fukuoka-Q Board	2000	
Japan	Tokyo Aim	2009	
Japan	Japan OTC	2013	
Jordan	Amman Bourse Second Market	1999	
Korea	KOSDAQ	1996	
Korea	Korea Freeboard Market	2010	
Lebanon	Beirut (Second Market)	2016	
Libya	Libyan Stock Market B Market	2007	
Malaysia	Kuala Lumpur Second Board	1991	
Malaysia	ACE Market	1997	
Morocco	Casablanca Development Market	1997	
Morocco	Casablanca Growth Market		
Netherlands	Euronext Growth	2005	
New Zealand	New Zealand Alternative Market	2007	2015
New Zealand	NXT Market	2015	2017
Norway	Oslo-OTC	1999	
Norway	Oslo Axess	2007	
Palestine	Palestine Securities Exchange Second Market	1995	
Poland	Warsaw Parallel Market	1991	
Poland	Warsaw Unregulated Market	1991	
Poland	New York OTC	2007	
Portugal	Euronext Lisbon Second Market	1990	
Portugal	Alternext	2005	
Singapore	Singapore Second Market	1990	1999
Singapore	Singapore SESDAQ	1990	2008
Singapore	Singapore Exchange Catalist Market	2008	
Slovakia	Bratislava Junior Market	1993	
Spain	Madrid Second Market	1997	
Spain	Mercado Alternativo Bursatil	2008	
Sweden	NASDAQ OMX Stockholm OTC Market	1996	
Sweden	Aktietorget	1997	
Sweden	First North Stockholm	1997	

Switzerland	Switzerland New market	1999	2002
Switzerland	Sparks	2021	
Syria	Damascus Growth Market	2009	
Tanzania	Dar es Salaam Enterprise Growth Market	2013	
Thailand	Thailand MAI	1998	
United Arab Emirates	Saadiyat Market	1996	1999
United Arab Emirates	NASDAQ Dubai Limited	2005	
United States	Emerging Company Mktplace of AMEX	1992	1995
United States	NYSE Arca	2006	
United States	NYSE Alternext US LLC	2008	
United Kingdom	Seaq International	1991	
United Kingdom	London Stock Exchange AIM Market	1995	
United Kingdom	London techMARK	1999	
United Kingdom	Stock Exchange Automated Quotations	1999	
United Kingdom	Specialist Fund Market	2010	
Zimbabwe	Zimbabwe secondary market	1996	