

The Economics of Patent Licensing: Theory and Evidence on the Determinants and Consequences of Patent Licensing Transactions

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Abstract

We investigate the economics of patent licensing theoretically and empirically. We first develop a dynamic search model in which an innovating firm chooses among three possibilities: retaining patents in-house; or monetizing them by licensing or selling to other firms. Our theoretical model allows us to develop several insights into the economics of patent licensing and to use its predictions to develop testable hypotheses. We address three research questions empirically: the characteristics of licensors and licensees and the determinants of the matching between the two; the patent characteristics driving a licensor's decision to retain, license, or sell certain patents; and the consequences of licensing transactions for licensors and licensees. Licensors prefer to license patents to downstream firms and to firms with less similar technology. Licensors retain patents closer in technology distance to their core operations in house; they monetize those patents that are farther away from their core operations, choosing to sell those patents that are farthest away from their core operations, while licensing out patents that are in-between in terms of technological distance from core operations. Licensees, on the other hand, license in only patents that are closer to their core operations. Both our baseline analysis and a difference-in-differences analysis around the National Technology Transfer and Advancement Act of 1995 show that licensing transactions are efficient, increasing the Tobin's Q of both licensors and licensees. The channels of equity market value creation are, however, different for licensors and licensees. Licensors benefit from the licensing fees they receive from licensees (with Tobin's Q greater for licensors that obtain higher royalties from licensees); licensors also devote greater resources to innovation inputs (R&D expenditures) after licensing transactions, with a resulting increase in innovation productivity. Licensees, on the other hand, benefit from exposure to new technologies, leading to an increase in their innovation efficiency and introducing more new products after licensing transactions.

Keywords: Patent licensing; Selling versus licensing; Licensors; Licensees; R&D; Corporate innovation

JEL classification: G32; L24; O32; O34

1 Introduction

The transfer of ideas is an important driver of economic growth. Two important ways in which patented ideas are transferred across firms are the buying and selling of patents between firms and the licensing of patents across firms. While a number of papers have analyzed the transfer of patents across firms through the buying and selling of patents both theoretically and empirically (e.g., [Serrano \(2010\)](#), [Akcigit et al. \(2016\)](#), [Zhang \(2020\)](#)), the economics of patent licensing is relatively less well understood. The objective of this paper is to fill this gap in the literature and analyze several interesting research questions regarding the economics of patent licensing both theoretically and empirically.

We first develop a dynamic search model which allows us to develop several insights into the economics of patent licensing. We then make use of our model predictions and insights to develop testable hypotheses for our empirical analysis. We consider a setting in which a firm develops patentable innovations, some of which are useful for its main line of business, while others are not. The firm retains and builds products around the patents close to its main line of business, while it attempts to monetize the patents further away from its main line of business by either selling these patents to other firms or licensing them. Retaining a patent in-house and integrating it into the innovating firm's production process involves significant costs, depending upon the closeness of the patent to the firm's current line of business. The firm may therefore choose to monetize patents that are technologically distant from its current operations by either selling the patent outright or by licensing them out to other firms. Selling and licensing a patent may involve different costs and benefits to the firm developing the patent. In our view, the most important difference between licensing and selling (which we incorporate into our model) is that, while selling a patent outright involves loss of control of the patent by the seller to the buyer (while receiving the selling price from the buyer), licensing allows the innovating firm to retain partial control of the patent, thus continuing to benefit from the underlying technology, while receiving the licensing fees from the licensee (of course, the licensee

firm also benefits from using the patent it has licensed). Our theoretical model will allow us to characterize the above innovating firm's equilibrium choice of what to do with a patent it has developed from among three possible options: integrate it into its production process and develop new products around it in-house; monetize the patent by licensing it to another firm; monetize it by selling it outright to another firm. We will also solve for the licensing fees or the selling price in case the innovator chooses to monetize the patent, and the consequences of a licensing transaction for the licensor and licensee firms in terms of improvements in their innovation productivity and also the cash flows received by the licensor from the licensee (and consequently for the effects of the licensing transaction on the equity market values of licensor and licensee firms).

We make use of the predictions and insights generated from our theoretical model to empirically analyze three important sets of research questions. The first set of research questions relates to the characteristics of licensor and licensee firms that drive the former firms to license patents to the latter. Under this overall research question, we empirically examine the following sub-questions. The first sub-question we ask here is regarding the innovation characteristics of a firm that drive it to be a licensor or a licensee in a patent licensing transaction. A market for licensing patents raises the incentive of firms to do R&D, since patents that are not useful for an innovating firm's own products can be licensed to other firms, thus raising the *ex-ante* return from the licensor's R&D expenditures. We thus expect the R&D expenditures of licensors to be higher than those of control firms in the same industry. On the other hand, from a licensee's point of view, when the firm needs a patent around which it can build products, the firm can choose to develop the patent in-house or to acquire it from other firms (by buying or licensing in the patent). When the firm is less able to efficiently conduct the innovation activity in-house, acquiring the patent from other firms through licensing may be a more cost-effective option. In addition, the fact that a firm can license a patent from another firm reduces the reward for it from developing the innovation internally by spending resources on R&D. Therefore, we expect

licensee firms to be less efficient in conducting the innovation activities in-house compared to control firms.

The second sub-question we address empirically here relates to the determinants of the matching between licensor and licensee firms. In determining which firm to license a patent to, a licensor firm may take into account not only the stream of licensing fees it can generate from the licensing transaction but also the indirect benefits and costs of licensing a patent to a particular firm. One indirect benefit of licensing a patent arises from the licensee firm buying the products of the licensor: i.e., the licensor and the licensee may potentially have an upstream-downstream relationship. In other words, licensing a patent to a certain firm may not only help the licensee firm, but may also help the licensor by inducing some demand for the licensor's products from the licensee firm.¹ Thus, we expect licensors to license their patents to firms having a downstream relationship with them. On the indirect cost side, if a licensor and licensee operate as competitors in the product market, licensing a patent to such a licensee may hurt the licensor, since the licensee firm may use this patent to improve its own products, thereby obtaining a competitive advantage with respect to the products of the licensor. This means that, if a licensor and a potential licensee are technologically similar (and therefore more likely to be competitors), then the two firms are less likely to form a licensor-licensee relationship.

We now turn to our second set of research questions, namely, the nature of the patents involved in licensing transactions. Under this overall research question, we empirically address the following sub-questions through analyses conducted at the patent level. The first sub-question is regarding the nature of patents that a licensor is likely to retain (and build

¹This argument can also be illustrated by a real-world example. Qualcomm Inc. is an industry leader in wireless communication, and its foundational innovation in 5G-related technology was patented. Many of these patents become Standard Essential Patents (SEPs), which means that any company implementing 5G standards will need to license Qualcomm's relevant patents. Typical examples of companies that license such technology from Qualcomm include handset Original Equipment Manufacturer (OEM) firms (i.e., cell phone manufacturers, such as Apple, Google, Samsung, and Xiaomi). Apart from licensing Qualcomm's technology, these firms also purchase Qualcomm's chipsets (such as the Snapdragon series), since these chipsets often have the most advanced, highest-performing, and most integrated implementations of Qualcomm's own technology.

products around) versus the type of patents it chooses to monetize (by either licensing or selling patents to another firm). Our theoretical model predicts that firms will retain those patents which are closer in technological distance (see [Akcigit et al. \(2016\)](#)) to their current patent portfolios, while monetizing (either by licensing or by selling) patents that are further away from their current patent portfolios. The intuition here is that, since the firm has to incur significant costs of integrating a patent in-house into its production process, and the benefits of such integration are greatest for patents closer to its current line of business, it pays the firm to incur the integration cost only for patents that are significantly close to its current line of business.

The second sub-question we examine empirically is regarding the nature of patents an innovating firm chooses to monetize. If a firm chooses to monetize a patent, does it do so by licensing the patent to another firm or by selling it outright? Our theoretical analysis predicts that, among the patents that they choose to monetize, firms are likely to sell patents that are further away (in terms of technological distance) from their current patent portfolios (which reflects their main lines of business) while licensing those patents that are closer to their current patent portfolios. The intuition here arises from the economic differences between selling versus licensing. On the one hand, licensing allows the licensor to share in the productivity gains from the patent while selling the patent requires them to give up control of the patent (and its productivity gains) completely to the buyer. On the other hand, the equilibrium selling price of a patent is higher than the present value of its licensing fees. Since the benefit of sharing in the productivity gains from a patent declines with its distance from the innovating firm's main line of business, selling dominates licensing when the patent is technologically more distant from the innovator's main line of business. Conversely, licensing out dominates selling when the patent is technologically closer to the innovating firm's main line of business.

The third sub-question we address here relates to the nature of patents licensed in by a licensee firm in a patent licensing transaction. Clearly, licensing transactions will

not occur for a patent without a firm demanding to license that patent. Our theoretical model predicts that licensee firms will choose to license-in patents closer in technological distance from the firm's current patent portfolio (which reflects its main line of business). The intuition here is that the productivity gain from licensing in a patent is declining in its technological distance from the licensee's current line of business. Therefore, it is not optimal for the licensee firm to pay the equilibrium licensing fee prevailing in the market for a patent that is at a technological distance greater than a certain threshold value from the firm's main line of business.²

Finally, we turn to our third set of research questions, namely, the consequences of patent licensing transactions and the channels through which they occur. We empirically investigate if the licensing transactions are efficient for both licensors and licensees. In other words, do licensing transactions create value for both the licensor and licensee firms? If they do, what are the channels through which licensing transactions create value? The measure of value we use here is equity market value, as captured by licensor and licensee firms' Tobin's Q. Our theoretical model suggests that licensing transactions are beneficial to both licensors and licensees in the sense that they create value for both parties.

However, the channels of value creation may differ between the licensor and licensee firms. On the one hand, we expect licensor firms that can extract higher rents from licensing transactions (i.e., receive higher licensing fees) to have a higher level of Tobin's Q. Licensors will be able to use the proceeds from licensing patents to invest in innovation-oriented activities (such as R&D) to further enhance their comparative advantage in innovation, which will contribute to an even higher level of Tobin's Q for these licensor firms. Turning to licensee firms, one potential way they may benefit from the licensing transactions is their exposure to new (or relatively unfamiliar) technologies. By getting exposed to new technologies through licensing patents from licensors, licensees can experience an increase in their Tobin's Q through a "learning by doing" channel and learn from using

²Note that the equilibrium licensing fee is set in the market based on the demand for the patent also from other firms whose patent portfolios may be at a smaller technological distance to the patent involved.

the patents they license. In other words, we expect to find that licensees who are more exposed to new technologies through licensing transactions are likely to achieve a greater increase in their Tobin's Q. Further, by using the patents they license and thereby learning by doing, licensee firms may increase their innovation efficiency and introduce a larger number of new products.

We address the above research questions using a large and unique sample of patent licensing transactions from the ktMINE Patent License Agreement Database. ktMINE compiles the data on patent licensing transactions primarily from SEC firm disclosures and various online sources. Our sample includes 7,204 patent licensing transactions between public firms from 1976 to 2022, with 1,935 of them specifically listing the patents being licensed in these transactions. The ktMINE database also provides detailed information on transaction terms, types of intellectual property involved, and associated licensing fees. This comprehensive dataset allows us to analyze the economics of patent licensing at both the firm and patent levels.

Our empirical results can be summarized as follows. Our first set of findings deals with the innovation characteristics of firms that drive them to be licensors and licensees, as well as the determinants of the pairing between these two sets of firms. We find that firms with higher innovation output (as proxied by their innovation quantity and innovation quality) and higher R&D expenditures are more likely to become licensors. We do not find any significant changes in these firms' innovation output prior to the licensing transactions. In contrast, firms with higher innovation stock but facing a deterioration in their innovation output are more likely to be licensees. Different from licensor firms, we do not find R&D expenditures to be an important determinant of firms becoming licensees in patent licensing transactions. Taken together, these results suggest that firms with a comparative advantage in conducting innovation are more likely to become licensors. On the other hand, firms that wish to complement their patent portfolios and build products around them but less able to conduct innovation efficiently in-house are more likely to become

licensees.

Our second set of findings is regarding the determinants of the pairing between licensor and licensee firms. Using a matching model, we document two determinants that facilitate the matching between licensors and licensees. The first determinant is the vertical integration potential, using the measure by [Frésard et al. \(2020\)](#), between firms. Specifically, we find that licensors are more likely to license patents to firms that have downstream potential for (upstream) licensor firms. The second determinant is the technological similarity between firms. Specifically, we find that licensors are less likely to license patents to firms that are technologically similar to them (as measured by the cosine similarity between their patent portfolios as of the licensing transaction). Taken together, these results are consistent with our hypothesis that a licensor firm may take into account the indirect benefits and costs of licensing a patent to a particular licensee firm. Licensors tend to license patents to their downstream firms, since this may induce demand for their products from licensee firms. On the other hand, by licensing patents to firms with less technological similarity, licensors take into account the potential costs arising from future product market competition from licensee firms.

Our third set of findings deals with the nature of the patents involved in licensing transactions. We document three findings here. First, licensors retain patents that are closer in technological distance to their firms' current patent portfolio, while monetizing (either by selling or by licensing them to other firms) the patents that are farther away from their current patent portfolio. Second, among the patents that licensors choose to monetize, we find that licensor firms sell patents that are farthest away (in terms of technological distance) from their current patent portfolio, while licensing those that are closer to their patent portfolio. This is consistent with our hypothesis that licensors license patents over which they would like to maintain some control in the future while selling off those patents over which they have no desire to maintain control. Third, among the patents available for licensing (from licensors), licensee firms choose to license those patents closer in tech-

nological distance to their own patent portfolio. This is consistent with our hypothesis that an important reason for licensee firms to license patents is to benefit from the productivity gains from licensing in these patents. Clearly, such productivity gains decline with the technological distance of a licensed patent from the firm's current line of business.

Our fourth set of findings deals with the consequences of licensing transactions for both licensor and licensee firms. First, we document that licensing transactions are efficient for both licensor and licensee firms, in the sense that these transactions create equity market value for both licensors and licensees. We measure value creation using the Tobin's Q of a firm, and document that, following patent licensing transactions, both licensor and licensee firms have significantly higher Tobin's Q than their matched control firms. To address endogeneity concerns and establish causality, we make use of the National Technology Transfer and Advancement Act (NTTAA) of 1995. The Act makes it easier for firms to enter into cooperative research and development agreements with the U.S. federal government and makes available the assistance of federal laboratories to the private sector. As a result, we argue that the Act not only makes licensing transactions more efficient but also spurs the demand for licensing and makes licensing more attractive for both potential licensors and licensees.³ Therefore, by utilizing this quasi-random experiment as a positive shock to licensing transactions, we show that the baseline value creation effect of licensing transactions is likely causal.

After documenting the positive effect of patent licensing transactions on both licensors' and licensees' valuations, we delve into the channels through which this effect occurs. For licensor firms, their ability to extract rents from licensing transactions is a plausible mechanism through which these transactions create value for them. Specifically, we find

³For potential licensors, after the passage of the Act, they can enter into cooperative research and development agreements with the federal government more easily and utilize technology from federal laboratories. This enables potential licensors to develop higher-quality technology and license it to others more easily in exchange for financial rewards, compared to the pre-NTTAA era. For potential licensees, the enactment of the NTTAA facilitates access to technology they previously could not obtain. Before the NTTAA, licensees might not have been able to secure exclusive licenses for federally funded technology. With the NTTAA in place, it is now easier for potential licensees to obtain these exclusive licenses.

that the increase in Tobin's Q is more pronounced for the sub-sample of licensors which receive higher licensing fees (as measured by the royalty received by licensors) from licensing transactions. Further, consistent with the notion that licensors use the proceeds from licensing fees to invest in innovation-oriented activities to further enhance their comparative advantage in innovation, we find that licensors increase their R&D expenditures significantly and produce more patents following licensing transactions. For licensees, their exposure to new technologies is a channel through which patent licensing transactions create value for them. Specifically, we find that licensee firms' increase in Tobin's Q is stronger for the sub-sample of licensees which are exposed to new technologies from licensors as a result of their licensing transactions. Consistent with licensees getting exposed to new technologies brought by licensors and learning by doing, licensees increase their innovation efficiency and introduce a larger number of new products, subsequent to patent licensing transactions. Additional evidence in support of the learning by doing channel is provided by the fact that licensees are more likely to cite licensors' patents compared to those of control firms, subsequent to licensing transactions.

The rest of the paper is organized as follows. Section 2 discusses how our paper is related to the existing literature. Section 3 presents our theoretical model and develops testable hypotheses. Section 4 describes our data and sample selection procedures and presents the summary statistics of our sample. Section 5 analyzes the innovation characteristics of firms that drive them to be licensors or licensees in licensing transactions and the determinants of the pairing between these two sets of firms. Section 6 characterizes the nature of the patents involved in licensing transactions and how they relate to the patent portfolios of licensor and licensee firms. Section 7 analyzes whether licensing transactions are efficient in the sense that they increase the equity market value of both licensor and licensee firms, as well as the different channels of value creation for licensors and licensees. Section 8 concludes.

2 Relation to the Existing Literature

Our paper is related to several strands in the literature on innovation and the transfer of technology. The literature closest to this paper is the theoretical and empirical literature on patent licensing and the literature on the transfer of patents across firms through the buying and selling of patents. In an important paper, [Akcigit et al. \(2016\)](#) develop a theoretical model involving the transfer of technology through the buying and selling of patents. In their model, a firm operates in a potential technology class, which is fixed over time. A firm developing an idea may wish to sell the idea (patent) that is not close to its own technology class; similarly, it may buy a patent if it fails to innovate. In this context, they explore how their buying and selling of ideas affect firms' incentive to spend resources on R&D. The fact that a patent not useful for the innovator's own production can be sold raises the return for R&D; on the other hand, the fact that a firm can buy a patent rather than generate the innovation internally reduces the return for R&D. [Akcigit et al. \(2016\)](#) calibrate their model using data from the United States Patent and Trademark Office (USPTO) on the buying and selling of patents. They also develop a measure of technological distance between patents, which they use in their empirical analysis. [Akcigit et al. \(2015, 2016\)](#) do not analyze the role of licensing in the transfer of patents (our main focus) either theoretically or empirically. When developing our theoretical model, we build on their base model by introducing licensing as an additional option for innovating firms to monetize their patents. As we discuss below, we also address several other novel research questions on patent licensing for the first time in the literature.

Our paper is also related to the extensive theoretical and empirical literature on the motivations for the licensing of patents set in various contexts (e.g., [Arora et al. \(2001\)](#); [Arora and Fosfuri \(2003\)](#); [Arora and Ceccagnoli \(2006\)](#); [Gambardella et al. \(2007\)](#)). In a theoretical paper, [Arora and Fosfuri \(2003\)](#) show that competition in the market for technology induces licensing of innovations, and incumbent firms may find it privately profitable to license even if their joint profits may be higher in the absence of licensing.

[Gambardella and Giarratana \(2013\)](#) find that licensing propensity increases with the degree of fragmentation of product markets. [Arora and Ceccagnoli \(2006\)](#) show empirically that increases in the effectiveness of patent protection enhance licensing propensity, but only when the licensor firm does not have the specialized complementary assets required to commercialize new technologies. A number of papers analyze the relationship between the intellectual property rights (IPR) in an industry and the propensity to license (e.g., [Yang and Maskus \(2001\)](#); [Gambardella et al. \(2007\)](#); [Yang and Maskus \(2009\)](#)). [Fosfuri \(2006\)](#) finds, using data from the chemical industry, a negative association between a licensor's market share and the rate of licensing. [Gambardella et al. \(2007\)](#) use a European dataset to document that firm size is an important factor in licensing: patents from smaller firms have a greater propensity to be licensed. Ours is the first theoretical analysis of a firm's choice between selling and licensing its patents when it wishes to monetize them. It is also the first empirical study of firms' choice between selling and licensing patents. Finally, it also provides the first large sample and cross-industry analysis of several other research questions related to the economics of licensing, among them, the characteristics of licensors and licensees; the determinants of the matching between the two; and the consequences of licensing transactions on licensors and licensees.⁴

There is also a small literature on the consequences of patent licensing. [Moreira et al. \(2020\)](#) use a dataset from the biopharmaceutical industry and show that licensing-in positively impacts firm innovation, particularly in areas where competitors exert pressure. [Moser and Voena \(2012\)](#) use a dataset from the chemical industry and show that confiscating and licensing enemy-owned patents to American firms boosted domestic innovation in the licensed subclasses, leading to a significant increase in patenting by U.S. inventors after World War I. We contribute to this literature by conducting the first large sample and cross-industry study of the consequences of licensing transactions for licensors and

⁴Appendix B shows that the firms in our sample are drawn from a broad set of industries. Compared with [Moreira et al. \(2020\)](#), which focuses on 206 firms in the global biopharmaceutical industry during 1989–2004, and [Fosfuri \(2006\)](#), which studies large chemical firms across 107 chemical products, our sample is fairly representative of licensor and licensee firms across industries and is substantially larger.

licensees. In particular, we are the first to show that licensing transactions causally lead to an increase in equity market value for both licensor and licensee firms and explore the channels through which such value creation occurs.

Our paper is also related to the broader literature on patent trading. [Serrano \(2010\)](#) and [Figueroa and Serrano \(2019\)](#) document the details of patent transfer and patent renewal. [Ma et al. \(2022\)](#) empirically analyze the trading of patents during bankruptcy reorganizations. [Arora et al. \(2022\)](#) document that science-based innovations are more likely to be traded, thereby enhancing the markets for technology. [Han et al. \(2025\)](#) make use of data from patent exchanges in China to show that patent trading leads to greater specialization by innovating firms. [Zhang \(2020\)](#) analyzes the effects of the selling of patents from the seller's point of view and shows that sellers benefit greatly from patent trading. In particular, he shows that patent trading leads to an increase in seller firms' innovation focus and an increase in their innovation quality and innovation efficiency. Our paper contributes to this literature by presenting the first theoretical and the first empirical analysis of an innovator firm's choice between selling and licensing those patents that it does not wish to retain in-house (and therefore that it wishes to monetize).

Lastly, our paper is related to the broader corporate innovation literature (e.g., [Manso \(2011\)](#); [Aghion et al. \(2013\)](#); [Chemmanur et al. \(2014\)](#); [Tian and Wang \(2014\)](#); [Bernstein \(2015\)](#); [Balsmeier et al. \(2017\)](#); [Kogan et al. \(2017\)](#)). The existing literature has primarily focused on how firm characteristics, organizational forms, and economic settings affect the development of innovation or how corporate innovation leads to subsequent firm growth and resource allocation. Different from the existing literature on corporate innovation, our paper focuses on how firms deal with the output of their innovation activity (i.e., patents) and how the management of such innovation output through licensing affects their equity market valuation and future innovation productivity.

While, as discussed above, there is a large existing literature on the licensing of patents in various specific contexts, there is a scarcity of large sample cross-industry evidence on

the economics of patent licensing. In this paper, we have compiled a large and unique dataset on licensing transactions spanning 1976-2022 across all industries, and address several novel research questions on the economics of patent licensing as discussed above.

3 Theoretical Model and Testable Hypotheses

In this section, we first develop a theoretical model of patent licensing transactions. We then make use of this model to develop testable hypotheses for our empirical analysis.

3.1 A Theoretical Model of Patent Markets with Licensing

We consider an innovative firm which encourages the scientists and inventors it employs to develop patentable innovations. The firm gives considerable freedom to its employees (inventors and scientists) regarding the types of innovative projects that they can work on. This means that not all of the innovations developed by the scientists and employees of the firm (some of which may be patented) are directly related to the main line of business of the firm: some of these innovations may indeed be closely related to the main line of business of the firm, while others may be distant from the firm's main line of business. This may arise due to the fact that innovation is ultimately uncertain and in-house R&D is usually conducted in a decentralized fashion. The firm may therefore have to decide which of the patents it has developed to keep within the firm; and which of these patents to monetize by either licensing them to other firms or selling them outright to other firms in return for financial rewards.

Our theoretical model will allow us to characterize the above innovating firm's equilibrium choice of what to do with a patent it has developed: integrate it into its production process and develop new products around it in-house; or monetize the patent by licensing it to another firm; or monetize it by selling it outright to another firm. We will also solve for the licensing fees or the selling price in case the innovator chooses to monetize the

patent, and the consequences of a licensing transaction for the licensor and licensee firms (in terms of improvements in innovation productivity and also the cash flows received by the licensor from the licensee, and consequently for the effects of the licensing transaction on the equity market values of licensor and licensee firms).

In developing our theoretical model, we build on the base model in [Akcigit et al. \(2015, 2016\)](#), who consider an innovator's choice between integrating a patent they have developed in-house into their own production process or selling it outright to another firm through a patent agent. The crucial difference from [Akcigit et al. \(2015, 2016\)](#) in our setting is that the innovator has a third choice, namely, to license the patent to another firm. In our view, the most important difference between licensing and selling (that we incorporate into our model) is that while selling a patent outright involves loss of control of the patent by the seller to the buyer (while receiving the selling price from the buyer), licensing allows the innovating firm to retain partial control of the patent, thus continuing to benefit from the underlying technology, while receiving the licensing fees from the licensee (of course, the licensee firm also benefits from using the patent it has licensed).⁵

3.1.1 Model Setup

We consider an economy that operates in continuous time. In the background of this economy, there is a representative agent with a logarithmic utility function $U(c) = \ln(c)$ so that his elasticity of intertemporal substitution ε equals 1. The agent's discount rate is ρ . This means that along a balanced growth path (i.e., in the steady state), the real interest rate will be given by $r = \rho + g$, where g is the endogenous growth rate of the economy in the steady state. There is a continuum of firms of measure 1 that are located on a circle, each producing output using a firm-specific productivity level z and aggregate productivity

⁵Another advantage of maintaining partial control of the patent to the licensor (compared to selling the patent outright), is that it allows the licensor to terminate the licensing contract after the initial licensing period (for example, in the case where the licensor observes the licensee engaging in activities detrimental to the interests of the licensor).

\bar{z} .⁶

The equilibrium profit rate of each firm is linear in its productivity z such that

$$\Pi(z) = \pi z. \quad (1)$$

The average (aggregate) productivity in the economy is $\bar{z} = \int z_j dj$.

A firm's productivity, z , increases through new innovations which arrive at an exogenous rate i . Once an innovation arrives, the firm draws the propinquity x of this innovation to the firm from a uniform distribution $U[0, 1]$.⁷ A patent with propinquity (closeness) x approaching 1 is highly compatible with the firm's existing operations; a patent with x approaching 0 is far from the firm's main line of business. In other words, the distance of the innovation to the firm's technology class is $d = 1 - x \in [0, 1]$.⁸

An innovating firm chooses among three options: a) retain the patent in-house and integrate it into its own production at some cost $\tau \bar{z}$, b) license the patent to the for-license market via an agent for a licensing fee $q_l = a_l \bar{z}$, c) sell the patent to the for-sale market through an agent for price $q_s = a_s \bar{z}$.

When a firm fully integrates a new innovation (a patent) into its production process (by retaining it in-house or buying it from another firm), it contributes to firm productivity according to the following law of motion:

$$z' = z + (\gamma x - \tau) \bar{z}. \quad (2)$$

The closer an innovation is to a firm's own technology class, as represented by a larger x ,

⁶Similar to the model of [Akcigit et al. \(2016\)](#), each firm belongs permanently to some technology class j that resides on a circle with radius $1/\pi$. At each point on the technology circle, there are firms of density $1/2$.

⁷The term "propinquity" means the fit between the patent and the firm's production process.

⁸It should be emphasized that the measure of propinquity, x , is one minus the technological distance of a patent to a firm's main line of operations (technology class). In our empirical analysis, we use technological distance as our main independent variable driving a firm's choice between retaining a patent in-house or monetizing it through selling or licensing to another firm.

the bigger will be the gross increase in productivity, $\gamma x \bar{z}$. Furthermore, the higher is the economy-wide baseline level of productivity, \bar{z} , the more valuable a patent is for increasing productivity. The fixed integration cost $\tau \bar{z}$ reflects the assumption that full integration requires reorganizing production processes, training workers, adapting complementary technologies, and building new product lines. Taken together and denoting the value function of a firm by $V(z, \bar{z})$, the firm's net value of keeping a patent and fully integrating it into its production process is given by

$$K(x, \bar{z}) \equiv V(z + (\gamma x - \tau)\bar{z}, \bar{z}) - V(z, \bar{z}). \quad (3)$$

We will later verify that the firm's value function $V(z, \bar{z})$ is linear in z and \bar{z} so that

$$V(z, \bar{z}) = v_1 z + v_2 \bar{z}, \quad (4)$$

where v_1 and v_2 are endogenous parameters to be determined.

The licensing technology is specified in our model as follows. When a patent is licensed, the licensor (original innovator) retains productivity gain $\alpha \gamma x \bar{z}$ in addition to earning the licensing fee $q_l = a_l \bar{z}$. The licensee (user of the patent) gains productivity $(1 - \alpha) \gamma x' \bar{z}$, where x' is the propinquity of the patent with the licensee. The parameter $\alpha \in (0, 1)$ captures the retention share, representing how much of the patent's productive value remains with the original owner. This reflects the ongoing use of the underlying technology by the licensor, the tacit knowledge that cannot be fully transferred to the licensee, and contractual limitations on the licensee's use. Furthermore, licensing the patent to another firm allows the innovating firm to maintain some control of the patent going forward while receiving a licensing fee. We assume that the licensee's fixed cost of using the patent in its production process is very small (normalized to 0 in the model) because the licensee

uses the patent in a more limited way.⁹ Thus, the net value of licensing out a patent to an innovating firm (the licensor) is given by

$$L(x, \bar{z}) \equiv V(z + \alpha\gamma x\bar{z}, \bar{z}) - V(z, \bar{z}) + q_l. \quad (5)$$

In the case of a patent sale, the innovating firm fully transfers the control of the patent to a buying firm via a patent agent in the for-sale market. All the net productivity gain, $(\gamma x' - \tau)\bar{z}$, accrues to the firm buying the patent and there is no productivity gain for the selling firm. The selling firm collects the patent selling price $q_s = a_s\bar{z}$.

Each matching market (for-sale and for-license markets) has a matching function with constant elasticity μ regulating the number of matches:

$$M^s = \eta^s (n_a^s)^\mu (n_b^s)^{1-\mu}, \quad M^l = \eta^l (n_a^l)^\mu (n_b^l)^{1-\mu}, \quad (6)$$

where n_a^s and n_b^s are the stocks of patents in each market, and M^s and M^l are the flow rates of matches. The parameters η^s and η^l represent the matching efficiencies in the for-sale market and the for-license market, respectively. We assume that any firm can buy or license an idea at any time, so that the measure of potential buyers/licensees is equal to 1, i.e., $n_b^s = n_b^l = 1$. Thus, the matching rates for patent agents in each market are given by:

$$m_a^s = \frac{M^s}{n_a^s} = \eta^s (n_a^s)^{\mu-1}, \quad m_a^l = \frac{M^l}{n_a^l} = \eta^l (n_a^l)^{\mu-1}. \quad (7)$$

3.1.2 The Value Function of a Firm

Given the model setup above, an innovating firm chooses the option (among the three options available to it) yielding highest value:

⁹This also partially reflects the idea that a firm will likely choose to license a patent from another firm when it needs that patent to develop a product, but it is more expensive for the licensee firm to fully develop and integrate the innovation internally, compared to licensing it from another firm. While we have normalized this cost borne by the licensee to be zero, our results go through as long as the licensee's cost of integrating the licensed patent into its production process is small.

$$\max \left\{ \underbrace{v_1(\gamma x - \tau)}_{\text{Retain}}, \underbrace{v_1 \alpha \gamma x + a_l}_{\text{License out}}, \underbrace{a_s}_{\text{Sell}} \right\}. \quad (8)$$

We focus on an equilibrium in which these value comparisons generate two cutoff thresholds on the innovator side for the propinquity x of the patent with the firm. An innovating firm keeps a patent if $x > x_k$ and monetizes it otherwise if $x < x_k$. Conditional on monetizing the patent, it licenses the patent out if $x_l < x < x_k$ and sells the patent outright if $x < x_l$. The ordering of these thresholds will be such that $0 < x_l < x_k < 1$.¹⁰

A non-innovating firm may match with a patent agent. Upon matching, the firm draws propinquity $x' \sim U[0, 1]$. If the non-innovating firm is matched with a for-sale patent agent, we assume that the agent extracts the full surplus ($\omega = 1$) so that the price of the patent is given by:¹¹

$$P(x') = V(z + (\gamma x - \tau)\bar{z}, \bar{z}) - V(z, \bar{z}). \quad (9)$$

Trade will occur if $P(x') \geq A_s(\bar{z}) = a_s \bar{z}$, yielding a buying threshold x_b . Thus, the matched firm will buy the patent if $x' > x_b$. Similarly, if the non-innovating firm is matched with a for-license patent agent, the licensing fee of the patent is given by:¹²

$$P_l(x') = V(z + (1 - \alpha)\gamma x \bar{z}, \bar{z}) - V(z, \bar{z}). \quad (10)$$

Trade will occur if $P_l(x') \geq A_l(\bar{z}) = a_l \bar{z}$, yielding a licensing threshold x_a . Thus, the matched firm will license in the patent if $x' > x_a$.

Discretizing time into small intervals of length Δ , the state of the firm can be summa-

¹⁰We characterize these equilibrium thresholds in our Internet Appendix.

¹¹The assumption that the for-sale and for-licensing agents extract the entire surplus of patent sale and patent licensing transactions (i.e., $\omega = 1$) is made only for analytical tractability. Our results go through qualitatively even if these agents and the firm involved share the surplus according to a pre-specified sharing rule (e.g., through Nash bargaining); the latter may be the case in practice.

¹²Of course, in practice, the licensing fee for a patent is paid periodically (such as an annual licensing fee). The equilibrium licensing fee paid by the licensee in (10) can be viewed as the present value of such periodic licensing fees.

ized by the pair (z, \bar{z}) and the value function for a firm can be written as:

$$\begin{aligned}
V(z, \bar{z}) = \pi z \Delta + \frac{1}{1+r\Delta} \left\{ & i\Delta \int_{x_k}^1 V(z + (\gamma x - \tau)\bar{z}, \bar{z}_{+\Delta}) dx \right. \\
& + i\Delta \int_{x_l}^{x_k} [V(z + \alpha\gamma x \bar{z}, \bar{z}_{+\Delta}) + q_l] dx + i\Delta \cdot x_l [V(z, \bar{z}_{+\Delta}) + q_s] \\
& + M^s \Delta \left(\int_{x_b}^1 [V(z + (\gamma x' - \tau)\bar{z}, \bar{z}_{+\Delta}) - P(x')] dx' + x_b \cdot V(z, \bar{z}_{+\Delta}) \right) \\
& + M^l \Delta \left(\int_{x_a}^1 [V(z + (1-\alpha)\gamma x' \bar{z}, \bar{z}_{+\Delta}) - P_l(x')] dx' + x_a \cdot V(z, \bar{z}_{+\Delta}) \right) \\
& \left. + (1 - i\Delta - M^s \Delta - M^l \Delta) V(z, \bar{z}_{+\Delta}) + o(\Delta) \right\}, \tag{11}
\end{aligned}$$

where $\bar{z}_{+\Delta} \equiv \bar{z} + g\bar{z}\Delta$ denotes aggregate productivity at the end of the period.

Over any time interval Δ , the firm collects $\pi z \Delta$ in profit. During the same period, the firm can generate a new patent with probability $i\Delta$. It will retain the patent and integrate it in-house if $x \in (x_k, 1)$. It will license the patent out through a patent agent for a licensing fee q_l if $x \in (x_l, x_k)$, and it will sell the patent to a patent agent for the price q_s if $x \in (0, x_l)$. Similarly, the third line of the above equation shows that a firm can receive an option to buy a patent with the endogenous matching probability $M^s \Delta$. It will decide to buy the patent from the patent agent at price $P(x')$ given in (9) if $x > x_b$. The firm will not buy the patent if $x < x_b$. The fourth line of the above equation shows that a firm can also receive an option to license in a patent with the endogenous matching probability $M^l \Delta$. It will decide to license in the patent from the patent agent by paying the licensing fee $P_l(x')$ given in (10) if $x > x_a$. The firm will not license in the patent if $x < x_a$. Finally, if the firm neither innovates nor meets a patent agent (for-sale or for-license) with probability $(1 - i\Delta - M^s \Delta - M^l \Delta)$, the firm moves to the next time interval with no change in its productivity and collects the continuation value $V(z, \bar{z}_{+\Delta})$, which is discounted by the

factor $1/(1 + r\Delta)$. Over the interval Δ , aggregate productivity evolves from \bar{z} to $\bar{z}_{+\Delta}$.¹³

Taking the limit as $\Delta \rightarrow 0$ and rearranging the above discrete-time Bellman equation in (11), we obtain the following Hamilton-Jacobi-Bellman (HJB) equation for the value function of the firm, presented in equation (E.1) of our Internet Appendix due to space constraints. Substituting the pricing rules for patent sales and licensing from equations (9) and (10) into (E.1), the firm's value function in (E.1) simplifies to:

$$rV(z, \bar{z}) = \pi z + i \left(\int_{x_k}^1 K(x, \bar{z}) dx + \int_{x_l}^{x_k} L(x, \bar{z}) dx + x_l q_s \right) + \dot{V}(z, \bar{z}), \quad (12)$$

where $K(x, \bar{z})$ given in (3) is the value of keeping a new patent that has propinquity x , and $L(x, \bar{z})$ given in (5) is the value of licensing out a new patent with propinquity x .¹⁴

The simplified HJB equation in (12) shows that the firm's value comes from: 1) flow profits: πz ; 2) retaining high-propinquity patents: $i \int_{x_k}^1 K(x, \bar{z}) dx$, with net productivity gains $(\gamma x - \tau)\bar{z}$ for patents with $x > x_k$; 3) licensing-out medium-propinquity patents: $i \int_{x_l}^{x_k} L(x, \bar{z}) dx$, with retained productivity $\alpha\gamma x\bar{z}$ plus licensing fee $q_l = a_l\bar{z}$ for patents with $x \in (x_l, x_k)$; 4) selling low-propinquity patents: $i x_l q_s$ with price $q_s = a_s\bar{z}$ for patents with $x < x_l$; 5) capital gains: $\dot{V}(z, \bar{z})$ capturing the increase in the firm's market value due to the growth in aggregate productivity, \bar{z} , in the economy.

We present further details about the derivation of the firm's value function $v(z, \bar{z})$, various propinquity thresholds such as x_k , x_l , x_a , x_b , licensing fee q_l and patent selling price q_s in the Internet Appendix (section E) due to space limitations.

¹³We observe the presence of some second-order terms denoted by $o(\Delta)$ in (11). These terms involve the occurrence of multiple simultaneous events, the probabilities of which are proportional to Δ^2 . As the length of period Δ shrinks, these terms will disappear relative to other terms in the expression.

¹⁴Note that the market terms M^s and M^l have vanished from equation (12) because patent agents extract all the surplus from such transactions ($\omega = 1$) as implied by the pricing rules given in (9) and (10).

3.2 Development of Testable Hypotheses

Based on insights from our theoretical analysis, we develop testable hypotheses for our empirical analysis. We consider three sets of research questions.

(i) Characteristics of Licensors and Licensees, and the Matching between Licensors and Licensees: As a prelude to analyzing the predictions of our theoretical model, we study the characteristics of licensors or licensees, and the determinants of the pairing between them.

We first study the characteristics of licensors and licensees. A market for licensing patents raises the incentive of firms to do R&D, since patents that are not useful for an innovating firm's own products can be licensed to other firms, thus raising the *ex-ante* return from the licensor's R&D expenditures. In addition, licensor firms are likely to have a comparative advantage in efficiently conducting innovation, given that there is demand for their innovation output. Therefore, compared to control firms, we expect licensors to have both higher input into innovation (in the form of R&D expenditures) and higher output from innovation (in the form of patents). On the other hand, from a licensee's point of view, when the firm needs a patent around which it can build products, the firm can choose to develop the patent in-house or acquire it from other firms (by buying or licensing in the patent). When the firm is less able to efficiently conduct the innovation activity in-house, licensing the patent from other firms may be the more cost-effective option.¹⁵ In addition, the fact that a firm can license a patent from another firm reduces the reward for it from developing the innovation internally by spending resources on R&D. Therefore, we expect licensee firms to be less efficient in conducting innovation activities in-house compared to control firms. The above predictions regarding the innovation characteristics of licensor and licensee firms respectively related to control firms is the first hypothesis that we test here (**H1**).

¹⁵Compared to purchasing of patents from other firms, licensing patents usually requires a smaller upfront payment (we show this to be the case in the equilibrium of our model). The majority of licensing fees paid by licensees is in the form of royalties, which are usually a certain percentage of licensees' sales in the next few years. This fee structure allows licensees to "test the water" with the patents that they choose to license.

We now turn to analyzing the factors that may determine the matching between licensors and licensees. In determining which firm to license a patent to, a licensor firm may take into account not only the stream of licensing fees it can generate from the licensing transaction, but also the benefits and costs of licensing a patent to a particular firm. One benefit of licensing a patent to a firm arises from the fact that it induces the licensee firm to buy the products of the licensor: i.e., the licensor and the licensee may have a potential upstream-downstream relationship. In other words, licensing a patent to a certain firm may not only help the licensee firm, but may also help the licensor by increasing the demand for the licensor's products from the licensee firm. Such arguments give rise to the testable hypothesis that licensors are more likely to license their patents to firms having a downstream relationship with them. This is the second hypothesis that we test here (**H2**).

A second factor that may affect the matching between licensors and licensees is the potential for competition between the two firms. If a licensor and licensee operate as competitors, licensing a patent to such a licensee may hurt the licensor, since the licensee firm may use the patent it has licensed to improve its own products, thereby obtaining a competitive advantage with respect to the products of the licensor. This means that, if a licensor and a potential licensee are technologically similar (and therefore more likely to compete in the product market), then the two firms are less likely to form a licensor-licensee relationship. This is the next hypothesis that we test here (**H3**).

(ii) Patent-Level Analysis—The Nature of Patents and Choices made by Licensors and Licensees: Our theoretical model predicts that firms will retain those patents that are closer in technological distance (see [Akcigit et al. \(2016\)](#) for a definition of technological distance and its empirical use) to their current patent portfolio, while monetizing (either by licensing or by selling outright) patents that are further away from their current patent portfolio. This is the next hypothesis that we test here (**H4**). If a firm chooses to monetize a patent, it has to decide how to monetize it: either by licensing the patent to another firm or by selling it outright. Our theoretical model predicts that, among the patents that

they choose to monetize, firms are likely to sell patents that are farther away in terms of technological distance from their current patent portfolio (which reflects their main line of business) while licensing out those patents that are closer to their current patent portfolio. This is the next hypothesis that we test here (**H5**).

Finally, we turn to the licensee's choice of patents to license in. Our theoretical model predicts that licensee firms are more likely to license in patents that are closer in technological distance to their current patent portfolio. This is the next hypothesis that we test here (**H6**).

(iii) Consequences of Patent Licensing Transactions: We now turn to our third set of research questions, dealing with the value created as a result of the licensing transaction for licensor and licensee firms and the channel through which such value is created. The first question we ask here is this: are licensing transactions efficient on average? In other words, are they value-creating for the licensor and licensee simultaneously? Our theoretical model predicts that licensing transactions are clearly value-increasing for the licensor, since they not only share part of the productivity benefit of the patent, but also the benefit of receiving the licensing fee from the licensee. As far as the licensee is concerned, our analysis shows that they receive the productivity gain from the patent they license, but they have to pay out the licensing fees. However, our theoretical analysis suggests that, at the very minimum, the licensing transaction will not be value-decreasing for the licensee.¹⁶ We hypothesize that licensing transactions are efficient so that the stock market valuation of both the licensor and licensee firms increase subsequent to the licensing transaction (**H7**).

We now turn to developing hypotheses about the specific channels through which licensing transactions create value for licensors and licensees. Our theoretical model suggests that an important benefit of a licensing transaction to a licensor firm is the stream

¹⁶In our theoretical model, the patent-licensing agent extracts all the surplus from the licensing transaction from the licensee firm, so that the licensing transaction will be a zero NPV transaction for the licensee firm (i.e., the transaction will not decrease the firm's value). More realistically, if the licensee firm and the licensing agent share the surplus from the licensing transaction, then the transaction will be strictly value-increasing for the licensee firm.

of licensing fees it will receive over time from licensee firms. The licensor firm may be able to use a part of these fees to create further value (and to enhance its comparative advantage in innovation) by investing some of the licensing fees it receives into innovation-oriented activities. Therefore, we hypothesize that the increase in valuation will be more pronounced for the sub-sample of licensors which receive higher licensing fees (**H8**). We further hypothesize that licensors will increase their R&D expenditures (i.e., increase their input into innovation) and produce more patents (i.e., increase their output from innovation) following licensing transactions (**H9**).

Our theoretical model suggests that, as part of the licensing transaction, the licensee firm pays a stream of licensing fees to the licensor and, in return, obtains the productivity gains from making use of the patent that it has licensed.¹⁷ An important implication of this is that the licensee firm is able to obtain exposure to new technology that it would not otherwise have been able to get exposure to. Then, after gaining access to new technologies incorporated in the patents it has licensed from licensor firms (and the licensor firms' technologies in general), licensee firms may be able to engage in "learning-by-doing" where they actively "absorb" and incorporate these technologies into their subsequent innovation and product development (Arrow (1962); Cohen and Levinthal (1990)). If the channel of exposure to new technologies (and correspondingly, "learning-by-doing") is plausible, we would also expect a gain in licensees' efficiency of conducting innovation activities following licensing transactions. Given this chain of thought, we hypothesize that the increase in firm valuation will be more pronounced for the sub-sample of licensee firms which obtain more exposure to new technologies (**H10**). Further, through this "learning-by-doing" channel (where a licensee firm learns from using the patents that it licenses), we hypothesize that licensee firms improve their innovation efficiency and develop more new products (**H11**). Finally, if licensee firms indeed learn from using the patents they

¹⁷While our theoretical model abstracts away from the channels through which the licensee firm may achieve such productivity gains, this is consistent with gains from exposure to new technologies embodied in the licensed patent and learning by doing (working with the patent); increases in innovation efficiency; or the development of new products.

have licensed from licensor firms, we expect future patents by licensee firms to cite the corresponding licensor's patents compared to those of control firms with which they do not have a licensing relationship (H12).

4 Data, Sample Selection, and Summary Statistics

The data used in our study is collected from several sources. The main source from which we obtain the licensing transaction-related information is the ktMINE Patent License Agreement Database. ktMINE collects the data on patent licensing transactions mainly from SEC firm disclosures, which are then supplemented with other various online data sources. With SEC firm disclosures being the main source from which ktMINE collects licensing transaction information, we are able to have relatively comprehensive coverage of substantial licensing transactions (as public firms are required to disclose such transactions). Since the majority of the database comes from SEC firm disclosures, the filer of every patent licensing transaction has a unique identifier denoted by CIK. This identifier allows us to link this firm to other standard databases (such as Compustat). As a result, our sample contains 7,204 patent licensing transactions spanning from 1976 to 2022. Of these, 1,935 of them have specifically listed patents being bundled and licensed out in these transactions. This comprehensive dataset thus allows us to conduct our empirical analysis at both the firm and patent levels.

Apart from the firms and patents involved in every patent licensing transaction, the ktMINE Patent License Agreement Database provides us with rich information on different terms of licensing transactions. For example, among many other things, this database provides information about the types of transactions (e.g., licensing, manufacturing, commercialization, and distribution), detailed terms of different transactions, filing and effective dates of transactions, and the types of intellectual property (IP) involved.¹⁸ This compre-

¹⁸Most of IP involved are patents, but many transactions include other types of IP, such as trademarks, copyrights, and brands, among others.

hensive database also provides information on the licensing fees associated with different transactions (in the form of upfront fixed payment as well as royalty).¹⁹

We link the ktMINE Patent License Agreement Database to Compustat using CIK as the identifier. However, the CIK provided by ktMINE is only the filer's CIK. There are other parties involved in a patent licensing transaction that could also be public firms. Therefore, to make sure we identify every public firm in every transaction, we isolate all the names from every patent licensing transaction, standardize them, and merge them with Compustat using fuzzy name matching. After the fuzzy name matching is completed, we manually inspect every transaction to ensure the quality of our matching. As a result, our sample contains 1,300 (1,954) unique Compustat public firms that engage in patent licensing transactions as licensors (licensees) over the sample period. We show in the Appendix B of the Internet Appendix that both licensor and licensee firms in our sample are broadly representative across different industries: Patent licensing is prevalent in Chemicals and Allied Products (with two-digit SIC code: 28), Measuring, Analyzing, and Controlling Instruments (with two-digit SIC code: 38), and Electronic and Other Electrical Equipment (with two-digit SIC code: 36). We also observe patent licensing transactions in industries such as Business Services (with two-digit SIC code: 73), Industrial and Commercial Machinery and Computer Equipment (with two-digit SIC code: 35), and Engineering, Accounting, Research, Management, and Related Services (with two-digit SIC code: 87).

In addition to the ktMINE Patent License Agreement Database and Compustat, we collect information on patent applications and grants, as well as patent-level statistics, from the USPTO PatentsView Database. We also collect trademark data from the USPTO to proxy for a firm's new product introduction. Further, we collect data on firms' vertical in-

¹⁹Generally, licensees pay two types of fees to licensors for the patents they license. The first type is fixed fees, which include upfront payments or one-time license fees. These require licensees to pay licensors a pre-determined amount of money. The second type is variable fees or royalties. This type of fee is typically charged as a percentage of the net sales of licensees over a certain period. It could also be charged as a particular dollar amount per unit of products sold by licensees. Among the transactions in our sample, only three exclusively use the fixed fee model, while the rest involve a combination of both fixed and variable payments (royalties).

tegration from Hoberg-Phillips Data Library.²⁰ This data is originally developed by Frésard et al. (2020) and captures the degree of vertical integration between a given pair of public firms. We report the firm- and patent-level summary statistics in Table 1. Panel A of Table 1 reports the summary statistics for licensor firms and their industry-size matched control firms. Panel B of Table 1 reports the summary statistics for licensee firms and their industry-size matched control firms. Panel C of Table 1 reports the summary statistics for licensor-licensee firm pairs and pairs formed by their industry-size matched control firms. Panel D of Table 1 summarizes the licensing fees involved in licensing transactions. Overall, there are three types of fees paid in licensing transactions in our sample. The first kind of fees is an upfront fixed fee paid for each licensing transaction. The second kind of fees is a variable payment based on the number of unit of products sold by the licensee. The third type of fees is a variable payment specified as a percentage of sales of the licensee over a particular period subsequently.²¹ Some licensing transactions involve multiple types of fees among the above three categories. Most of the transactions in our sample report have missing (or zero) values for the upfront fixed fees and variable payment based on the number of unit of products sold by the licensee. However, the majority of the transactions in our sample report values on the variable payment specified as a percentage of sales of the licensee over a particular period. Hence, we mainly rely on the latter type of licensing fees when conducting our cross-sectional analysis in Section 7.3.1. Lastly, we trim all the continuous variables at the 1st and 99th percentile levels to minimize the impact of outliers.

²⁰The data is downloaded from: <https://faculty.marshall.usc.edu/Gerard-Hoberg/FresardHobergPhillipsDataSite/index.html>.

²¹Both the second and third types of licensee fees are usually referred to as royalty.

5 Licensors' and Licensees' Characteristics, Matching Between Licensors and Licensees, and Licensing Transaction Incidence

In this section, we analyze the determinants of patent licensing transactions from both the licensors' and the licensees' point of view. Specifically, we first explore what innovation characteristics drive a firm to become a licensor or licensee in a patent licensing transaction. We then analyze the determinants driving the matching between potential licensor and licensee firms.

5.1 Licensors' and Licensees' Characteristics and Licensing Transaction Incidence

To begin with, we examine the firm-level innovation characteristics that drive a firm to be a licensor or a licensee firm in a patent licensing transaction. We employ the following specification.

$$\begin{aligned} \text{Licensor}_{i,k,t} \text{ (or Licensee}_{i,k,t}) &= \alpha + \beta_1 \text{Firm Innovation Characteristics}_{i,t-1} \\ &\quad + \beta_2 \text{Firm Characteristics}_{i,t-1} + \text{Transaction FE}_k + \epsilon_{i,k,t} \end{aligned} \tag{13}$$

In specification (13), the dependent variable, $\text{Licensor}_{i,k,t}$ (or $\text{Licensee}_{i,k,t}$), is a dummy variable that equals one if firm i is a licensor (licensee) firm in a patent licensing transaction k in year t . This variable is equal to zero for the licensor's (licensee's) matched control firms.

For every patent licensing transaction, we match the actual licensor (licensee) firms with non-licensor (non-licensee) firms based on the industry and firm size measured as of the year prior to the patent licensing transaction. Specifically, for each licensor (licensee) of a licensing transaction in year t , we identify up to five non-licensors (non-licensees)

in the same industry with the closest firm size measured in year $t - 1$. For industry classification, we start selecting matched non-licensor or non-licensee firms using the most stringent industry classification (i.e., four-digit SIC). In our final sample, 94.79% of licensors and 93.61% of licensees are matched with five control firms from the same four-digit SIC industry. When there are not enough control firms in the same four-digit SIC industry, we then gradually relax our industry classification to three-digit and finally two-digit SIC industry levels. We also require that these matched control firms not be licensors or licensees in the last three years prior to year t . Finally, we run a conditional logit regression of specification (13), since the conditional logit model allows us to account for matching (e.g., [Bena and Li \(2014\)](#); [Cunningham et al. \(2021\)](#)).

The main independent variable of interest, *Firm Innovation Characteristics* $_{i,t-1}$, includes a set of different innovation characteristics of firm i measured in year $t-1$ that proxy for the firm's innovation quantity or innovation quality. Specifically, we examine the effect of the following innovation characteristics on the probability of patent licensing transaction: (i) *Num_Pat_3*, which is the truncation-adjusted number of patents generated by a firm in the last three years up to a given year; (ii) *CPP_3*, which is the number of truncation-adjusted lifetime citations per patent for patents generated by a firm in the last three years up to a given year; (iii) ΔNum_Pat_3 , which is the growth rate of a firm's truncation-adjusted number of patents over the last three years; and (iv) ΔCPP_3 is the growth rate of a firm's truncation-adjusted number of citations per patent over the last three years. We adjust for the truncation bias in the number of patents a firm generates as well as the number of citations received by patents following the methodology in [Hall et al. \(2001\)](#) and [Seru \(2014\)](#). Together, these variables capture a firm's innovation output (as measured by its quantity and quality of innovation) and the firm's innovation dynamics (as measured by the growth rate of its innovation activity).

In specification (13), we also include several firm-level fundamentals that may be important for a firm to engage in a licensing transaction as a licensor or licensee. These

firm-level controls, $Firm\ Characteristics_{i,t-1}$, are measured for firms in year $t - 1$ and include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, and *B/M*. The definitions of these variables are illustrated in Appendix A. Further, we include licensing transaction fixed effects, so that we are comparing an actual licensor (licensee) firm with its matched non-licensor (non-licensee) firms within the same licensing transaction.

We first examine which firms are more likely to become licensors in patent licensing transactions. Columns (1) to (4) of Table 2 present the results on the effect of a firm's innovation characteristics on the probability of the firm becoming a licensor in a patent licensing transaction. On average, a firm's innovation quantity and quality have a positive and significant effect on the probability of the firm licensing out some of its patents, as indicated by the positive and statistically significant coefficients of *Num_Pat_3* and *CPP_3*. However, the growth rate of a firm's innovation quantity or quality over the last three years does not significantly predict the likelihood of the firm becoming a licensor. Notably, across Columns (1) to (4) of Table 2, the coefficients of a firm's R&D expenditures in the year prior to a licensing transaction are positive and statistically significant.

In terms of economic significance, since we obtain coefficient estimates by running a conditional logit regression of specification (13), the coefficient estimates should be interpreted in a relative odds fashion. Specifically, one standard deviation increase in *Num_Pat_3* is associated with an approximately 35% increase in the propensity of a firm to become a licensor. This is almost twice as much as the unconditional probability. On the other hand, a standard deviation increase in *CPP_3* is associated with an approximately 8% increase in the propensity of the firm to become a licensor, or 43% of the unconditional sample mean. The coefficients of *R&D* is also of great economic significance. Take the coefficient of *R&D* in Column (1) of Table 2 as an example: one standard deviation increase in *R&D* translates to an 18% increase in the propensity of the firm to become a licensor. This is economically very significant, since this is close in magnitude to the unconditional mean. Overall, the results in Columns (1) to (4) of Table 2 suggest that firms characterized

by higher innovation quantity, higher innovation quality, and higher R&D expenditures are more likely to become licensors in patent licensing transactions.

Next, we turn to the other side of patent licensing transactions, namely, the licensees, and examine which innovation characteristics drive a firm to become a licensee firm in a patent licensing transaction. Columns (5) to (8) of Table 2 present the results. Columns (5) and (6) of Table 2 suggest that firms with higher innovation quantity or quality are more likely to become licensees in patent licensing transactions, as indicated by the positive and statistically significant coefficients of *Num_Pat_3* and *CPP_3*. However, when we examine firms' innovation dynamics (as captured by the growth rate in their innovation quantity or quality) and their effects on firms' propensity to become licensees, we document a pattern in sharp contrast to that of licensors (Columns (3) and (4) of Table 2). Specifically, we find that firms that experience a decline in their growth of innovation quantity or quality are more likely to become licensees. These effects are economically meaningful. For instance, a standard deviation decrease in ΔNum_Pat_3 is associated with a 14% increase in the probability of a firm becoming a licensee, compared to its matched control firms. This is about 82% of the unconditional mean. On the other hand, one standard deviation decrease in ΔCPP_3 is associated with a 17% increase in the probability of a firm becoming a licensee. This is economically significant, since it is slightly greater in magnitude than the unconditional mean. Further, it should be noted that we also document an opposing pattern when it comes to the effect of R&D expenditures: compared to what we find for licensor firms, a firm's R&D expenditures in the previous year have an insignificant effect on the probability of the firm becoming a licensee.

Taken together, the results presented in Tables 2 suggest that while firms with higher innovation output (as captured by their innovation quantity or quality) and higher R&D expenditures are more likely to be licensors, firms that face a deterioration in their internal innovation (as captured by the growth rate of their innovation quantity or quality) are more likely to be licensees. These results together support the conjectures of our first

hypothesis (H1).

5.2 The Matching Between Licensors and Licensees and Licensing Transaction Incidence

In this section, we examine the determinants of the matching between potential licensor and licensee firms. We using the following regression specification.

$$\begin{aligned}
 Actual_Pair_{i,j,k,t} = & \alpha + \beta_1 Pairing\ Characteristics_{i,j,k,t-1} \\
 & + \beta_2 Licensor\ Innovation\ Characteristics_{i,k,t-1} \\
 & + \beta_3 Licensee\ Innovation\ Characteristics_{j,k,t-1} \\
 & + \beta_4 Licensor\ Characteristics_{i,k,t-1} + \beta_5 Licensee\ Characteristics_{j,k,t-1} \\
 & + Transaction\ FE_k + \epsilon_{i,j,k,t}
 \end{aligned} \tag{14}$$

In specification (14), the dependent variable, $Actual_Pair_{i,j,k,t}$, is equal to one if a firm pair $i-j$ is the actual licensor-licensee pair in licensing transaction k . This dummy variable is equal to zero otherwise. The main independent variable of interest here is $Pairing\ Characteristics_{i,j,k,t-1}$. This variable measures the characteristics between a firm pair $i-j$. In this paper, we focus on two particular characteristics for a given pair of firms: $Vertical_Integrate_{i,j,k,t-1}$ and $Tech_Similarity_{i,j,k,t-1}$. These two variables capture the product market as well as the technological relationship between a pair of firms. Specifically, $Vertical_Integrate_{i,j,k,t-1}$ captures the vertical integration potential for a given pair of firms. It is a dummy variable equal to one if firm i and j are vertically integrated in year $t - 1$ (i.e., the year prior to licensing transaction k). It is equal to zero otherwise. We obtain the data on the vertical integration relationship between a given pair of firms from [Frésard et al. \(2020\)](#), where we use the

10% granularity version of the VTNIC (Vertical TNIC) database provided by the authors.²² This version of the VTNIC database contains the firm pairs that have vertical relatedness scores in the top 10% of all pairwise scores in the given year. If a given firm pair in our sample appears in this database (with the order of firm i being the upstream firm and firm j being the downstream firm), the $Vertical_Integrate_{i,j,k,t-1}$ for this pair of firms will take the value of one. Otherwise, it is equal to zero. On the other hand, $Tech_Similarity_{i,j,k,t-1}$ captures the technological similarity between a given pair of firms. This variable is constructed as the cosine similarity between firm i 's and firm j 's patent portfolios by counting the number of patents in different technology classes of these firms' portfolio up to the year $t - 1$ (i.e., the year prior to licensing transaction k). This variable takes values that range from zero to one. If this variable takes a value that is closer to one (zero) for a given firm pair $i-j$, this indicates that firm i and j are more (less) similar to each other in their technology expertise. All other variables included in specification (14) are constructed in the same way as those in specification (13).

To be able to run regressions of specification (14), we need both actual licensor-licensee pairs and pseudo pairs formed by matched non-licensor and non-licensee firms. We employ an identical matching procedure to that in specification (13) and choose size-matched control firms that are in the same industry and year as licensors and licensees. Specifically, for a given licensor-licensee firm pair in our sample, we first select up to five industry- and size-matched control firms in the same year for this licensor and licensee. Then, we form pairwise combinations between each of these matched non-licensor firms and each of these matched non-licensee firms. As a result, for every actual licensor-licensee firm pair, we generate up to 25 (i.e., 5×5) pairwise combinations of matched non-licensor and non-licensee control firms.

Table 3 reports the results of different pairing characteristics that drive a given pair of firms to form a licensor-licensee relationship in a patent licensing transaction. Columns

²²We use the data from “Pairwise Vertical Related Network: Basic 10% Granularity Version” on the website: <https://faculty.marshall.usc.edu/Gerard-Hoberg/FresardHobergPhillipsDataSite/index.html>.

(1) and (2) of Table 3 report the regression results of the effect of the vertical integration between two firms on the probability of these two firms forming a licensor-licensee relationship in a licensing transaction. Column (1) presents the results in a univariate setting. The positive and statistically significant coefficient of *Vertical_Integrate* indicates that, if firms *i* and *j* are vertically integrated in the product market where firm *i* (*j*) is the upstream (downstream) firm, it is more likely for firm *i* to license out some of its patents to firm *j* (i.e., firm *i* being the licensor and firm *j* being the licensee in a licensing transaction). In Column (2), we include controls (such as firms' innovation characteristics and firms' fundamentals) for both licensors and licensees and their matched firms. Further, we include transaction fixed effects in the regression. The coefficient of *Vertical_Integrate* becomes larger in magnitude while remains statistically significant. Overall, these results suggest that, when deciding which firm to license patents to, licensor firms prefer to license patents to firms that are more likely to be their downstream partners. These findings confirm the prediction in Hypothesis H2.

Columns (3) and (4) of Table 3 report the regression results of the effect of the technological similarity between two firms on the probability of these two firms forming a licensor-licensee relationship in a patent licensing transaction. Column (3) presents the regression results in a univariate setting. The negative and statistically coefficient of *Tech_Similarity* suggests that if firms *i* and *j* are similar to each other in terms of their technological expertise (indicated by a greater value of *Tech_Similarity*), then it is less likely for firm *i* (i.e., licensor) to license out some of its patents to firm *j* (i.e., licensee). In Column (2), apart from controlling for transaction fixed effects, we also control for innovation characteristics and firms' fundamentals for licensors and licensees and their matched firms. The coefficient of *Tech_Similarity* remains negative and statistically significant. Overall, these results suggest that licensors are less likely to license their patents to firms that are technologically more similar to themselves (and thus less likely to be their competitors). These findings confirm the prediction in our Hypothesis H3.

6 The Nature of Patents Involved in Licensing Transactions

In this section, we delve into patent-level analysis and characterize the patents that are licensed in patent licensing transactions. We use the following patent-level regression specification to address our second set of research questions: What is the type of patents that a firm is likely to retain (and build products around) versus monetize (by licensing or selling it to another firm)? In addition, conditional on a firm choosing to monetize some of its patents, what is the type of patents that are more likely to be licensed versus sold?

$$Licensed_Patent_{i,j,t} = \alpha + \beta Tech_Dist_{i,j,t} + \mathbf{X}_{i,\tau}\boldsymbol{\gamma} + \epsilon_{i,j,t} \quad (15)$$

The dependent variable in specification (15), $Licensed_Patent_{i,j,t}$, is a dummy variable. It equals one if patent i is licensed out by licensor j or licensed in by licensee j at year t , and it equals zero otherwise. $\mathbf{X}_{i,\tau}$ is a vector of patent-level control variables for patent i filed in year τ . These patent-level controls include the number of backward citations, the number of forward citations, the number of claims, and a patent litigation dummy. The main independent variable of interest is $Tech_Dist_{i,j,t}$, representing the technological distance of patent i from firm j 's patent portfolio in the licensing transaction year t . We follow Akcigit et al. (2016) to construct the measure of technological distance between a patent and the owning firm's existing patent portfolio.²³ We discuss the construction of this variable in detail in the Appendix C of the Internet Appendix.

We first start with the monetization decision faced by firms in general. Firms may choose to retain some of the patents developed by them and build products around these patents. Clearly, it is less costly for firms to retain patents that are more relevant to their main line of business and thus build products around such patents. In other words, firms

²³This measure is widely used in other papers (e.g., Zhang (2020), Ma et al. (2022), and Han et al. (2025)).

will retain those patents that are closer (in technological distance) to their current patent portfolio, while monetizing (either by licensing or by selling outright) patents that are further away from their current patent portfolio.

We empirically examine this conjecture and report the patent-level results in Table 4. Here, the dependent variable is a dummy that is equal to one if a patent is monetized by a firm. Here, we define a patent as monetized if the firm chooses to license it or sell it to another firm. This dummy variable is equal to zero otherwise. The main independent variable of interest here is *Dist_to_Owner*, which captures a focal patent's technological distance to the owning firm's patent portfolio. We include firm fixed effects in Columns (1) and (2) of Table 4 in order to absorb any firm-specific factors that affect a firm's propensity to monetize a focal patent. The coefficients of *Dist_to_Owner* in Columns (1) and (2) are positive and statistically significant. This suggests that, within the same firm, patents that are technologically further away from the owning firm's main knowledge space (as captured by its patent portfolio) are more likely to be monetized (i.e., either sold or licensed out) by the owning firm. In Columns (3) and (4), we include tech class-by-filing year fixed effects to absorb the varying technological trend over time, and the main empirical pattern remains consistent. Overall, the results in Tables 4 suggest that firms are more likely to monetize patents that are technologically further away from their main operations while retaining patents that are technologically closer to their main operations. Overall, the results in Table 4 are consistent with the prediction of our Hypothesis H4.

Next, we examine, conditional on a firm monetizing some of its patents, how the firm will monetize these patents. If a firm chooses to monetize some of its patents, it can do that either by licensing these patents to another firm or by selling them outright. On the one hand, licensing a patent to another firm allows the firm to maintain some control of the patent going forward (since it has the ability not to renew the license after the initial licensing period) while receiving a periodic licensing fee. On the other hand, if the firm sells that patent, the firm will have no remaining control of the patent going forward.

However, the monetary reward from the sale of the patent is likely to be greater than the present value of the licensing fees the firm may receive from licensing that patent to another firm. The above cost-benefit trade-off suggests that, among the patents that they choose to monetize, firms are likely to sell patents that are farther away (in technological distance) from their current patent portfolio since these patents are less relevant to their main operations, while licensing out those patents that are closer to their current patent portfolio.

We empirically examine this conjecture and report the results in Table 5. Here, the dependent variable is a dummy variable that equals one if a focal patent is licensed out by the owning firm. It is equal to zero if this patent is sold by the firm. The main independent variable of interest here is *Dist.to.Licensor*, which captures a focal patent's technological distance to the licensor firm's patent portfolio. Column (1) of Table 5 includes firm and year fixed effects to account for any firm-specific and time-varying factors that may potentially affect the choices made by licensors regarding different ways to monetize a patent. The negative and statistically significant coefficient of *Dist.to.Licensor* suggests that a patent with a greater technological distance from the licensor's patent portfolio is less likely to be licensed out relative to being sold in a patent transaction. In other words, conditional on a firm choosing to monetize a patent, the firm is more likely to sell patents that are technologically further away from its main operation. On the contrary, a firm is more likely to license out patents that are technologically closer to its main operation. When we control for a set of patent-level variables in Column (2) or technology class by filing year fixed effects in Columns (3) and (4), the overall empirical pattern remains consistent. Put together, the results in Table 5 support the prediction of Hypothesis H5.

We now turn to the licensee's point of view. A firm will likely choose to license a patent from another firm when it needs that patent to develop a product, but it is more expensive for the licensee firm to develop the innovation internally, compared to licensing it from another firm. Further, the above demand for licensing a patent is likely to be greater for

patents that are closer to the licensee firm’s current line of activity, since it is cheaper for licensee firms to build new products more closely related to their current lines of business. Thus, licensee firms are likely to license in patents that are technologically closer to their main lines of business.

To empirically examine the above conjecture, we run specification (15) with $Licensed_Patent_{i,j,t}$ being equal to one for the licensed patent i and zero for other patents in the corresponding licensor’s patent portfolio as of the transaction year t .²⁴ The independent variable $Tech_Dist_{i,j,t}$ in the specification (15) is now $Dist_to_Licensee$, which denotes the technological distance of every patent in the corresponding licensor’s patent portfolio to the licensee’s patent portfolio as of the transaction year t .

Table 6 reports the results on the relationship between a patent’s distance from the patent portfolio of a licensee firm and the probability of the patent being licensed in by the licensee. Column (1) of Table 6 reports the results in a univariate regression. The coefficient of $Dist_to_Licensee$ is negative and statistically significant. This indicates that the shorter the technological distance between a patent and a licensee firm’s patent portfolio, the more likely the licensee will choose to license in that patent. The implications remain consistent when we add patent-level control variables (Columns (2) and (4)) and control for technology-specific time-varying factors that may potentially affect the licensee’s decision to license a patent (Columns (3) and (4)). Overall, the results in Table 6 are consistent with the prediction in Hypothesis H6, which suggests that licensee firms are more likely to license patents that are closer to their current patent portfolio.²⁵

In summary, our patent-level analysis finds that, for licensors, when choosing to mon-

²⁴Here we examine, conditional on a licensee firm licensing from the corresponding licensor, which patents in the licensor’s patent portfolio will the licensee choose to license. Of course, it could be the case that licensee firms first consider which technology class they need to license a patent from and then choose a specific patent from this technology class to license in. Thus, we also use a different control group, where $Licensed_Patent_{i,j,t}$ dummy equals one for the actual licensed patents and zero for all the other patents in the same technology class as of the transaction year. The results continue to hold.

²⁵It is interesting to note that the coefficients on the litigation dummy are positive and significant in Tables 5 and 6. This suggests that when a patent has been subject to litigation (perhaps indicating greater demand for using that patent), it is more likely to be licensed.

etize a patent (by either licensing it to another firm or by selling it outright), firms tend to sell patents that are most distant from their current patent portfolio and license those that are closer to it. By engaging in patent licensing transactions, licensor firms are able to monetize those patents that they do not wish to build products around while maintaining some control over those patents. Licensee firms, on the other hand, are more likely to license patents that are closer to their current line of business, since it would be more cost-effective for them to build products around such patents.

7 Are Patent Licensing Transactions Value-Enhancing?

In this section, we empirically test whether patent licensing transactions are value-enhancing in the sense that they increase the equity market value of both licensor and licensee firms.

7.1 Baseline Analysis

We first test if patent licensing transactions are value-enhancing for both licensors and licensees in the baseline. To test these hypotheses, we construct a control group for each licensor or licensee firm. Specifically, for each firm that becomes a licensor or licensee firm in year t , we select up to five control firms that have the closest propensity score to that of a licensor or licensee firm. We implement the propensity score matching based on firms' sizes, R&D expenditures, ROA, leverage, cash, capital expenditures, total number of patents filed in the last three years (that are eventually granted), and total number of citations per patent of patents filed in the last three years (that are eventually granted).²⁶ In addition, we also require that the control firms be in the same industry and year as the licensor or licensee firms. To some extent, this matching procedure allows us to attribute the differences in outcomes between licensor or licensee firms and control firms to the patent licensing transaction.

²⁶All of these variables are lagged (i.e., they are measured in year $t - 1$) when we calculate the propensity score.

In the baseline, we examine whether patent licensing transactions are value-enhancing for both licensor and licensee firms using the following specification:

$$TobinQ_{-1-3_{i,t}} = \alpha_j \times \alpha_t + \beta Licensor_{i,t} \text{ (or Licensee}_{i,t}) + \mathbf{X}_{i,t}\gamma + \epsilon_{i,t} \quad (16)$$

we use Tobin's Q to measure a firm's equity market valuation. Specifically, the dependent variable in specification (16) is firm i 's average Tobin's Q in the three years following year t . The independent variable of interest is $Licensor_{i,t}$ ($Licensee_{i,t}$), which equals one if the firm i is a licensor (licensee) in year t . It is equal to zero for the matched control firms. We control for a vector of firm-level variables, $\mathbf{X}_{i,t}$, which include the number of patents filed by firm i (that are eventually granted), size, R&D expenditures, ROA, leverage, cash, Tobin's Q, and capital expenditures. All of these control variables are measured in year t . We also include industry-by-year fixed effects to account for any industry-specific unobservables that may vary over time. Robust standard errors are clustered at the industry level.

Table 7 reports the results associated with specification (16). Panel A shows the results for licensors, while Panel B shows the results for licensees. In both panels, Column (1) shows the univariate regression results. Building on Column (1), Column (2) controls for industry-year fixed effects, and Column (3) further controls for firm-level characteristics. To further test whether patent licensing transactions indeed increase the subsequent Tobin's Q for licensor and licensee firms, Column (4) controls for the Tobin's Q at the year of the patent licensing transactions. In panel A, we find that, across all the columns, the estimated coefficients of $Licensor$ are positive and statistically significant. These results suggest that licensor firms have higher equity market valuations in the three years following patent licensing transactions than their matched firms. When looking at the licensee firms, we also document positive and significant increases in their Tobin's Q following licensing transactions. The positive coefficients of $Licensee$ in Columns (1) to (4) of Panel B suggest that licensee firms also have higher equity market valuation over the three years following

patent licensing transactions compared to their matched firms. The estimated coefficients are also of economic significance. Take the coefficients of the *Licensor* and the *Licensee* dummy in Columns (3) of both panels for example: on average, a licensor (licensee) has 21.1% (21.6%) higher Tobin's Q, relative to the sample mean, than its matched control firms over the three years following a patent licensing transaction. Together, the baseline results support the prediction of our testable hypothesis **H7**.

7.2 Identification

7.2.1 Difference-in-Differences Analysis

Our baseline regressions above may still be subject to endogeneity concerns even after we carefully designed and implemented a propensity score matching procedure. For example, one endogeneity that may bias our baseline estimates is the omitted variable problem. Specifically, there may be some omitted variables that correlate with the main independent variable *Licensor* (or *Licensee*) and affect a firm's Tobin's Q at the same time. One example of such omitted variables would be (unobserved) innovation capability of a firm, which may simultaneously drive a firm's decision to license patents and its subsequent Tobin's Q. To address this concern and establish the causality between patent licensing transactions and equity market value, we utilize a Difference-in-Differences (DiD) framework. Our DiD analysis is conducted based on the National Technology Transfer and Advancement Act (NTTAA) of 1995, which, we argue (and also empirically show later), serves as a positive exogenous shock to firms' patent licensing decisions.

The National Technology Transfer and Advancement Act of 1995 was signed into law on March 7, 1996. The NTTAA amended several existing laws and mandated new directions for federal agencies with the purpose of accelerating the commercialization of technology and industrial innovation. It aimed to encourage cooperative research and development between businesses and the federal government by providing access to federal

laboratories and making it easier for businesses to obtain exclusive licenses to technology and inventions resulting from such cooperative research.

Given this background, we argue that the NTTAA is an appropriate positive shock to licensing transaction incidence, since it spurs the demand for licensing and makes licensing more attractive for both future potential licensors and licensees. For potential licensors, the Act allows them to enter into cooperative research and development agreements with the federal government and utilize technology from federal laboratories. This enables potential licensors to develop higher-quality technology and more easily license it to others in exchange for financial rewards, compared to the pre-NTTAA era. For potential licensees, the enactment of the NTTAA facilitates access to technology they previously could not obtain. Before the NTTAA, licensees might not have been able to secure exclusive licenses for federally funded technology. With the NTTAA in place, it is now easier for potential licensees to obtain these exclusive licenses. We also empirically show that the passage of NTTAA is associated with greater patent licensing transaction incidence in Table D.1, where we regress the *Licensor* (or *Licensee*) dummy in Panel A (Panel B) on a dummy variable $I(\text{After Act})$. The latter dummy variable, $I(\text{After Act})$, is equal to one for years after 1996 (when the NTTAA was enacted) and is equal to zero otherwise. The coefficients of $I(\text{After Act})$ across different specifications in both Panel A and Panel B are positive and statistically significant. This suggests that the passage of the NTTAA is associated with a greater likelihood of a firm engaging in a patent licensing transaction as a licensor or licensee.

Based on the above arguments, we utilize the passage of the NTTAA as a positive exogenous shock to the licensing transaction for both licensor and licensee firms. We estimate the following DiD regression using the panel data of a five-year window around the year 1996:

$$TobinQ_{i,t} = \alpha_i + \alpha_t + \beta Licensor_i \text{ (or Licensee}_i) \times Post_t + \mathbf{X}_{i,t}\gamma + \epsilon_{i,t} \quad (17)$$

where the dependent variable is firm i 's Tobin's Q in year t . The independent variable of interest is the interaction term $Licensor_i$ (or $Licensee_i$) \times $Post_t$. $Licensor_i$ ($Licensee_i$) equals one if firm i is a licensor (licensee) firm during the five-year window around 1996. It is equal to zero for the matched control firms.²⁷ $Post_t$ is a dummy variable that equals one if an observation is within five years after 1996. It is equal to zero if an observation is within the five-year window prior to 1996. We control for the same firm-level characteristics as in our earlier specification (16) and include both firm and year fixed effects.

Table 8 reports our regression results associated with the specification (17). Column (1) shows the univariate regression results for $Licensor_i \times Post_t$. The estimated coefficient is positive and significant, indicating that in the five years following the enactment of the NTTAA, licensor firms, on average, experience an increase in their Tobin's Q compared to matched non-licensor firms. In Column (2), we control for firm characteristics that may be correlated with firms' licensing decision and may affect firms' Tobin's Q simultaneously, and the empirical pattern remains consistent. Column (3) and (4) report the DiD results for licensees' Tobin's Q. Column (3) reports such results in a univariate setting, while we control for firm characteristics in Column (4). Both the coefficients of the interaction term $Licensee_i \times Post_t$ in Columns (3) and (4) are positive and statistically significant at 5% level. This suggests that licensee firms similarly show an increase in their Tobin's Q five years following the NTTAA compared to matched non-licensee firms. Overall, Table 8 suggests that patent licensing transactions create greater equity market value for both licensor and licensee firms.

7.2.2 Discussion of the DiD Analysis

The causal interpretation of the above DiD results (i.e., the patent licensing transactions causally create value for both licensor and licensee firms) relies on a few key assumptions. In this section, we discuss and test those assumptions.

²⁷Here, when selecting the matched control firms for either licensors or licensees, we follow the same propensity score matching procedure that we mentioned when we discussed the specification (16).

First, the causal interpretation of a DiD analysis requires the parallel trend assumption to be satisfied. In our context, the parallel trend assumption implies that, in the absence of patent licensing, the average change in firms' Tobin's Q over time would have been the same for both licensors (licensees) and matched non-licensor (non-licensee) firms. To empirically test this assumption, we estimate the following regressions:

$$TobinQ_{i,t} = \alpha_i + \alpha_t + \sum_{t=-5, t \neq 0}^5 \beta_t Licensor_i \text{ (or Licensee}_i) \times Period_t + \mathbf{X}_{i,t}\gamma + \epsilon_{i,t} \quad (18)$$

Here, we examine the dynamics of the impact of NTTAA by replacing the time dummy ($Post_t$) in specification (17) with a set of dummies representing each year during this ten-year window ($Period_t$). The dummy for the year when the NTTAA was signed into law (i.e., 1996) is dropped to avoid multicollinearity and thus serves as the baseline group for comparison. Other variables are the same as those in specification (17). We plot the coefficients of β_t for the regression specification (18) in Figure 1. The left panel (Panel A) shows the estimated coefficients for licensor firms, and the right panel (Panel B) shows the coefficients for licensee firms.

A visual inspection of Figure 1 confirms the parallel trend: Neither of the panels in Figure 1 shows a significant trend prior to the enactment of NTTAA. Specifically, none of the coefficient estimates on $Licensor_i \text{ (or Licensee}_i) \times Period_t$ is statistically different from zero at the 10% significance level. After the enactment, both licensor and licensee firms exhibit an increasing trend, indicating that the passage of the NTTAA indeed has a positive effect on the equity market valuation (as measured by their Tobin's Q) of both licensor and licensee firms.

Second, for our DiD estimates to provide a causal interpretation of the value enhancing effect of patent licensing, the exclusion restriction assumption must be satisfied as well. In this context, the exclusion restriction suggests that the NTTAA affects the Tobin's Q of licensors or licensees only through the patent licensing channel.

We empirically examine this assumption by conducting a placebo test. Specifically, we falsely assume that the NTTAA took effect six years earlier than it actually did (i.e., year 1990).²⁸ The rationale behind this placebo test is straightforward: if it was the case that the NTTAA affects Tobin’s Q of licensors or licensees through other channels than the patent licensing per se, by falsely assuming a placebo shock, we would still observe an increase in Tobin’s Q of licensors or licensees relative to their matched control firms following the onset of this placebo shock.

Table D.2 in the Internet Appendix shows the results of the placebo test. In this table, we are essentially re-running specification (17) except that (i) $Licensor_i$ ($Licensee_i$) now equals one if firm i is a licensor (licensee) firm during the five-year window around 1990, and it is equal to zero for the matched control firms; and (ii) $Post_t$ is a dummy variable that equals one if an observation is within five years after 1990, and it is equal to zero if an observation is within the five-year window prior to 1990. In this table, the independent variable of interest is still the interaction term $Licensor_i$ (or $Licensee_i$) \times $Post_t$: if the exclusion restriction assumption was violated, we would expect to find the coefficient estimates of the interaction terms for both licensors and licensees to be statistically significant. As with Table 8, we report the univariate regression results in Columns (1) and (3) while controlling for the same firm-level characteristics in Columns (2) and (4). The coefficients of the interaction terms $Licensor_i \times Post_t$ or $Licensee_i \times Post_t$ are all statistically indistinguishable from zero. This indicates that it is likely that the NTTAA affects Tobin’s Q of licensors and licensees through the patent licensing per se rather than some other channels. Overall, we argue that patent licensing transactions are efficient for both licensor and licensee firms in the sense that they causally create value for licensors and licensees involved in licensing transactions, thus supporting the prediction of our Hypothesis H7.

²⁸We require this so that the panel dataset used for the placebo test ends before the actual year when NTTAA was enacted.

7.3 Channels of Value Creation

7.3.1 Channels of Value Creation for Licensors

We next examine the channels through which patent licensing transactions create value for both licensor and licensee firms. We first examine the channel of value creation for licensor firms. Licensor firms receive licensee fees (usually in the form of royalties) in exchange for licensing out their patents. Licensor firms may then efficiently direct these monetary proceeds toward areas where they have a comparative advantage (e.g., producing innovation). This is, in turn, reflected in their higher equity market valuation (as measured by Tobin's Q) following licensing transactions. Therefore, if this is a potential channel of value creation for licensor firms, we should expect that the increase in Tobin's Q will be greater for the sub-sample of licensor firms that receive higher licensing fees from patent licensing transactions.

We test this channel by utilizing the licensing fee data from ktMINE. As discussed in Section 4, while patent licensing transactions generally involve three different types of licensing fees, the predominant type of licensing fees in our sample is the variable payment specified as a percentage of the sales of the licensee (i.e., royalties). Therefore, we mainly rely on the royalties data to conduct our channel test. Specifically, we divide the licensors into two groups based on the median value of the royalties that they charge licensees: one group with above-median royalties (labeled "High Royalty") and the other group with below-median royalties (labeled "Low Royalty").²⁹ After we split licensor firms into two sub-samples based on the royalties, we combine the licensors in each sub-sample with corresponding propensity score-matched non-licensor firms and run two separate regressions based on specification (16).

Table 9 shows the regression results. The coefficient of *Licensor* dummy in Column (1) is positive and statistically significant. This indicates that, compared to their matched counterparts, licensors that receive higher royalties experience higher Tobin's Q over the

²⁹Detailed summary statistics are reported in Table 1.

three years following patent licensing transactions. The inference remains similar when we control for firms' Tobin's Q in the year of licensing transactions in Column (4). On the other hand, the coefficient of *Licensor* dummy in Column (2) is positive but statistically insignificant. This suggests that, compared to their matched counterparts, licensors that receive lower royalties do not exhibit higher Tobin's Q over the three years following patent licensing transactions. The pattern remains consistent when we control for firms' Tobin's Q in the year of licensing transactions in Column (5). Column (3) (Column (6)) presents the difference between the estimated coefficients of the *Licensor* dummy in Columns (1) and (2) (Columns (4) and (5)). Both of these differences are positive and at least statistically significant at the 5% level. Overall, the results suggest that the increase in subsequent equity market valuation (as measured by firms' Tobin's Q) is stronger for the sub-sample of licensors that receive higher royalties. Therefore, the results in Table 9 support the prediction of our hypothesis H8, in the sense that the ability to charge licensing fees is a plausible channel underlying licensors' higher equity market valuation following patent licensing transactions.

If the ability to extract rents (i.e., charge licensing fees) from licensing transactions is one potential mechanism of the value creation for licensors, we would further expect that licensors reinvest some of the proceeds in innovation-oriented activities (such as R&D) to further enhance their comparative advantage in developing innovation. If this is the case and licensors increase their input into innovation (in the form of R&D expenditures) subsequent to licensing transactions, we would also expect an increase in their innovation output (in the form of new patents).

To empirically examine the conjectures that licensor firms increase their R&D expenditures and produce more new patents following licensing transactions, we run a regression based on specification (16). The independent variable is *Licensor*, which equals one for licensor firms and zero for the propensity score-matched non-licensor firms. All the firm-level control variables and fixed effects remain the same as in specification (16). Now,

the dependent variables of interest become $R\&D_{1-3_{i,t}}$ and $Num_Pat_{1-3_{i,t}}$. $R\&D_{1-3_{i,t}}$ represents the average R&D expenditures that firm i spend over the three years following the patent licensing transaction year t , while $Num_Pat_{1-3_{i,t}}$ represents the total number of (truncation-adjusted) patents filed by firm i (that are eventually granted) over the three years following the patent licensing transaction year t .

Table 10 shows the results when we have firms' subsequent R&D expenditures, $R\&D_{1-3_{i,t}}$, as the dependent variable. Column (1) reports the univariate regression results of the difference in their subsequent R&D expenditures between licensors and matched control firms. We document a positive and statistically significant coefficient of the *Licensor* dummy, which indicates that licensors spend more on R&D expenditures than their matched counterparts over the three years following patent licensing transactions. The inference remains the same when we include industry-by-year fixed effects in Column (2) and control for firm-level characteristics in Column (3).

After documenting that licensors invest more into the input of innovation (i.e., R&D expenditures) following patent licensing transactions, we further examine if the greater R&D expenditures put down by licensors will translate to more innovation output produced by them relative to their matched control firms after patent licensing transactions. Table 11 reports the results associated with this conjecture. We first test this conjecture using a univariate regression as shown in Column (1) of Table 11. The positive and statistically significant coefficient of the *Licensor* dummy suggests that, relative to their matched control firms, licensor firms produce more innovation output (as measured by the total number of patents they generate) over the three years following licensing transactions. The coefficient remains positive and significant when we add industry-year fixed effects in Column (2) and control for a series of firm-level characteristics in Column (3). Overall, the results in Table 11 indicate that licensors produce more innovation output than their control firms in the three years following patent licensing transactions. Together, the findings in Tables 10 and 11 suggest that licensor firms direct some of the licensing fees to-

ward innovation-oriented activities (where they supposedly have a comparative advantage relative to other firms), and this greater investment in the input of innovation also leads to more output of innovation produced by licensor firms following licensing transactions. Overall, these results support the prediction of our Hypothesis **H9** and are consistent with the notion that licensors utilize the licensing fees that they charge from licensing transactions into R&D activity and produce more patents accordingly. All of these are perceived positively by the equity market and are thus reflected in the higher Tobin's Q of licensors after patent licensing transactions.

7.3.2 Channels of Value Creation for Licensees

We now examine the channel of value creation of licensing transactions for licensee firms. In patent licensing transactions, licensees gain access to new technologies brought by licensors. By accessing the technologies of licensors, licensees may be able to engage in “learning-by-doing”. If the channel of exposure to new technologies (and correspondingly, “learning-by-doing”) is plausible, we would also expect a gain in licensees' efficiency in conducting innovation activities following licensing transactions. Through the “learning-by-doing” process, licensee firms can further “absorb” and incorporate these technologies into their subsequent product development and innovation ([Arrow \(1962\)](#); [Cohen and Levinthal \(1990\)](#)).

We test this logic chain in a few steps. First, we examine whether licensees' exposure to new technologies brought by licensors is a potential channel underlying the higher Tobin's Q of licensees after patent licensing transactions. If this is the case, we would expect that the increase in Tobin's Q would be greater for licensees with more exposure to new technologies. We test this conjecture by dividing licensees into two sub-samples based on their relative exposure to new technologies brought by licensors. We utilize the cosine similarity between the patent portfolios of the licensee and the corresponding licensor in a licensing transaction to proxy for the exposure. The overall idea is that if a

licensor and a licensee have lower similarity in their technologies (captured by their patent portfolios up to the licensing transaction year), then it is more likely for the licensee to get exposed to the licensor's new technology. As a result, the sub-sample of licensee firms with above-median cosine similarity scores is labeled as the "Less Exposure" group, while the sub-sample of licensee firms with below-median cosine similarity scores is labeled as the "More Exposure" group. For each group of licensee firms, we combine the corresponding propensity-score matched non-licensee control firms and run regressions for each group based on the specification (16).

Table 12 shows the regression results associated with the above conjecture. The coefficient of *Licensee* dummy in Column (1) is positive and statistically significant. This indicates that, compared to their matched non-licensee firms, licensees that have lower similarity between their technologies and those of the corresponding licensors (and thus, more exposure to new technologies of licensors) experience higher Tobin's Q over the three years following patent licensing transactions. This empirical pattern remains similar when we control for firms' Tobin's Q in the year of licensing transactions in Column (4). However, the coefficient of *Licensee* dummy in Column (2) is positive but insignificant. This suggests that, compared to their matched counterparts, licensees that have higher similarity between their technologies and those of the corresponding licensors (and thus, less exposure to new technologies of licensors) do not exhibit higher Tobin's Q over the three years following patent licensing transactions. The result remains consistent when we control for firms' Tobin's Q in the year of licensing transactions in Column (5). In Column (3) (Column (6)), we also present the difference between the estimated coefficients of the *Licensee* dummy in Columns (1) and (2) (Columns (4) and (5)). Both of these differences are positive and statistically significant at the 1% level. Overall, the results suggest that the increase in subsequent equity market valuation (as measured by firms' Tobin's Q) is greater for the sub-sample of licensees that get more exposure to new technologies brought by licensors. Therefore, the results in Table 12 are consistent with our aforemen-

tioned conjecture and thus support the prediction of our hypothesis **H10**: the exposure to new technologies that licensees obtain through licensing transactions is a plausible channel underlying licensees' higher equity market valuation subsequent to patent licensing transactions.

Second, we test the next part of our logic chain above: by engaging in “learning-by-doing”, licensees will likely experience an increase in their efficiency in conducting innovation activities after patent licensing transactions. Through the “learning-by-doing” process, they can further “absorb” and incorporate these technologies into their subsequent product development (Arrow (1962); Cohen and Levinthal (1990)).

We formally test the former conjecture by constructing a proxy of a firm's innovation efficiency following the methodology of Hirshleifer et al. (2013).³⁰ Table 13 presents the results associated with the above conjecture. In this table, the dependent variable, *Innovation_Efficiency_1_3*, is the average innovation efficiency of firm *i* over the three years following a patent transaction in year *t*. Column (1) reports the univariate regression results. We find that the coefficient of the *Licensee* dummy is positive and statistically significant at the 5% level. This indicates that, compared to their matched counterparts, licensee firms increase their innovation efficiency over the three years after patent licensing transactions. We control for industry-by-year fixed effects in Column (2) and firm-level characteristics in Column (3), and the inference remains similar.

Table 14 reports the results where we examine the latter part of the above conjecture (i.e., introduction of new products by licensees). In this table, the dependent variable, *Num_Trademark_1_3*, is the number of trademarks filed by firm *i* over the three years following year *t*. We use the number of trademarks filed by a firm to proxy for the number of new products introduced by the firm. Column (1) reports the univariate regression results.

³⁰Specifically, innovation efficiency of firm *i* in year *t* is calculated as the ratio of the number of patents of the firm filed in year *t* that are eventually granted ($Patents_{i,t}$) scaled by the firm's R&D capital. Firm *i*'s R&D capital is calculated as cumulative R&D expenses over the last five years, assuming an annual depreciation rate of 20%, ending in year $t - 2$: $Innovation_Efficiency_{i,t} = Patents_{i,t} / (R\&D_{i,t-2} + 0.8 \times R\&D_{i,t-3} + 0.6 \times R\&D_{i,t-4} + 0.4 \times R\&D_{i,t-5} + 0.2 \times R\&D_{i,t-6})$, where $R\&D_{i,t-2}$ denotes firm *i*'s R&D expenses in the fiscal year ending in year $t-2$, and so on. We set missing R&D to zero when computing the denominator.

We find that the coefficient of the *Licensee* dummy is positive and statistically significant at the 1% level. This indicates that, compared to the matched non-licensee firms, licensees introduce more new products (as proxied by the number of new trademarks filed by them) over the three years following patent licensing transactions. We control for industry-by-year fixed effects in Column (2) and firm-level characteristics in Column (3), and the empirical pattern remains consistent. Overall, the results in Tables 13 and 14 collectively support the logic chain outlined above and the prediction of our hypothesis H11. These results indicate the “learning-by-doing” process of licensees, whereby they efficiently leverage licensors’ technologies and incorporate them into their future innovation and product development.

Third, we test the final part of our logic chain above: if licensees indeed learn from using the patents they have licenses from licensor firms, then we would expect future patents by licensee firms to cite the corresponding licensor’s patents (i.e., incorporating technologies into their subsequent innovation).

Table D.3 reports the results associated with licensees’ citation patterns following patent licensing transactions. Here, the dependent variable is a dummy that equals one if an actual (matched) licensee (non-licensee) cites the patents of the corresponding (matched) licensor (non-licensor) over the three years following a licensing transaction. This dummy variable is equal to zero otherwise. The main independent variable of interest is *Actual_Pair*, which is an indicator equal to one if a licensor-licensee pair is an actual transaction pair. It is equal to zero if a firm pair is a pseudo/matched pair. Columns (1) and (2) of Table D.3 test the first part of the above conjecture in a univariate regression framework, where the only difference between these two columns is the inclusion of transaction fixed effects in Column (2). In Columns (3) to (5), we include the full set of firm-level controls (i.e., the same as in Tables 3) for both licensors and licensees. We also include some important innovation characteristics of licensors and licensees. The positive and statistically significant coefficients of *Actual_Pair* across all columns suggest that licensees are

more likely to cite licensors' patents over the three years following patent licensing transactions, compared to their matched counterparts. Thus, the results in Table D.3 support the prediction of our testable hypothesis H12.

Together, the results in Tables 13, 14, and D.3 provide further evidence that licensee firms benefit from licensing transactions through their exposure to new technologies brought by licensor firms. By gaining access to new technologies and “learning by doing”, licensees significantly increase their innovation efficiency and introduce more new products. Furthermore, licensees actively “absorb” technologies of licensors and incorporate them into their future innovation (in the form of citing licensors' patents). Overall, the increase in the equity market value of licensee firms following patent licensing transactions that we documented earlier (as measured by Tobin's Q) may be potentially attributable to the channel that we showed in this section.

8 Conclusion

In this paper, we investigated the economics of patent licensing theoretically and empirically. We first developed a dynamic search model in which an innovating firm chooses among three possibilities: retaining patents in-house; or monetizing them by licensing or selling to other firms. Our theoretical model allowed us to develop several insights into the economics of patent licensing and to use its predictions to develop testable hypotheses.

We addressed three research questions empirically using a large and unique sample of patent licensing transactions from the ktMINE Patent License Agreement database: the characteristics of licensors and licensees and the determinants of the matching between the two; the patent characteristics driving a licensor's decision to retain, license, or sell certain patents; and the consequences of licensing transactions for licensors and licensees. Our findings can be summarized as follows. Licensors prefer to license patents to downstream firms and to firms with less similar technology. Licensors retain patents closer in technology

distance to their core operations in house; they monetize those patents that are farther away from their core operations, choosing to sell those patents that are farthest away from their core operations, while licensing out patents that are in-between in terms of technological distance from core operations. Licensees, on the other hand, license in only patents that are closer to their core operations. Both our baseline analysis and a difference-in-differences analysis around the National Technology Transfer and Advancement Act of 1995 show that licensing transactions are efficient, increasing the Tobin's Q of both licensors and licensees.

The channels of equity market value creation are, however, different for licensors and licensees. Licensors benefit from the licensing fees they receive from licensees (with Tobin's Q greater for licensors that obtain higher royalties from licensees); licensors also devote greater resources to innovation inputs (R&D expenditures) after licensing transactions, with a resulting increase in innovation productivity. Licensees, on the other hand, benefit from exposure to new technologies, leading to an increase in their innovation efficiency and introducing more new products after licensing transactions. We also provided additional evidence in support of licensees learning from their exposure to new technologies by licensing patents by documenting that, after licensing transactions, licensee patents are more likely to cite the patents of the licensor firm.

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Table 1: Summary Statistics

This table reports the summary statistics of variables used in this paper. Panel A (Panel B) reports the summary statistics for the sample of licensors (licensees) and their corresponding industry-size matched firms. *Licensor* is a dummy variable equal to one if a firm is a licensor in a patent licensing transaction, and it is equal to zero for the industry-size matched non-licensor firms. *Licensee* is a dummy variable equal to one if a firm is a licensee in a patent licensing transaction, and it is equal to zero for the industry-size matched non-licensee firms. *Num_Pat_3* is the truncation-adjusted number of patents filed by a firm (that are eventually granted) in the last three years up to a given year. *CPP_3* is the number of truncation-adjusted lifetime citations per patent for patents filed by a firm (that are eventually granted) in the last three years up to a given year. ΔNum_Pat_3 is the growth rate of a firm's truncation-adjusted number of patents over the last three years. ΔCPP_3 is the growth rate of a firm's truncation-adjusted number of citations per patent over the last three years. Panel C reports the summary statistics for the sample of licensor-licensee pairs and their corresponding industry-size matched pairs. *Actual_Pair* is a dummy variable equal to one if a firm pair is the actual licensor-licensee pair in a patent licensing transaction. It is equal to zero if a firm pair is a pseudo licensor-licensee pair formed by the industry-size matched firms of licensors and licensees. *Vertical_Integrate* is a dummy equal to one if a firm pair is vertically integrated and equal to zero otherwise. The data on firm pairs' vertical integration relationship is obtained from [Frésard, Hoberg, and Phillips \(2020\)](#). *Tech_Similarity* is the cosine similarity between the patent portfolios (as of a licensing transaction year) of two firms forming a pair. Panel D reports the summary statistics of licensing fees at the licensor firm-level and transaction level. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *B/M*, and *CAPEX*, all of which are defined the same as in Appendix A. All continuous variables are trimmed at 1% and 99% percentile to minimize the impact of outliers.

| Variables | Mean | Median | Std. Dev. | Num. of Obs. |
|--|--------|--------|-----------|--------------|
| | (1) | (2) | (3) | (4) |
| Panel A: Licensors and Industry-Size Matched Firms | | | | |
| Licensor | 0.184 | 0 | 0.387 | 8,872 |
| Num_Pat_3 | 0.087 | 0.003 | 0.305 | 8,784 |
| CPP_3 | 0.665 | 0.465 | 0.681 | 7,023 |
| ΔNum_Pat_3 | 0.720 | -0.133 | 3.270 | 5,534 |
| ΔCPP_3 | 0.735 | -0.075 | 2.995 | 4,753 |
| Size | 5.338 | 4.900 | 2.948 | 8,583 |
| R&D | 0.220 | 0.115 | 0.298 | 8,533 |
| ROA | -0.244 | 0.011 | 0.647 | 8,574 |
| Leverage | 0.220 | 0.124 | 0.334 | 8,647 |
| Cash | 0.222 | 0.132 | 0.230 | 8,501 |
| B/M | 0.315 | 0.245 | 0.375 | 7,495 |

| | | | | |
|--|--------|--------|--------|--------|
| CAPEX | 0.045 | 0.033 | 0.044 | 8,543 |
| <hr/> | | | | |
| Panel B: Licensees and Industry-Size Matched Firms | | | | |
| Licensee | 0.170 | 0 | 0.376 | 10,088 |
| Num_Pat_3 | 0.050 | 0.001 | 0.171 | 9,988 |
| CPP_3 | 0.694 | 0.455 | 0.772 | 7,660 |
| ΔNum_Pat_3 | 0.704 | -0.170 | 3.033 | 5,779 |
| ΔCPP_3 | 0.900 | -0.065 | 3.647 | 4,836 |
| Size | 4.917 | 4.454 | 2.817 | 9,713 |
| R&D | 0.233 | 0.116 | 0.317 | 9,660 |
| ROA | -0.286 | -0.032 | 0.728 | 9,684 |
| Leverage | 0.234 | 0.111 | 0.456 | 9,772 |
| Cash | 0.236 | 0.143 | 0.242 | 9,670 |
| B/M | 0.312 | 0.253 | 0.451 | 8,445 |
| CAPEX | 0.043 | 0.031 | 0.044 | 9,661 |
| <hr/> | | | | |
| Panel C: Licensor-Licensee Pairs and Industry-Size Matched Pairs | | | | |
| Actual_Pair | 0.023 | 0 | 0.148 | 28,374 |
| Vertical_Integrate | 0.044 | 0 | 0.206 | 28,294 |
| Tech_Similarity | 0.443 | 0.084 | 0.474 | 28,374 |
| <hr/> | | | | |
| Panel D: Licensing Fees | | | | |
| <hr/> | | | | |
| <i>Transaction Level:</i> | | | | |
| Fixed Payment (million \$) | 0.723 | 0 | 16.275 | 7,124 |
| Variable Payment Based on Unit (million \$) | 0.025 | 0 | 1.027 | 7,124 |
| Variable Payment Based on Sales (%) | 14.548 | 6.667 | 30.421 | 7,124 |
| <i>Licensor Firm Level:</i> | | | | |
| Fixed Payment (million \$) | 1.787 | 0 | 27.286 | 1,328 |
| Variable Payment Based on Unit (million \$) | 0.100 | 0 | 2.448 | 1,328 |
| Variable Payment Based on Sales (%) | 15.324 | 7.500 | 21.564 | 1,328 |
| <hr/> | | | | |

Table 2: Which Firms Are More Likely to Be Licensors or Licensees?

This table reports the results on the relationship between a firm's innovation characteristics and the probability of the firm being a licensor in a patent licensing transaction. *Licensor* is a dummy variable equal to one if firm i is an actual licensor firm who licenses out some of its patents in year t . This variable is equal to zero for the corresponding industry-size matched non-licensor firms. *Num_Pat_3* is the truncation-adjusted number of patents filed by firm i (that are eventually granted) in the last three years prior to the transaction year t . *CPP_3* is the number of truncation-adjusted lifetime citations per patent for patents filed by firm i (that are eventually granted) in the last three years prior to the transaction year t . ΔNum_Pat_3 is the growth rate of firm i 's truncation-adjusted number of patents over the last three years prior to the transaction year t . ΔCPP_3 is the growth rate of firm i 's truncation-adjusted number of citations per patent over the last three years prior to the transaction year t . Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *B/M*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year prior to a licensing transaction. Transaction fixed effects are included. Robust standard errors are clustered at the transaction level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Licensor | | | | Licensee | | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Num_Pat_3 | 0.975*** (0.175) | | | | 1.786*** (0.297) | | | |
| CPP_3 | | 0.117* (0.062) | | | | 0.132** (0.054) | | |
| ΔNum_Pat_3 | | | -0.011 (0.015) | | | | -0.042* (0.024) | |
| ΔCPP_3 | | | | 0.013 (0.017) | | | | -0.044** (0.021) |
| R&D | 0.556** (0.220) | 0.772** (0.318) | 0.907** (0.447) | 1.326** (0.565) | -0.133 (0.188) | -0.133 (0.335) | 0.049 (0.493) | 0.274 (0.545) |
| Size | 0.351*** (0.070) | 0.501*** (0.077) | 0.701*** (0.099) | 0.856*** (0.128) | 0.297*** (0.061) | 0.620*** (0.090) | 0.989*** (0.104) | 1.230*** (0.125) |
| ROA | -0.389*** (0.138) | 0.130 (0.179) | -0.626** (0.258) | 0.061 (0.347) | -0.860*** (0.145) | -1.020*** (0.276) | -1.367*** (0.387) | -1.330*** (0.502) |
| Leverage | -0.398*** (0.147) | 0.034 (0.202) | 0.472* (0.242) | 0.585** (0.290) | -0.122 (0.134) | -0.268 (0.196) | 0.514* (0.277) | 0.927*** (0.320) |
| Cash | 0.309 (0.197) | 0.551** (0.226) | 0.467 (0.312) | 0.618 (0.385) | 0.532*** (0.180) | 0.289 (0.220) | 0.048 (0.301) | 0.521 (0.376) |
| B/M | -0.502*** (0.139) | -0.578*** (0.152) | -0.667*** (0.191) | -0.722*** (0.212) | -0.585*** (0.106) | -0.541*** (0.126) | -0.369*** (0.142) | -0.478*** (0.152) |
| CAPEX | -4.451*** (1.161) | -3.127*** (1.215) | -2.110** (1.404) | -1.533 (1.449) | 0.907 (1.070) | 0.686 (1.156) | 2.915** (1.363) | 3.050** (1.527) |
| Transaction FE | Yes |
| Number of Obs. | 4,727 | 3,759 | 2,858 | 2,341 | 4,828 | 3,526 | 2,424 | 2,022 |
| Pseudo R^2 | 0.0718 | 0.0624 | 0.0955 | 0.1126 | 0.0709 | 0.0669 | 0.1105 | 0.1434 |

Table 3: Matching Between Potential Licensors and Licensees and Licensing Transaction Incidence

This table reports the results on the determinants of the pairing between licensor and licensee firms. *Actual_Pair* is a dummy variable equal to one if a firm pair is an actual licensor-licensee pair in a patent licensing transaction, and it is equal to zero if the firm pair is a pseudo licensor-licensee pair formed by the corresponding industry-size matched firms of licensors and licensees. *Vertical_Integrate* is a dummy variable equal to one if a firm pair is vertically integrated: this variable is equal to one if licensees (matched pseudo licensees) have a downstream relationship with licensors (matched pseudo licensors). It is equal to zero otherwise. The data on firm pairs' vertical integration relationship is obtained from [Frésard, Hoberg, and Phillips \(2020\)](#). *Tech_Similarity* is the cosine similarity between the patent portfolios (as of the licensing transaction year) of the two firms forming a pair. *Licensor_Num_Pat_3* (*Licensee_Num_Pat_3*) is the truncation-adjusted number of patents filed by a licensor (licensee) firm or its corresponding industry-size matched non-licensor (non-licensee) firms in the last three years up to a transaction year that are eventually granted. *Licensor_CPP_3* (*Licensee_CPP_3*) is the number of truncation-adjusted lifetime citations per patent for patents filed by a licensor (licensee) firm or its corresponding industry-size matched non-licensor (non-licensee) firms in the last three years up to a transaction year that are eventually granted. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *B/M*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year prior to a licensing transaction. Transaction fixed effects are included. Robust standard errors are clustered at the transaction level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Actual_Pair | | | |
|------------------------|-------------|----------|-----------|----------|
| | (1) | (2) | (3) | (4) |
| Vertical_Integrate | 0.328* | 0.692* | | |
| | (0.168) | (0.391) | | |
| Tech_Similarity | | | -0.354*** | -0.491** |
| | | | (0.100) | (0.219) |
| Licensor_Num_Pat_3 | | 2.129*** | | 2.076*** |
| | | (0.512) | | (0.499) |
| Licensee_Num_Pat_3 | | 2.144*** | | 2.064*** |
| | | (0.506) | | (0.488) |
| Licensor_CPP_3 | | 0.478*** | | 0.488*** |
| | | (0.112) | | (0.113) |
| Licensee_CPP_3 | | 0.262** | | 0.257** |
| | | (0.126) | | (0.126) |
| Licensor Firm Controls | No | Yes | No | Yes |
| Licensee Firm Controls | No | Yes | No | Yes |
| Transaction FE | No | Yes | No | Yes |
| Number of Obs. | 28,294 | 5,225 | 28,374 | 5,229 |
| Pseudo R^2 | 0.0006 | 0.0914 | 0.0028 | 0.0951 |

Table 4: Retaining versus Monetizing Patents by Firms

This table reports the results on the relationship between a patent’s technological distance from a firm’s patent portfolio and the probability of the patent being retained versus monetized (either by licensing or by selling) by the firm. The dependent variable, *Monetized_Pat*, is an indicator variable equal to one if patent *i* filed in the year *t* is monetized by owning firm *j* and equal to zero otherwise. We define the monetization of a patent as the focal patent being licensed out or sold by owning firm *j*. *Dist_to_Owner* is the technological distance of patent *i* filed in year *t* to the patent portfolio of owning firm *j*. This variable is constructed based on the methodology in [Akcigit et al. \(2016\)](#) and is detailed in Section 6. Patent-level control variables include *Backward_Cite*, *Forward_Cite*, *Num_Claim*, and *Litigate*, all of which are defined the same as in Appendix A. Owning firm and filing year (or tech class-by-filing year) fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Monetized_Pat | | | |
|-----------------------------|---------------|-----------|-----------|-----------|
| | (1) | (2) | (3) | (4) |
| Dist_to_Owner | 0.189* | 0.197** | 0.167* | 0.184* |
| | (0.098) | (0.100) | (0.099) | (0.101) |
| Backward_Cite | | -0.015 | | 0.002 |
| | | (0.019) | | (0.015) |
| Forward_Cite | | 0.118*** | | 0.124*** |
| | | (0.017) | | (0.013) |
| Num_Claim | | -0.005 | | 0.014 |
| | | (0.044) | | (0.026) |
| Litigate | | 0.948** | | 0.988*** |
| | | (0.092) | | (0.092) |
| Firm FE | Yes | Yes | Yes | Yes |
| Filing Year FE | Yes | Yes | No | No |
| Tech Class × Filing Year FE | No | No | Yes | Yes |
| Number of Obs. | 2,307,100 | 2,138,703 | 2,276,373 | 2,109,463 |
| Pseudo R^2 | 0.3524 | 0.3591 | 0.3688 | 0.3749 |

Table 5: Licensing versus Selling Patents by Licensors

This table reports the results on the relationship between a patent’s technological distance from a licensor firm’s patent portfolio and the probability of the patent being licensed out versus sold by the licensor firm. The dependent variable, *Licensed_Pat*, is an indicator variable equal to one if patent *i* filed in the year *t* is licensed out by firm *j*, and zero if patent *i* filed in year *t* is sold by firm *j*. *Dist_to_Licensor* is the technological distance of patent *i* filed in year *t* to the patent portfolio of licensor firm *j*. This variable is constructed based on the methodology in [Akcigit et al. \(2016\)](#) and is detailed in Section 6. Patent-level control variables include *Backward_Cite*, *Forward_Cite*, *Num_Claim*, and *Litigate*, all of which are defined the same as in Appendix A. Licensor firm and filing year (or tech class-by-filing year) fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Licensed_Pat (Licensed Patent = 1, Sold Patent = 0) | | | |
|-----------------------------|--|----------|----------|----------|
| | (1) | (2) | (3) | (4) |
| Dist_to_Licensor | -1.050* | -1.313** | -1.311** | -1.413** |
| | (0.605) | (0.627) | (0.670) | (0.689) |
| Backward_Cite | | 0.364*** | | 0.372*** |
| | | (0.126) | | (0.125) |
| Forward_Cite | | 0.135 | | 0.163** |
| | | (0.089) | | (0.075) |
| Num_Claim | | 0.082 | | 0.053 |
| | | (0.126) | | (0.138) |
| Litigate | | 0.956** | | 0.838** |
| | | (0.442) | | (0.421) |
| Firm FE | Yes | Yes | Yes | Yes |
| Filing Year FE | Yes | Yes | No | No |
| Tech Class × Filing Year FE | No | No | Yes | Yes |
| Number of Obs. | 72,046 | 71,031 | 33,025 | 32,400 |
| Pseudo R^2 | 0.5629 | 0.6384 | 0.6714 | 0.6897 |

Table 6: Which Patents Are More Likely to be Licensed in by Licensees?

This table reports the results on the relationship between a patent’s technological distance from a licensee firm’s patent portfolio and the probability of the patent being licensed in by the licensee firm in a patent transaction. The dependent variable, *Licensed_Pat*, is an indicator variable equal to one if patent *i* filed in the year *t* is licensed in by firm *j* and equal to zero otherwise. *Dist_to_Licensee* is the technological distance of patent *i* filed in year *t* to the patent portfolio of licensee firm *j*. This variable is constructed based on the methodology in Akcigit et al. (2016) and is detailed in section 6. Patent-level control variables include *Backward_Cite*, *Forward_Cite*, *Num_Claim*, and *Litigate*, all of which are defined the same as in Appendix A. Licensee firm and tech class-by-filing year fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Licensed_Pat | | | |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) |
| Dist_to_Licensee | -1.381*** (0.378) | -1.385*** (0.410) | -2.255*** (0.345) | -1.980*** (0.347) |
| Backward_Cite | | 0.217** (0.087) | | 0.291*** (0.090) |
| Forward_Cite | | 0.414*** (0.069) | | 0.449*** (0.075) |
| Num_Claim | | -0.182* (0.105) | | -0.156 (0.114) |
| Litigate | | 1.728*** (0.273) | | 1.648*** (0.320) |
| Firm FE | Yes | Yes | Yes | Yes |
| Filing Year FE | Yes | Yes | No | No |
| Tech Class × Filing Year FE | No | No | Yes | Yes |
| Number of Obs. | 159,166 | 144,553 | 106,085 | 93,303 |
| Pseudo R^2 | 0.4728 | 0.5185 | 0.5363 | 0.5504 |

Table 7: The Effect of Patent Licensing Transactions on Firm Valuation: Baseline Analysis

This table reports the results on the baseline effect of patent licensing transactions on the subsequent performance of both licensor and licensee firms, where we measure firms' performance using their Tobin's Q. Panel A reports the results on the effect of licensing transactions on licensors' Tobin's Q, and Panel B reports the results on the effect of licensing transactions on licensees' Tobin's Q. The dependent variable in both panels, *TobinQ_1_3*, is firm *i*'s average Tobin's Q over the three years following the transaction year *t*. Firm *i*'s Tobin's Q in an individual year is calculated as the sum of its book value of debt and market value of equity and then divided by the sum of its book value of debt and book value of equity (Compustat item: $(dlc+dltt+csho \times prcc.f)/(dlc+dltt+ceq)$). The independent variable of interest, *Licensor (Licensee)*, is an indicator variable equal to one if the firm *i* is an actual licensor (licensee). It is equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in the transaction year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are excluded in the specification (1) for both panels and included in other specifications. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| Panel A: Licensors | | | | |
|--------------------|---------------------|---------------------|---------------------|---------------------|
| | TobinQ_1_3 | | | |
| | (1) | (2) | (3) | (4) |
| Licensor | 1.231*** (0.225) | 1.093*** (0.253) | 0.993*** (0.235) | 0.865*** (0.217) |
| Num_Pat | | | 1.855 (4.210) | 0.463 (4.229) |
| Size | | | -0.110 (0.083) | -0.079 (0.085) |
| R&D | | | 0.869 (0.608) | 0.007 (0.656) |
| ROA | | | 0.387 (0.377) | -0.020 (0.427) |
| Leverage | | | 0.186 (0.883) | 0.272 (0.853) |
| Cash | | | 2.987*** (0.294) | 2.018*** (0.316) |
| CAPEX | | | 5.414** (1.604) | 5.682*** (1.396) |

TobinQ 0.185***
(0.033)

| Industry \times Year FE | No | Yes | Yes | Yes |
|---------------------------|--------|--------|--------|--------|
| Number of Obs. | 2,329 | 2,329 | 2,184 | 2,071 |
| Adj. R^2 | 0.0066 | 0.0233 | 0.0258 | 0.0827 |

Panel B: Licensees

| | TobinQ_1_3 | | | |
|----------|---------------------|---------------------|----------------------|---------------------|
| | (1) | (2) | (3) | (4) |
| Licensee | 0.654*** (0.106) | 0.598*** (0.092) | 0.801*** (0.123) | 0.655*** (0.119) |
| Num_Pat | | | 4.477 (3.462) | 3.631 (2.488) |
| Size | | | -0.066 (0.045) | -0.052 (0.031) |
| R&D | | | 1.623*** (0.304) | -0.106 (0.403) |
| ROA | | | 0.852*** (0.187) | 0.156 (0.276) |
| Leverage | | | -0.363* (0.176) | 0.411 (0.270) |
| Cash | | | 2.695*** (0.356) | 1.922*** (0.208) |
| CAPEX | | | -4.523*** (0.924) | -2.105* (1.069) |
| TobinQ | | | | 0.233*** (0.029) |

| Industry \times Year FE | No | Yes | Yes | Yes |
|---------------------------|--------|--------|--------|--------|
| Number of Obs. | 2,741 | 2,740 | 2,576 | 2,403 |
| Adj. R^2 | 0.0019 | 0.0127 | 0.0408 | 0.1046 |

Table 8: The Effect of Patent Licensing Transactions on Firm Valuation:
Difference-in-Differences (DiD) Analysis

This table reports the difference-in-differences (DiD) results on the effect of a positive shock to patent licensing transaction incidence, based on the National Technology Transfer and Advancement Act of 1995, on firms' performance. The dependent variable, *TobinQ*, is firm *i*'s Tobin's Q in year *t*. It is calculated as the sum of its book value of debt and market value of equity and then divided by the sum of its book value of debt and book value of equity (Compustat item: $(dlc+dltt+csho \times prcc.f)/(dlc+dltt+ceq)$). *Licensor* and *Licensee* are dummy variables equal to one if firm *i* is an actual licensor firm or licensee firm in a patent transaction, respectively, during the five-year window around 1996. They are equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Post* is a dummy variable equal to one if the observation is within a five-year period after the year 1996 (when the Act was enacted). It is equal to zero if the observation is within a five-year period before 1996. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in year *t*. Firm and year fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | TobinQ | | | |
|----------------------------|---------------------|----------------------|--------------------|----------------------|
| | Licensor | | Licensee | |
| | (1) | (2) | (3) | (4) |
| Licensor × Post | 1.218*** (0.463) | 1.123** (0.478) | | |
| Licensee × Post | | | 0.814** (0.397) | 0.943** (0.392) |
| Num_Pat | | 2.237 (2.283) | | 2.513 (2.889) |
| Size | | -0.843*** (0.212) | | -0.628*** (0.170) |
| R&D | | 3.183*** (1.217) | | 3.146*** (0.967) |
| ROA | | -0.343 (0.769) | | -0.438 (0.628) |
| Leverage | | 0.198 (0.782) | | -0.670 (0.737) |
| Cash | | 3.906*** (0.747) | | 2.876*** (0.618) |
| CAPEX | | 5.229** (2.290) | | 3.979* (2.090) |
| Firm FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Number of Obs. | 5,746 | 5,268 | 6,750 | 6,188 |
| Adj. <i>R</i> ² | 0.2903 | 0.3418 | 0.3237 | 0.3613 |

Table 9: Channel of Licensors' Valuation Improvement: Licensing Fees

This table reports the results on the heterogeneous effects of licensing transactions on licensors' subsequent Tobin's Q based on their ability to extract rents from patent licensing transactions. The "High Royalty" denotes the sub-sample of licensor firms that charge above-median royalties for the patents they license out, while the "Low Royalty" denotes the sub-sample of licensor firms that charge below-median royalties. The dependent variable, *TobinQ_1_3*, is firm *i*'s average Tobin's Q over the three years following the licensing transaction year *t*. Firm *i*'s Tobin's Q in an individual year is calculated as the sum of its book value of debt and market value of equity and then divided by the sum of its book value of debt and book value of equity (Compustat item: $(dlc+dltt+csho \times prcc.f)/(dlc+dltt+ceq)$). *Licensor* is an indicator variable equal to one if firm *i* is an actual licensor in a licensing transaction in year *t*. It is equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in the transaction year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of licensing transaction. Industry-by-year fixed effects are included. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | TobinQ_1_3 | | | TobinQ_1_3 | | |
|---------------------------|----------------------|----------------------|---------------------|---------------------|----------------------|--------------------|
| | (1) High Royalty | (2) Low Royalty | (3) Difference | (4) High Royalty | (5) Low Royalty | (6) Difference |
| Licensor | 1.503*** (0.236) | 0.635 (0.352) | 0.868*** (0.229) | 1.136*** (0.241) | 0.614 (0.400) | 0.522** (0.227) |
| Num_Pat | 6.731 (3.784) | 1.464 (3.039) | | 5.964 (4.145) | -0.519 (2.710) | |
| Size | -0.083*** (0.024) | -0.064 (0.036) | | -0.059** (0.023) | -0.038 (0.029) | |
| R&D | 0.136 (0.701) | -0.130 (0.796) | | -0.967 (0.751) | -0.768 (0.801) | |
| ROA | -0.206 (0.284) | -0.151 (0.306) | | -0.651* (0.340) | -0.376 (0.366) | |
| Leverage | -0.529* (0.258) | -0.884*** (0.250) | | -0.745** (0.230) | -1.101*** (0.140) | |
| Cash | 2.698*** (0.720) | 2.274*** (0.552) | | 1.463*** (0.420) | 1.433*** (0.317) | |
| CAPEX | 7.254*** (1.003) | 2.306** (0.693) | | 7.529*** (1.709) | 2.661* (1.193) | |
| TobinQ | | | | 0.186*** (0.051) | 0.164* (0.076) | |
| Industry \times Year FE | Yes | Yes | | Yes | Yes | |
| Number of Obs. | 1,879 | 1,848 | | 1,780 | 1,751 | |
| Adj. R^2 | 0.0430 | 0.0340 | | 0.0833 | 0.0689 | |

Table 10: Licensors' R&D Expenditures Following Patent Licensing Transactions

This table reports the results on the effect of patent licensing transactions on licensor firms' subsequent R&D expenditures. The dependent variable, $R\&D_{1-3}$, is firm i 's average R&D ratio over the three years following the licensing transaction year t . Firm i 's R&D ratio in an individual year is constructed as its R&D expense in that year scaled by its total assets (i.e., the same as the construction in Appendix A). $Licensor$ is an indicator variable equal to one if firm i is an actual licensor in a licensing transaction in year t . It is equal to zero for firm i 's corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on $Size$, $R\&D$, ROA , $Leverage$, $Cash$, $CAPEX$, Num_Pat_3 , and CPP_3 , all of which are measured in the year prior to a licensing transaction. Num_Pat is the number of patents filed by firm i (that are eventually granted) in the transaction year t . Firm-level control variables include $Size$, $R\&D$, ROA , $Leverage$, $Cash$, and $CAPEX$, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are excluded in the specification (1) and included in other specifications. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | R&D_1_3 | | |
|---------------------------|---------------------|---------------------|----------------------|
| | (1) | (2) | (3) |
| Licensor | 0.047*** (0.011) | 0.040*** (0.011) | 0.033** (0.010) |
| Num_Pat | | | 0.306** (0.126) |
| Size | | | -0.021*** (0.004) |
| R&D | | | 0.468*** (0.031) |
| ROA | | | -0.030** (0.011) |
| Leverage | | | -0.012 (0.007) |
| Cash | | | 0.160*** (0.002) |
| CAPEX | | | -0.313*** (0.075) |
| Industry \times Year FE | No | Yes | Yes |
| Number of Obs. | 2,324 | 2,324 | 2,203 |
| Adj. R^2 | 0.0032 | 0.0511 | 0.4475 |

Table 11: Licensors' Innovation Output Following Patent Licensing Transactions

This table reports the results on the effect of patent licensing transactions on licensor firms' subsequent innovation output. The dependent variable, *Num_Pat_1_3*, is the average (truncation-adjusted) number of patents filed by firm *i* (that are eventually granted) over the three years subsequent to the licensing transaction in year *t*. *Licensor* is an indicator variable equal to one if firm *i* is an actual licensor in a licensing transaction in year *t*. It is equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in the transaction year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are excluded in the specification (1) and included in other specifications. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Num_Pat_1_3 | | |
|--------------------|---------------------|---------------------|---------------------|
| | (1) | (2) | (3) |
| Licensor | 0.019*** (0.005) | 0.019*** (0.005) | 0.004*** (0.001) |
| Num_Pat | | | 2.123*** (0.258) |
| Size | | | 0.002*** (0.001) |
| R&D | | | 0.002*** (0.000) |
| ROA | | | -0.001 (0.001) |
| Leverage | | | 0.001** (0.000) |
| Cash | | | 0.000 (0.001) |
| CAPEX | | | 0.013 (0.021) |
| Industry × Year FE | No | Yes | Yes |
| Number of Obs. | 2,920 | 2,920 | 2,751 |
| Adj. R^2 | 0.0206 | 0.1360 | 0.6808 |

Table 12: Channel of Licensees’ Valuation Improvement: Exposure to New Technologies

This table reports the results on the heterogeneous effects of licensing transactions on licensees’ subsequent Tobin’s Q based on their exposure to licensors’ new technologies. The “More Exposure” denotes the sub-sample of licensee firms that have below-median cosine similarity scores between their patent portfolio and the corresponding licensor firms’ patent portfolios (i.e., thus greater exposure to new technologies). The “Less Exposure” denotes the sub-sample of licensee firms that have above-median cosine similarity scores discussed above (i.e., thus less exposure to new technologies). The dependent variable, *TobinQ_1_3*, is firm *i*’s average Tobin’s Q over the three years following the transaction year *t*. Firm *i*’s Tobin’s Q in an individual year is calculated as the sum of its book value of debt and market value of equity and then divided by the sum of its book value of debt and book value of equity (Compustat item: $(dlc+dltt+csho \times prcc.f)/(dlc+dltt+ceq)$). *Licensee* is an indicator variable equal to one if firm *i* is an actual licensee in a licensing transaction in year *t*. It is equal to zero for firm *i*’s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm *i*’s (that are eventually granted) in the transaction year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are included. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | TobinQ_1.3 | | | TobinQ_1.3 | | |
|---------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|
| | (1) More Exposure | (2) Less Exposure | (3) Difference | (4) More Exposure | (5) Less Exposure | (6) Difference |
| Licensee | 1.403*** (0.230) | 0.197 (0.213) | 1.206*** (0.348) | 1.139*** (0.270) | 0.072 (0.190) | 1.067*** (0.316) |
| Num_Pat | 4.120 (5.145) | 5.642 (3.593) | | 2.856 (4.141) | 4.541* (2.443) | |
| Size | -0.154** (0.056) | -0.063 (0.052) | | -0.105** (0.039) | -0.052 (0.036) | |
| R&D | 1.489*** (0.282) | 2.154*** (0.428) | | 0.016 (0.636) | 0.373 (0.416) | |
| ROA | 0.882*** (0.183) | 1.273*** (0.246) | | 0.297 (0.397) | 0.599* (0.295) | |
| Leverage | -0.468** (0.205) | -0.647** (0.242) | | 0.534 (0.470) | 0.256 (0.363) | |
| Cash | 2.712*** (0.422) | 2.996*** (0.368) | | 2.121*** (0.219) | 2.262*** (0.184) | |
| CAPEX | -5.424*** (1.558) | -6.403*** (1.167) | | -2.961*** (0.802) | -3.441* (1.650) | |
| TobinQ | | | | 0.260*** (0.023) | 0.248*** (0.033) | |
| Industry × Year FE | Yes | Yes | | Yes | Yes | |
| Number of Obs. | 2,170 | 2,146 | | 2,035 | 2,009 | |
| Adj. R ² | 0.0363 | 0.0414 | | 0.1129 | 0.1128 | |

Table 13: Licensees' Innovation Efficiency Following Licensing Transactions

This table reports the results of the effect of patent licensing transactions on licensee firms' subsequent innovation efficiency. The dependent variable, *Innovation_Efficiency_1_3*, is the average innovation efficiency of firm i over the three years following a patent transaction in year t . A firm's innovation efficiency in an individual year is constructed following the methodology in [Hirshleifer et al. \(2013\)](#). *Licensee* is an indicator variable equal to one if firm i is an actual licensee in a patent licensing transaction in year t . It is equal to zero for firm i 's corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm i (that are eventually granted) in the transaction year t . Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are excluded in the specification (1) and included in other specifications. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Innovation_Efficiency_1_3 | | |
|---------------------------|---------------------------|--------------------|----------------------|
| | (1) | (2) | (3) |
| Licensee | 0.036** (0.013) | 0.037** (0.015) | 0.036** (0.015) |
| Num_Pat | | | 0.826*** (0.091) |
| Size | | | -0.015*** (0.003) |
| R&D | | | -0.037** (0.017) |
| ROA | | | 0.007 (0.006) |
| Leverage | | | -0.005 (0.006) |
| Cash | | | 0.049 (0.030) |
| CAPEX | | | 0.377 (0.246) |
| Industry \times Year FE | No | Yes | Yes |
| Number of Obs. | 2,811 | 2,810 | 2,630 |
| Adj. R^2 | 0.0038 | 0.1105 | 0.1380 |

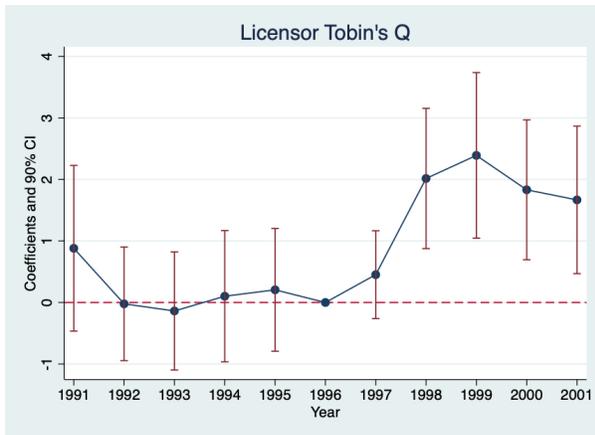
Table 14: Licensees' Trademark Activity Following Licensing Transactions

This table reports the results of the effect of patent licensing transactions on licensee firms' introduction of new products after licensing transactions. The dependent variable, *Num_Trademark_1_3*, is the average number of new trademarks filed by firm *i* over the three years following the licensing transaction in year *t*. *Licensee* is an indicator variable equal to one if firm *i* is an actual licensee in a patent licensing transaction in year *t*. It is equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *CAPEX*, *Num_Pat_3*, and *CPP_3*, all of which are measured in the year prior to a licensing transaction. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in the transaction year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year of a licensing transaction. Industry-by-year fixed effects are excluded in the specification (1) and included in other specifications. Robust standard errors are clustered at the industry level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

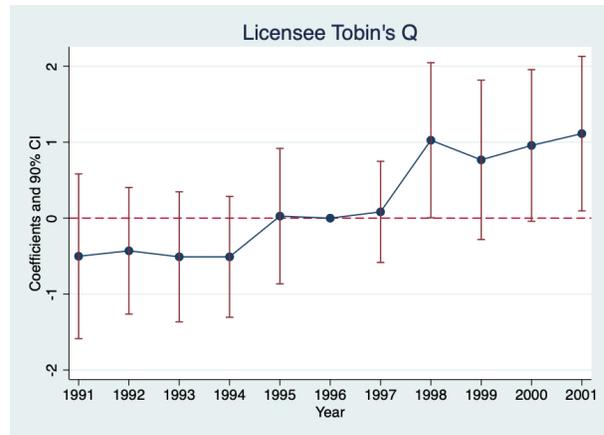
| | Num_Trademark_1_3 | | |
|--------------------|---------------------|---------------------|----------------------|
| | (1) | (2) | (3) |
| Licensee | 0.600*** (0.176) | 0.616*** (0.154) | 0.431** (0.154) |
| Num_Pat | | | 11.762*** (2.100) |
| Size | | | 0.575*** (0.056) |
| R&D | | | -0.099 (0.240) |
| ROA | | | -0.268* (0.130) |
| Leverage | | | 0.078** (0.034) |
| Cash | | | -0.228** (0.998) |
| CAPEX | | | 2.464** (1.086) |
| Industry × Year FE | No | Yes | Yes |
| Number of Obs. | 2,776 | 2,774 | 2,621 |
| Adj. R^2 | 0.0084 | 0.0473 | 0.2165 |

Figure 1: Dynamic Effects of the National Technology Transfer and Advancement Act of 1995 on Firms' Valuation

This figure shows the dynamics of licensors' and licensees' Tobin's Q around the enactment of the National Technology Transfer and Advancement Act of 1995. The center points represent the point estimates of β_t and the vertical lines denote the 90% confidence intervals of β_t estimates in the regression specification (18). Panel A plots the coefficient dynamics for licensor firms, while Panel B plots such dynamics for licensee firms. The dependent variable here is firm i 's Tobin's Q in year t (Compustat item: $(dlc+dltt+csho \times prcc.f)/(dlc+dltt+ceq)$). $Licensor_i$ ($Licensee_i$) is a dummy variable equal to one if firm i is an actual licensor (licensee) firm. It is equal to zero for firm i 's corresponding control firms in the same industry and year. We select the control firms using a propensity-score matching procedure based on $Size$, $R\&D$, ROA , $Leverage$, $Cash$, $CAPEX$, Num_Pat_3 , and CPP_3 , all of which are measured in the year prior to a licensing transaction. $Period_t$ is a set of dummies denoting every year within a five-year period around the year 1996 (when the Act was enacted). The year dummy denoting the year 1996 is dropped to avoid collinearity. Firm-level control variables include $Size$, $R\&D$, ROA , $Leverage$, $Cash$, $CAPEX$, and Num_Pat , all of which are defined the same as in Table 8 and are measured in year t . Firm and year fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.



(a) Panel A: Licensor Tobin's Q



(b) Panel B: Licensee Tobin's Q

Internet Appendix to

**The Economics of Patent Licensing: Theory and Evidence
on the Determinants and Consequences of Patent
Licensing Transactions**

A Variable Definition

This table shows the detailed constructions of all firm-level and patent-level control variables used across different specifications.

| Panel A: Firm-level Control Variables | |
|---------------------------------------|--|
| Size | Natural logarithm of a firm's book assets (Compustat item: at) in a given year |
| R&D | The ratio of a firm's R&D expense (Compustat item: xrd) to its book assets (Compustat item: at) in a given year |
| ROA | The ratio of a firm's EBIT (Earnings Before Interest) (Compustat item: ebit) to its book assets (Compustat item: at) in a given year |
| Leverage | The ratio of a firm's total debt (Compustat item: dlc+dltt) to its book assets (Compustat item: at) in a given year |
| Cash | The ratio of a firm's cash (Compustat item: ch) to its book assets (Compustat item: at) in a given year |
| B/M | The ratio of a firm's book value of common equity (Compustat item: ceq+txdb) to its market value of common equity (Compustat item: prcc.f \times csho) in a given year |
| CAPEX | The ratio of a firm's capital expenditure (Compustat item: capx) to its book assets (Compustat item: at) in a given year |

| Panel B: Patent-level Control Variables | |
|---|---|
| Backward_Cite | The number of backward citations of a patent |
| Forward_Cite | The number of truncation-adjusted lifetime forward citation received by a patent |
| Num.Claim | The number of claims in a patent's application |
| Litigate | A dummy variable equal to one if a patent is ever litigated and equal to zero otherwise |

B Licensor and Licensee Firms' Industry Distribution

This table summarizes the industry composition of firms that appear in our sample of patent-licensing transactions. Panel A (Panel B) reports the distribution for licensor (licensee) firms. Industries are defined by each firm's primary two-digit SIC code. For each industry, we report the number of unique firms and the percentage of the total number of firms on that side of the market. The six most common industries are listed separately, and all remaining two-digit SIC codes are grouped under "Others". For both sides of the market, Chemicals and Allied Products (Two-digit SIC Code: 28) is the most prevalent category (44.8% of licensors; 44.6% of licensees), followed by Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods (Two-digit SIC Code: 38).

Panel A : Licensor Firms' Industry Distribution

| Two-digit SIC Code | Industry | Number of Firms | Percentage on Total Number of Firms |
|--------------------|--|-----------------|-------------------------------------|
| 28 | Chemicals And Allied Products | 366 | 44.80% |
| 38 | Measuring, Analyzing, And Controlling Instruments; Photographic, Medical And Optical Goods; Watches And Clocks | 93 | 11.38% |
| 36 | Electronic And Other Electrical Equipment And Components, Except Computer Equipment | 67 | 8.20% |
| 73 | Business Services | 59 | 7.22% |
| 35 | Industrial And Commercial Machinery And Computer Equipment | 44 | 5.39% |
| 87 | Engineering, Accounting, Research, Management, And Related Services | 24 | 2.94% |
| Others | Others | 164 | 20.07% |

Panel B: Licensee Firms' Industry Distribution

| Two-digit SIC Code | Industry | Number of Firms | Percentage on Total Number of Firms |
|--------------------|--|-----------------|-------------------------------------|
| 28 | Chemicals And Allied Products | 484 | 44.57% |
| 38 | Measuring, Analyzing, And Controlling Instruments; Photographic, Medical And Optical Goods; Watches And Clocks | 140 | 12.89% |
| 36 | Electronic And Other Electrical Equipment And Components, Except Computer Equipment | 94 | 8.66% |
| 73 | Business Services | 75 | 6.91% |
| 35 | Industrial And Commercial Machinery And Computer Equipment | 56 | 5.16% |
| 87 | Engineering, Accounting, Research, Management, And Related Services | 24 | 2.21% |
| Others | Others | 213 | 19.60% |

C Construction of Technological Distance of Patents

In this section, we discuss in detail how we construct the technological distance/proximity of patents to owning firms' patent portfolios. We follow the methodology in [Akcigit et al. \(2016\)](#) to construct this measure.

This measure is constructed in two steps. In the first step, we calculate the technological distance between technology classes X and Y based on the citation pattern of patents:

$$d(X, Y) = 1 - \frac{\#(X \cap Y)}{\#(X \cup Y)} \quad (\text{C.1})$$

In equation (C.1), $d(X, Y)$ denotes the technological distance between technology classes X and Y . The numerator, $\#(X \cap Y)$, denotes the number of patents that cite patents from both technology classes X and Y simultaneously. The denominator, $\#(X \cup Y)$, denotes the number of patents that cite patents in either technology class X or Y . This symmetric measure suggests that, among all the patents that cite patents in either technology class X or Y , if the number of patents that simultaneously cite patents in technology classes X and Y is larger, then it indicates that the technology class X and Y is more proximate to each other in the knowledge space. This will lead to $d(X, Y)$ taking a value closer to zero. In sum, a higher value of $d(X, Y)$ indicates that X and Y are technologically more distant from each other.

After constructing the technological distance between every pair of technology classes X and Y in the first step, we calculate the technological distance between a patent p and the owning firm f 's patent portfolio as follows in the second step:

$$d_i(p, f) = \left(\frac{1}{\|P_f\|} \sum_{p' \in P_f} d(X_p, Y_{p'})^t \right)^{\frac{1}{t}} \quad (\text{C.2})$$

In equation (C.2), $d_i(p, f)$ denotes the technological distance of patent p from the owning firm f 's patent portfolio. P_f denotes the set (i.e., portfolio) of patents of firm f filed prior

to patent p . Thus, $\| P_f \|$ denotes the number of patents in the firm f 's patent portfolio before patent p . $d(X_p, Y_{p'})$ denotes the technological distance between technology class of patent p and that of every other patent p' in the owning firm's patent portfolio. In addition, ι is a weighting parameter, where $0 < \iota \leq 1$. In this paper, we follow the existing literature and set ι equal to $2/3$.³¹ In sum, a higher value of $d_\iota(p, f)$ indicates that the focal patent p is technologically more distant to the patent portfolio of the owning firm f .

³¹See [Akcigit et al. \(2016\)](#), [Brav et al. \(2018\)](#), [Zhang \(2020\)](#), [Han et al. \(2025\)](#), and [Ma et al. \(2022\)](#).

D Additional Empirical Results

In this section, we discuss some additional results. The first set of results is regarding the effect of the National Technology Transfer and Advancement Act of 1995 (NTTAA) on the patent transaction incidence. As we argued in Section 7.2, NTTAA can be viewed as a positive shock to patent licensing transaction incidence, since it spurs the demand for licensing and makes licensing more attractive for both future potential licensors and licensees. For potential licensors, NTTAA allows them to enter into cooperative research and development agreements with the federal government and utilize technology from federal laboratories. This enables potential licensors to develop higher-quality technology and more easily license it to others in exchange for financial rewards, compared to the pre-NTTAA era. For potential licensees, the enactment of the NTTAA facilitates access to technology they previously could not obtain. Before the NTTAA, licensees might not have been able to secure exclusive licenses for federally funded technology. With the NTTAA in place, it is now easier for potential licensees to obtain these exclusive licenses.

We also empirically show that the passage of NTTAA is associated with greater patent licensing transaction incidence in Table D.1. In this table, the dependent variable, *Licensor* (or *Licensee*), is a dummy variable that equals one if firm i becomes a licensor (licensee) in a patent licensing transaction in year t . It is equal to zero otherwise. The main independent variable of interest is $I(\textit{After Act})$, which is a dummy variable equal to one if an observation is after year 1996 (i.e., the year when the NTTAA was enacted). We regress *Licensor* in Panel A (or *Licensee* in Panel B) on the dummy $I(\textit{After Act})$ in Column (1) in a univariate setting. The coefficient of $I(\textit{After Act})$ is positive and statistically significant at 1% level. This result suggests that NTTAA can indeed be viewed as a positive shock to the patent licensing transaction: a firm is more likely to become a licensor or licensee in a licensing transaction after the passage of NTTAA. We subsequently add firm-level controls and industry/firm fixed effects (Columns (2) to (5)), and also detrend the regressions (Columns (6) and (7)) to account for the possibility that there may be a general trend of

licensing transactions over the years. The coefficients of $I(\text{After Act})$ remain positive and significant. Put together, these results lend support to NTTAA serving as a positive shock to the licensing transaction incidence.

The second set of results is with respect to a placebo test for our DiD analysis in Section 7.2. For our DiD estimates to provide a causal interpretation of the value enhancing effect of patent licensing, the exclusion restriction assumption must be satisfied as well. In this context, the exclusion restriction suggests that the NTTAA affects the Tobin's Q of licensors or licensees only through the patent licensing channel.

We empirically examine this assumption by conducting a placebo test. Specifically, we falsely assume that the NTTAA took effect six years earlier than it actually did (i.e., year 1990).³² The rationale behind this placebo test is straightforward: if it was the case that the NTTAA affects Tobin's Q of licensors or licensees through other channels than the patent licensing per se, by falsely assuming a placebo shock, we would still observe an increase in Tobin's Q of licensors or licensees relative to their matched control firms following the onset of this placebo shock.

Table D.2 shows the results of the placebo test. In this table, we are essentially re-running specification (17) except that (i) $Licensor_i$ ($Licensee_i$) now equals one if firm i is a licensor (licensee) firm during the five-year window around 1990, and it is equal to zero for the matched control firms; and (ii) $Post_t$ is a dummy variable that equals one if an observation is within five years after 1990, and it is equal to zero if an observation is within the five-year window prior to 1990. In this table, the independent variable of interest is still the interaction term $Licensor_i$ (or $Licensee_i$) \times $Post_t$: if the exclusion restriction assumption was violated, we would expect to find the coefficient estimates of the interaction terms for both licensors and licensees to be statistically significant. As with Table 8, we report the univariate regression results in Columns (1) and (3) while controlling for the same firm-level characteristics in Columns (2) and (4). The coefficients of the interaction

³²We require this so that the panel dataset used for the placebo test ends before the actual year when NTTAA was enacted.

terms $Licensor_i \times Post_t$ or $Licensee_i \times Post_t$ are all statistically indistinguishable from zero. This indicates that it is likely that the NTTAA affects Tobin's Q of licensors and licensees through the patent licensing per se rather than some other channels.

The third set of results of the effect of patent licensing transactions on the subsequent citing of licensors' patents by licensees, which provides additional evidence that supports the "learning-by-doing" channel of licensees. Here, the dependent variable is a dummy that equals one if an actual (matched) licensee (non-licensee) cites the patents of the corresponding (matched) licensor (non-licensor) over the three years following a licensing transaction. This dummy variable is equal to zero otherwise. The main independent variable of interest is *Actual_Pair*, which is an indicator equal to one if a licensor-licensee pair is an actual transaction pair. It is equal to zero if a firm pair is a pseudo/matched pair. This specification is very similar to the specification (14), except that we are now focusing on the citing of licensors' patents by licensees. Columns (1) and (2) of Table D.3 report the results in a univariate regression framework, where the only difference between these two columns is the inclusion of transaction fixed effects in Column (2). In Columns (3) to (5), we include the full set of firm-level controls (i.e., the same as in Tables 3) for both licensors and licensees. We also include some important innovation characteristics of licensors and licensees. The positive and statistically significant coefficients of *Actual_Pair* across all columns suggest that licensees are more likely to cite licensors' patents over the three years following patent licensing transactions, compared to their matched counterparts. Overall, these results indicate that licensees are more likely to cite licensors' patents (compared to their matched control firms) over the three years following licensing transactions, which lends further support to the "learning-by-doing" channel of licensee firms.

Table D.1: The Passage of the National Technology Transfer and Advancement Act of 1995 and the Propensity of Patent Licensing

This table reports the effect of the passage of the National Technology Transfer and Advancement Act of 1995 on firms' propensity to become licensors or licensees in patent licensing transactions. Panel A (Panel B) reports the results on firms' propensity to become licensors (licensees) following the Act. The dependent variable in Panel A (Panel B) is *Licensor* (*Licensee*), which is a dummy variable equal to one if firm i becomes a licensor (licensee) in year t . It is equal to zero otherwise. The main independent variable of interest is $I(\textit{After Act})$, which is a dummy variable equal to one if an observation is after the year 1996 (when the Act was enacted). It is equal to zero if the observation is before 1996. In some of the regressions, we control for firm-level variables, which include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*. All of these variables are defined the same as in Appendix A and are measured for firm i in year t . Further, we add *Num.Pat* as an additional control for firm i 's innovation productivity, which is the number of patents filed by firm i (that are eventually granted) in year t . In different regressions, we separately add industry or firm fixed effects to absorb any industry- or firm-specific unobservables that may affect a firm's propensity to become a licensor or licensee. We also detrend the last two regressions in each panel to remove the trend of patent licensing transactions over time. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| Panel A: Licensors | | | | | | | |
|-------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | Licensor | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $I(\textit{After Act})$ | 0.005*** (0.000) | 0.004*** (0.000) | 0.005*** (0.000) | 0.008*** (0.001) | 0.013*** (0.001) | 0.021*** (0.001) | 0.019*** (0.001) |
| Firm-level Controls | No | No | No | Yes | Yes | Yes | Yes |
| Industry FE | No | Yes | No | Yes | No | Yes | No |
| Firm FE | No | No | Yes | No | Yes | No | Yes |
| Detrend | No | No | No | No | No | Yes | Yes |
| Number of Obs. | 353,688 | 353,688 | 353,210 | 131,686 | 130,562 | 131,686 | 130,562 |
| Adj. R^2 | 0.0016 | 0.0151 | 0.0644 | 0.0190 | 0.0690 | 0.0231 | 0.0701 |
| Panel B: Licensees | | | | | | | |
| | Licensee | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $I(\textit{After Act})$ | 0.006*** (0.000) | 0.005*** (0.000) | 0.005*** (0.000) | 0.009*** (0.001) | 0.013*** (0.001) | 0.024*** (0.001) | 0.021*** (0.001) |
| Firm-level Controls | No | No | No | Yes | Yes | Yes | Yes |
| Industry FE | No | Yes | No | Yes | No | Yes | No |
| Firm FE | No | No | Yes | No | Yes | No | Yes |
| Detrend | No | No | No | No | No | Yes | Yes |
| Number of Obs. | 353,688 | 353,688 | 353,210 | 131,686 | 130,562 | 131,686 | 130,562 |
| Adj. R^2 | 0.0019 | 0.0191 | 0.0715 | 0.0208 | 0.0758 | 0.0253 | 0.0777 |

Table D.2: Difference-in-Differences (DiD) Analysis with the NTTAA of 1995: Placebo Test

This table reports the results of the placebo test for the difference-in-differences (DiD) analysis using the National Technology Transfer and Advancement Act of 1995 as a positive shock to patent licensing transactions. The dependent variable, *TobinQ*, is firm *i*'s Tobin's Q in year *t*. It is calculated as the sum of its book value of debt and market value of equity and then divided by the sum of its book value of debt and book value of equity (Compustat item: $(dlc+dltt+csho \times prcc_f)/(dlc+dltt+ceq)$). *Licensor* and *Licensee* are dummy variables equal to one if firm *i* is an actual licensor firm or licensee firm in a patent transaction, respectively, during the five-year window around year 1990 (i.e., the year we falsely assume as the onset of the NTTAA). They are equal to zero for firm *i*'s corresponding control firms in the same industry and year. We select the control firms using the same propensity-score matching procedure as in Table 8. *Post* is a dummy variable equal to one if the observation is within a five-year period after the year 1990. It is equal to zero if the observation is within a five-year period before 1990. *Num_Pat* is the number of patents filed by firm *i* (that are eventually granted) in year *t*. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in year *t*. Firm and year fixed effects are included. Robust standard errors are clustered at the firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | TobinQ | | | |
|----------------------------|-------------------|----------------------|------------------|----------------------|
| | Licensor | | Licensee | |
| | (1) | (2) | (3) | (4) |
| Licensor × Post | -0.519 (0.979) | 0.150 (1.015) | | |
| Licensee × Post | | | 0.494 (0.681) | 0.707 (0.713) |
| Num_Pat | | 2.250 (2.452) | | 0.710 (1.182) |
| Size | | -1.415*** (0.345) | | -1.243*** (0.223) |
| R&D | | 2.495 (1.833) | | 3.484** (1.417) |
| ROA | | -1.550 (1.281) | | -0.999 (0.938) |
| Leverage | | 1.219 (1.032) | | 0.601 (0.845) |
| Cash | | 1.376* (0.801) | | 1.424** (0.594) |
| CAPEX | | 4.606** (2.040) | | 6.954*** (1.873) |
| Firm FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Number of Obs. | 4,126 | 3,408 | 4,774 | 3,907 |
| Adj. <i>R</i> ² | 0.4578 | 0.4762 | 0.4857 | 0.5227 |

Table D.3: Licensing Transaction and Subsequent Citing of Licensors' Patents by Licensees

This table reports the results of the effect of patent licensing transactions on the subsequent citing of licensors' patents by licensees. *Cite* is a dummy variable equal to one if the licensee firm *i* (its corresponding matched non-licensee firms) in a patent licensing transaction cites the patents of the licensor firm *j* (its corresponding matched non-licensor firms) over the three years following the licensing transaction in year *t*. This dummy variable is equal to zero otherwise. *Actual_Pair* is a dummy variable equal to one if a firm pair is an actual licensor-licensee pair in a patent licensing transaction, and it is equal to zero if the firm pair is a pseudo licensor-licensee pair formed by the corresponding industry-size matched firms of licensors and licensees. *Licensor_Num_Pat_3* (*Licensee_Num_Pat_3*) is the truncation-adjusted number of patents filed by a licensor (licensee) firm or its corresponding industry-size matched non-licensor (non-licensee) firms in the last three years up to the transaction year *t* that are eventually granted. *Licensor_CPP_3* (*Licensee_CPP_3*) is the number of truncation-adjusted lifetime citations per patent for patents filed by a licensor (licensee) firm or its corresponding industry-size matched non-licensor (non-licensee) firms in the last three years up to the transaction year *t* that are eventually granted. Firm-level control variables include *Size*, *R&D*, *ROA*, *Leverage*, *Cash*, *B/M*, and *CAPEX*, all of which are defined the same as in Appendix A and are measured in the year prior to a licensing transaction. Transaction fixed effects are included. Robust standard errors are clustered at the transaction level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

| | Cite | | | | |
|------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | (1) | (2) | (3) | (4) | (5) |
| <i>Actual_Pair</i> | 1.213*** (0.094) | 1.762*** (0.125) | 1.676*** (0.192) | 1.614*** (0.223) | 1.351*** (0.230) |
| <i>Licensor_Num_Pat_3</i> | | | 2.376*** (0.429) | | 2.504*** (0.396) |
| <i>Licensee_Num_Pat_3</i> | | | 2.125*** (0.285) | | 2.142*** (0.277) |
| <i>Licensor_CPP_3</i> | | | | 0.360*** (0.076) | 0.357*** (0.074) |
| <i>Licensee_CPP_3</i> | | | | 0.355*** (0.057) | 0.365*** (0.057) |
| Licensor Firm Controls | No | No | Yes | Yes | Yes |
| Licensee Firm Controls | No | No | Yes | Yes | Yes |
| Transaction FE | No | Yes | Yes | Yes | Yes |
| Number of Obs. | 28,374 | 22,543 | 12,442 | 10,146 | 9,825 |
| Pseudo <i>R</i> ² | 0.0077 | 0.0170 | 0.1736 | 0.1197 | 0.1796 |

E Supplemental Material for the Theoretical Model and Proofs of Propositions

E.1 Value Function of the Firm

Taking the limit as $\Delta \rightarrow 0$ and rearranging the discrete-time Bellman equation given in (11), we obtain the following Hamilton-Jacobi-Bellman (HJB) equation for the value function of the firm:

$$\begin{aligned}
 rV(z, \bar{z}) &= \pi z + i \int_{x_k}^1 [V(z + (\gamma x - \tau)\bar{z}, \bar{z}) - V(z, \bar{z})] dx \\
 &+ i \int_{x_l}^{x_k} [V(z + \alpha\gamma x\bar{z}, \bar{z}) - V(z, \bar{z}) + q_l] dx + i \cdot x_l \cdot q_s \\
 &+ M^s \int_{x_b}^1 [V(z + (\gamma x' - \tau)\bar{z}, \bar{z}) - V(z, \bar{z}) - P(x')] dx' \\
 &+ M^l \int_{x_a}^1 [V(z + (1 - \alpha)\gamma x'\bar{z}, \bar{z}) - V(z, \bar{z}) - P_l(x')] dx' + \dot{V}(z, \bar{z}),
 \end{aligned} \tag{E.1}$$

where $\dot{V}(z, \bar{z}) \equiv \lim_{\Delta \rightarrow 0} [V(z, \bar{z}_{+\Delta}) - V(z, \bar{z})]/\Delta$. We solve for the value function for a firm as follows.

Proposition 1 (Value Function of a Firm). *Assume that the patent agents' value functions take the linear forms $A_s(\bar{z}) = a_s\bar{z}$ and $A_l(\bar{z}) = a_l\bar{z}$. Then the firm's value function is:*

$$V(z, \bar{z}) = v_1 z + v_2 \bar{z}, \tag{E.2}$$

where

$$v_1 = \frac{\pi}{r}, \tag{E.3}$$

and

$$v_2 = \frac{1}{\rho} \left[i v_1 \left(\gamma \frac{(1 - x_k^2)}{2} - \tau(1 - x_k) \right) + i v_1 \alpha \gamma \frac{(x_k^2 - x_l^2)}{2} + i a_l (x_k - x_l) + i x_l a_s \right], \tag{E.4}$$

with $\rho = r - g$.

Proof of Proposition 1. Substitute the conjecture $V(z, \bar{z}) = v_1 z + v_2 \bar{z}$ into (E.1), using free entry conditions $q_s = a_s \bar{z}$ and $q_l = a_l \bar{z}$, and pricing with $\omega = 1$: $P(x') = v_1 (\gamma x' - \tau) \bar{z}$ and $P_l(x') = v_1 (1 - \alpha) \gamma x' \bar{z}$. Note also that $\dot{V}(z, \bar{z}) = v_2 \dot{\bar{z}} = v_2 g \bar{z}$. With $\omega = 1$, the market terms vanish. Evaluating the integrals:

$$i \int_{x_k}^1 v_1 (\gamma x - \tau) \bar{z} dx = i v_1 \bar{z} \left[\gamma \frac{(1 - x_k^2)}{2} - \tau(1 - x_k) \right] \tag{E.5}$$

$$i \int_{x_l}^{x_k} [v_1 \alpha \gamma x + a_l] \bar{z} dx = i \bar{z} \left[v_1 \alpha \gamma \frac{(x_k^2 - x_l^2)}{2} + a_l (x_k - x_l) \right] \tag{E.6}$$

Equating coefficients of z and \bar{z} yields the result. ■

Note that given the firm's value function, the price of a patent, $P(x')$ in (9), for a buying firm with propinquity x' can be expressed as

$$P(x') = V(z + (\gamma x - \tau)\bar{z}, \bar{z}) - V(z, \bar{z}) = v_1(\gamma x' - \tau)\bar{z}. \quad (\text{E.7})$$

Similarly, the licensing fee, $P_l(x')$, that a firm with propinquity x' will pay for to license it in from the agent can be expressed as

$$P_l(x') = V(z + (1 - \alpha)\gamma x\bar{z}, \bar{z}) - V(z, \bar{z}) = v_1(1 - \alpha)\gamma x'\bar{z}. \quad (\text{E.8})$$

E.2 Patent Agent Value Functions

We denote the value function of a patent agent who is about to sell a patent by $A_s(\bar{z})$. This can be expressed as

$$rA_s(\bar{z}) = \frac{M^s}{n_a^s} \int_{x_b}^1 [P(x' - A_s(\bar{z}))] dx' + \dot{A}_s(\bar{z}). \quad (\text{E.9})$$

Similarly, we denote the value function of a patent agent who is about to license out a patent by $A_l(\bar{z})$, which can be expressed as

$$rA_l(\bar{z}) = \frac{M^l}{n_a^l} \int_{x_a}^1 [P_l(x' - A_l(\bar{z}))] dx' + \dot{A}_l(\bar{z}). \quad (\text{E.10})$$

We conjecture that the patent agents' value functions are linear in aggregate productivity \bar{z} :

$$A_s(\bar{z}) = a_s\bar{z}, \quad A_l(\bar{z}) = a_l\bar{z}. \quad (\text{E.11})$$

Given free entry by agents into the for-sale and for-license markets to trade patents from firms, the selling patent price q_s and the licensing fee q_l that an innovating firm will charge in equilibrium is determined as:

$$q_s = A_s(\bar{z}), \quad q_l = A_l\bar{z}. \quad (\text{E.12})$$

E.3 Steady-State Conditions in Patent Markets

The law of motion for the stock of patents on the for-sale patent market is given by:

$$\dot{n}_a^s = ix_l - M^s(1 - x^b). \quad (\text{E.13})$$

The equilibrium number of matches M^s in the for-sale market can be found by setting $\dot{n}_a^s = 0$, so that

$$M^s = \frac{ix_l}{1 - x^b}. \quad (\text{E.14})$$

Plugging in the equilibrium number of matches M^s from (E.14) into the matching technology given in (6) (with $n_b^s = 1$) yields the equilibrium number of patents on the for-sale market:

$$n_a^s = \left[\frac{ix_l}{\eta^s(1-x_b)} \right]^{1/\mu} \quad (\text{E.15})$$

The matching rate per seller (patent agent) is then given by:

$$m_a^s \equiv \frac{M^s}{n_a^s} = \eta^s \left[\frac{ix_l}{\eta^s(1-x_b)} \right]^{\frac{\mu-1}{\mu}}. \quad (\text{E.16})$$

The law of motion for the stock of patents on the for-license patent market is given by:

$$\dot{n}_a^l = i(x_k - x_l) - M^l(1 - x^a). \quad (\text{E.17})$$

The equilibrium number of matches M^l in the for-license market can be found by setting $\dot{n}_a^l = 0$, so that

$$M^l = \frac{i(x_k - x_l)}{1 - x^a}. \quad (\text{E.18})$$

Plugging in the equilibrium number of matches M^l from (E.18) into the matching technology given in (6) (with $n_b^l = 1$) yields the equilibrium number of patents on the for-license market:

$$n_a^l = \left[\frac{i(x_k - x_l)}{\eta^l(1-x_a)} \right]^{1/\mu} \quad (\text{E.19})$$

The matching rate per for-license patent agent is then given by:

$$m_a^l \equiv \frac{M^l}{n_a^l} = \eta^l \left[\frac{i(x_k - x_l)}{\eta^l(1-x_a)} \right]^{\frac{\mu-1}{\mu}}. \quad (\text{E.20})$$

Given the matching rates m_a^s and m_a^l in equations (E.16) and (E.20), we can solve for the patent agents' value functions.

Proposition 2 (Patent Selling Price and Licensing Fee). *With $P(x') = v_1(\gamma x' - \tau)\bar{z}$, the value function of a for-sale patent agent satisfies $A_s(\bar{z}) = a_s\bar{z}$, where:*

$$a_s = \frac{m_a^s v_1 \left[\gamma \frac{(1-x_b^2)}{2} - \tau(1-x_b) \right]}{\rho + m_a^s(1-x_b)}, \quad (\text{E.21})$$

and x_b is the buying threshold. The patent price received by a firm selling its patent is $q_s = a_s\bar{z}$.

With $P_l(x') = v_1(1-\alpha)\gamma x'\bar{z}$, the value function of a for-license patent agent satisfies $A_l(\bar{z}) = a_l\bar{z}$, where:

$$a_l = \frac{m_a^l v_1(1-\alpha)\gamma \frac{(1-x_a^2)}{2}}{\rho + m_a^l(1-x_a)}, \quad (\text{E.22})$$

and x_a is the licensing-in threshold. The licensing fee received by a firm licensing out its patent is $q_s = a_s \bar{z}$.

Proof of Proposition 2. Substituting the conjecture $A_s(\bar{z}) = a_s \bar{z}$ into (E.9) and using $\dot{A}_s(\bar{z}) = a_s \dot{\bar{z}} = a_s g \bar{z}$, where g is the growth rate of the economy, and $P(x') = v_1(\gamma x' - \tau)\bar{z}$, we obtain:

$$r a_s \bar{z} = m_a^s \int_{x_b}^1 [v_1(\gamma x' - \tau)\bar{z} - a_s \bar{z}] dx' + a_s g \bar{z}. \quad (\text{E.23})$$

Dividing both sides of this equation by \bar{z} , evaluating the integral, and using $r - g = \rho$, we can solve for a_s as:

$$a_s = \frac{m_a^s v_1 \left[\gamma \frac{(1-x_b^2)}{2} - \tau(1-x_b) \right]}{\rho + m_a^s (1-x_b)}. \quad (\text{E.24})$$

Similarly, substituting the conjecture $A_l(\bar{z}) = a_l \bar{z}$ into (E.10) and using $\dot{A}_l(\bar{z}) = a_l \dot{\bar{z}} = a_l g \bar{z}$, where g is the growth rate of the economy, and $P_l(x') = v_1(1-\alpha)\gamma x' \bar{z}$, we obtain:

$$r a_l \bar{z} = m_a^l \int_{x_a}^1 [v_1(1-\alpha)\gamma x' \bar{z} - a_l \bar{z}] dx' + a_l g \bar{z}. \quad (\text{E.25})$$

Dividing both sides of this equation by \bar{z} , evaluating the integral, and using $r - g = \rho$, we can solve for a_l as:

$$a_l = \frac{m_a^l v_1 (1-\alpha) \gamma \frac{(1-x_a^2)}{2}}{\rho + m_a^l (1-x_a)}. \quad (\text{E.26})$$

■

E.4 Characterization of Thresholds

The only remaining equilibrium variables to be determined are the threshold values x_a , x_b , x_k , and x_l .

E.4.1 Market Thresholds

At the threshold x_b , the for-sale agent is indifferent between trading and waiting:

$$P(x_b) = A_s(\bar{z}) \implies v_1(\gamma x_b - \tau) = a_s. \quad (\text{E.27})$$

The buying threshold x_b is then given by:

$$x_b = \frac{a_s}{v_1 \gamma} + \frac{\tau}{\gamma}. \quad (\text{E.28})$$

Substituting a_s from (E.21) into (E.28), we obtain the following fixed-point equation for x_b :

$$x_b = \frac{m_a^s \left[\frac{(1-x_b^2)}{2} - \frac{\tau}{\gamma}(1-x_b) \right]}{\rho + m_a^s(1-x_b)} + \frac{\tau}{\gamma}. \quad (\text{E.29})$$

At the threshold x_a , the for-license agent is indifferent between trading and waiting:

$$P_l(x_a) = A_l(\bar{z}) \implies v_1(1-\alpha)\gamma x_a = a_l \quad (\text{E.30})$$

The licensing threshold x_a is then given by:

$$x_a = \frac{a_l}{v_1(1-\alpha)\gamma}. \quad (\text{E.31})$$

Substituting a_l from (E.22) into (E.31), we obtain the following fixed-point equation for x_a :

$$x_a = \frac{m_a^l(1-x_a^2)}{2[\rho + m_a^l(1-x_a)]}. \quad (\text{E.32})$$

E.4.2 Innovator Thresholds

At the threshold x_k , the innovator is indifferent between retaining the patent and licensing it out:

$$v_1(\gamma x_k - \tau) = v_1\alpha\gamma x_k + a_l. \quad (\text{E.33})$$

The threshold x_k is then given by:

$$x_k = \frac{a_l}{v_1\gamma(1-\alpha)} + \frac{\tau}{\gamma(1-\alpha)}. \quad (\text{E.34})$$

At the threshold x_l , the innovator is indifferent between licensing the patent out and selling it outright:

$$v_1\alpha\gamma x_l + a_l = a_s. \quad (\text{E.35})$$

The threshold x_l is then given by:

$$x_l = \frac{a_s - a_l}{v_1\alpha\gamma}. \quad (\text{E.36})$$

The relationship between the innovator thresholds (x_k and x_l) and market thresholds (x_a and x_b) is characterized the by the following proposition.

Proposition 3 (Relationship between Innovator Thresholds and Market Thresholds). *The innovator's indifference threshold x_k between retaining the patent and licensing it out is related to the patent agent's licensing threshold x_a as follows:*

$$x_k = x_a + \frac{\tau}{\gamma(1-\alpha)}. \quad (\text{E.37})$$

The innovator's indifference threshold x_l between licensing the patent out and selling it outright are related to market thresholds x_a and x_b as follows:

$$x_l = \frac{x_b - (1 - \alpha)x_a}{\alpha} - \frac{\tau}{\alpha\gamma}. \quad (\text{E.38})$$

Proof. From (E.31), it follows that $a_l = v_1(1 - \alpha)\gamma x_a$. Substituting into (E.34), we obtain:

$$\begin{aligned} x_k &= \frac{v_1(1 - \alpha)\gamma x_a}{v_1\gamma(1 - \alpha)} + \frac{\tau}{\gamma(1 - \alpha)} \\ &= x_a + \frac{\tau}{\gamma(1 - \alpha)}. \end{aligned} \quad (\text{E.39})$$

Similarly, from (E.28), it follows that $a_s = \gamma v_1 \left(x_b - \frac{\tau}{v_1} \right)$. Substituting this and $a_l = v_1(1 - \alpha)\gamma x_a$ into (E.36), we obtain:

$$x_l = \frac{x_b - (1 - \alpha)x_a}{\alpha} - \frac{\tau}{\alpha\gamma}. \quad (\text{E.40})$$

■

Proposition 4 (Valid Threshold Ordering). *The innovator threshold ordering $0 < x_l < x_k < 1$ holds if and only if:*

1. $x_b > (1 - \alpha)x_a + \frac{\tau}{\gamma}$
2. $x_b < x_a + \frac{\tau}{\gamma(1 - \alpha)}$
3. $x_a < 1 - \frac{\tau}{\gamma(1 - \alpha)}$

Proof. The proof follows from the equilibrium identities given in (E.34) and (E.38). The first condition ensures that $x_l > 0$. The second condition ensures that $x_l < x_k$. Finally, the third condition ensures $x_k < 1$. ■

E.5 Equilibrium

The equilibrium is characterized by the following system of equations where the endogenous variables are: $x_a, x_b, x_k, x_l, m_a^s, m_a^l, n_a^s, n_a^l, M^s, M^l, a_s, a_l, v_1, v_2, g, r$:

$$v_1 = \frac{\pi}{r}, \quad (\text{E.41})$$

$$v_2 = \frac{1}{\rho} \left[i v_1 \left(\gamma \frac{(1 - x_k^2)}{2} - \tau(1 - x_k) \right) + i v_1 \alpha \gamma \frac{(x_k^2 - x_l^2)}{2} + i a_l (x_k - x_l) + i x_l a_s \right], \quad (\text{E.42})$$

$$x_a = \frac{a_l}{v_1(1-\alpha)\gamma}, \quad x_b = \frac{a_s}{v_1\gamma} + \frac{\tau}{\gamma}, \quad (\text{E.43})$$

$$x_k = x_a + \frac{\tau}{\gamma(1-\alpha)} \quad x_l = \frac{x_b - (1-\alpha)x_a}{\alpha} - \frac{\tau}{\alpha\gamma}, \quad (\text{E.44})$$

$$M^s = \frac{ix_l}{1-x_b}, \quad M^l = \frac{i(x_k - x_l)}{1-x_a}, \quad (\text{E.45})$$

$$n_a^s = \left[\frac{M^s}{\eta^s} \right]^{1/\mu}, \quad n_a^l = \left[\frac{M^l}{\eta^l} \right]^{1/\mu}, \quad (\text{E.46})$$

$$m_a^s = \eta^s (n_a^s)^{\mu-1}, \quad m_a^l = \eta^l (n_a^l)^{\mu-1} \quad (\text{E.47})$$

$$a_s = \frac{m_a^s v_1 \left[\gamma \frac{(1-x_b^2)}{2} - \tau(1-x_b) \right]}{\rho + m_a^s (1-x_b)}, \quad a_l = \frac{m_a^l v_1 (1-\alpha) \gamma \frac{(1-x_a^2)}{2}}{\rho + m_a^l (1-x_a)}, \quad (\text{E.48})$$

$$g = i\gamma \left[\frac{(1-x_k^2)}{2} + \alpha \frac{(x_k^2 - x_l^2)}{2} + (1-\alpha)(x_k - x_l) \frac{(1+x_a)}{2} + x_l \frac{(1+x_b)}{2} \right] - i\tau(1-x_k+x_l), \quad (\text{E.49})$$

$$r = \rho + g. \quad (\text{E.50})$$

E.6 Sufficient Conditions for a Well-Behaved Equilibrium

In this section, We identify sufficient conditions guaranteeing the following properties for a well-behaved equilibrium:

1. Licensing region exists for innovators: $0 < x_l < x_k < 1$,
2. Both markets are active: $0 < x_a < x_b < 1$,
3. Proper ordering: $x_l < x_a < x_b < x_k$,
4. Agent values are positive and ranked: $a_s > a_l > 0$.

Proposition 5 (Sufficient Conditions for Well-Behaved Equilibrium). *Let $\mu = 1$ and $\eta^s = \eta^l = \eta > 0$.*

Define:

$$\lambda \equiv \frac{\rho}{\eta}, \quad x_a^* \equiv 1 + \lambda - \sqrt{\lambda(\lambda+2)}, \quad \tilde{\tau} \equiv \frac{\tau}{\gamma} \quad (\text{E.51})$$

If $\alpha \in (0, 1)$ and $0 < \tilde{\tau} < \min \{ \alpha x_a^, (1-\alpha)(1-x_a^*) \}$, then the equilibrium exhibits:*

- (i) *The threshold ordering: $0 < x_l < x_a < x_b < x_k < 1$,*
- (ii) *The agent value ranking: $a_s > a_l > 0$.*

The proof proceeds through a series of lemmas, presented in subsection [E.6.1](#), with the main proof assembled in subsection [E.6.2](#).

E.6.1 Preliminary Lemmas

Definition 1. Define the function $F : [0, 1] \rightarrow \mathbb{R}$ by:

$$F(x) \equiv \frac{\eta(1-x^2)/2}{\rho + \eta(1-x)} = \frac{\eta(1-x)(1+x)}{2[\rho + \eta(1-x)]}. \quad (\text{E.52})$$

This function emerges from the patent agent's fixed-point equation for x_a in (E.32) when $\mu = 1$ and $\eta^s = \eta^l = \eta > 0$.

Lemma 1 (Properties of $F(x)$). *The function $F(x)$ satisfies:*

- (a) $F(0) = \frac{\eta}{2(\rho+\eta)} \in (0, 1/2)$,
- (b) $F(1) = 0$,
- (c) $F(x)$ is continuous on $[0, 1]$,
- (d) $F(x)$ is strictly decreasing on $[0, 1]$.

Proof. Parts (a), (b), and (c) follow directly from the definition. For part (d), differentiate $F(x)$ to obtain:

$$F'(x) = \frac{d}{dx} \left[\frac{\eta(1-x^2)/2}{\rho + \eta(1-x)} \right]. \quad (\text{E.53})$$

Using the quotient rule and simplifying, one can verify that $F'(x) < 0$ for $x \in (0, 1)$. ■

Lemma 2 (Existence and Uniqueness). *For any $\rho > 0$ and $\eta > 0$, there exists a unique $x_a^* \in (0, 1)$ satisfying $x_a^* = F(x_a^*)$. Moreover, we have:*

$$x_a^* = 1 + \lambda - \sqrt{\lambda(\lambda + 2)}, \quad (\text{E.54})$$

where $\lambda \equiv \rho/\eta$.

Proof. Define $\Phi(x) \equiv x - F(x)$. By Lemma 1, it follows that

$$\Phi(0) = 0 - F(0) = -\frac{\eta}{2(\rho + \eta)} < 0, \quad (\text{E.55})$$

$$\Phi(1) = 1 - F(1) = 1 - 0 = 1 > 0. \quad (\text{E.56})$$

Since Φ is continuous, by the Intermediate Value Theorem, there exists $x_a^* \in (0, 1)$ such that $\Phi(x_a^*) = 0$, i.e., $x_a^* = F(x_a^*)$. Since F is strictly decreasing (Lemma 1(d)), the function $\Phi(x) = x - F(x)$ is strictly increasing. Therefore, there is at most one root.

Setting $x = F(x)$ and cross-multiplying, we obtain:

$$x[\rho + \eta(1-x)] = \frac{\eta(1-x)(1+x)}{2}. \quad (\text{E.57})$$

For $x < 1$, divide both sides by $(1 - x)$, so that we obtain:

$$\frac{x[\rho + \eta(1 - x)]}{1 - x} = \frac{\eta(1 + x)}{2}. \quad (\text{E.58})$$

Letting $y = 1 - x$ and substituting $x = 1 - y$, we obtain:

$$(1 - y)[\rho + \eta y] = \frac{\eta(2 - y)}{2} \cdot y. \quad (\text{E.59})$$

Expanding, we obtain:

$$\rho - \rho y + \eta y - \eta y^2 = \eta y - \frac{\eta y^2}{2}. \quad (\text{E.60})$$

Simplifying, we obtain:

$$\rho - \rho y = \frac{\eta y^2}{2}. \quad (\text{E.61})$$

Rearranging, we obtain:

$$\frac{\eta}{2}y^2 + \rho y - \rho = 0. \quad (\text{E.62})$$

Multiplying by $2/\eta$ and letting $\lambda = \rho/\eta$, we have:

$$y^2 + 2\lambda y - 2\lambda = 0. \quad (\text{E.63})$$

By the quadratic formula, we have:

$$y = -\lambda + \sqrt{\lambda^2 + 2\lambda} = -\lambda + \sqrt{\lambda(\lambda + 2)}. \quad (\text{E.64})$$

(taking the positive root since $y = 1 - x > 0$). Therefore, we have:

$$x_a^* = 1 - y = 1 + \lambda - \sqrt{\lambda(\lambda + 2)}. \quad (\text{E.65})$$

■

Lemma 3 (Properties of x_a^*). *The threshold x_a^* satisfies:*

- (a) $x_a^* \in (0, 1)$ for all $\lambda > 0$,
- (b) x_a^* is strictly decreasing in $\lambda = \rho/\eta$,
- (c) $\lim_{\lambda \rightarrow 0} x_a^* = 1$ and $\lim_{\lambda \rightarrow \infty} x_a^* = 0$.

Proof. From Lemma 2, $y = 1 - x_a^* = -\lambda + \sqrt{\lambda^2 + 2\lambda}$. Since $\sqrt{\lambda^2 + 2\lambda} > \lambda$ for $\lambda > 0$, we have $y > 0$, so $x_a^* < 1$.

For $x_a^* > 0$, we need $y < 1$, which requires $\sqrt{\lambda^2 + 2\lambda} < \lambda + 1$. Squaring: $\lambda^2 + 2\lambda < \lambda^2 + 2\lambda + 1$, which always holds.

Differentiating $x_a^* = 1 + \lambda - \sqrt{\lambda(\lambda + 2)}$, we obtain:

$$\frac{dx_a^*}{d\lambda} = 1 - \frac{2\lambda + 2}{2\sqrt{\lambda(\lambda + 2)}} = 1 - \frac{\lambda + 1}{\sqrt{\lambda(\lambda + 2)}}. \quad (\text{E.66})$$

Since $(\lambda + 1)^2 = \lambda^2 + 2\lambda + 1 > \lambda^2 + 2\lambda = \lambda(\lambda + 2)$, we have $\lambda + 1 > \sqrt{\lambda(\lambda + 2)}$, so $\frac{dx_a^*}{d\lambda} < 0$.

As $\lambda \rightarrow 0$: $x_a^* \rightarrow 1 + 0 - 0 = 1$.

As $\lambda \rightarrow \infty$: $\sqrt{\lambda(\lambda + 2)} = \lambda\sqrt{1 + 2/\lambda} \approx \lambda(1 + 1/\lambda) = \lambda + 1$, so $x_a^* \rightarrow 1 + \lambda - (\lambda + 1) = 0$. ■

Definition 2. Define the function $G : [0, 1] \rightarrow \mathbb{R}$ by:

$$G(x) \equiv \frac{\rho}{\rho + \eta(1 - x)}. \quad (\text{E.67})$$

Lemma 4 (Properties of $G(x)$). *The function $G(x)$ satisfies:*

- (a) $G(x) \in (0, 1)$ for all $x \in [0, 1]$,
- (b) $G(0) = \frac{\rho}{\rho + \eta}$ and $G(1) = 1$,
- (c) $G(x)$ is strictly increasing on $[0, 1]$.

Proof. Parts (a) and (b) follow directly from the definition. For part (c), we have:

$$G'(x) = \frac{\rho\eta}{[\rho + \eta(1 - x)]^2} > 0. \quad (\text{E.68})$$

■

Lemma 5 (Fixed-Point Equation for x_b). *When $\eta^s = \eta^l = \eta$ and $\mu = 1$, the buying threshold x_b satisfies:*

$$x_b = F(x_b) + \tilde{\tau} \cdot G(x_b). \quad (\text{E.69})$$

Proof. From the agent value equation (E.21) with $m_a^s = \eta$, it follows that

$$a_s = \frac{\eta v_1 [\gamma(1 - x_b^2)/2 - \tau(1 - x_b)]}{\rho + \eta(1 - x_b)}. \quad (\text{E.70})$$

From the threshold condition (E.28), it follows that $a_s = v_1(\gamma x_b - \tau)$.

Equating:

$$v_1(\gamma x_b - \tau) = \frac{\eta v_1 [\gamma(1 - x_b^2)/2 - \tau(1 - x_b)]}{\rho + \eta(1 - x_b)}. \quad (\text{E.71})$$

Dividing by $v_1\gamma$ and letting $\tilde{\tau} = \tau/\gamma$:

$$x_b - \tilde{\tau} = \frac{\eta[(1 - x_b^2)/2 - \tilde{\tau}(1 - x_b)]}{\rho + \eta(1 - x_b)}. \quad (\text{E.72})$$

Rearranging:

$$x_b = \frac{\eta(1 - x_b^2)/2}{\rho + \eta(1 - x_b)} - \frac{\eta\tilde{\tau}(1 - x_b)}{\rho + \eta(1 - x_b)} + \tilde{\tau}, \quad (\text{E.73})$$

$$= F(x_b) + \tilde{\tau} \left[1 - \frac{\eta(1 - x_b)}{\rho + \eta(1 - x_b)} \right], \quad (\text{E.74})$$

$$= F(x_b) + \tilde{\tau} \cdot \frac{\rho}{\rho + \eta(1 - x_b)}, \quad (\text{E.75})$$

$$= F(x_b) + \tilde{\tau} \cdot G(x_b). \quad (\text{E.76})$$

■

Lemma 6 (Ordering $x_a < x_b$). *When $\eta^s = \eta^l = \eta$ and $\tilde{\tau} > 0$, we have $x_b > x_a$.*

Proof. From Lemma 2, we know that $x_a = F(x_a)$. From Lemma 5, we know that $x_b = F(x_b) + \tilde{\tau} \cdot G(x_b)$. Define $H(x) \equiv x - F(x)$. Then:

$$\begin{aligned} H(x_a) &= x_a - F(x_a) = 0, \\ H(x_b) &= x_b - F(x_b) = \tilde{\tau} \cdot G(x_b) > 0, \end{aligned}$$

since $\tilde{\tau} > 0$ and $G(x_b) > 0$.

Since F is strictly decreasing (Lemma 1(d)), $H(x) = x - F(x)$ is strictly increasing. Therefore, $H(x_b) > H(x_a) = 0$ implies that $x_b > x_a$. ■

Lemma 7 (Bound on the Gap $x_b - x_a$). *When $\eta^s = \eta^l = \eta$ and $\tilde{\tau} > 0$:*

$$x_b - x_a < \tilde{\tau}. \quad (\text{E.77})$$

Proof. From the fixed-point equations, we have:

$$x_b - x_a = [F(x_b) + \tilde{\tau} \cdot G(x_b)] - F(x_a), \quad (\text{E.78})$$

$$= [F(x_b) - F(x_a)] + \tilde{\tau} \cdot G(x_b). \quad (\text{E.79})$$

Since $x_b > x_a$ (Lemma 6) and F is strictly decreasing (Lemma 1(d)), it follows that

$$F(x_b) - F(x_a) < 0. \quad (\text{E.80})$$

Therefore,

$$x_b - x_a < \tilde{\tau} \cdot G(x_b). \quad (\text{E.81})$$

Since $G(x) < 1$ for all $x < 1$ (Lemma 4(a)), it follows that

$$x_b - x_a < \tilde{\tau} \cdot G(x_b) < \tilde{\tau}. \quad (\text{E.82})$$

■

Lemma 8 (Equivalence Conditions for $a_s > a_l$). *The following conditions are equivalent:*

- (i) $a_s > a_l$,
- (ii) $x_l > 0$,
- (iii) $x_b > (1 - \alpha)x_a + \tilde{\tau}$,

Proof. From the threshold definitions (E.31) and (E.28), we know that

$$a_l = v_1(1 - \alpha)\gamma x_a, \quad (\text{E.83})$$

$$a_s = v_1(\gamma x_b - \tau) = v_1\gamma(x_b - \tilde{\tau}). \quad (\text{E.84})$$

From (E.36), we know that

$$x_l = \frac{a_s - a_l}{v_1\alpha\gamma}. \quad (\text{E.85})$$

Since $v_1 > 0$, $\alpha > 0$, $\gamma > 0$:

$$x_l > 0 \iff a_s > a_l. \quad ((\text{i}) \iff (\text{ii}))$$

Now, we have:

$$a_s - a_l = v_1\gamma(x_b - \tilde{\tau}) - v_1(1 - \alpha)\gamma x_a, \quad (\text{E.86})$$

$$= v_1\gamma[x_b - \tilde{\tau} - (1 - \alpha)x_a]. \quad (\text{E.87})$$

Therefore, it follows that

$$a_s > a_l \iff x_b - \tilde{\tau} - (1 - \alpha)x_a > 0 \iff x_b > (1 - \alpha)x_a + \tilde{\tau}. \quad ((\text{i}) \iff (\text{iii}))$$

■

Lemma 9 (Sufficient Condition for $a_s > a_l$). *When $\eta^s = \eta^l = \eta$ and $\tilde{\tau} < \alpha x_a$, we have $a_s > a_l$.*

Proof. By Lemma 8, it suffices to show $x_b > (1 - \alpha)x_a + \tilde{\tau}$. Since $x_b > x_a$ (Lemma 6), it follows that

$$x_b - (1 - \alpha)x_a - \tilde{\tau} > x_a - (1 - \alpha)x_a - \tilde{\tau}, \quad (\text{E.88})$$

$$= \alpha x_a - \tilde{\tau}. \quad (\text{E.89})$$

If $\tilde{\tau} < \alpha x_a$, then it follows that

$$x_b - (1 - \alpha)x_a - \tilde{\tau} > \alpha x_a - \tilde{\tau} > 0. \quad (\text{E.90})$$

Therefore $a_s > a_l$. ■

E.6.2 Proof of Proposition 5

We now prove Proposition 5 by establishing each component of the ordering.

Proof of Proposition 5.

Part 1: $x_a \in (0, 1)$.

By Lemma 2, when $\eta^s = \eta^l = \eta$, the licensing-in threshold x_a satisfies $x_a = F(x_a)$, which has a unique solution $x_a = x_a^* \in (0, 1)$.

Part 2: $x_a < x_b$.

This follows directly from Lemma 6, which requires $\tilde{\tau} > 0$.

Part 3: $x_b < x_k$.

Recall from (E.34) that $x_k = x_a + \frac{\tilde{\tau}}{1-\alpha}$. We need to show $x_b < x_a + \frac{\tilde{\tau}}{1-\alpha}$. From Lemma 7, it follows that $x_b - x_a < \tilde{\tau}$.

Since $\alpha \in (0, 1)$, we have $\frac{1}{1-\alpha} > 1$, so:

$$x_b < x_a + \tilde{\tau} < x_a + \frac{\tilde{\tau}}{1-\alpha} = x_k. \quad (\text{E.91})$$

Part 4: $x_k < 1$.

We have $x_k = x_a + \frac{\tilde{\tau}}{1-\alpha}$. The condition $x_k < 1$ requires:

$$x_a + \frac{\tilde{\tau}}{1-\alpha} < 1 \iff \tilde{\tau} < (1-\alpha)(1-x_a). \quad (\text{E.92})$$

This is guaranteed by the condition $\tilde{\tau} < \min\{\alpha x_a^*, (1-\alpha)(1-x_a^*)\}$.

Part 5: $x_l > 0$.

By Lemma 8, $x_l > 0 \iff a_s > a_l$. By Lemma 9, $a_s > a_l$ when $\tilde{\tau} < \alpha x_a$. This is guaranteed by the condition $\tilde{\tau} < \min\{\alpha x_a^*, (1-\alpha)(1-x_a^*)\}$.

Part 6: $x_l < x_a$.

From (E.36), we know that

$$x_l = \frac{a_s - a_l}{v_1 \alpha \gamma} = \frac{x_b - (1-\alpha)x_a - \tilde{\tau}}{\alpha} \quad (\text{E.93})$$

We need $x_l < x_a$, that is:

$$\frac{x_b - (1-\alpha)x_a - \tilde{\tau}}{\alpha} < x_a, \quad (\text{E.94})$$

$$x_b - (1-\alpha)x_a - \tilde{\tau} < \alpha x_a, \quad (\text{E.95})$$

$$x_b < x_a + \tilde{\tau}. \quad (\text{E.96})$$

This follows directly from Lemma 7, where $x_b - x_a < \tilde{\tau}$.

Part 7: $a_s > a_l > 0$.

We have $a_s > a_l$ from Part 5. For $a_l > 0$, note that from (E.22) with $\eta > 0$ and $x_a \in (0, 1)$, it

follows that

$$a_l = \frac{\eta v_1 (1 - \alpha) \gamma (1 - x_a^2) / 2}{\rho + \eta (1 - x_a)} > 0. \quad (\text{E.97})$$

■