



Prestige and technology-transaction prices: Evidence from patent-selling by Chinese universities

Huijun Shen^a, Wim Coreynen^{b,c}, Can Huang^{d,*}

^a International Business School Suzhou, Xi'an Jiaotong-Liverpool University, Suzhou, Jiangsu Province, China

^b School of Business and Economics, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands

^c Utrecht University School of Economics, Utrecht University, Utrecht, the Netherlands

^d Institute for Intellectual Property Management, School of Management, Zijingang Campus, Zhejiang University, Yuhangtang Road 866, Hangzhou, Zhejiang Province, China

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ABSTRACT

Pricing is important to the functioning of markets for technology. A considerable body of research has studied how various factors contribute to determining prices, yet the effects of both technology providers' and buyers' prestige on prices remain underexplored. This study investigates how prestige affects pricing in university–firm technology transactions. We argue that prestige shapes prices by influencing both technology valuation and negotiations. Using transaction data on patented university technologies in Zhejiang Province in China during the period spanning 2017–2019, we examine the relationship between inventor team prestige and transaction prices. We also investigate how this relationship depends on organizational prestige, specifically that of a supplying university and a buying firm. We find a positive relationship between inventor team prestige and transaction prices. Furthermore, this relationship is positively moderated by university prestige, while it is negatively moderated by firm prestige. This study generates implications for universities as they manage technology transfer to firms.

1. Introduction

The market for technology plays an important role in exploiting the value of research and development (R&D), facilitating the diffusion of technology and increasing the efficiency of innovations (Arora et al., 2001; Gambardella et al., 2007; Chatterji and Fabrizio 2014). In this market, selling or licensing inventions generated in universities facilitates the realization of the potential economic and social value of universities' technological knowledge (Jensen and Thursby 2001; Caviggioli et al., 2020; Aksoy and Beaudry 2021). Understanding how best to successfully transfer scientific knowledge to industry is considered a crucial issue for national innovation systems and economic development (Agrawal 2006; Bradley et al., 2013; Klofsten et al., 2019).

Pricing, the process of determining technology-transaction prices, is one of the most significant issues in technology transfer (Sherry and Teece 2004; Odasso et al., 2015; Frattini et al., 2019). Information asymmetry between the supply and demand sides makes it difficult to determine the price of a technology efficiently (Arrow 1962; Arora and

Gambardella 2010). This is particularly the case in the context of university technology transfer (UTT), where the immaturity of university technologies makes valuation especially problematic (Jensen and Thursby 2001; Caviggioli et al., 2020). Both scholars and practitioners have long sought to identify the key factors that determine fair prices in technology transactions (Shane 2002; Sakakibara 2010; Frattini et al., 2019).

The price of a technology is determined primarily by its quality or value (Arrow 1962; Sakakibara 2010). Thus, prospective buyers collect as much information about a technology as possible for the purpose of valuation (Molhova 2014). Patent information is typically used to indicate a technology's value (Gambardella et al. 2007, 2008; Sakakibara 2010; Odasso et al., 2015). Although patent documents can provide useful public information regarding the codified part of a technology, they fail to reveal tacit knowledge and thereby eliminate all information asymmetry (Munari and Oriani 2011; Aksoy and Beaudry 2021).

When information regarding a technology is insufficient for buyer firms to assess its value accurately, as external appraisers they are more

* Corresponding author. School of Management, Institute for Intellectual Property Management, Department of Innovation, Entrepreneurship and Strategy, Zijingang campus, Zhejiang University, Building Room A918, Yuhangtang Road 866, Hangzhou, Zhejiang Province, 310058, China.

E-mail address: canhuang@zju.edu.cn (C. Huang).

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likely to infer a technology's value based on certain features of technology providers (Podolny 1994; Lichtenhaler and Ernst 2007). Prestige is considered an important feature of technology providers (Sine et al., 2003; Simcoe and Waguespack 2011). We define prestige as an actor's (i.e., an individual, a group, or an organization) hierarchical position in an ordered total system of differentiated evaluation (Sine et al., 2003; Acharya and Pollock, 2013). Theoretically, commodities provided by prestigious actors are more likely to be perceived as valuable (Azoulay et al., 2014). Therefore, holding all else equal, the price of a technology rises with the prestige of the technology provider. Contrary to this theoretical prediction, however, empirical results regarding the effects of technology provider prestige are mixed. For instance, while Sine et al. (2003) confirm the existence of a positive relationship between institutional prestige and university licensing revenue, Elfenbein (2007) finds that prestige does not affect inferences regarding the value of university inventions.

Such inconclusive evidence results from the incompleteness of prior investigations. Specifically, prior studies focus mainly on the impact of prestige on prospective buyers' valuation of a technology, while neglecting prestige as a factor in price negotiations by shaping actors' bargaining power (Frattini et al., 2019; Khoury et al., 2019). Therefore, further investigation is warranted to understand how the negotiation stage of pricing is affected by the prestige of *all* actors involved—the inventor, the university and the buyer. Prior studies (e.g., Sine et al., 2003; Elfenbein 2007) also fail to investigate the contingencies that reinforce or constrain the effects of provider prestige on technology prices. For instance, the effects of a university inventor team's prestige may be moderated by the university's prestige, a factor that has not been examined fully.

To fill these gaps in the literature, this study examines how prestige influences transaction prices in the technology market. We focus specifically on the case of the Chinese technology market, wherein the generation of patented technologies by universities has increased dramatically over the past decade (Chen et al., 2016; Ye et al., 2020) and local universities actively transfer patented technologies to firms. In China, inventor teams and the universities with which they are affiliated are important actors on the supply side. Yet most Chinese universities' technology transfer offices (TTOs) have limited competence (Chen et al., 2016; Rotenberg 2016; Li et al., 2020; Shen et al., 2022). As a result, the participation of TTOs in technology transfer is generally restricted to administrative work, and Chinese universities' inventor teams often take the lead in searching for prospective buyers, connecting and negotiating with them to determine prices (Li et al., 2020; Shen et al., 2022). We therefore consider the roles of both the inventor team and the university on the supply side and the firm on the demand side.

We first consider the relationship between inventor team prestige and the prices of university technologies that are sold. We argue that inventor team prestige affects technology prices by (1) shaping how much firms are willing to pay during the valuation stage and (2) influencing inventor teams' bargaining power in the negotiation stage. Next, we discuss the moderating effects of both university prestige and firm prestige on this relationship. To test our hypotheses, we use data on university patent sales in Zhejiang province during the period spanning 2017–2019. The empirical results show that there is a positive relationship between inventor team prestige and technology transaction prices. Moreover, university prestige moderates this relationship positively while firm prestige moderates it negatively.

This study makes several contributions to the literature. First, we contribute to the growing stream of literature on the role of prestige in UTT (Rothaermel et al., 2007; Pitsakis et al., 2015; Houweling and Wolff 2020). In addition to considering how prestige influences the willingness to pay (WTP) of a buyer in the valuation stage, we investigate another mechanism through which prestige shapes transaction prices for university technologies, namely the role that prestige plays in negotiations by affecting actors' bargaining power. Second, we investigate how the prestige of both technology providers and buyers influences prices in

technology transactions. We argue that technology buyer prestige can also influence prices through bargaining power. This means that any understanding of the impact of prestige on pricing in technology transactions is more complete when both technology provider and buyer prestige are considered. Third, we contribute to rationalizing the inconclusive results reported in the literature regarding the relationship between prestige and the price of university technology by identifying organizational contingencies such as university and firm prestige. We demonstrate that inventor teams benefit differentially from university prestige. The extent to which inventor teams can leverage university prestige also depends on their own prestige.

The remainder of the study is structured as follows. In the next section, we introduce a new theoretical framework for analyzing pricing in technology transactions and develop our hypotheses. In the third section, we explain the data, our sample, the variables, and our methodology, after which we report the empirical results in the fourth section. In the fifth and final section, we elaborate on the contributions, implications and limitations of our analysis and provide conclusions.

2. Theory and hypotheses

2.1. The process of university technology pricing: a double-sided framework

The price in a transaction in the market for technology is determined jointly by the supply and demand sides. In the context of transacting with university technologies, the actors on the supply side are inventor teams and their universities, and those on the demand side are firms. Pricing in technology transactions involves two types of activities: valuation and negotiations (Sohn et al., 2013; Frattini et al., 2019). In the first stage, the supply and demand sides assess the prospective value of the patented technology. In the second stage, the two sides reach agreement on the price after negotiating (Bradley et al., 2013). Difficulties related to pricing often arise in both stages. Considering both the valuation and negotiation stages, this study offers a theoretical framework for further discussion and analysis (see Fig. 1).

2.1.1. Valuation stage

In the valuation stage, a buyer's willingness to pay (WTP) is determined for transactions involving patented technologies (Shapiro 1985; Sohn et al., 2013). A firm's WTP is influenced by the perceived benefits and risks of the patented technology (Aksoy and Beaudry 2021). In the context of UTT, when firms assess a technology, they scrutinize both the technology and the inventor team, because firms want assurance that the inventor team will provide sufficient human and social capital in addition to technological expertise, all of which are essential for successful commercialization of university technology (Shane and Stuart 2002; Houweling and Wolff 2020). The firm's perceptions of the benefits and risks of the technology transfer result from its analysis and interpretation of the information that it can collect pertaining to the technology and the inventor team (Molhova 2014). Therefore, a firm's WTP will strengthen as a technology's perceived benefits rise while it will weaken as the perceived risks rise.

In the valuation stage, several obstacles exist in determining the price of a technology. The first and foremost obstacle is what is known as the "information paradox" (Arrow 1962). Technology providers possess all relevant information about the technologies to be traded, including codified knowledge and uncoded (or tacit) knowledge (Shane 2002; Agrawal 2006). As it is difficult for prospective buyers to access uncoded knowledge, they have difficulty in valuating technologies (Arora 1995; Agrawal 2006). If the provider reveals such uncoded knowledge before signing a contract, however, a prospective buyer could acquire valuable technological knowledge without paying for it (Arrow 1962). Such a risk makes technology suppliers reluctant to provide sufficient critical information, thus making it difficult for prospective buyers to evaluate a technology *ex ante* (Arora and Gambardella

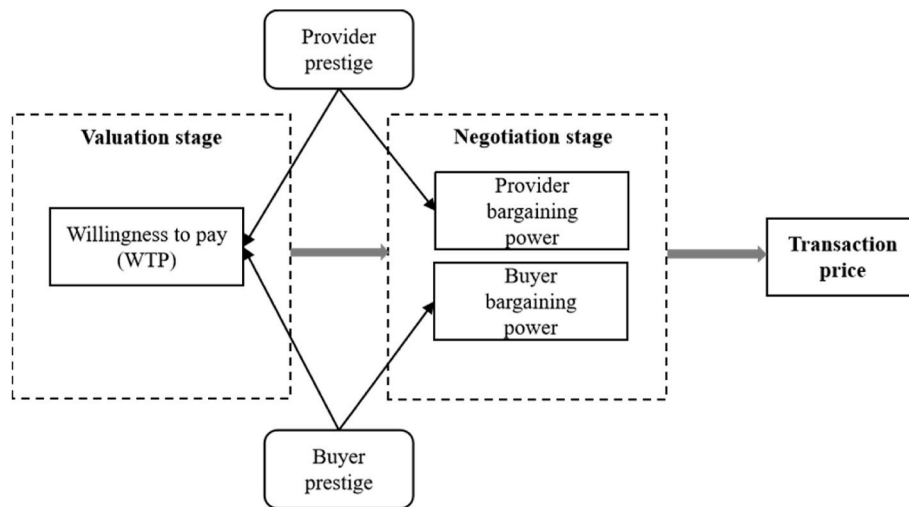


Fig. 1. The influences of actors' prestige in pricing process for technology transactions: A theoretical framework.

2010).

Another obstacle in valuation is the immaturity of university technologies (Caviggioli et al., 2020). Scientific discoveries occur at an early stage of technological development (Jensen and Thursby 2001). On the supply side, university faculties typically lack knowledge about the market (Sohn et al., 2013) and they find it difficult to describe and scrutinize embryonic technologies (Elfenbein 2007; Swamidass and Vulasa 2009). On the demand side, there are often no track records for embryonic patented technologies, and prospective buyers can observe the quality of a technology only after they actually apply it. Moreover, because the prospects of embryonic technologies are highly uncertain, it is difficult to ensure that firms can obtain revenues and make profits in the future from purchasing those technologies (Shane and Stuart 2002). Therefore, it is challenging for both universities and firms to assess the value of technologies (Hsieh 2013).

2.1.2. Negotiation stage

Following valuation, negotiating is the next step in determining prices in technology transactions (Frattini et al., 2019; Santiago et al., 2015). In addition to a buyer's WTP, the transaction price is also influenced by their respective bargaining power in the negotiation stage (Ariño et al., 2008; Sakakibara 2010; Khoury et al., 2019). Bargaining power reflects the ability of actors to influence the outcome of negotiations to obtain preferred terms and conditions in a transaction (Argyres and Liebeskind 1999; Khoury et al., 2019). When a provider has greater bargaining power, it can ask a higher price. When a buyer has greater bargaining power, it can agree on a price that is below its maximum WTP.

As in the valuation stage, difficulties related to pricing also arise in the negotiation stage. First, negotiators in product markets often refer to prices in deals involving similar commodities, but this tactic does not work well in the technology market, because each technology is unique and comparability across technology transactions is low (Munari and Oriani 2011). Therefore, during negotiations, neither the supplier nor the buyer side can refer to the prices of similar technologies as benchmarks to persuade the other side.

Second, it is especially difficult to reach consensus on prices in the context of UTT because universities and the firms with which they hope to do business often disagree over the likelihood of successful commercialization of a given technology (Ali and Gittelman 2016). Universities typically lack knowledge about the market, while firms have more in-depth information regarding the commercial potential of a technology (Sohn et al., 2013). Therefore, universities may overestimate the chances that their technologies can be commercialized successfully. This difference between universities and firms can cause gaps regarding

their price expectations, leading to failures to reach agreement on pricing during negotiations.

2.2. Factors influencing university technology pricing

University technology prices can be influenced by both technology-level and actor-level features. Some technological and patent features, including patent age, number of claims, originality, and generality, affect technology pricing (Gambardella et al., 2008; Odasso et al., 2015), because they influence the perceived value of patented technologies (Munari and Oriani 2011). However, due to information asymmetry and the uncertainty of embryonic technologies, prospective buyers prefer not relying only on publicly available technological and patent information to evaluate a technology *ex ante*. They also examine features of the technology provider to infer the technology's value (Spence 1974; Sine et al., 2003; Lichtenthaler and Ernst 2007).

Among technology providers' features, prestige deserves particular attention (Merton 1968; Stuart et al., 1999; Azoulay et al., 2014). An actor's prestige is regarded as an important indicator of the quality of his/her products. It is a lens through which external appraisers form perceptions of the quality of both the actor and his/her products (Podolny 2005), especially when there is uncertainty about the products' value (Jensen and Roy, 2008; Azoulay et al., 2014). Despite the importance of investigating the influence of an actor's prestige in transactions, the relationship between providers' prestige and UTT pricing is still underexplored. Two noticeable exceptions are the studies by Sine et al. (2003) and Elfenbein (2007), who found seemingly inconclusive results. Sine et al. (2003) found that more prestigious universities acquire higher licensing revenues. Elfenbein (2007), who investigated the impact of inventors' academic prestige on licensing prices for US universities, did not however support the theoretical prediction that prices rise with the prestige of inventors.

We argue that the limitations of prior studies lead to these mixed results. One such limitation is that previous studies have largely overlooked the impact of prestige on transaction pricing through negotiations. Prestige is a source of power that can bring status-driven bargaining advantages to social exchanges (Finkelstein, 1992; Thye, 2000). An actor with high prestige produces high expectations by other actors, specifically about its future task performance (Thye and Harrell, 2017). A prestigious actor is therefore regarded as more competent than less prestigious actors (Azoulay et al., 2014). Moreover, as highly competent actors are considered less likely to be replaced, they attract multiple prospective buyers to compete for transaction opportunities (Sine et al., 2003). Given the expected value and irreplaceability of a deal, other prospective buyers are more willing to compromise and

agree with the conditions specified by prestigious providers. Thus, the more prestigious an actor is, the more influential is that actor in the negotiation process to obtain a bargaining outcome (Thye and Harrell, 2017). Technology providers can take advantage of their bargaining power to obtain higher prices, but buyer bargaining power can influence prices as well. Therefore, the role of the bargaining power of both parties in jointly shaping prices deserves investigation (Sakakibara 2010; Frattini et al., 2019; Khoury et al., 2019).

Another limitation we observe in the literature is that contingencies that moderate the effect of technology provider prestige on transaction prices have not been fully revealed. The value of technology is contextual and varies across organizations that possess it (Munari and Oriani 2011). Moreover, each firm has its own criteria for valuing technology, so perceptions of the same technology across firms can diverge (Arora and Gambardella 2010). For instance, Lo and Li (2018) found that the outcomes of technology valuations are different between firms that follow the logic of technological advancement and those that follow the logic of market value. It remains, however, to investigate how features of firms on the demand side impact the effects of organizational prestige on transaction prices.

To transcend these limitations, we use the theoretical framework proposed earlier to analyze the role of prestige in the process of pricing university technology transactions. The framework illustrates how actors' prestige impacts the process of pricing in technology transfers. Furthermore, we discuss the relationship between inventor team prestige and technology prices and explore how this relationship is moderated by organizational prestige, including the prestige of universities and firms.

2.3. Hypotheses

2.3.1. Inventor team prestige and prices in university technology transactions

Inventor team prestige can impact transaction prices through two mechanisms. First, inventor team prestige influences WTP by shaping a firm's perceptions of the benefits of a transaction. On the one hand, inventor team prestige shapes inferences regarding the quality of a technology (Sine et al., 2003; Simcoe and Waguespack 2011). In the presence of information asymmetry and uncertainty, a firm tends to value a technology conservatively (Gallini and Wright 1990; Molhova 2014). When an inventor team is considered more prestigious, however, the firm is more likely to accept the inventor team's valuation of the technology and perceive the technology as valuable (Merton 1968; Higgins et al., 2011; Azoulay et al., 2014). Thus, the perceived value of technologies is positively related to inventor team prestige.

On the other hand, inventor teams with greater prestige can provide more robust social capital, which is beneficial to firms (Houweling and Wolff 2020). By participating in UTT, firms not only access technological resources and human capital, but they also acquire social capital by building formal collaborative relationships with the inventor team as well as the university (Tallman and Shenkar 1994; Sine et al., 2003). For instance, through collaboration, firms can increase their embeddedness in the university's innovation network, which creates additional opportunities to work with other network members in the future (Ahuja 2000; Cattaneo et al., 2015).

Second, inventor team prestige affects WTP by influencing the perceived risks involved in buying a university technology. Commercializing university technologies requires considerable investment, while firms, especially start-ups, face risks derived from thin financial resources (Jensen and Thursby 2001; Higgins et al., 2011; Aksoy and Beaudry 2021). Social capital contributed by partners such as universities may help firms obtain financial resources from investors and government funding agencies (Fuller and Rothaermel 2012; Shane and Stuart 2002). For instance, an inventor team's prestige can support a firm's efforts to convince venture capitalists to invest in a technology it seeks to acquire (Higgins et al., 2011; Stuart et al., 1999). The prestige of

an inventor team can also amplify the market's recognition of a technology, reducing the risks caused by market uncertainty (Halperin et al., 1976; Pitsakis et al., 2015). In summary, when an inventor team's prestige is higher, the perceived benefits are greater while the perceived risks are lower, and thus a firm's WTP is stronger.

The second mechanism through which prestige affects pricing in university-firm technology transactions involves the effects of actor prestige on bargaining power in the negotiation stage. Highly prestigious inventor teams that are expected to perform better draw attention from multiple prospective buyers (Azoulay et al., 2014; Granovetter 1985; Houweling and Wolff 2020; Sine et al., 2003). As a result, prestigious providers enjoy higher irreplaceability, and it is likely that multiple firms will compete to exchange with them. During negotiations, if one firm rejects the price proposed by the inventor team, the inventor team can turn to other firms that are willing to accept the asking price (Khoury et al., 2019). In such a seller's market, the prestigious inventor team possesses greater bargaining power (Finkelstein, 1992; Thye 2000; Acharya and Pollock, 2013), and they can use their bargaining advantages to obtain higher prices for their technologies (Thye 2000). Based on the above discussion, we propose the following hypothesis.

Hypothesis 1. When an inventor team's prestige is higher, the transaction price of a technology it has developed is higher.

2.3.2. The moderating effect of organizational prestige

We posit that the level of prestige of the university with which an inventor team is affiliated can affect the price of a technology. First, university prestige increases the credibility of the inventor team's knowledge and information (Sine et al., 2003; Pollock et al., 2010). Prestige at the organizational level can bring additional resources to organizational members (Cattaneo et al., 2015; Kwon et al., 2013). In the case of universities, prestigious academic institutions are more likely to provide their research faculty with the conditions necessary for the generation, maintenance, and reinforcement of inventor team prestige (Bothner et al., 2012). Thus, university prestige can amplify the positive effects of inventor team prestige on a firm's assessment of a technology. Second, university prestige reinforces the bargaining power derived from inventor team prestige. The promise of a prestigious affiliation raises firms' expectations of the prospects of an inventor team's technology (Pollock et al., 2010). Partnering with inventor teams from prestigious universities also provides firms with certification benefits (Stuart et al., 1999), and firms thus prefer to transact with them (Sine et al., 2003). Inventor teams from prestigious universities are therefore more likely to attract buyers to transfer their technology, so their bargaining power is greater in negotiations. Based on the above discussion, we propose the following hypothesis.

Hypothesis 2. When university prestige is higher, the positive relationship between inventor team prestige and transaction prices is more salient.

A firm's prestige is another contingency that influences the effects of inventor team prestige. First, a firm's prestige affects its perception of the benefits to be derived from UTT. When the firm itself possesses high prestige, it can take advantage of its own network to acquire resources (Ahuja 2000). In that case, the firm depends less critically on obtaining social capital by developing collaborative relationships with prestigious inventor teams and their universities. In the valuation stage, prestigious firms are less likely to tie a technology's perceived benefits to an inventor team's prestige than firms that lack comparable prestige. Therefore, holding all else equal, firms' WTP weakens when their prestige is higher.

Second, prestige affects a firm's bargaining power. Firms hope to leverage their bargaining power to gain better discounts in negotiating the price of a technology to be transferred (Gallini and Wright 1990; Dushnitsky 2010; Frattini et al., 2019). Just as an inventor team's

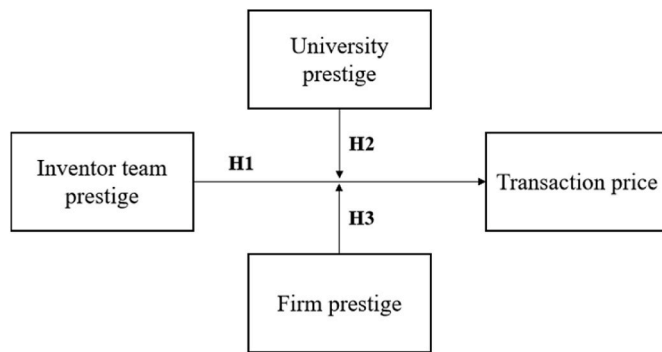


Fig. 2. The conceptual model.

prestige can strengthen its bargaining power in negotiations, so a firm's prestige can also increase its bargaining power. The more prestigious the firm, the weaker the relative bargaining power of the inventor team (Dencker 2009). Therefore, when inventor teams negotiate with highly prestigious firms, the prices they command are lower than when they negotiate with firms that lack prestige. Based on the above discussion, we propose the following hypothesis.

Hypothesis 3. When firm prestige is higher, the positive relationship between an inventor team's prestige and transaction prices is less salient.

Fig. 2 demonstrates the conceptual model of this study and its hypotheses.

3. Data and sample

3.1. Data source

To test our hypotheses, we use data on patent sales by universities located in Zhejiang Province in China.¹ Universities in Zhejiang Province are active providers of patented technology. According to the Zhejiang Intellectual Property Exchange Center,² an important official platform for transacting technologies in the province, more than 1200 patents have been transacted by universities and public research institutions via licensing and selling during the period spanning 2017–2018, generating gross revenue over this period of RMB 460 million. Zhejiang University, for example, is one of China's leading universities that participates actively in UTT. According to the 2017 Annual Statistical Report of China Technology Market (Ministry of Science and Technology of China, 2017), Zhejiang University was ranked eleventh among all domestic universities with respect to the total value of its technology transactions, and first among all universities in Zhejiang Province.

Following the amendment in 2015 of the Law on Promoting the Transformation of Scientific and Technological Achievements, universities in Zhejiang Province are required to disclose their patent sales information to the public through the official website of the Zhejiang Intellectual Property Exchange Center starting from 2017. We collect information on university patent transactions in Zhejiang Province from this website, identifying patent numbers, the names of patentees (i.e., universities), inventors, and the prices and dates of transactions. We use this basic information to collect additional information. First, we use the

Table 1

Patents sold and average transaction prices of patents from Chinese universities.

University	Number of patents sold	Average Price (Unit: RMB 10,000)	Std. Dev.
Zhejiang Normal University	6	28.5	7.12
Zhejiang University	157	18.92	19.68
Hangzhou Normal University	5	9.72	11.35
Zhejiang A&F University	18	6.82	6.71
Ningbo University	16	6.46	13.26
Zhejiang University of Technology	158	3.42	4.57
Zhejiang Ocean University	11	3.13	1.99
Wenzhou University	53	1.55	1.25
Zhejiang Wanli University	1	1.5	0
Hangzhou Dianzi University	4	1	0
Zhejiang University of Water Resources and Electric Power	7	1	0.65
Total	436	9.37	14.89

patent database incoPat to collect more detailed information on the sold patents,³ including the names of buyer firms, application year, number of claims, and so on. Second, we collect additional information on inventor teams, universities, and firms from other public information sources such as the official homepages of faculty, universities, and firms. The sample we selected for this study consists of 436 patent transactions published between January 2017 and August 2019. These patents were sold by 11 universities that operate in Zhejiang Province. In Table 1 we report the number of patents sold and the average transaction price for each university in the sample.

3.2. Variables

Transaction price is our dependent variable. Original information on the specific price of a sold patent is provided by the Zhejiang Intellectual Property Exchange Center. *Transaction price* is a continuous variable with positive values and is reported in units of ten thousand yuan (or RMB), the official currency of China.

We include three independent variables in our analysis. The first is *Inventor team prestige*. Prior studies indicate that recognition, especially in the form of prizes, is an important mark of prestige (Azoulay et al., 2014). Typically, a title such as Nobel Laureate can significantly change an individual's prestige. Therefore, we use well-known grants in China's academic evaluation system to construct an indicator of inventor team prestige. In China, winning important national grants is an important indicator of researchers' prominence and prestige in academia. Moreover, many firms participate in competitions for national grants and are familiar with them. Thus, grants are generally an important source of information for external appraisers in both academia and industry as they form perceptions of an inventor team's achievements, and thus prestige. Specifically, our criterion for assessing a single inventor is whether (s)he has won at least one grant from the National Natural Science Foundation of China (NSFC).⁴ Considering that an inventor team's prestige reflects the aggregate prestige of all its members, we count the total number of members who have won grants from the NSFC as the value of *Inventor team prestige*. Moreover, for the purpose of a robustness check, we use an alternative criterion, namely whether an inventor has won at least one grant from the National High-tech R&D Program (863 Program), another influential research program in

³ Its website is located at <https://www.incopat.com>.

⁴ An NSFC grant is regarded as an important status-conferring prize in China. Statistical data show that the number of applications for NSFC grants increased from about 165,000 in 2015 to 240,000 in 2019, while the share of successful applications decreased from 22.91% to 17.62%. Applicants for NSFC grants must be competitive to successfully obtain such grants based on reviewers' evaluations. Successful NSFC grants reflect inventors' relative positions, and therefore their (combined) prestige, in the academic hierarchy in China.

¹ Because relevant data were not available, we did not analyze the prices of patent licensing deals.

² The Zhejiang Intellectual Property Exchange Center was established in 2016 by the Science and Technology Department of the Zhejiang Provincial Government and Zhejiang University. Its official website: <http://www.zjipx.com/>.

Table 2
Rankings of sample universities among all Chinese universities.

University	Ranking among all Chinese universities
Zhejiang University	5
Zhejiang University of Technology	93
Zhejiang Normal University	96
Hangzhou Dianzi University	105
Ningbo University	134
Hangzhou Normal University	185
Zhejiang A&F University	276
Wenzhou University	279
Zhejiang Ocean University	289
Zhejiang Wanli University	453
Zhejiang University of Water Resources and Electric Power	500

China's evaluation system, to construct *Inventor team prestige*.

Our second independent variable is *University prestige*, the first moderator in our analysis. Following Sine et al. (2003), we use rankings published by authoritative, third-party organizations to measure university prestige. For instance, Zhejiang University usually ranks among the top five of all domestic universities and is one of the most prestigious universities in China. Because the transactions in our sample took place between 2017 and 2019, we use university rankings in 2016 to measure prestige. Specifically, we use Chinese university rankings published by Cuaa.Net,⁵ which includes all Chinese universities and is one of the most influential university rankings in China. Table 2 shows the specific rankings of universities in our sample. For the purpose of illustrating and analyzing our empirical results, we designated 1 as the value of *University prestige* for the lowest-ranked university in our sample, which is Zhejiang University of Water Resources and Electric Power (ZJWEU). For other universities, we designate 1 plus the place difference between the rankings of a given university and ZJWEU as the value of *University prestige*.

Our third independent variable is *Firm prestige*, our second moderator. It is a dummy variable. The criterion for measuring firm prestige is whether a firm has won certification as a "High-Technology Company" granted by the Chinese government.⁶ This certification system began in 2008, and the total number of certified firms reached more than 100,000 in 2016 (Li, 2019). This certification is well-known in China and firms are highly motivated to compete for it, because those gaining this title can enjoy tax reductions and receive other supportive resources from the government. The Chinese Ministry of Science and Technology, the Ministry of Finance, and the State Administration of Taxation are responsible for the screening process, with the evaluation criteria covering five aspects of a firm's operations: (1) intellectual property (particularly patents), (2) the technical fields for which a firm's products are designed, (3) the educational attainment of a firm's R&D employees, (4) R&D expenditures, and (5) a firm's financial situation. Therefore, certification as a "High-Technology Company" is an important and influential title that indicates firms' prominence regarding their technological innovation and performance in their respective industries, illustrating their relative positions. Therefore, we consider such certification an effective proxy for firm prestige. If a firm that buys a patent has

⁵ The data on these rankings can be accessed at <http://www.cuaa.net/>. The Alumni Association Network (Cuaa.Net) has published annual Chinese university rankings since 2003. The publication of these rankings is led by Professor Yanhou Cai from Central South University. These rankings have been cited by Chinese official media such as *People's Daily* and the China Central Television (CCTV) network. We choose these rankings primarily because they cover all universities in our sample while other influential domestic university rankings cover only some of these universities.

⁶ The official website of this certification is located at <http://www.innocom.gov.cn>.

Table 3
Summary statistics.

	Variable	Observations	Mean	Std. Dev.	Min	Max
1	Transaction price	436	9.37	14.89	0.2	200
2	Inventor team prestige	430	0.59	1.04	0	7
3	Inventor team prestige (for robustness check)	430	0.26	0.68	0	4
4	University prestige	436	394.51	110.95	1	496
5	Firm prestige	242	0.36	0.48	0	1
6	Patent age	436	5.02	2.24	0	15
7	Claims	436	4.53	2.75	1	13
8	Originality	436	0.70	0.30	0	1
9	Patent type	436	0.92	0.27	0	1

won certification before executing the transaction, the value of *Firm prestige* equals 1 while equaling 0 otherwise. We obtain information on certification from TianYanCha.com.⁷

We include several control variables in our analysis. Technological and patent features influence the outcomes of valuation (Munari and Oriani 2011). Thus, we construct several value indicators that have been used frequently in prior studies (Gambardella et al., 2008; Odasso et al., 2015) to control for the quality and value of patented technologies. First, we control for patent age. China's patent law grants invention patents 20 years of protection starting on the date of application, while it grants utility model patents 10 years of protection. With the emergence of substitutive technology and as the period of protection nears its end, the value of a patent will depreciate. Holding all else equal, the value of a patent reflects the years of protection that remain. We count the number of years between the application year and the transaction year as the value of *Patent age*.

Second, we control for patent value by constructing a variable, *Claims*, whose value is the number of claims associated with a patent. Third, we use information regarding backward citations to construct *Originality* (Trajtenberg et al., 1997), which takes a value between 0 and 1. The formula we use to calculate the level of originality of patent *i* is as follows:

$$Originality_i = 1 - \sum_{k=1}^{N_i} \left(\frac{Ncited_{ik}}{Ncited_i} \right)^2$$

where $Ncited_{i,k}$ is the number of patents based on a 4-digit International Patent Classification (IPC) class *k* but cited by patent *i*, $Ncited_i$ is the total number of patents cited by patent *i*, and N_i is the total number of distinct 4-digit IPC classes to which the citing patent belongs. The higher the value of *Originality*, the broader is the range of technology fields on which the patent is built. The ability to synthesize a broader range of knowledge enhances a patent's originality (Trajtenberg et al., 1997). Therefore, as a patent's level of *Originality* rises, its value also rises. Fourth, we control for patent type. The variable *Patent type* is a dummy variable that equals 1 if a patent is an invention patent and 0 if it is a utility model patent. Finally, we control for differences between technical fields by adding a group of dummy variables. We use the classification method published by the World Intellectual Property Organization (WIPO) and information pertaining to main IPC classes of patents to classify 35 technical fields.⁸

Because the dependent variable is a continuous variable, we use OLS

⁷ This online information provider collects information from the National Enterprise Credit Information Publicity System, China Judgement Online, Enforcement of Court Decisions, and other governmental public information portals. Because of the quality of its enterprise credit information service, TianYanCha.com is referenced by the Chinese Central Bank—the People's Bank of China.

⁸ The classification can be seen in an IPC concordance table that can be accessed at <http://www.wipo.int/ipstats/en/#publications>.

Table 4
Pairwise correlation matrix.

Variable	1	2	3	4	5	6	7	8	9
1 Transaction price	1								
2 Inventor team prestige	0.12*	1							
3 Inventor team prestige (for robustness check)	0.12*	0.74*	1						
4 University prestige	0.36*	0.16*	0.21*	1					
5 Firm prestige	0.22*	0.00	−0.11*	0.25*	1				
6 Patent age	−0.01	0.06	0.09	0.22*	−0.10	1			
7 Claims	0.05	−0.09*	−0.02	−0.03	0.06	−0.09*	1		
8 Originality	−0.04	0.02	−0.02	−0.11*	0.01	−0.10*	0.05	1	
9 Patent Type	0.13*	0.13*	0.07	0.24*	0.10	0.22*	−0.09*	−0.29*	1

Notes: * $p < 0.1$.

to run our regressions. Tables 3 and 4 present the descriptive statistics and correlation matrix, respectively. The absolute value of the correlations between the independent variables entering the same regression is below 0.30.⁹ Thus, there is no serious issue related to multicollinearity.

4. Empirical results

Table 5 presents the regression results. Model 1 is the baseline model that includes only the control variables. To test hypothesis H1, the independent variable *Inventor team prestige* is included in Model 2. The coefficient of *Inventor team prestige* is 1.781 and significant ($p < 0.05$). This result implies that, when an inventor team's prestige is higher, the transaction price will also be higher. This is consistent with what H1 predicts, so the hypothesis is supported.

To test hypothesis H2, the linear term *University prestige* is first included in Model 3. The coefficient of *University prestige* is 0.0558 and is significant ($p < 0.01$). This result is consistent with the results of prior studies (e.g., Sine et al., 2003). Next, the interaction term between *Inventor team prestige* and *University prestige* is included in Model 4. The coefficient of the interaction term is 0.0175 and is significant ($p < 0.05$), and it has the same sign as *Inventor team prestige* in Model 2. These results imply that university prestige positively moderates the relationship between inventor team prestige and transaction prices. In other words, when university prestige is higher, the relationship between inventor team prestige and prices is even more salient. This is consistent with H2, so the hypothesis is supported.

To illustrate the moderating effect of university prestige, we use the coefficients derived from Model 4 to plot the main effects at varying levels of university prestige, as shown in Fig. 3. The solid line represents the case of high university prestige while the dashed line represents the case of low university prestige. We can see that the solid line is steeper than the dashed line, indicating that the positive effects of inventor team prestige on transaction prices is reinforced by university prestige, confirming the positive moderating effect of university prestige.

To test hypothesis 3, the linear term *Firm prestige* is first included in Model 5.¹⁰ Next, the interaction term between *Inventor team prestige* and

Firm prestige is included in Model 6. The coefficient of the interaction term is -3.772 and significant ($p < 0.05$), and its sign is the opposite of the sign of *Inventor team prestige* as derived from Model 2. These results imply that firm prestige negatively moderates the relationship between inventor team prestige and transaction prices. In other words, when firm prestige is high, the relationship is less salient. These results are consistent with H3, so the hypothesis is supported.

To illustrate the moderating effect of firm prestige, we use the coefficients of Model 6 to plot the main effects under varying levels of firm prestige in Fig. 4. The solid line represents the case of high firm prestige while the dashed line represents the case of low firm prestige. We can see that the solid line is less steep than the dashed line, which indicates that the positive effects of inventor team prestige on transaction prices is mitigated by firm prestige, which confirms the negative moderating effect of firm prestige.

Model 7 is the full model. We see that the interaction term between *Inventor team prestige* and *University prestige* is positive and significant ($p < 0.01$) while the interaction term between *Inventor team prestige* and *Firm prestige* is negative and significant ($p < 0.01$). Thus, the moderating effects are robust across models.

To check for robustness, we also use an alternative measure of *Inventor team prestige* based on whether the inventor team has won at least one grant from the National High-tech R&D program (863 Program) to run regressions. The 863 Program is one of the most well-known and prestigious high-technology R&D programs in China. It was established in 1986 with the approval of the late Chinese leader Deng Xiaoping, and many Chinese scientists have participated in this program over a long period of time. With Models 1 through 6, Table 6 shows that the significance and signs of the coefficients of the independent variables are consistent with those reported in Table 5. Only with Model 7 does the coefficient of the interaction term between *Inventor team prestige* and *Firm prestige* become nonsignificant. Despite this exception, the results imply that the impacts of *Inventor team prestige*, *University prestige* and *Firm prestige* are overall robust.

5. Discussion

5.1. Theoretical contributions

This study makes three main theoretical contributions to the literature. First, we contribute to the literature that investigates the role of prestige in UTT by proposing a theoretical framework that spans both the technology valuation and negotiation stages. Scholars have suggested that bargaining power in negotiations, which is influenced by prestige, should be considered when investigating how organizations reach agreements (Lerner and Merges 1998; Shervani et al., 2007), yet prior studies have focused mainly on technology valuation, paying insufficient attention to negotiations (Frattini et al., 2019). We take both stages into account and highlight the role of bargaining power in negotiations when analyzing the pricing process.

Second, this study sheds light on how the prestige of both technology providers and buyers affects pricing in university technology

⁹ The correlation coefficient of *inventor team prestige* and *inventor team prestige* (for a robustness check) is 0.74, but these two variables are not included in the same regression.

¹⁰ The number of observations associated with Models 5–7 is lower because data for the variable *firm prestige* were unavailable for 194 observations when we collected data (January 2020). Although transaction-related information is disclosed on the website of the Zhejiang Intellectual Property Exchange Center, the names of the firms that buy university patents are not disclosed. We had to search in the incoPat database to find buyer names because new holders of patent rights would be registered in the National Intellectual Property Administration of China. When we collected data, the names of the buyers of 152 patents were unavailable. Moreover, among the buyers whose names were known to us, detailed information on 24 firms that bought 42 patents were not found in TianYanCha.com. Finally, the value of *firm prestige* for 194 patents is missing from our sample.

Table 5
OLS estimation results.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Dependent variable: Transaction price							
Inventor team prestige		1.781** (0.698)	0.525 (0.673)	−7.447** (3.750)	2.633** (0.928)	3.988*** (1.147)	−4.870 (3.152)
University prestige			0.0558*** (0.00684)	0.0480*** (0.00770)			0.0308*** (0.00634)
Inventor team prestige * University prestige				0.0175** (0.00808)			0.0218*** (0.00772)
Firm prestige					4.130*** (1.191)	5.780*** (1.446)	4.978*** (1.376)
Inventor team prestige * Firm prestige						−3.772** (1.900)	−6.097*** (1.789)
Claims	−0.115 (0.285)	0.0335 (0.278)	−0.101 (0.268)	−0.0823 (0.267)	0.266 (0.217)	0.283 (0.216)	0.0698 (0.206)
Originality	−0.011 (2.477)	−1.157 (2.408)	0.390 (2.297)	0.282 (2.287)	0.957 (1.808)	1.057 (1.797)	1.340 (1.657)
Patent age	−0.026 (0.329)	−0.114 (0.308)	−0.512 (0.315)	−0.573* (0.314)	0.137 (0.262)	0.193 (0.261)	−0.0618 (0.268)
Patent type	7.116** (2.936)	5.890** (2.939)	1.201 (2.859)	2.178 (2.881)	2.814 (2.816)	2.309 (2.809)	0.452 (2.572)
Technological sector dummies	Added	Added	Added	Added	Added	Added	Added
Constant	4.862 (4.644)	5.587 (4.657)	−11.604** (4.856)	−9.263* (4.956)	−0.958 (4.062)	−1.126 (4.036)	−9.879** (4.100)
Number of observations	436	430	430	430	240	240	240
Adjusted R-squared	0.098	0.104	0.231	0.238	0.253	0.263	0.435

Notes: Standard errors are shown in parentheses. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

transactions. Prior studies indicate that technology provider prestige influences the price of technology by shaping buyer perceptions of a technology's value. Technology buyer prestige can influence prices as well, mostly through a buyer's bargaining power (Frattini et al., 2019; Khoury et al., 2019). We fill a gap in this discussion by studying the impact of the prestige of both actors.

Third, this study helps to explain why prior findings regarding the effect of prestige on prices in university technology transactions have been inconclusive by identifying contingencies that weaken or reinforce this effect. Our results indicate that university prestige has a positive moderating effect while firm prestige has a negative moderating effect. Our results reveal that members benefit unevenly from the prestige of their organizations (Kwon et al., 2013). Thus, an inventor team with higher prestige benefits from university prestige to a greater extent than a less prestigious team. In other words, the extent to which members leverage organizational prestige also depends on their own prestige.

5.2. Managerial implications

This study also generates important practical implications. We argue that inventor team prestige and university prestige influence not only a firm's valuation of technologies but also an inventor team's bargaining power during negotiations. Sakakibara (2010) showed that universities, as research organizations, typically are hindered by weak bargaining power in technology transactions. Our results show that prestige can be a source of bargaining power and that being prestigious offers advantages to inventors and universities when negotiating prices in technology transactions. Thus inventors from less prestigious universities who themselves lack prestige may face steeper challenges. Therefore, universities should consider developing professional intermediaries to assist such inventor teams. Such intermediaries could use their expertise and authoritative certifications to demonstrate the value of technologies and also leverage their negotiating skills to help inventor teams bargain for higher prices. In light of these findings, we suggest that universities and policymakers in China should make developing competent intermediary organizations, such as effective TTOs, a key objective and

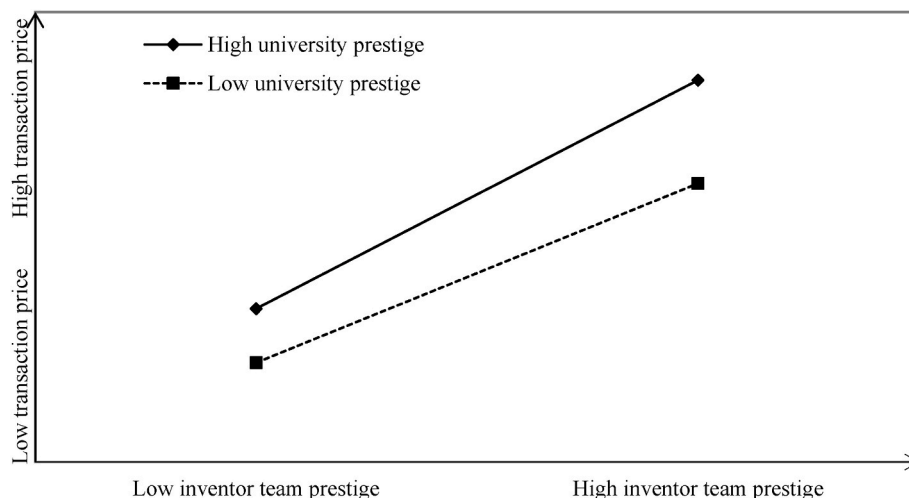


Fig. 3. The moderating effect of university prestige.

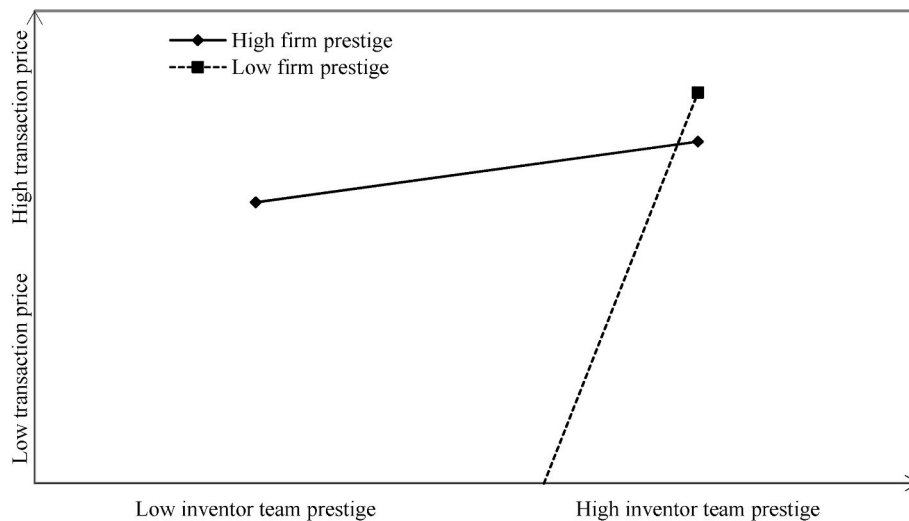


Fig. 4. The moderating effect of firm prestige.

Table 6
Results of robustness checks.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Dependent Variable: Transaction price							
Inventor team prestige		3.197*** (1.072)	0.996 (1.042)	−18.044** (7.506)	3.483*** (1.150)	4.516*** (1.292)	−11.860** (5.946)
University prestige			0.0553*** (0.00690)	0.0509*** (0.00707)			0.0332*** (0.00593)
Inventor team prestige * University prestige				0.0407** (0.0160)			0.0336** (0.0137)
Firm prestige					4.264*** (1.192)	5.068*** (1.275)	3.264** (1.265)
Inventor team prestige * Firm prestige						−4.940* (2.870)	−2.065 (2.885)
Claims	−0.115 (0.285)	−0.0123 (0.276)	−0.113 (0.265)	−0.0620 (0.264)	0.225 (0.217)	0.187 (0.217)	0.100 (0.214)
Originality	−0.011 (2.477)	−0.647 (2.394)	0.536 (2.287)	0.229 (2.274)	1.456 (1.821)	1.603 (1.815)	1.798 (1.712)
Patent age	−0.026 (0.329)	−0.182 (0.309)	−0.529* (0.315)	−0.547* (0.313)	0.0522 (0.259)	0.0259 (0.258)	−0.120 (0.272)
Patent type	7.116** (2.936)	6.191** (2.923)	1.332 (2.858)	2.097 (2.854)	3.441 (2.805)	3.419 (2.792)	2.411 (2.664)
Technological sector dummies	Added	Added	Added	Added	Added	Added	Added
Constant	4.862 (4.644)	5.949 (4.640)	−11.356** (4.871)	−10.308** (4.855)	−0.271 (4.016)	−0.679 (4.005)	−11.758** (4.017)
Number of observations	436	430	430	430	240	240	240
Adjusted R-squared	0.098	0.109	0.232	0.242	0.257	0.263	0.407

Notes: Standard errors are shown in parentheses. All tests are two-tailed. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

provide additional resources, such as institutional support, to assist in their development.

5.3. Limitations and future research directions

Despite its contributions and implications, this study is subject to several limitations. First, a lack of available data prevented us from including data on university patent licenses in our analyses. Patent licensing is representative and important in UTT, especially in the United States (Caviggioli et al., 2020). Agreements under licensing deals can include terms stipulating the length of a license and can establish fixed fees and royalty fees (Aksoy and Beaudry 2021; Caviggioli et al., 2020). Prestige may have differential effects on these separate components. Therefore, future studies could advance our understanding of these factors by comparing multiple transaction types, including patent licensing and patent selling.

Second, our measure of firm prestige suffers from an important

shortcoming. We recognize varying levels of prestige, so a measure of prestige should, ideally, be continuous. Constrained by limited data availability, however, we constructed a dummy variable that divides firms only into high- and low-prestige groups. Future studies could improve on this measure by adopting other indicators, such as market share or firm size.

Third, in our empirical analysis we do not measure the mechanism through which bargaining power operates directly, although it is an important part of this study's theoretical framework. Prior studies have attempted to quantify bargaining power empirically. For instance, Thye (2000) and Thye and Harrell (2017) used mathematical models and a series of experiments in dyadic negotiated exchange settings to study the relationship between actor prestige and bargaining power. We suggest that future studies could measure bargaining power by employing other empirical methods, such as surveys.

Fourth, while we identified and tested relevant moderators of the relationship between technology providers' prestige and transaction

prices, we did not consider any mediators. Therefore, we suggest that future studies investigate potentially important mediators and further deepen our understanding of this relationship. For instance, inventor teams' propensity for exploration could be an interesting mediator worthy of further attention. In this context exploration involves experimentation (e.g., with new technologies) undertaken to create new knowledge, and it is generally associated with greater risk and a higher probability of failure (Bierly and Daly, 2007; March, 1991). An actor's earned level of prestige may influence its attitude toward exploration as well as its success in obtaining resources for explorative activities. Specifically, prestigious inventor teams may have the confidence needed to undertake explorative research, and they may also obtain more robust support from their universities to do so (Bothner et al., 2012; Shea and Howell 2000). Thus, prestigious inventor teams may be more likely to undertake exploration, potentially generating new, cutting-edge technologies that will attract more prospective buyers, thereby increasing transaction prices.

Finally, this study investigated UTT in a single province in China. Future studies could consider contingency factors in other contexts, including other regions and countries, as well as technology transactions between firms. We believe that our main finding regarding the relationship between actors' prestige and technology pricing can be generalized to other contexts, because the valuation and negotiation stages in pricing also exist whether a technology provider is a firm or a university from another country (Frattini et al., 2019). The economic, social, and institutional environments surrounding universities differ across regions (Klofsten et al., 2019), however, and local UTT practices may affect the relationship between actor prestige and technology pricing in ways that reflect local conditions. For instance, UTT in other countries (e.g., the US and Europe) is usually managed by TTOs (Markman et al., 2005), so technology prices are then also influenced by TTO features and behaviors. For instance, Macho-Stadler et al. (2007) indicated that TTOs may "shelve" some projects to enable seemingly more valuable inventions to be sold at higher prices. Future studies could investigate these potentially moderating effects.

6. Conclusion

This study extends the research stream that studies university entrepreneurial activities (Rothaermel et al., 2007; Cattaneo et al., 2015; Klofsten et al., 2019; Houweling and Wolff 2020) by examining the role of actors' prestige in the pricing of technology transactions between universities and firms. We propose two underlying mechanisms associated with prestige. First, inventor team prestige influences the WTP of buyers in the valuation stage during the pricing process. Second, inventor team prestige and buyer prestige affect the bargaining power of technology providers and buyers, respectively, in the negotiation stage. We analyze data on patents sold by universities in Zhejiang Province in China between 2017 and 2019, and the empirical results confirm the existence of a positive relationship between inventor team prestige and transaction prices. Furthermore, we find that this relationship is positively moderated by university prestige and negatively moderated by firm prestige. This study generates implications for universities as they manage technology transfer to firms.

Data availability

The authors do not have permission to share data.

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