Industry-University Collaboration and Commercializing Chinese Corporate Innovation*

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Abstract

We examine how industry-university collaboration (IUC) enhances Chinese firms' commercialization of their technologies using a comprehensive dataset of medium-sized and large industrial firms and research universities in China. Measuring IUC with the occurrence and frequency of patents co-assigned to both firms and universities, we first document that firms with more IUC activities report more new product sales. Both dynamic difference-in-differences analysis and instrumental variable regressions support a causal interpretation of the positive relation. In addition, firms with more IUC activities produce more patents and patents that are of higher quality, are closer to basic science, and are more exploratory – all confirming an innovation-enhancing mechanism. Further evidence suggests that our results can be attributed to two channels through which firms benefit from IUC: knowledge acquisition and talent recruiting.

Keywords: Industry-University Collaboration, Corporate Innovation, Technology Commercialization, Technology Transfers, Knowledge Acquisition, Talent Recruiting

JEL codes: O31, O33

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1. Introduction

Since the initiation of Project 211 and Project 985 in the 1990s,[1] Chinese central and provincial governments have consistently increased their investment in research-oriented universities (Zhang, Patton, and Kenney, 2013; Jia and Li, 2021). Likewise, Chinese firms have also invested heavily in R&D and created a large number of patented inventions every year (Fang, Lerner, and Wu, 2017; Fang, He, and Li, 2020). With the surge of Chinese-made innovation among universities and corporates, the extent to which these two parties cooperate and create innovation has public and business policy implications. As Premier Keqiang Li advocated in the 2018 Summer Davos Forum, "*one of the characteristics of integration and innovation under the new development phase should be that the technological achievements of a large number of universities and research institutes could be effectively transferred to enterprises.*"[2]

In this paper, we examine whether and how industry-university collaboration (IUC) enhances corporates' technology commercialization using a comprehensive census of industrial firms in China.[3] The IUC effect lacks large-scale empirical analysis in the literature, perhaps for the following reasons: first, prior IUC research tends to focus on the benefits to universities rather than to corporates (e.g., Link and Siegel, 2005; Siegel and Wright, 2015). Second, due to the lack of firm-level technology commercialization data, empirical studies of corporate innovation often rely on firms' patents and inventions instead of their revenue from these innovations. Instead, studies with firm-level technology commercialization data are based on small-scale survey data in developed countries. The role of IUC in Chinese firms' innovation, especially their commercialization of new technologies, is therefore an area calling for large-scale investigation.

Although university research is commonly regarded as more basic, it is not necessarily disconnected from market commercialization (Roberts and Peters, 1981; Chang, Yang, and Chen, 2009; Glenna et al., 2011). Basic research may have broader applications across technology fields, which creates synergies across product lines

[1] Project 985 was first announced on May 4, 1998 and Project 211 was initiated in November 1995. Both projects aim to promote the quality and reputation of the higher education system by founding world-class universities. The national Ministry of Education is the major coordinator of Project 985, while provincial and city Departments of Education play a more leading role in Project 211. The "985"-entitled universities and "211"-entitled universities are regarded as the first-tier and second-tier universities in the Chinese higher education system.

[2] Source: http://www.gov.cn/xinwen/2018-09/28/content_5326409.htm.

[3] Commercialization is a crucial step of a firm that converts innovation and invention into profitability, competitiveness, and long-term performance (Adams, 1990; Damanpour, 1991; Cooper, 2000; Zahra and Nielsen, 2002). Prior studies on firm-level technology commercialization are mainly based on small-scale survey data in developed countries (Kaufmann and Tödtling, 2001; Becker and Dietz, 2004; Belderbos, Carree, and Lokshin, 2004; Motohashi, 2005; Laursen and Salter, 2006; Berchicci, 2013; Maietta, 2015; Walsh, Lee, and Nagaoka, 2016).

(Pavitt, 1991). Basic research may also allow firms to be on the technological frontier and enable a first mover strategy (Rosenberg, 1990). In addition, universities serve as hubs of social and information networks (Obukhova, Wang, and Li, 2012). As a result, IUC facilitates basic technology transfers from universities to corporates, which may promote firms' commercialization efforts.[4] In Section A of the Online Appendix, we provide a more complete review of the literature for the IUC and its potential effect on Chinese firms' technology commercialization.

We start from the National Bureau of Statistics firm-level dataset (hereafter, "NBS data"), which is a census of over 0.5 million unique industrial firms from 1998 to 2013. The most important variable in the dataset is the firms' new product sales (i.e., the revenue from new products that are introduced to the market for the first year or are defined by the government), which is a compulsory accounting item in the NBS data, and allows us to measure firms' technology commercialization. This sample set is comprehensive because it is not subject to any selection or survivorship issues, and is not limited to specific industries. We also collect these firms' patent information from the China National Intellectual Property Administration (CNIPA) by matching firm names with patent assignee names. As a result, we identify nearly 2.8 million patents that were applied by (and were later granted to) these firms from 1994 to 2016.

To capture these firms' IUC activities, we first construct a list of 153 universities including the 39 "985"-entitled universities, 112 "211"-entitled universities, and notable research institutes such as Chinese Academy of Sciences and Chinese Academy of Social Sciences. We identify over 0.5 million university patents that were applied by (and were later granted to) these universities from 1994 to 2016.

In the last step of our data collection, we identify over 20 thousand IUC patents with each co-assigned to a sample firm and a sample university. We measure a firm's IUC activities using the existence or the intensity of its IUC patents in the most recent three years. Our final sample period includes over 90 thousand unique patenting firms after excluding those which are likely to be university spin-offs.

Our empirical analysis suggests that firms with a higher level of IUC activities are associated with more new product sales in the following three years. This relation remains robust when we include: (1) firm fixed effects to control for firm-invariant characteristics such as corporate culture; (2) province-by-year fixed effects to control

[4] Consistent with this hypothesis, Mansfield's (1991) survey of 76 firms suggests that prior academic research facilitated about 10 percent of new products and processes. Using a survey among 517 European firms, Kaufmann and Tödtling (2001) find that firms' forming partnership with universities is associated with higher rates of product inventions. Kafouros et al. (2015) find a significant effect of university collaboration on firms' new product sales using the survey data of 400 innovative Chinese companies for the 2008-2011 period.

for local innovation policies, and (3) industry-by-year fixed effects to control for industry cycles, as well as an extensive list of innovation-related and other firm characteristics. In terms of economic magnitude, we find that engaging in any IUC (versus not) is associated with an increase of 61-63% (relative to the sample mean) in new product sales. In addition, a firm's IUC intensity increase by one standard deviation is associated with an increase of 3-5% (relative to the sample mean) in new product sales.

To strengthen a causal interpretation for the positive relation between IUC and new produce sales, we employ staggered difference-in-differences (DiD) analysis based on policy shocks and instrumental variable regressions. We first utilize university science park establishment as shocks to regional IUC activities, as these initiatives were promoted by local governments rather than universities and corporates (Tan, 2006). We find that establishing university science parks enhances local firms' IUC and new product sales. We also use the frequency of IUC mentions in provincial governments' official newspapers to measure their emphasis on IUC, which serves as an instrumental variable that affects universities and IUC but does not directly influence corporate operations. We find that the instrumented IUC variables still significantly explain local firms' new product sales.

Further subsample analysis indicates that the relation between IUC and technology commercialization is more pronounced for firms in industries whose innovation relies more on basic science or university innovation. These results further support the view that firms' technology commercialization performance benefits from technology transfers in IUC.

We propose that IUC enhances firms' technology commercialization by improving their innovation capability (patenting outcomes) and find supportive evidence. We find that, for firms engaging in any IUC, their number of patents and average forward citations per patent are 27-31% and 11-12%, respectively, higher than those without IUC. We additionally examine other attributes of corporate patent outputs. Consistent with the arguments that IUC helps firms access more fundamental science and expands their technology base, we find that IUC is associated with corporate patents that rely more on basic research, are more exploratory in new directions, and are of higher technology breadth. These additional results highlight the role of universities in strengthening firms' science foundation and expanding firms' technology search areas, which in turn improves firms' technology commercialization.

In the final set of empirical analyses, we test the two specific channels of technology transfer: knowledge acquisition and talent recruitment (Prager and Omenn, 1980; Mowery and Ziedonis, 2014; Babina et al. 2020). As argued by Prager and

Omenn (1980), firms could benefit from IUC for "*additional sources of ideas, knowledge, and technology on which to base potential new products and processes*" [5] and for "*source[s] of potential research employees sympathetic to industry needs.*" [6] These two channels receive strong empirical support: based on over 3 million patents and 1.4 million patent citing-cited pairs, we find that firms with higher IUC intensity are more likely to cite university patents. In addition, based on the data of 1.3 million unique inventors[7] and 13 million inventor-patent pairs, we document that firms with higher IUC intensity are more likely to hire former university inventors.[8] These findings collectively highlight the unique role of university technologies in firms' development and commercialization of technologies, suggesting the importance of IUC and universities' technology transfers in economic growth.

This study adds to the literature in the following ways. First, our unique dataset, covering over 2.7 million patents of about 93 thousand medium-sized and large industrial firms and 0.6 million patents assigned to 153 universities in China for the 1994-2016 period, enables us to provide novel, large-scale evidence on the effect of IUC on firms' technology commercialization, especially from the perspective of emerging countries.[9] Previous studies, such as Eisenhardt and Schoonhoven (1990), Nevens et al. (1990), Brown, Berry, and Goel (1991), George et al. (2002), Eesley, Hsu, and Roberts (2014), among others, have identified that the composition of research teams, technological capacity, market position, management techniques, and corporate culture are factors that influence the effectiveness of a firm's technology commercialization. We contribute to this stream of the literature by showing IUC as an additional driving force, which complements the finding of Mansfield (1991).

Second, this paper also adds to the literature on how universities' innovation

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[5] Consistent with this view, the survey on R&D managers by Cohen, Nelson, and Walsh (2002) points out that firms learn from universities through published papers and reports, public conferences and meetings, informal information exchange, and consulting. The literature on between-firm collaboration has documented that collaboration facilitates cross-learning (Powell, Koput, and Smith-Doerr, 1996; Cassiman and Veugelers, 2002), which is likely effective in IUC because learning from university research lowers the R&D costs of firms (Belderbos, Carree, and Lokshin, 2004; Scandura, 2016).

[6] As IUC creates opportunities for university researchers, corporate managers, and R&D staff to interact, it could increase inventor flows into industry (Lee, 1996). As patent inventors from universities can bring in new knowledge that are complementary to research experience of incumbent corporate R&D staff, such inflow is conducive to corporate innovation (Østergaard, Timmermans, and Kristinsson, 2011; Qian, Cao, and Takeuchi, 2013; Che and Zhang, 2018). In addition, there may exist synergies from the integration of basic research and commercial development may enhance innovation efficiency (Gittelman and Kogut, 2003; Walsh, Lee, and Nagaoka, 2016).

[7] We acknowledge the difficulty in identifying individual Chinese inventors using their names. Therefore, we conduct several robustness checks at the end of Section 5.

[8] We conduct placebo tests using sample firms' citations to other firms' patents and their recruitment of inventors from other firms and do not find any effect, which confirms that our finding is only relevant to knowledge and inventor flows from universities.

[9] Prior studies on China's university-industry link include Motohashi and Yun (2007) and Kafouros et al. (2015).

influences firms. Jaffe (1989) presents empirical evidence for the positive effect of university spillover on local firms' patents, especially in high-tech industries, and Audretsch and Stephan (1996) show that university scientists bring valuable knowledge to local firms through employment or consultation relationships. Our various tests based on citations to basic science and inventor flows provide direct, large-scale evidence for how Chinese universities spill over to firms. Given the prominent role that university spillover plays in science and technology infrastructure (e.g., Furman, Porter, and Stern, 2002), this study offers insights to policy makers, university administrations, and firm managers.

Third, our research also contributes to the literature on the impact of technology partnership by presenting new evidence based on a particularly important emerging economy – China. The collaboration between universities and corporates is an important form of technology partnership but whether and how such collaboration enhances firms' innovation performance is subject to debate (e.g., Mowery et al., 2004) and still needs further empirical analysis in emerging economies. Some prior studies have also pointed out the barriers and obstacles to such collaborations (Siegel, Waldman, and Link, 2003; Bruneel, D'Este, and Salter, 2010). Our empirical analyses suggest that such collaboration seems to function well in China.

Finally, this research is related to the literature on firms' incentives to invest in basic research and their appropriability. Arora, Belenzon, and Patacconi (2018) have documented a consistent decline in corporates' investment in scientific research since the 1980s, which is especially true when their knowledge creation results in spillovers to rivals (Arora, Belenzon, and Sheer, 2020). A similar pattern is also observed in China. Motohashi and Yun (2007) find an increasing trend in Chinese manufacturing firms' outsourcing R&D to universities and public research institutes (PRIs) for the 1996-2002 period. The declining efforts in corporate scientific research due to intensified technology competition and declining appropriability of scientific research imply an increasingly important role of IUC in corporate innovation, which this study illuminates.

The rest of our paper is organized as follows. In Section 2, we describe our data and introduce the empirical measures of industry-university collaboration, technology commercialization, and innovation outputs. In Section 3, we first discuss the baseline results for the relation between IUC and corporate technology commercialization. We then propose identification tests to support causal inferences and conduct subsample analyses. In Section 4, we further examine the innovation-enhancing mechanism for IUC to influence technology commercialization. In Section 5, we empirically test two channels of technology transfers: knowledge acquisition and talent recruiting. We conclude the paper in Section 6. The Online Appendix contains an expanded literature review, detailed descriptions of the NBS data variables, the list of 153 universities, and some additional test results for robustness checks.

2. Data Sources and Variable Construction

2.1. Data sources

We start from the National Bureau of Statistics (NBS) firm-level dataset, which provides the complete accounting information of a full list of over 0.5 million unique industrial firms with annual revenue equal to or higher than 5 million RMB that operated from 1998 to 2013. Such a set of firms is not subject to any selection or survivorship issues, is not limited to specific industries and provinces, and is therefore representative of the heterogeneous characteristics of Chinese manufacturing firms. We follow the code of Brandt, Van Biesebroeck, and Zhang (2014) that allows us to track the same firm that changed its names over time.[10] Online Appendix Table OA.1 provides a comprehensive list of variables that are included in the NBS data.

We then collect patent information from the China National Intellectual Property Administration (CNIPA) and restrict our analysis to a sample of innovative firms that have patent records. After matching the firm names with the patent assignee names, we identify 2,789,133 patent applications (which were subsequently successfully granted) from 1994 to 2016 and 93,303 unique firms with at least one granted patent. Given the existence of university-run firms, university spin-offs, and professor-run firms that may bias our analysis of the IUC effect, we exclude any firm from our sample if it files IUC patents in its first three sample years. We thus have 92,521 unique patenting firms in our final sample.

We also collect the information of university patents. We focus on 39 "985"-entitled universities, 112 "211"-entitled universities, and notable research institutes such as the Chinese Academy of Sciences and Chinese Academy of Social Sciences. This results in a list of 153 universities. In our sample, all 153 universities have at least one IUC patent (which are listed in Online Appendix Table OA.2). As research resources are concentrated in well-established universities and research institutes in China, our sample of university patents is reasonably representative. We identify 553,316 university patents that were applied by (and were later granted to) these universities from 1994 to 2016.

2.2. IUC measures

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[10] To ensure continuous operation, we restrict to a sample of firms with accounting data in at least three consecutive years, yielding a firm-year dataset of 539,709 unique firms.

Based on our datasets of corporate patents and university patents, we define an industry-university collaborating (IUC) patent as one which is co-assigned to both a firm and a university (Hong, 2008; Walsh, Lee, and Nagaoka, 2016). In our sample period from 1994 to 2016, we identify 20,388 IUC patents. Despite our large-scale data efforts, we acknowledge two limitations of our IUC measures: first, our use of granted patents to measure IUC activities unavoidably limits us to only "successful" IUC activities. Second, as the NBS data only include industrial firms with annual revenue equal to or higher than 5 million RMB, we inevitably under-estimate the total number of IUC patents.

As shown in Figure 1 Panel A, the number of Chinese IUC patents per year increases dramatically from about 20 in 1994 to over 2,000 in 2016, reflecting both universities' and corporates' increasing efforts in collaborative innovation. In comparison, the number of IUC patents filed from 1994 to 2016 in the U.S. is quite stable, ranging from 280 to 650.[11] In addition, as illustrated in Figure 1 Panel B, the ratio of IUC patents as compared to all corporate patents in China fluctuates around 1% — it increases dramatically from 1999 to 2002 but declines gradually later on.[12] In contrast, the ratio of IUC patents relative to all corporate patents in the U.S. remains at 0.5%, which is much lower than that in China in the available sample period. These patterns suggest that IUC may play an important role in China's innovation development and warrants further investigation.

[Insert Figure 1 here.]

We measure a firm's IUC intensity in year t in three ways: dummy, count, and ratio. *IUC Dummy* equals one if the focal firm has an IUC patent filed in years $t-2$ to t, and zero otherwise.[13] *IUC Count* denotes the number of patents that are filed by both a university and the focal firm in years $t-2$ to t. *IUC Ratio* denotes the ratio of the number of patents filed by both a university and the focal firm over the total number of patents filed by the focal firm in years $t-2$ to t.

Table 1 shows the pooled distribution of the three measures of IUC intensity. Overall, 0.6% of firm-year observations have non-zero IUC patents (*IUC Dummy*). In addition, among the firm-year observations with at least one IUC patent, the mean and median of *IUC Count* are 1.66 and 1, respectively; and the mean and median of *IUC*

[11] For the US data, we use the Patentsview database and examine the assignee codes of all co-assignees of a patent to identify if it is assigned to a company and a university or research organization.

[12] The decline of the ratio of IUC around 2002 can be attributed to the fact that Chinese firms have become more willing to invest in in-house R&D due to global competition, government policies, and strengthened patent protection. Online Appendix Table OA.3 confirms that our baseline results are robust in two subsample periods.

[13] We use this three-year window due to the low frequency of patents of our sample firms, following Bena and Li (2014) and Hsu et al. (2018).

Ratio are 49.6% and 40.0%, respectively.

[Insert Table 1 here.]

2.3. Firm-level technology commercialization and innovation output

In the NBS data, firms are required to report their new product sales (i.e., the revenue from new products) in each year, which allows us to measure revenues associated with firms' innovation. According to the guidance provided by NBS, new products are defined by two non-mutually exclusive standards: first, products that are introduced to the market for the first time in a fiscal year; and second, products that are recognized as new products by relevant government departments (e.g., Science and Technology Committee, Development and Reform Commission, Economic Information Bureau, Bureau of Economy and Information Technology, and Market Supervision Bureau).

We measure a firm's future technology commercialization performance using its new product sales in years $t + 1$ to $t + 3$.[14] As our sample only includes innovative industrial firms, higher new product sales are likely to be attributed to their stronger performance in realizing revenue from commercializing their technologies. Table 1 shows that the average annual new product sales is 6.92 (=20.76÷3) million RMB, as compared to the average annual total sales of 125.83 million RMB (included as a control variable).

We also construct five measures for innovation outputs and characteristics at the firm level. In particular, we consider corporate patents that are only assigned to our sample firms and thus exclude patents that are also granted to co-assignees. The first two measures reflect innovation quantity and quality: *PatCount* denotes the number of patents (both invention model and utility model) that are filed by the focal firm from years $t + 1$ to $t + 3$; *PatCite* denotes the average number of forward three-year citations of each patent filed by the focal firm from years $t + 1$ to $t + 3$.[15] Table 1 shows that the mean of *PatCount* and *PatCite* in all firm-year observations are 3.29 and 0.09, respectively.

Following Trajtenberg, Henderson, and Jaffe (1997) and Fleming and Sorenson (2004), we construct *PatBasic* as the ratio of backward citations (i.e., references) to

[14] Prior literature has used new product sales from survey to measure technology commercialization or innovation performance (Kelm, Narayanan, and Pinches, 1995; Laursen and Salter, 2006; Berchicci, 2013).

[15] We focus on invention and utility patents as they are more related to technological development (Huang, 2010; Hu, Zhang, and Zhao, 2017). A patent's backward citations are defined as its patent reference documents (专利对比文件 in Chinese) listed in the patent authorization document (专利授权书 in Chinese).

non-patent prior art (mostly academic papers) divided by total backward patent citations that are filed by the focal firm from years $t + 1$ to $t + 3$.[16] A higher value of *PatBasic* suggests that a firm's patents cite academic papers more often and are thus more directly building on basic research. *PatExplore* denotes the ratio of exploratory patents over the number of patents filed by the focal firm from years $t + 1$ to $t + 3$. A patent is defined as an exploratory patent if its applicable primary International Patent Classification (IPC) codes are different from those of patents filed by the same firm in years $t - 2$ to t.[17] *PatExplore* measures how different a firm's future innovation outputs are from its historical innovation outputs in term of technology fields. As shown in Table 1, conditional on firm-year observations with a least one patent, the mean of *PatBasic* and *PatExplore* are 0.46 and 0.88, respectively.

Following Lerner (1995), we construct *TechBreadth* as the average number of unique primary IPC codes per patent filed by the focal firm in years $t + 1$ to $t + 3$.[18] Following such definitions, *TechBreadth* measures how a patent's technology can be generally applied *across* technology fields. Table 1 shows that, conditional on firm-year observations with a least one patent, the mean of *TechBreadth* is 1.22.

2.4. Control variables

In our empirical analysis, we control for total sales for the scaling effect and the following two innovation-related variables: *Patent Portfolio Size* denotes the number of patents filed by the focal firm in years $t - 2$ to t; and *R&D Intensity* is the ratio of a focal firm's R&D expenditure over its total assets in year t. In addition, we include the following firm characteristic control variables for focal firms in year t: *Total Assets*, the value of total assets; *Age*, the number of years in the gap between the registration year and the data year; *Cash Ratio*, the ratio of cash over total assets; *Capital Expenditure Intensity*, the ratio of capital expenditure over total physical assets; *Profitability Ratio*, the ratio of net profits over total sales; *Sales Growth*, the ratio of this year's total sales over last year's total sales minus one; *Leverage Ratio*, the ratio of total debts over total assets. We further control of additional variables: *Export Ratio*, the ratio of total exports over total sales; *Labor Ratio*, the ratio of employees over total assets; *Wage per Employee*, the ratio of labor costs over employees; and *Subsidy Ratio*, the ratio of

[16] Cassiman, Veugelers, and Zuniga (2008) show that firms' publication records and references to academic research are positively associated with firms' patent quality.

[17] If a patent has the following five detailed IPC codes: C22C19/00 (primary IPC is C22), C23C4/00 (primary IPC is C23), C23C4/02 (primary IPC is C23), H01L23/36 (primary IPC is H01), and H05K7/20 (primary IPC is H05), then its applicable primary IPCs include C22, C23, H01, and H05.

[18] If a patent has the following five detailed IPC codes: C22C19/00, C23C4/00, C23C4/02, H01L23/36, and H05K7/20, then it has four unique primary IPCs (i.e., C22, C23, H01, and H05) its measure of *TechBreadth* is 4.

government subsidies over total revenue. The summary statistics of these control variables are presented in Table 1.

3. IUC and Technology Commercialization

3.1. Baseline results

We employ the following ordinary least squares (OLS) regression model[19] to examine the association between firms' industry-university collaboration and their technology commercialization performance:

$$NewProductSales_{t+1\to t+3} = \beta \cdot IUC_{t-2\to t} + Controls + FEs + \varepsilon_t, \quad (1)$$

in which the dependent variable, $NewProductSales_{t+1\to t+3}$, denotes *New Product Sales* from year t+1 to t+3. The key independent variable, $IUC_{t-2\to t}$, represents various operationalized measures of IUC: *IUC Dummy*, *IUC Count*, or *IUC Ratio* from year t–2 to t. Besides total sales, innovation-related variables, and other firm characteristic control variables as discussed in the prior section, we include as regressors firm fixed effects, province-by-year fixed effects, and industry-by-year fixed effects. Firm fixed effects control for all time-invariant firm characteristics, such as an organization's culture of innovation; province-by-year fixed effects absorb all time-varying local factors, such as local institutional environments or government policies;[20] and industry-by-year fixed effects control for time-varying industry-specific factors, such as industry life cycles and innovation opportunities. We cluster standard errors by firm to accommodate all firm-specific variation in estimation errors, such as autocorrelation. The estimation results for Equation (1) are presented in Table 2.

[Insert Table 2 here.]

Table 2 presents a significantly positive relation between IUC and technology commercialization. All coefficient estimates are both statistically significant at the 5% level and economically significant. For instance, Panel A shows that firms engaging in any industry-university collaboration have significantly higher new product sales. When a sample firm becomes engaged in any IUC, its new product sales increase by 12.84 and 12.99 million RMB, as indicated in Columns (1) and (2), respectively; such numbers correspond to 61-63% of sample mean or 24% of sample standard deviation of *New Product Sales*.

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[19] The results of OLS regressions deliver clear economic interpretation to the coefficient estimates. In Online Appendix Table OA.4, we employ Poisson pseudo-maximum likelihood (PPML) regressions and confirm that our main findings are not driven by the right tail of the dependent variable.

[20] It is well documented that Chinese firms' innovation activities are sensitive to local institutional environments and government policies (including subsidies), see Huang, Geng, and Wang (2017) and Fang, He, and Li (2020).

Panel B implies that, when a firm's IUC intensity measured by *IUC Count* increases by one standard deviation, its *New Product Sales* increase by 1.09 (=0.14×7.78) and 1.12 (=0.14×8.00) million RMB in Columns (1) and (2), respectively, which correspond to 5% of the sample mean of the dependent variable. Panel C further indicates that the relation between IUC intensity and future technology commercialization is robust when we measure IUC intensity with *IUC Ratio*. Specifically, when a firm's *IUC Ratio* increases by one standard deviation, its *New Product Sales* increase by 0.64 (=0.05×12.78) and 0.65 (=0.05×12.93) million RMB in Columns (1) and (2), which correspond to 3% of the sample mean of the dependent variable.

All results presented in Table 2 point to a significant and robust positive association between industry-university collaboration and technology commercialization even when we include an extensive set of control variables and fixed effects, as previously noted.

3.2. Identification test: Policy shocks

Potential endogeneity issues limit a causal interpretation of the results presented thus far. On the one hand, some firms that are able to develop and commercialize their own technologies may be less motivated to engage in IUC – such a scenario may cause an underestimation of the IUC effect on corporate technology commercialization. On the other hand, some firms with better abilities to commercialize technologies may attract more universities to collaborate – such issue may cause us to overestimate the effect of IUC on corporate technology commercialization. We thus consider two tests to mitigate these endogeneity concerns: staggered difference-in-differences (DiD) analysis based on policy shocks, and instrumental variable regressions.

In our first identification test, we consider the establishment of university science parks as exogenous shocks to regional IUC activities and implement a dynamic DiD analysis. University science parks in China are initiated by local governments (Tan, 2006) rather than due to decisions made by corporations and managers. As advocated in the *Measures for the identification and administration of National University Science and Technology Parks* issued by the Ministry of Science and Technology and the Ministry of Education in 2019, university science parks should serve as a platform to facilitate industry-university collaboration and realize its social services function.[21] Although university science parks are usually established in the same city of the managing universities, the timing of their establishment is arguably exogenous. For

[21] Source: 国家大学科技园认定和管理办法, http://www.gov.cn/gongbao/content/2019/content_5416182.htm.

example, Tsinghua University in Beijing built its first university science park in 1993, while the science park of Shanghai Jiaotong University in Shanghai was not built until 2001. In addition, some university science parks were established geographically distant from their managing universities. For instance, the Chinese Academy of Sciences (located in Beijing) established a science park in Hangzhou in 2002. In sum, the main purpose of university science parks is to directly promote industry-university collaboration as well as technology transfers; in addition, their establishment is unrelated to managerial and firm choices.

To execute the DiD analysis, we first construct a dummy variable of *University Science Park (Post)*: If a firm's city establishes at least one university science park during or before year *t*, then *University Science Park (Post)* equals one; otherwise it equals zero.[22] Regressing IUC measured in *Dummy*, *Count*, or *Ratio* on *University Science Park (Post)* in Columns (1) of Table 3 Panels A1-A3, we find that the intensity of industry-university collaboration increases significantly after the establishment of university science parks.

We further assess the dynamics of the treatment effect by replacing *University Science Park (Post)* with six dummy variables indicating the two years prior to the treatment (i.e., *Event Year = -2* and *Event Year = -1*), the year of the treatment (i.e., *Event Year = 0*), the first and second years after the treatment (i.e., *Event Year = +1* and *Event Year = +2*), and three or more years after the treatment (i.e., *Event Year >= +3*). As shown in Columns (2) of Table 3 Panels A1-A3, for all measures of IUC intensity, the coefficients of pre-treatment dummies are economically small and statistically insignificant, which rules out preexisting trends. More importantly, the coefficients of post-treatment dummies are positive and statistically significant at the 5% level. This confirms that an average firm's IUC intensity increases after its city establishes a university science park.

[Insert Table 3 here.]

After confirming that the establishment of university science parks serves as positive shocks to industry-university collaboration, we regress our measure of corporate technology commercialization, *New Product Sales*, on *University Science Park (Post)* and report the results in Table 3 Panel B. As expected, through exogenously enhancing industry-university collaboration, the establishment of university science parks increases local firms' technology commercialization performance. Similarly, we find that the coefficients of pre-treatment dummies are economically small and

[22] To ensure that our sample is "balanced" before and after the treatments, it only includes firms that enter the sample before and exit the sample after the establishment of their regional university science parks.

statistically insignificant, which support that the parallel trends assumption is satisfied. More importantly, the coefficients of post-treatment dummies are positive and statistically significant at the 5% level. Table 3 thus supports a causal effect of IUC on corporate technology commercialization.

3.3. Identification test: instrumental variable regression

We further mitigate endogeneity concerns using instrumental variable regressions. We introduce a continuous instrumental variable based on local governments' variant policy guidance to industry-university collaboration, which is arguably exogenous to firms' decisions and choices. Specifically, the instrumental variable, *IV: Policy Guidance*, denotes the ratio of the number of articles mentioning "industry-university collaboration" (产学研 or 产学研合作 in Chinese) that are published in official newspapers affiliated with provincial governments in years *t* – 2 to *t* from 2000 to 2016. As argued by Ang, Cheng, and Wu (2014), the goal of provincial newspapers is to propagandize and interpret provincial policies – as a result, articles covered in such newspapers could largely reflect local governments' policy guidance. When *IV: Policy Guidance* is larger, the focal firm's IUC activities are more encouraged by policy guidance of local governments.

The results of the first-stage regressions are shown in Columns (1) across Panels A-C in Table 4, in which we regress each IUC measure on the instrumental variable and other control variables to generate *predicted* IUC measures. We confirm that both instrumental variables correlate positively with all three IUC measures (*IUC Dummy*, *IUC Count*, and *IUC Ratio*). The predicted IUC measures are denoted as "instrumented" IUC measures and are free of omitted variables. In the second stage, we regress *New Product Sales* on each instrumented IUC measure as independent variable in years *t* – 2 to *t*, the coefficient estimates on instrumented IUC measures are all statistically significant at the 10% statistical level as shown in Columns (2). As the under-identification *LM* statistics for weak instruments (Kleibergen and Paap, 2006) reject the null hypothesis, we confirm that the instrumental variable is strong.

We may also quantify the effect of IUC on technology commercialization based on the results. When we consider measuring IUC in *Count*, Column (2) in Panel B implies that a one-standard-deviation increase in IUC increases *New Product Sales* by 2.93 (=0.024×121.94) million RMB, which corresponds to 14% of the sample mean of the dependent variable.[23] When we consider measuring IUC in *Ratio*, Column (2) in Panel C indicates that a one-standard-deviation increase in IUC increases *New Product*

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[23] 0.024 is the standard deviation of the instrumented *IUC Count* in the first stage and 121.94 is the coefficient estimate of interest in the second stage in Panel B.

Sales by 0.62 (=0.003×205.15) million RMB, which corresponds to 3% of the sample mean of the dependent variable. Comparing the economic magnitudes in Table 4 with those in Table 2, we find that the endogeneity-free effect of IUC on technology commercialization is fairly estimated or slightly under-estimated in the baseline regressions.

[Insert Table 4 here.]

Table 4 thus mitigates various endogeneity problems and supports a causal interpretation of our baseline results, i.e., firms' IUC activities enhance their technology commercialization.

3.4. Heterogeneous effects across industries

As IUC strengthens technology transfers from universities to corporates, it is natural to expect that the effect of IUC on technology commercialization is more pronounced for firms in industries in which corporate innovation relies more on university innovation. Following Mansfield (1991, 1998), Klevorick et al. (1995), Narin, Hamilton, and Olivastro (1997), and Cohen, Nelson, and Walsh (2002), we propose two measures of reliance on science: *Citations to Basic Science* is the ratio of backward citations to non-patent prior arts over total backward citations of patents applied by (and finally granted to) firms in an industry; *Citations to University Patents* is the ratio of backward citations to university patents over total backward citations of patents applied by (and finally granted to) firms in an industry. Firms in an industry is expected to cite more non-patent prior arts (likely academic research) and university patents when the inputs of fundamental research are more essential to their innovation activities.

We implement subsample analyses in Table 5, in which we split our sample into a high group and a low group. In Panel A, we split all firm-year observations into two groups according to the sample median of *Citations to Basic Science*, and find that the association between IUC and technology commercialization remains strong and statistically significant for firms in the high group. However, this association is insignificant in the low group. Similar patterns appear in Panel B for *Citations to University Patents*.

Overall, results from the subsample analysis in Table 5 are largely consistent with our main argument that IUC facilitates technology transfers from universities to corporates. Moreover, these tests for heterogeneous treatment effects also strengthen a causal interpretation of our baseline results: if our results are driven by an unobserved factor, then that factor must necessarily correlate with our subsampling procedures to deliver the subsample results we show. As it is difficult for us to think of such a factor (other than technology transfers that we argue), our baseline results are more likely causal.

[Insert Table 5 here.]

4. The Innovation-Enhancing Mechanism of IUC

4.1. Patent quantity and quality

The literature has suggested that IUC enhances firms' innovation capability, which is likely the mechanism underlying our baseline results. In this section, we examine this innovation-enhancing mechanism by exploiting various patent-based variables in Chinese data. Our first two measures of innovation performance are *PatCount* that measures the quantity of innovation outputs and *PatCite* that measures the quality of innovation outputs (Trajtenberg, 1990; Sampat and Ziedonis, 2004; Hall, Jaffe, and Trajtenberg, 2005). Both variables are defined in Section 2. We regress these two variables on each of our three IUC measures, *IUC Dummy*, *IUC Count*, and *IUC Ratio*, together innovation-related control variables, firm characteristic control variables, as well as firm fixed effects, province-by-year fixed effects, and industry-by-year fixed effects.

The results are reported in Table 6, which shows that firms' IUC activities are positively associated with their innovation output in both quantity and quality. For example, using *PatCount* as the dependent variable in Panel A1, engaging in any IUC is associated with an increase of 0.86 and 0.74 in patent output in Columns (1) and (2), respectively, which correspond to 27-31% of the sample mean of *PatCount*. Panel A2 indicates that, when a firm's IUC intensity measured by *IUC Count* increases by one sample standard deviation, its patent output increases by 0.06 (=0.14×0.4139) and 0.05 (=0.14×0.3678) in Columns (1) and (2), respectively, which correspond to 2% of the sample mean of *PatCount*. Panel A3 further indicates that the relation between IUC intensity and future patent output is robust when we measure IUC intensity with *IUC Ratio*. Consistent results are found in Panel B when we use *PatCite*. All results remain robust when we employ Poisson regressions in Online Appendix Table OA.5.

[Insert Table 6 here.]

4.2. Patent basicness, exploration, and technology breadth

In addition to patent counts and forward citations, we further consider the following three measures defined in Section 2: *PatBasic* for patents' dependence on basic science, *PatExplore* for firms' exploration beyond their existing technology domain, and *TechBreadth* for firms' breadth in technology areas. Since universities specialize in fundamental research, the IUC-induced technology transfers could enhance the reliance of corporate innovation on basic science. Secondly, as patents that are more based on basic research tend to have broader applications (Trajtenberg, Henderson, and Jaffe, 1997), we expect IUC to be associated with more exploratory corporate innovation (i.e., different from the firm's existing technology expertise). Similarly, the strengthened base on basic science could also be reflected in firms' technology breadth (i.e., corporate patents could be more general across and within technology classes).

We regress *PatBasic*, *PatExplore*, and *TechBreadth* on each of the three IUC measures, and present the estimation results in Table 7. We find that IUC is associated with significantly higher *PatBasic* in Panel A, significantly higher *PatExplore* in Panel B, and significantly higher *TechBreadth* in Panel C. All coefficients are statistically significant at the 1% level and remain highly robust when we control for an extensive list of innovation-related and other firm characteristics, as well as saturated fixed effects. These results are consistent with the fact that university-generated technologies tend to be more generalizable and cover broader applications, which create more commercialization opportunities for firms through IUC.

[Insert Table 7 here.]

5. Two Channels of Technology Transfers

In this section, we propose and examine two main channels for IUC to enhance firms' development and commercialization of technologies: knowledge acquisition and talent recruiting (Prager and Omenn, 1980; Mowery and Ziedonis, 2014; Babina et al. 2020).

5.1. Channel of knowledge acquisition

To examine the two mechanisms we propose, we estimate the following regression model using OLS:

$$Channels_{t+1\rightarrow t+3} = \gamma \cdot IUC_{t-2\rightarrow t} + Controls + FEs + \varepsilon_t. \quad (2)$$

We propose the following channel variables, as $Channels_{t+1\rightarrow t+3}$. First, to measure knowledge acquired from universities, we use *UnivCite*, which denotes the ratio of backward citations to university patents over all backward citations made by corporate patents filed by the focal firm in years t + 1 to t + 3. Since patent citations reflect knowledge flows (Tijssen, 2001; Peri, 2005; Alcacer and Gittelman, 2006; Gomes-Casseres, Hagedoorn, and Jaffe, 2006), firms with higher *UnivCite* are likely to be those acquiring more knowledge from universities. In comparison, we also use *CorpCite* to measure knowledge acquired from other firms as a "placebo". Specifically, *CorpCite* is the ratio of backward citations to other firms' patents over all backward citations made by corporate patents filed by the focal firm in years $t + 1$ to $t + 3$.

Table 8 presents estimation results for Equation (2) and provides supportive evidence for the knowledge acquisition channel. Panel A is for *UnivCite* and Panel B is for *CorpCite*. Panel A1 shows that by engaging in industry-university collaboration, firms' *UnivCite* increase by 1.3-1.4% in the future three years. The coefficient estimate is statistically significant at the 1% level. Such magnitude is also economically significant, as the sample mean and standard deviation of *UnivCite* are 1% and 10%, respectively (as shown in Table 1). Panels A2 and A3 show consistent results when we measure IUC intensity by *IUC Count* and *IUC Ratio*, respectively.

In comparison, we also examine whether IUC enhances direct knowledge flows between firms. Using *CorpCite* as a placebo dependent variable, we do not have any significant results in Panel B. Thus, firms' access to other firms' knowledge does not increase with IUC. This result suggests that our results from Panel A are not driven by some industry trends or macro factors. As a result, Table 8 provides micro-evidence that industry-university collaboration facilitates firms' learning from universities' knowledge base.

[Insert Table 8 here.]

5.2. Channel of talent recruiting

To measure how firms recruit talents from universities, we use *UnivInventor*, which is the ratio of former university inventors over total inventors of all patents filed by the focal firm in years $t + 1$ to $t + 3$. An inventor is defined as a former university inventor if he/she files a corporate patent in years $t + 1$ to $t + 3$ but files a university patent before year t.[24] Since the flows of inventors could largely reflect the flows of talents, firms with higher *UnivInventor* are likely to be those recruiting more talents from universities. In comparison, we also construct *CorpInventor* to measure talents recruited from other firms as a placebo. Specifically, *CorpInventor* is the ratio of inventors who work for other firms in the past over total inventors of corporate patents filed by the focal firm in years $t + 1$ to $t + 3$. An inventor is assumed to move from

[24] We acknowledge the difficulty in identifying individual Chinese inventors using their names (Wang and Guan, 2011; Fisch, Block, and Sandner, 2016), and conduct further robustness checks at the end of this section.

another firm to the focal firm if he/she files a corporate patent in the focal firm in years $t + 1$ to $t + 3$ but files a corporate patent in another firm before year t. Table 9 uses *UnivInventor* as the dependent variable in Equation (2). Panel A is for *UnivInventor* and Panel B is for *CorpInventor*.

Panel A supports the channel of talent recruiting. Panel A1 suggests that engaging in industry-university collaboration increases firms' ratio of former university inventors by 1.5-1.6% in the future three years. The coefficient estimate is statistically significant at the 1% level. Such magnitude is also economically significant given the sample mean and standard deviation of *UnivInventor* are 1% and 6%, respectively. The result remains robust when we measure IUC intensity with *IUC Count* and *IUC Ratio*, as shown in Panels A2 and A3.

[Insert Table 9 here.]

In contrast, we find that industry-university collaboration weakens direct talent flows between firms, as shown in Panel B. Specifically, regressing *CorpInventor* on one of the three measures of IUC intensity, the coefficients of IUC are all negative and statistically significant at the 1% level. This finding suggests that talent flows from universities act as potential substitutes to talent flows from corporates. Bringing Panels A and B of Table 9 together, we present micro-evidence for the channel that IUC enhances a firm's incentive to recruit talents from universities.

Last but not least, we acknowledge the difficulty in identifying individual Chinese inventors using their names due to the population issue, which could introduce noise to our estimation. We further conduct two further robustness checks to disambiguate inventors. In Online Appendix Table OA.6, we disambiguate a unique inventor not only with the same name but also in the same primary IPC of the patents he/she filed. We also drop the inventors with the most common names (i.e., the inventors whose names are in the top one percentile of appearance frequency) in Online Appendix Table OA.7.[25] All robustness checks confirm our findings in Table 9 about the channel of talent recruiting – IUC enhances firms' hiring from universities' pool of human resources.

6. Conclusion

In this paper, we examine to what extent and how industry-university collaboration (IUC) promotes corporate technology commercialization, innovation outputs, and technology spillovers. To do so, we collect patent data covering over 90 thousand patenting medium-sized and large firms and 153 notable research universities and

[25] These most frequent inventor names appear in 29.3% of patents in our sample.

institutes in China. We measure firms' IUC intensity using the occurrence and frequency of patents co-assigned to both firms and universities. Taking advantage of the accounting information about new product sales, which is a compulsory item in the NBS data, we measure firms' performance of technology commercialization using their new product sales.

Our empirical analyses suggest that firms' IUC activities are positively associated with technology commercialization. This relation is more pronounced among industries that are more dependent on university research. We further consider two identification tests for a causal interpretation of the positive relation. First, we use the establishment of university science parks as plausible policy shocks to regional industry-university collaboration activities and estimate a dynamic difference-in-differences regressions. Second, we implement instrumental variable regressions using local governments' policy guidance as an instrumental variable and find that the instrumented industry-university collaboration remains its explanatory ability for corporate technology commercialization.

Examining other attributes of corporate patent outputs, we further document that firms' IUC activities are positively related to their quantity and quality of patent output. Moreover, higher IUC is associated with higher basicness, higher exploration, and higher technology breadth. All these confirm that the innovation-enhancing mechanism underlying the IUC's effect on technology commercialization. We further test and support the two channels through which university technologies spill over via IUC: knowledge acquisition and talent recruitment.

Our empirical evidence is consistent with the beneficial impact of IUC on both technology commercialization and innovation performance from the standpoint of corporates. This complements the literature in this domain, which has focused on the impact of such collaboration on universities and academic researchers, but rarely considers its impact on corporates. We study in an emerging country's context, which allows for a variety of additional empirical analyses to explore the underlying mechanisms and make causal inferences.

One limitation of the work presented here (and is therefore ripe for follow-on research) is that we lack a direct "paper trail" between the academic work and its application in the corporate setting. Our empirical strategy is instead to characterize aggregate firm-level patterns in the absence of such direct linkages, which is hard to imagine achieving at scale. Perhaps for this reason, the prior literature in this domain has tended to employ survey methods, which is attractive from the standpoint of depth of information, but holds the drawback of sampling (as compared to the census of the relevant population approach we employ) as well as potential subjective response concerns. We see our work as a complement to the survey-based work, but also acknowledge that future research would ideally improve our evidence and understanding of IUC in this and other domains.

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Figures and Tables

Figure 1: Time Series of IUC Patents in China and the U.S.

In Panel A, the dashed blue and red lines represent the numbers of corporate patents applied (and finally granted) in year *t* in China and the U.S., respectively. In Panel B, the blue and red lines represent the ratios of industry-university collaborative patents applied (and finally granted) in year *t* over corporate patents applied (and finally granted) in year *t* in China and the U.S., respectively. A patent is defined as industry-university collaborative if it is assigned to both a university and a corporate. Sample period: 1994-2016 for the patent data in China and in the U.S.

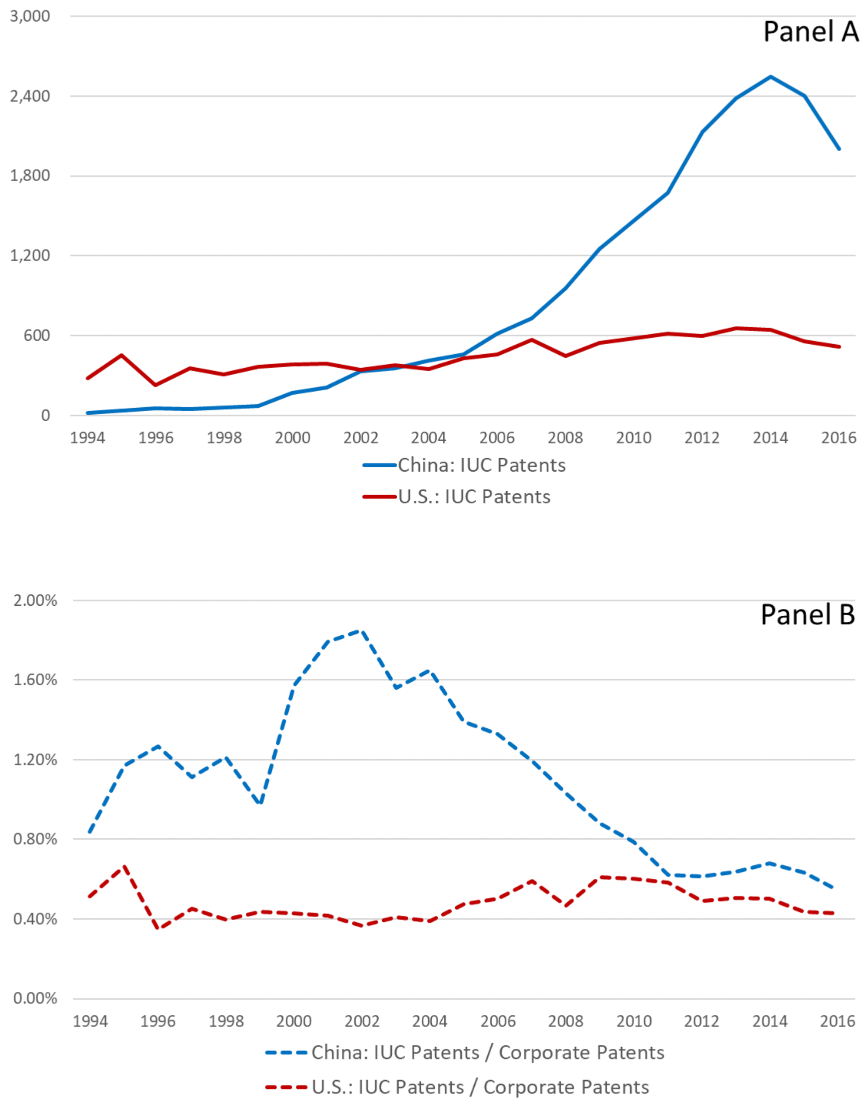

Table 1: Summary Statistics.

A firm is included if it has at least one patent in 1996-2016 and its accounting information is non-missing from 1998 to 2013 for at least three consecutive years. A firm is excluded from the sample if it files any IUC patents in its first three sample years. In the category of "industry-university collaboration," all variables are measured in a window from year *t*-2 to *t*. *Dummy* equals one if the focal firm has an IUC patent; otherwise it equals to zero. *Count* denotes the number of patents assigned to both a university and the focal firm. *Ratio* denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. In the category of "technology commercialization," *New Product Sales* denotes the output value of new products (in million RMB) in year *t*+1 to *t*+3. In the category of "innovation outputs," all variables are measured in a window from year *t*+1 to *t*+3. *PatCount* denotes the number of patents solely assigned to the focal firm. *PatCite* denotes the average number of forward three-year citations of patents solely assigned to the focal firm. *PatBasic* denotes the ratio of academic papers over total backward citations of patents that are solely assigned to the focal firm. *PatExplore* denotes the ratio of exploratory patents over the number of patents that are solely assigned to the focal firm. A patent applied in year *t*+1 to *t*+3 is defined as exploratory if its secondary IPC codes are different from those of patents applied in year *t*-2 to *t*. *TechBreadth* denotes the average number of unique primary IPC codes per patent that is solely assigned to the focal firm. In the category of "channel variables," all variables are measured in a window from year *t*+1 to *t*+3. *UnivCite* denotes the ratio of university patents cited divided by total patents cited by patents that are solely assigned to the focal firm. *CorpCite* denotes the ratio of other firms' patents cited divided by total patents cited by patents that are solely assigned to the focal firm. *UnivInventor* denotes the ratio of university inventors over total inventors filing patents that are solely assigned to the focal firm. A university inventor is defined if he/she files a sole corporate patent in year *t*+1 to *t*+3 but files a sole university patent before year *t*. *CorpInventor* denotes the ratio of other firms' inventors over total inventors filing patents that are solely assigned to the focal firm. An inventor is defined as moving from another firm to the focal firm if he/she files a sole corporate patent in the focal firm in year *t*+1 to *t*+3 but files a sole corporate patent in another firm before year *t*. In the category of "innovation-related variables," *Patent Portfolio Size* denotes the number of patents assigned to the focal firm in year *t*-2 to *t*. *R&D Intensity* denotes the ratio of R&D expenditure over total assets (in percentage) in year *t*. In the category of "instrumental variables," all variables are measured in a window from year *t*-2 to *t*. *IV: Policy Guidance* (in percentage) denotes the ratio of the number of articles mentioning "industry-university collaboration, 产学研 or 产学研合作 in Chinese" in their titles over the total number of articles published in official newspapers affiliated with provincial governments. In the category of "other control variables," all variables are measured in year *t*. *Total Sales* denotes the total value of sales (in million yuan). *Total Assets* denotes the value of total assets (in million yuan). *Age* denotes the number of years gap between the registration year and the data year. *Cash Ratio* denotes the ratio of cash over total assets (in percentage). *Capital Expenditure Intensity* denotes the ratio of capital expenditure over total physical assets (in percentage). *Profitability Ratio* denotes the ratio of net profits over total sales (in percentage). *Sales Growth* denotes the ratio of this year's total sales over last year's total sales minus one (in percentage), *Export Ratio* denotes the ratio of total exports over total sales (in percentage). *Leverage Ratio* denotes the ratio of total debts over total assets (in percentage). *Labor Ratio* denotes the ratio of employees over total assets (in person/million RMB). *Wage per Employee* denote the ratio of labor costs over employees (in thousand RMB/person). *Subsidy Ratio* denotes the ratio of subsidies over total revenue (in percentage). All variables in the categories of "innovation outputs," "innovation-related variables," "channel variables," and "other control variables" are winsorized at their 1st and 99th percentiles.

(Table 1 continued)

	Mean	Std	Min	Q1	Median	Q3	Max
Industry-University Collaboration							
IUC Dummy	0.006	0.074	0.000	0.000	0.000	0.000	1.000
--(Conditional on non-zero obs)	1.000	0.000	1.000	1.000	1.000	1.000	1.000
IUC Count	0.009	0.137	0.000	0.000	0.000	0.000	3.000
--(Conditional on non-zero obs)	1.655	0.818	1.000	1.000	1.000	2.000	3.000
IUC Ratio	0.003	0.047	0.000	0.000	0.000	0.000	1.000
--(Conditional on non-zero obs)	0.496	0.394	0.000	0.111	0.400	1.000	1.000
Technology Commercialization							
New Product Sales	20.76	54.45	0.00	0.00	0.00	3.13	218.62
--(Conditional on non-zero-patent obs)	63.50	79.71	0.00	3.59	21.40	101.18	218.62
Innovation Outputs							
PatCount	2.79	7.36	0.00	0.00	0.00	2.00	58.00
--(Conditional on non-zero obs)	7.59	10.53	1.00	2.00	4.00	9.00	58.00
PatCite	0.09	0.24	0.00	0.00	0.00	0.00	1.25
--(Conditional on non-zero obs)	0.50	0.35	0.01	0.22	0.40	0.67	1.25
PatBasic	0.03	0.13	0.00	0.00	0.00	0.00	0.90
--(Conditional on non-zero obs)	0.48	0.29	0.00	0.22	0.50	0.75	0.90
PatExplore	0.28	0.43	0.00	0.00	0.00	0.75	1.00
--(Conditional on non-zero obs)	0.89	0.20	0.04	0.86	1.00	1.00	1.00
TechBreadth	0.42	0.61	0.00	0.00	0.00	1.00	2.01
--(Conditional on non-zero obs)	1.22	0.32	1.00	1.00	1.00	1.37	2.01
Channel Variables							
UnivCite	0.01	0.10	0.00	0.00	0.00	0.00	1.00
--(Conditional on non-zero obs)	0.46	0.33	0.00	0.17	0.33	0.67	1.00
CorpCite	0.09	0.28	0.00	0.00	0.00	0.00	1.00
--(Conditional on non-zero obs)	0.92	0.17	0.06	0.95	1.00	1.00	1.00
UnivInventor	0.01	0.06	0.00	0.00	0.00	0.00	0.79
--(Conditional on non-zero obs)	0.19	0.15	0.00	0.09	0.15	0.25	0.79
CorpInventor	0.05	0.18	0.00	0.00	0.00	0.00	1.00
--(Conditional on non-zero obs)	0.55	0.27	0.00	0.33	0.50	0.75	1.00
Scale of Sales							
Total Sales	125.83	194.23	6.28	17.40	43.86	127.12	770.18
Innovation-Related Control Variables							
Patent Portfolio Size	1.88	5.04	0.00	0.00	0.00	1.00	34.00
--(Conditional on non-zero obs)	5.70	7.43	1.00	1.00	3.00	7.00	34.00
R&D Intensity	0.44	1.38	0.00	0.00	0.00	0.08	9.06
--(Conditional on non-zero obs)	1.33	2.13	0.00	0.08	0.38	1.51	9.06
Instrumental Variables							
IV: Policy Guidance	0.25	0.26	0.00	0.05	0.19	0.37	1.15
Other Control Variables							
Total Assets	183.12	526.66	1.83	13.58	35.47	110.03	3,947.78
Age	10.85	11.73	1.00	4.00	7.00	12.00	56.00
Cash Ratio	51.95	27.98	0.02	32.67	55.57	73.57	100.00
Capital Expenditure Intensity	21.62	28.60	0.00	3.28	12.59	27.05	170.41
Profitability Ratio	3.81	8.92	-33.94	0.26	2.35	6.66	36.99
Sales Growth	29.97	118.44	-84.32	-0.61	0.00	23.43	836.61
Export Ratio	12.67	27.13	0.00	0.00	0.00	6.40	100.00
Leverage Ratio	59.50	25.10	4.06	41.57	60.62	78.45	100.00
Labor Ratio	7.52	9.80	0.24	2.23	4.51	8.77	66.61
Wage per Employee	23.37	24.35	2.41	10.55	16.20	26.06	163.87
Subsidy Ratio	0.25	0.91	0.00	0.00	0.00	0.02	6.43

Table 2: Industry-University Collaboration and Future Technology Commercialization.

We execute pooled regressions to estimate the effect of industry-university collaboration (IUC) on a firm's future performance of technology commercialization. Specifically, we regress the dependent variable, *New Product Sales*, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variable, *New Product Sales* denotes the output value of new products (in million RMB) in year *t*+1 to *t*+3. As independent variables, IUC measured in *Dummy* (in Panel A) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panel B) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panel C) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We control for *Total Sales* (in billion RMB). We also control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We further control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Dept Var = New Product Sales						
	Panel A		Panel B		Panel C	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	12.8433**	12.9913**				
	(5.6023)	(5.5503)				
IUC measured in *Count*			7.7782**	8.0037**		
			(3.2632)	(3.2364)		
IUC measured in *Ratio*					12.7779**	12.9313**
					(5.6830)	(5.6786)
Total Sales	34.5696***	18.6088***	34.5727***	18.5995***	34.6355***	18.6817***
	(2.5668)	(2.4846)	(2.5677)	(2.4851)	(2.5685)	(2.4888)
Patent Portfolio Size	0.9470***	0.8264***	0.9388***	0.8174***	0.9768***	0.8566***
	(0.1346)	(0.1334)	(0.1345)	(0.1334)	(0.1363)	(0.1351)
R&D Intensity	132.0053***	140.4294***	131.8120***	140.2298***	132.4999***	140.8807***
	(22.7005)	(22.9101)	(22.6962)	(22.9053)	(22.7083)	(22.9162)
Total Assets		32.2180***		32.2408***		32.2081***
		(3.2630)		(3.2622)		(3.2633)
Age		-0.0159*		-0.0159*		-0.0159*
		(0.0092)		(0.0092)		(0.0092)
Cash Ratio		3.0873***		3.0897***		3.0813***
		(0.8045)		(0.8045)		(0.8048)
Capital Expenditure Intensity		3.4667***		3.4668***		3.4735***
		(0.3905)		(0.3906)		(0.3905)
Profitability Ratio		18.2758***		18.2809***		18.2611***
		(2.2558)		(2.2555)		(2.2565)
Sales Growth		0.2026**		0.2014**		0.2023**
		(0.0953)		(0.0953)		(0.0953)
Export Ratio		7.7240***		7.7264***		7.7181***
		(1.0974)		(1.0975)		(1.0975)
Leverage Ratio		0.7541		0.7585		0.7527
		(0.8914)		(0.8912)		(0.8915)
Labor Ratio		108.3507***		108.2369***		108.3207***
		(14.3521)		(14.3485)		(14.3509)
Wage per Employee		0.0713***		0.0712***		0.0715***
		(0.0082)		(0.0082)		(0.0082)
Subsidy Ratio		58.4751***		58.6867***		58.6687***
		(19.4046)		(19.3968)		(19.3938)
#Obs	566,633	566,633	566,633	566,633	566,633	566,633
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.8862	0.8868	0.8862	0.8869	0.8862	0.8868
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 3: Establishments of University Science Park as Exogenous Shocks.

We execute pooled regressions to estimate the effect of establishment of university science parks on a firm's industry-university collaboration intensity and performance of technology commercialization. As dependent variables, IUC measured in *Dummy* (in Panel A1) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panel A2) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panel A3) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. *New Product Sales* denotes the output value of new products (in million RMB). As the independent variable in Columns (1), *University Science Park (Post)* of a firm in year *t* equals one at least one university science park is established in its city in or before year *t*; otherwise it equals zero. In Columns (2), *University Science Park (Post)* is decomposed into six event year related dummy variables. We control for *Total Sales* (in billion RMB). We also control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We further control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. We only include firms that enter the sample before and exit the sample after the establishment of their regional university science parks. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

	Panel A: Dept Var = IUC						Panel B: Dept Var = New Product Sales	
	Panel A1: IUC measured in *Dummy*		Panel A2: IUC measured in *Count*		Panel A3: IUC measured in *Ratio*			
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
University Science Park (Post)	0.3226**		0.0032**		0.3327***		6.4688***	
	(0.1310)		(0.0013)		(0.0753)		(1.4348)	
Event Year = -2		-0.1402		-0.0014		-0.0877		-2.1339
		(0.1604)		(0.0016)		(0.0767)		(1.7647)
Event Year = -1		0.0290		0.0003		0.0691		-0.6458
		(0.1804)		(0.0018)		(0.0976)		(2.0768)
Event Year = 0		0.0359		0.0004		0.1694*		0.0559
		(0.1867)		(0.0019)		(0.1003)		(2.1495)
Event Year = +1		0.2992		0.0030		0.4063***		6.0925***
		(0.2127)		(0.0021)		(0.1193)		(2.3458)
Event Year = +2		0.3935*		0.0039*		0.4358***		5.5294**
		(0.2316)		(0.0023)		(0.1244)		(2.2512)
Event Year >= +3		0.4828**		0.0048**		0.3910***		10.7785***
		(0.2274)		(0.0023)		(0.1231)		(2.5284)
#Obs	80,137	80,137	80,137	80,137	80,137	80,137	80,137	80,137
#Firms	8,467	8,467	8,467	8,467	8,467	8,467	8,467	8,467
R-squared	0.4273	0.4274	0.4273	0.4274	0.4076	0.4077	0.8648	0.8649
Total Sales as a Control	YES	YES	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 4: Instrumental Regressions.

We report the results of the first and second stages of the 2SLS regressions. In the first stage, we regress each of the three measures of IUC as the dependent variable in year *t*-2 to *t* on the instrumental variable in year *t*-2 to *t*. As endogenous independent variables, IUC measured in *Dummy* (in Panel A) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panel B) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panel C) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. As the instrumental variable, *IV: Policy Guidance* denotes the ratio of the number of articles mentioning "industry-university collaboration, 产学研 in Chinese" in their titles over the total number of articles published in official newspapers affiliated with provincial governments in year *t*-2 to *t* from 2000 to 2016. In the second stage, we regress *New Product Sales* as the dependent variable on each of the three instrumented measures of IUC as independent variable in year *t*-2 to *t*. As dependent variable, *New Product Sales* denotes the output value of new products (in million RMB) in year *t*+1 to *t*+3. We control for *Total Sales* (in billion RMB). We also control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We further control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province fixed effects, and industry-year fixed effects. All control variables are defined in Table. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

	Panel A: IUC measured in *Dummy*		Panel B: IUC measured in *Count*		Panel C: IUC measured in *Ratio*	
	1st Stage: Dept Var = IUC	2nd Stage: Dept Var = NPS	1st Stage: Dept Var = IUC	2nd Stage: Dept Var = NPS	1st Stage: Dept Var = IUC	2nd Stage: Dept Var = NPS
	(1)	(2)	(1)	(2)	(1)	(2)
Predicted Industry-University Collaboration		175.8948*		121.9432*		205.1512*
		(92.9853)		(64.9905)		(107.8250)
IV: Policy Guidance	65.0591***		93.8432***		55.7810***	
	(5.7885)		(10.6361)		(3.7396)	
#Obs	566,633	566,633	566,633	566,633	566,633	566,633
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
***F* Statistic**	517.8		589.9		79.86	
Underidentification *LM* Statistic (*p* Value)		148.1 (0.000)		91.29 (0.000)		260.8 (0.000)
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 5: Effects of IUC Conditional on Industries' Reliance on Basic Science.

We execute pooled regressions to examine whether the positive effects of industry-university collaboration (IUC) on a firm's future performance of technology commercialization increase with the industries' reliance on science. we regress the dependent variable, *New Product Sales*, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variable, *New Product Sales* denotes the output value of new products (in million RMB) in year *t*+1 to *t*+3. As independent variables, IUC measured in *Dummy* (in Panel A) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panel B) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panel C) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We propose the following two proxies of reliance on science: *Citations to Basic Science* measures the ratio of backward citations to non-patent prior arts over total backward citations of patents applied by (and finally granted to) an industry; *Citations to University Patents* measures the ratio of backward citations to university patents over total backward citations of patents applied by (and finally granted to) an industry. All firm-year observations are split into two groups according to their measures of reliance on science: if a firm-year observation's *measure* is higher than the all-sample median, then it is included in the high group; otherwise, it is included in the low group. We control for *Total Sales* (in billion RMB). We also control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We further control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Measuring Industry's Reliance on Science with Citations to Basic Science

	Dept Var = New Product Sales					
	Panel A1		Panel A2		Panel A3	
	High Group	Low Group	High Group	Low Group	High Group	Low Group
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	19.3208***	-2.8249				
	(7.0979)	(8.8523)				
IUC measured in *Count*			11.6726***	-0.8137		
			(4.1938)	(4.8939)		
IUC measured in *Ratio*					13.5537*	-0.3690
					(6.9892)	(8.9570)
#Obs	283,350	283,283	283,350	283,283	283,350	283,283
#Firms	92,521		92,521		92,521	
R-squared	0.8792	0.8965	0.8792	0.8965	0.8791	0.8965
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel B: Measuring Industry's Reliance on Science with Citations to University Patents

	Dept Var = New Product Sales					
	Panel B1		Panel B2		Panel B3	
	High Group	Low Group	High Group	Low Group	High Group	Low Group
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	19.4121***	-4.8452				
	(7.4217)	(6.9379)				
IUC measured in *Count*			12.3726***	-3.0843		
			(4.3077)	(4.1627)		
IUC measured in *Ratio*					14.1482*	-2.3122
					(7.4380)	(6.9193)
#Obs	282,005	284,628	282,005	284,628	282,005	284,628
#Firms	92,521		92,521		92,521	
R-squared	0.8836	0.8915	0.8837	0.8915	0.8836	0.8915
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 6: Industry-University Collaboration and Future Outputs of Corporate Patents.

We execute pooled regressions to estimate the association between industry-university collaboration (IUC) and a firm's future outputs of solo patents. Specifically, we regress the dependent variables, *PatCount* in Panel A or *PatCite* in Panel B, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variables, *PatCount* denotes the number of patents solely assigned to the focal firm in years *t*+1 to *t*+3. *PatCite* denotes the average number of forward three-year citations of patents solely assigned to the focal firm in years *t*+1 to *t*+3. As independent variables, IUC measured in *Dummy* (in Panels A1 and B1) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panels A2 and B2) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panels A3 and B3) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We also control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = PatCount

	Panel A1		Panel A2		Panel A3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.8603***	0.7429***				
	(0.1271)	(0.1265)				
IUC measured in *Count*			0.4139***	0.3678***		
			(0.0644)	(0.0643)		
IUC measured in *Ratio*					0.3344**	0.2827*
					(0.1498)	(0.1510)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.6203	0.6236	0.6203	0.6236	0.6202	0.6235
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel B: Dept Var = PatCite

	Panel B1		Panel B2		Panel B3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0110***	0.0101***				
	(0.0038)	(0.0038)				
IUC measured in *Count*			0.0052***	0.0049***		
			(0.0018)	(0.0018)		
IUC measured in *Ratio*					0.0113**	0.0110**
					(0.0054)	(0.0055)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4867	0.4873	0.4867	0.4873	0.4867	0.4873
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 7: Industry-University Collaboration and Future Technological Attributes of Corporate Patents. We execute pooled regressions to estimate the effect of industry-university collaboration (IUC) on a firm's future attributes of solo patents. Specifically, we regress the dependent variables, *PatBasic* in Panel A, *PatExplore* in Panel B, or *TechBreadth* in Panel C, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variables, *PatBasic* denotes the ratio of academic papers over total backward citations of patents that are solely assigned to the focal firm in years *t*+1 to *t*+3. *PatExplore* denotes the ratio of exploratory patents over the number of patents that are solely assigned to the focal firm in years *t*+1 to t+3. A patent applied in year *t*+1 to *t*+3 is defined as exploration if its secondary IPC codes are different from those of patents applied in year *t*-2 to *t*. *TechBreadth* denotes the natural logarithm of one plus average number of unique primary IPC codes per patent that is solely assigned to the focal firm in years *t*+1 to *t*+3. As independent variables, IUC measured in *Dummy* (in Panels A1 and B1) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panels A2 and B2) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panels A3 and B3) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We also control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

(Table 7 continued)

Panel A: Dept Var = PatBasic	Panel A1		Panel A2		Panel A3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0073*** (0.0012)	0.0071*** (0.0012)				
IUC measured in *Count*			0.0029*** (0.0006)	0.0028*** (0.0006)		
IUC measured in *Ratio*					0.0053*** (0.0018)	0.0053*** (0.0018)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4742	0.4751	0.4742	0.4751	0.4741	0.4750
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel B: Dept Var = PatExplore	Panel B1		Panel B2		Panel B3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0469*** (0.0120)	0.0442*** (0.0119)				
IUC measured in *Count*			0.0183*** (0.0056)	0.0178*** (0.0056)		
IUC measured in *Ratio*					0.0975*** (0.0206)	0.0974*** (0.0204)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4952	0.5001	0.4951	0.5001	0.4952	0.5001
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel C: Dept Var = TechBreadth	Panel C1		Panel C2		Panel C3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0929*** (0.0088)	0.0909*** (0.0088)				
IUC measured in *Count*			0.0410*** (0.0042)	0.0406*** (0.0042)		
IUC measured in *Ratio*					0.2055*** (0.0164)	0.2055*** (0.0163)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4011	0.4066	0.4011	0.4066	0.4012	0.4067
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 8: Industry-University Collaboration and Future Knowledge Acquisition.

We execute pooled regressions to estimate the effect of industry-university collaboration (IUC) on a firm's future knowledge acquisition. Specifically, we regress the dependent variables, *UnivCite* in Panel A or *CorpCite* in Panel B, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variable, *UnivCite* denotes the ratio of university patents cited divided by total patents cited by patents that are solely assigned to the focal firm in year *t*+1 to *t*+3. *CorpCite* denotes the ratio of other firms' patents cited divided by total patents cited by patents that are solely assigned to the focal firm in year *t*+1 to *t*+3. As independent variables, IUC measured in *Dummy* (in Panels A1 and B1) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panels A2 and B2) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panels A3 and B3) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We also control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = UnivCite						
	Panel A1		**Panel A2**		**Panel A3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0139***	0.0133***				
	(0.0030)	(0.0030)				
IUC measured in *Count*			0.0060***	0.0058***		
			(0.0015)	(0.0015)		
IUC measured in *Ratio*					0.0174***	0.0171***
					(0.0042)	(0.0042)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4125	0.4128	0.4125	0.4128	0.4124	0.4128
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel B: Dept Var = CorpCite						
	Panel B1		**Panel B2**		**Panel B3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0005	-0.0022				
	(0.0063)	(0.0063)				
IUC measured in *Count*			0.0001	-0.0010		
			(0.0030)	(0.0030)		
IUC measured in *Ratio*					-0.0126	-0.0137
					(0.0090)	(0.0090)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4139	0.4147	0.4139	0.4147	0.4139	0.4147
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table 9: Industry-University Collaboration and Future Talent Recruiting.

We execute pooled regressions to estimate the effect of industry-university collaboration (IUC) on a firm's future knowledge acquisition. Specifically, we regress the dependent variables, *UnivInventor* in Panel A or *CorpInventor* in Panel B, on each of the three measures of IUC as independent variable in year *t*-2 to *t*. As dependent variables, *UnivInventor* in Panel A denotes the ratio of former university inventors over total inventors filing patents that are solely assigned to the focal firm. A former university inventor is defined if he/she files a sole corporate patent in the focal firm in year *t*+1 to *t*+3 but files a sole university patent before year *t*. *CorpInventor* in Panel B denotes the ratio of former inventors in other firms over total inventors filing patents that are solely assigned to the focal firm. An inventor is defined as moving from another firm to the focal firm if he/she files a sole corporate patent in the focal firm in year *t*+1 to *t*+3 but files a sole corporate patent in another firm before year *t*. As independent variables, IUC measured in *Dummy* (in Panels A1 and B1) equals one if the focal firm has an IUC patent; otherwise it equals to zero. IUC measured in *Count* (in Panels A2 and B2) denotes the number of patents assigned to both a university and the focal firm. IUC measured in *Ratio* (in Panels A3 and B3) denotes the ratio of the number of patents assigned to both a university and the focal firm over the number of patents assigned to the focal firm. We control for innovation-related variables such as *Patent Portfolio Size* and *R&D Intensity*. We also control for firm characteristics such as *Total Assets* (in billion RMB), *Age*, *Cash Ratio*, *Capital Expenditure Intensity*, *Profitability Ratio*, *Sales Growth*, *Export Ratio*, *Leverage Ratio*, *Labor Ratio*, *Wage per Employee*, *Subsidy Ratio*, as well as firm fixed effects, province-year fixed effects, and industry-year fixed effects. All control variables are defined in Table 1. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = UnivInventor

	Panel A1		Panel A2		Panel A3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0156***	0.0148***				
	(0.0017)	(0.0017)				
IUC measured in *Count*			0.0069***	0.0066***		
			(0.0008)	(0.0008)		
IUC measured in *Ratio*					0.0154***	0.0151***
					(0.0025)	(0.0025)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4630	0.4641	0.4630	0.4641	0.4627	0.4639
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Panel B: Dept Var = CorpInventor

	Panel B1		Panel B2		Panel B3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	-0.0106***	-0.0104***				
	(0.0035)	(0.0035)				
IUC measured in *Count*			-0.0074***	-0.0073***		
			(0.0016)	(0.0016)		
IUC measured in *Ratio*					-0.0127***	-0.0126***
					(0.0038)	(0.0038)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4056	0.4058	0.4057	0.4058	0.4056	0.4058
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Online Appendix for "*Industry-University Collaboration and Commercializing Chinese Corporate Innovation*"

A. Extended Literature Review

A.1. The influence of university research: overview

The literature documents that universities specialize in basic research while corporates focus on development and commercialization (Jaffe, 1989; Rosenberg and Nelson, 1994; Trajtenberg, Henderson, and Jaffe, 1997). Such specialization in technology development in turn calls for technologies transfers between universities and corporates and across-sector synergies in innovation.[1]

The influence of universities on industry R&D and innovation has been studied since Nelson (1986) and Levin et al. (1987): their survey suggests that university research is perceived as relevant for industry technological development, especially in high-tech industries including computer sciences, biotechnology, and medical and agricultural science. Jaffe (1989) shows that university research budgets positively influence local firms' patent outputs in medical technology, electronics, optics, and nuclear technology. Acs, Audretsch, and Feldman (1992, 1994) find that a positive relation between universities' R&D spending and local firms' innovation activities; moreover, this relation intensifies with geographic proximity. The survey of Cohen, Nelson, and Walsh (2002) also supports the positive influence of public research (conducted in either academia or government labs) on industrial R&D. Narin, Hamilton,

[1] The influence of universities on industry R&D and innovation has been studied since Nelson (1986) and Levin et al. (1987): their survey suggests that university research is perceived as relevant for industry technological development, especially in high-tech industries including computer sciences, biotechnology, and medical and agricultural science. Jaffe (1989) shows that university research budgets positively influence local firms' patent outputs in medical technology, electronics, optics, and nuclear technology. Acs, Audretsch, and Feldman (1992, 1994) find that a positive relation between universities' R&D spending and local firms' innovation activities; moreover, this relation intensifies with geographic proximity. The survey of Cohen, Nelson, and Walsh (2002) also supports the positive influence of public research (conducted in either academia or government labs) on industrial R&D. Narin, Hamilton, and Olivastro (1997) find that references from U.S. patents to U.S.-authored research papers have tripled between the late-1980s and early-to-mid-1990s, confirming the linkages between current public research (conducted in either academia or government labs) and industrial technology. Sorenson and Fleming (2004) and Hsu et al. (2021) pointed out that the forward citations and value of corporate patents are positively associated with their backward citations to basic research. All these discussions collectively support the pivotal role of university research and spillover on industrial technology. There are also studies that suggest that the impact of university spillover on industrial technology is smaller than that of between-firm spillover (e.g., Klevorick et al., 1995). Lacking complementary assets, universities suffer from a low direct commercialization rate of technologies. For example, Hsu et al. (2021) document that only 16% of patent value is realized through university licensing. Industry-university collaboration (IUC) is an essential mechanism to solve such dilemma (Lee, 1996; Hanel and St-Pierre; 2006; Bruneel, D'Este, and Salter, 2010; Perkmann, King, and Pavelin, 2011).

and Olivastro (1997) find that references from U.S. patents to U.S.-authored research papers have tripled between the late-1980s and early-to-mid-1990s, confirming the linkages between current public research (conducted in either academia or government labs) and industrial technology. Sorenson and Fleming (2004) and Hsu et al. (2021) pointed out that the forward citations and value of corporate patents are positively associated with their backward citations to basic research. All these discussions collectively support the pivotal role of university research and spillover on industrial technology.

There are also studies that suggest that the impact of university spillover on industrial technology is smaller than that of between-firm spillover (e.g., Klevorick et al., 1995). Prior studies have shown the importance of between-firm technology collaboration and cross-learning (Powell, Koput, and Smith-Doerr, 1996; Cassiman and Veugelers, 2002), which lowers the R&D costs and increases the quantity and quality of firms' innovation outputs (Belderbos, Carree, and Lokshin, 2004; Scandura, 2016). The collaboration between universities and corporates is an important form of technology partnership but whether and how such collaboration enhances firms' innovation performance remains under debate (e.g., Mowery et al., 2004) and still needs further empirical analysis. Some prior studies have also pointed out the barriers and obstacles in such collaborations (Siegel, Waldman, and Link, 2003; Bruneel, D'Este, and Salter, 2010).

The positive effect of IUC on corporate innovation has been well-documented in the literature (Gittelman and Kogut, 2003; Walsh, Lee, and Nagaoka, 2016; Scandura, 2016). We note that prior studies on the effects of IUC on corporate innovation are mainly based on survey data in developed countries.[2] Collaborating with universities is particularly relevant for Chinese firms that tend to have shorter histories and weaker R&D capabilities. In addition, universities serve as hubs of social networks in Chinese society (Obukhova, Wang, and Li, 2012) and may thus enable collaborating firms to access broader knowledge and technology sources. All these make it important for us to examine the effects of IUC in China.

However, Arora, Belenzon, and Patacconi (2018) have documented a consistent decline in corporates' investment in scientific research since the 1980s, which is especially true when their knowledge creation results in spillovers to rivals (Arora, Belenzon, and Sheer, 2020). A similar pattern is also observed in China. Motohashi and

[2] An incomplete list of prior studies includes Azagra-Caro et al. (2006), D'Este and Patel (2007), Motohashi and Yun (2007), Segarra-Blasco and Arauzo-Carod (2008), Perkmann and Walsh (2009), Bruneel, D'Este, and Salter (2010), Giuliani et al. (2010), D'Este and Perkmann (2011), Motohashi and Muramatsu (2012), Hewitt-Dundas (2013), Scandura (2016), among others. Using an IUC survey among U.K. firms, Scandura (2016) find that firms participating at IUC projects are associated with significant increases in R&D investment.

Yun (2007) find an increasing trend in Chinese manufacturing firms' outsourcing R&D to universities and public research institutes (PRIs) for the 1996-2002 period. The declining efforts in corporate scientific research due to intensified technology competition and declining appropriability of scientific research implies an increasingly important role of IUC in corporate innovation.

A.2. The influence of university research: corporate technology commercialization

Previous studies, such as Eisenhardt and Schoonhoven (1990), Nevens, Summe, and Uttal (1990), Brown, Berry, and Goel (1991), George, Zahra, and Wood (2002), Eesley, Hsu, and Roberts (2014), among many others, have identified that the composition of research teams, technological capacity, market position, management techniques, and corporate culture are factors that influence the effectiveness of a firm's technology commercialization. This study adds this stream of the literature by showing IUC as an additional driving force, which complements the finding of Mansfield (1991).

On the other hand, the effect of IUC on technology commercialization is important yet lacking large-scale empirical analysis in the literature for the following reasons:[3] first, prior IUC research tends to focus on the benefits to universities rather than corporates (e.g., Link and Siegel, 2005; Siegel and Wright, 2015). Second, due to the lack of firm-level technology commercialization data, empirical studies for corporate innovation often rely on firms' patents and inventions instead of their revenue from these innovations. In addition, those with firm-level technology commercialization data are based on small-scale survey data in developed countries.[4] Third, universities lack complementary assets and related experience for commercialization. For example, Hsu et al. (2021) document that only 16% of patent value is realized through university licensing.

A.3. Channels

Our literature review suggests two main channels for IUC to enhance corporate innovation and technology commercialization: knowledge acquisition and talent recruiting (Prager and Omenn, 1980; Mowery and Ziedonis, 2014). As argued by Prager

[3] Our literature review finds two pioneer works in this area: Mansfield's (1991) survey of 76 firms suggests that prior academic research facilitates about 10 percent of new products and processes. Using a survey among 517 European firms, Kaufmann and Tödtling (2001) find that firms' forming partnership with universities leads to higher possibility of product inventions.

[4] Prior studies on firm-level technology commercialization are mainly based on small-scale survey data in developed countries. For example, Kaufmann and Tödtling (2001) use a survey of 517 firms in European regions; Becker and Dietz (2004) consider a manufacturing industry survey of about 2,900 firms in Germany; Belderbos, Carree, and Lokshin (2004) use community innovation surveys of 2,056 in the Netherlands; Motohashi (2005) studies an industry survey of 724 firms in Japan; Berchicci (2013) consider a survey on about 2,900 Italian manufacturing firms between 1998 and 2004; Maietta (2015) examines a manufacturing industry survey of 1,744 firms in Italy; Walsh, Lee, and Nagaoka (2016) studies a survey of about 1,900 inventors in the U.S.

and Omenn (1980), firms could benefit from IUC for "*additional sources of ideas, knowledge, and technology on which to base potential new products and processes.*" The survey on R&D managers of Cohen, Nelson, and Walsh (2002) points out that firms indeed learn from universities through published papers and reports, public conferences and meetings, informal information exchange, and consulting. The literature on between-firm collaboration has documented that collaboration facilitates cross-learning (Powell, Koput, and Smith-Doerr, 1996; Cassiman and Veugelers, 2002), which is likely effective in IUC because learning from university research lowers the R&D costs of firms (Belderbos, Carree, and Lokshin, 2004; Scandura, 2016).

Human capital from universities is another important mechanism. Prager and Omenn (1980) argue that firms could benefit from IUC for "*source of potential research employees sympathetic to industry needs.*" As IUC creates opportunities for university researchers and corporate managers and R&D staff to interact, it could increase inventor flows into industry (Lee, 1996). As patent inventors from universities can bring in new knowledge that are complementary to research experience of incumbent corporate R&D staff, such inflow is conducive to corporate innovation (Østergaard, Timmermans, and Kristinsson, 2011; Qian et al., 2013; Che and Zhang, 2018). In addition, there may exist synergies from the integration of basic research and commercial development may enhance innovation efficiency. This is supported by the individual- or patent-level data: Gittelman and Kogut (2003) show that scientists who are capable in both publishing at academic journals and patenting can produce more influential patents, and Walsh, Lee, and Nagaoka (2016) find that U.S. patents resulting from collaboration with universities are associated with higher technical significance.

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B. Online Appendix Tables

Table OA.1: Variable list of the NBS data.

We provide a comprehensive list of variables in the NBS data. The variables labelled in bold are those used in our empirical analysis.

Panel A: Background Information

Variable Name	Item Name (translated in English)
qymc	Firm Name
frdm	Code of Legal Person
frdbxm	Name of Legal Person
zw	Position of Legal Person
dqdm	Location
yzbm	Zipcode
cp1	Name of Product 1
cp2	Name of Product 2
cp3	Name of Product 3
hylb	Industry
djzclx	Registration Type
gykgqk	State Own Enterprise (dummy)
kysjn	Establishment Year
kysjy	Establishment Month
cyhddwshj	Number of Business Units
qygm	Firm Size Category
qzgy	Light/Heavy Industry (binary)
dzyj	Email
wz	Website
gszch	Business Registration Number

Panel B: Balance Sheet

Variable Name	Item Name (translated in English)
ldzchj	Current Assets
yszkje	Accounts Receivable
ch	Inventories
ccp	Finished Products
gdzchj	Physical Assets
scjyy	Physical Assets (used in production process)
ljzj	Total Depreciation
jsjs	Computers
qzwj	Micro-Computers
wxjdyzchj	Intangibles and Deferred Assets
wxzc	Intangibles
zczj	Total Assets
ldfzhj	Current Liabilities
yfzk	Accounts Payable
cqfzhj	Long-Term Liabilities
fzhj	Total Liabilities
syzqyhj	Total Equity
sszb	Paid-in Capital
gjzbj	Capital (paid in by the state)
jtzbj	Capital (paid in by collective owners)
frzbj	Capital (paid in by the legal persons)
grzbj	Capital (paid in by individuals)
gatzbj	Capital (paid in by owners in HK, Macau, and Taiwan)
wszbj	Capital (paid in by foreign owners)
cyrs	Total Employees

Panel C: Income Statement & Cash Flow Statement (part 1)

Variable Name	Item Name (translated in English)
gyxsczxjxgd	Total Sales
xcpcz	New Product Sales
gyzczxjxgd	Total Industrial Output Value
gyzjz	Industrial Added Value
yysr	Operating Revenue
qtsr	Other Revenue
zyywsr	Main Business Revenue
tzsy	Income from Investment
yywsr	Non-Operating Revenue
cpxscb	Cost Of Goods Sold
zycb	Main Business Costs
cpxsfy	Sales Expenses
ggf	Advertisement Expenses
glfy	Administration Expenses
yyfy	Operating Expenses
clf	Travel Expenses
ghjf	Labor Union Expenditure
bgf	Office Allowance
zgjyf	Employee Educational Expenses
pwf	Sewage Charges
yywzc	Non-Operating Expenses
yjkff	R&D Expenditure
lrze	Total Profits
cpxslr	Sales Profits
yylr	Operating Profits
qtywlr	Other Business Profits
qtlr	Other Profits
ckjhz	Exports
cqtz	Capital Expenditure
dqtz	Long-Term Investment
bnzj	Depreciation of the year
lsze	Total Interest Expenses and Tax

Panel C: Income Statement & Cash Flow Statement (part 2)

Variable Name	Item Name (translated in English)
sj	Tax
cpxssjjfj	Tax and Surcharge on Sales
zysj	Main Business Tax
ccbxf	Property Insurance Premiums
lddybxf	Unemployment Insurance Premiums
ldbxf	Workers Insurance Expenses
ylylbxf	Medical Insurance Expenses
ylbxf	Pension
zfgjj	Housing Reserves
cwfy	Financial Expenses
lxzc	Interest Expenses
btsr	Subsidies Received
yjsds	Income Tax Payable
yflr	Profits Payable
bnyfgzze	Wages Payable
zyywyfgzze	Wages Payable (for main business)
bnyfflfze	Welfare Payable
zyywyfflfze	Welfare Payable (for main business)
bnyjzzs	Value Added Tax payable
bnjxse	Input VAT
bnxxse	VAT on Sales
zjtrhj	Intermediate Inputs
jyxje	Operating Cash Flow
jyxjr	Operating Cash In-Flow
jyxjc	Operating Cash Out-Flow
tzxje	Investing Cash Flow
tzxjr	Investing Cash In-Flow
tzxjc	Investing Cash Out-Flow
czxje	Financing Cash Flow
czxjr	Financing Cash In-Flow
czxjc	Financing Cash Out-Flow

Table OA.2: The List of 153 Universities in Our Sample.

Entitlement	University Name	Entitlement	University Name	Entitlement	University Name
Project 985	北京大学	Project 211	安徽大学	Project 211	南京师范大学
Project 985	北京航空航天大学	Project 211	北京工业大学	Project 211	内蒙古大学
Project 985	北京理工大学	Project 211	北京化工大学	Project 211	宁夏大学
Project 985	北京师范大学	Project 211	北京交通大学	Project 211	青海大学
Project 985	大连理工大学	Project 211	北京科技大学	Project 211	陕西师范大学
Project 985	电子科技大学	Project 211	北京林业大学	Project 211	上海财经大学
Project 985	东北大学	Project 211	北京体育大学	Project 211	上海大学
Project 985	东南大学	Project 211	北京外国语大学	Project 211	上海外国语大学
Project 985	复旦大学	Project 211	北京邮电大学	Project 211	石河子大学
Project 985	国防科技大学	Project 211	北京中医药大学	Project 211	四川农业大学
Project 985	哈尔滨工业大学	Project 211	大连海事大学	Project 211	苏州大学
Project 985	湖南大学	Project 211	第二军医大学	Project 211	太原理工大学
Project 985	华东师范大学	Project 211	第四军医大学	Project 211	天津医科大学
Project 985	华南理工大学	Project 211	东北林业大学	Project 211	武汉理工大学
Project 985	华中科技大学	Project 211	东北农业大学	Project 211	西安电子科技大学
Project 985	吉林大学	Project 211	东北师范大学	Project 211	西北大学
Project 985	兰州大学	Project 211	东华大学	Project 211	西藏大学
Project 985	南京大学	Project 211	对外经济贸易大学	Project 211	西南财经大学
Project 985	南开大学	Project 211	福州大学	Project 211	西南大学
Project 985	清华大学	Project 211	广西大学	Project 211	西南交通大学
Project 985	厦门大学	Project 211	贵州大学	Project 211	新疆大学
Project 985	山东大学	Project 211	哈尔滨工程大学	Project 211	延边大学
Project 985	上海交通大学	Project 211	海南大学	Project 211	云南大学
Project 985	四川大学	Project 211	合肥工业大学	Project 211	长安大学
Project 985	天津大学	Project 211	河北工业大学	Project 211	郑州大学
Project 985	同济大学	Project 211	河海大学	Project 211	中国传媒大学
Project 985	武汉大学	Project 211	湖南师范大学	Project 211	中国地质大学（北京）
Project 985	西安交通大学	Project 211	华北电力大学	Project 211	中国地质大学（武汉）
Project 985	西北工业大学	Project 211	华东理工大学	Project 211	中国矿业大学
Project 985	西北农林科技大学	Project 211	华南师范大学	Project 211	中国石油大学（北京）
Project 985	浙江大学	Project 211	华中农业大学	Project 211	中国石油大学（华东）
Project 985	中国海洋大学	Project 211	华中师范大学	Project 211	中国药科大学
Project 985	中国科学技术大学	Project 211	暨南大学	Project 211	中国政法大学
Project 985	中国农业大学	Project 211	江南大学	Project 211	中南财经政法大学
Project 985	中国人民大学	Project 211	辽宁大学	Project 211	中央财经大学
Project 985	中南大学	Project 211	南昌大学	Project 211	中央音乐学院
Project 985	中山大学	Project 211	南京航空航天大学	Institute	中国科学院
Project 985	中央民族大学	Project 211	南京理工大学	Institute	中国社会科学院
Project 985	重庆大学	Project 211	南京农业大学		

Table OA.3: Results of Table 2 in Two Halves of the Sample Period.

We estimate Table 2 in the first half (*t* is from 1998 to 2005) and the second half (*t* is from 2006 to 2013) of the sample period, respectively. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Dept Var = New Product Sales						
Panel A: Sample Period from 1998 to 2005						
	Panel A1		**Panel A2**		**Panel A3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	76.2691***	75.2024***				
	(22.6882)	(22.6816)				
IUC measured in *Count*			47.2062***	46.2294***		
			(16.4796)	(16.5129)		
IUC measured in *Ratio*					66.5112***	66.1463***
					(23.0449)	(22.9871)
#Obs	230,331	230,331	230,331	230,331	230,331	230,331
#Firms	53,646	53,646	53,646	53,646	53,646	53,646
R-squared	0.9046	0.9048	0.9045	0.9048	0.9045	0.9047
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES
Panel B: Sample Period from 2006 to 2013						
	Panel B1		**Panel B2**		**Panel B3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	15.4537*	15.3505*				
	(7.9055)	(7.9136)				
IUC measured in *Count*			7.6527*	7.7309*		
			(4.6129)	(4.6101)		
IUC measured in *Ratio*					15.1208	15.3410
					(9.6456)	(9.6347)
#Obs	336,302	336,302	336,302	336,302	336,302	336,302
#Firms	75,078	75,078	75,078	75,078	75,078	75,078
R-squared	0.9416	0.9416	0.9416	0.9416	0.9416	0.9416
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table OA.4: Robustness Checks for Table 2 Using Poisson regressions.

We estimate Table 2 using Poisson pseudo-maximum likelihood (PPML) regressions. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

	Dept Var = New Product Sales					
	Panel A		Panel B		Panel C	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.0529**	0.0528**				
	(0.0240)	(0.0228)				
IUC measured in *Count*			0.0242**	0.0223**		
			(0.0112)	(0.0106)		
IUC measured in *Ratio*					0.1996***	0.1854***
					(0.0508)	(0.0484)
#Obs	566,633	566,633	566,633	566,633	566,633	566,633
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
Pseudo R-squared	0.899	0.903	0.899	0.903	0.899	0.903
Total Sales as a Control	YES	YES	YES	YES	YES	YES
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table OA.5: Robustness Checks for Table 6 Using Poisson Regressions.

We estimate Table 5 using Poisson pseudo-maximum likelihood (PPML) regressions. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = PatCount						
	Panel A1		Panel A2		Panel A3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.2769***	0.1628***				
	(0.0213)	(0.0228)				
IUC measured in *Count*			0.0895***	0.0493***		
			(0.0088)	(0.0095)		
IUC measured in *Ratio*					1.0170***	0.8932***
					(0.0684)	(0.0661)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
Pseudo R-squared	0.418	0.433	0.418	0.433	0.418	0.433
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES
Panel B: Dept Var = PatCite						
	Panel B1		Panel B2		Panel B3	
	(1)	(2)	(1)	(2)	(1)	(2)
IUC measured in *Dummy*	0.2224***	0.1459***				
	(0.0289)	(0.0287)				
IUC measured in *Count*			0.0859***	0.0579***		
			(0.0127)	(0.0127)		
IUC measured in *Ratio*					0.6571***	0.5586***
					(0.0796)	(0.0800)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
Pseudo R-squared	0.0897	0.0971	0.0897	0.0971	0.0897	0.0972
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table OA.6: Robustness Checks for Table 9 Using New Inventor Disambiguation Approach.

We disambiguate a unique inventor not only with the same name but also in the same primary IPC and rerun the pooled regressions in Table 9 to test the talent recruiting channel with refined measurements of inventor flows. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = UnivInventor						
	Panel A1		**Panel A2**		**Panel A3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0081***	0.0078***				
	(0.0008)	(0.0008)				
IUC measured in *Count*			0.0034***	0.0033***		
			(0.0004)	(0.0004)		
IUC measured in *Ratio*					0.0066***	0.0065***
					(0.0012)	(0.0012)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4087	0.4095	0.4085	0.4094	0.4081	0.4089
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES
Panel B: Dept Var = CorpInventor						
	Panel B1		**Panel B2**		**Panel B3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0015	0.0010				
	(0.0038)	(0.0038)				
IUC measured in *Count*			-0.0017	-0.0019		
			(0.0018)	(0.0018)		
IUC measured in *Ratio*					-0.0094**	-0.0096**
					(0.0040)	(0.0040)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4328	0.4331	0.4328	0.4331	0.4328	0.4331
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES

Table OA.7: Robustness Checks for Table 9 Dropping Inventors with the Most Common Names.

We rerun the pooled regressions in Table 9 to test the talent recruiting channel by dropping the inventors whose names are in the top one percentile of appearance frequency. Sample period of *t* is from 1998 to 2013. A firm is included if it has at least one patent in 1996-2016. We exclude the firms that file any IUC patents in their first three sample years. The outcome variable and all control variables are winsorized at their 1st and 99th percentiles. Numbers in parentheses denote standard errors clustered by firms. ***, **, * indicate significance levels of 1%, 5%, and 10%, respectively.

Panel A: Dept Var = UnivInventor						
	Panel A1		**Panel A2**		**Panel A3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0134***	0.0128***				
	(0.0014)	(0.0014)				
IUC measured in *Count*			0.0059***	0.0056***		
			(0.0007)	(0.0007)		
IUC measured in *Ratio*					0.0117***	0.0114***
					(0.0021)	(0.0021)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4241	0.4252	0.4240	0.4251	0.4237	0.4248
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES
Panel B: Dept Var = CorpInventor						
	Panel B1		**Panel B2**		**Panel B3**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
IUC measured in *Dummy*	0.0010	0.0005				
	(0.0042)	(0.0042)				
IUC measured in *Count*			-0.0022	-0.0024		
			(0.0019)	(0.0019)		
IUC measured in *Ratio*					-0.0063	-0.0065
					(0.0045)	(0.0045)
#Obs	784,025	784,025	784,025	784,025	784,025	784,025
#Firms	92,521	92,521	92,521	92,521	92,521	92,521
R-squared	0.4282	0.4284	0.4282	0.4284	0.4282	0.4284
Innovation-Related Controls	YES	YES	YES	YES	YES	YES
Firm Characteristics Controls	NO	YES	NO	YES	NO	YES
Firm FE	YES	YES	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES