The Economics of Patent Licensing: An Empirical Analysis of the Determinants and Consequences of Patent Licensing Transactions

Thomas J. Chemmanur* Xi Chen† Jingxuan Zhang‡

July 2024

*Corresponding Author and Professor of Finance and Hillenbrand Distinguished Fellow, Finance Department, Carroll School of Management, Boston College. Email:chemmanu@bc.edu.

†Ph.D. Candidate, Finance Department, C. T. Bauer College of Business, University of Houston. Email: xchen2@bauer.uh.edu.

‡Assistant Professor, Finance Department, Alberta School of Business, University of Alberta. Email: jingxuan.zhang@ualberta.ca.

We thank Juejie Chen for providing excellent research assistance. Any errors or omissions remain our responsibility.

The Economics of Patent Licensing: An Empirical Analysis of the Determinants and Consequences of Patent Licensing Transactions

Abstract

In this paper, we investigate the economics of patent licensing using a large and unique sample of patent licensing transactions from the ktMINE Patent License Agreement Database. We address three key research questions for the first time in the literature: the characteristics of licensor and licensee firms driving the former firms to license patents to the latter; the patent characteristics driving a licensor's decision to retain, sell, or license certain patents; and the consequences of patent licensing transactions for licensor and licensee firms. Our findings indicate that licensors prefer licensing to downstream firms while avoiding firms with similar patent portfolios. Licensors retain patents closer in technological distance to their own portfolios and sell those farther away, while licensing out patents that are in-between the two. Licensees, on the other hand, prefer to license in patents closer to their own patent portfolios. Both our baseline analysis and a difference-in-differences analysis around the National Technology Transfer and Advancement Act of 1995 show that patent licensing transactions are efficient: they increase the Tobin's Q of both licensors and licensees. However, the channels of equity market value creation for licensors and licensees are different: while licensors' increases in Tobin's Q are greater for firms that can charge higher licensing fees, exposure to new technologies is a source of value increase for licensees. We further find that licensors increase their R&D expenditures and generate more patents following licensing transactions, suggesting that they use some of their proceeds from licensing transactions to enhance their innovation productivity. Licensees, on the other hand, introduce more new products and increase their innovation efficiency subsequent to licensing transactions, suggesting that they are able to learn from using the patents they license.

Keywords: Patent licensing; Selling versus licensing; Licensors; Licensees; 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 studied the transfer of patents across firms through the buying and selling of patents (e.g., Akcigit et al. (2016), Zhang (2020)), there has been a relatively few large sample analyses of the licensing of patents across firms. 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 by making use of a large sample of licensing transactions provided by the ktMINE Patent License Agreement Database.

We first develop a conceptual framework in order 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 by licensing them. Selling and licensing a patent may involve different costs and benefits to the firm developing the patent. Selling a patent, while the firm may reap substantial financial rewards from the sale, requires the firm to relinquish control of the patent completely to the buying firm, which may eventually use it for uses that are detrimental to the interests of the firm developing the patent. Licensing enables the firm licensing the patent (the licensor) to obtain a periodic (quarterly, semi-annually, or annually) licensing fee from the firm to which the patent is licensed (the licensee). Licensing allows the licensor to maintain more control of the patent than selling the patent outright since it allows the licensor to terminate the licensing contract after the initial licensing period.

In the above framework, we address three important sets of research questions. The first set of research questions we examine relates to the characteristics of licensor and licensee firms. The first question we ask here is the following: is it the case that firms with greater innovation productivity (in terms of the quantity and quality of patents they have generated) become licensors? 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 return from the licensor's R&D expenditures. In other words, we expect the R&D expenditures of licensors to be higher than those of control firms in the industry. On the other hand, 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. We, therefore, do not expect licensee firms to have high R&D expenditures relative to control firms prior to licensing transactions. This is second question we address through our empirical analysis.

The third question we address here relates to the determinants of the pairing between licensor and licensee firms. In determining which firm to licensee 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 to a firm arises from the licensee firm buying the products of the licensor: i.e., the licensor and the licensee may 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 increasing the demand for the licensor's products from the licensee firm. Thus, licensors are more likely 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, 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. We empirically address this set of questions through a patent-level analysis. The first question we address here is regarding the nature of patents that a licensor is likely to retain (and build products around) versus the type of patents it chooses to monetize by licensing or selling to another firm. Clearly, it is less costly for firms to build products around patents closer to their current line of business. In other words, firms will retain those patents which are closer in technological distance (see Akcigit et al. (2016)) to their current patent portfolio, while monetizing (either by licensing or by selling) patents that are further away from their current patent portfolio.

The second question we address here is regarding the patents a firm has chosen 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? On the one hand, licensing the 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 licensing fee. On the other hand, if the firm sells a given patent outright, it has no remaining control of the patent going forward, though 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 most far away (in terms of technological distance) from their current patent portfolio (which reflects their main line of business) while licensing those patents that are closer to their current patent portfolio.

The third question we address here relates to the choices made by a licensee firm regarding a licensing transaction. Clearly, licensing transactions will not occur for a patent without a firm demanding to license that patent. 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 line of business. Thus, we expect licensee firms to license in patents that are closer in terms of technological distance to the licensee firm compared to its distance from the licensor firms.

Finally, we turn to our third set of research questions, namely, the consequences of licensing transactions and the channels through which they occur. The first question we ask here is regarding the efficiency of licensing transactions: do licensing transactions create value for both the licensor and the licensee? The measure of value we use here is equity market value, as captured by licensor and licensee firms' Tobin's Q. We would expect licensor firms who receive higher licensing fees to have a higher level of Tobin's Q since receiving higher cash flows through licensing fees will increase the market value of licensor firms. Turning to licensee firms, they may benefit in multiple ways from the licensing transactions, resulting in a higher level of Tobin's Q. First, licensee firms may receive technological exposure to new areas of innovation as a result of the patents they license from the licensor: greater the level of exposure, higher the level of the licensee firm's Tobin's Q we expect to find. Second, the higher the number of new products that the licensee firm is able to develop subsequent to the patent transactions, the higher the level of Tobin's Q we expect for the licensee firm.

The second question we ask here is regarding the other consequences of the licensing transaction for licensor firms. Given that, by engaging in licensing, licensor firms will receive licensing fees and thereby are able to monetize some of their patents, licensor firms may be able to increase their R&D expenditures subsequent to the licensing transaction. This may also lead to a higher level of innovation productivity for the licensor, which is a related question that we examine here.

The third (and final) question we ask here is regarding the other consequences of the licensing transaction for licensee firms. First, the number of new products introduced by the licensee firms using the patents they license subsequent to the licensing transaction is likely to be greater. Second, by using the licensed patent and building patents around them, licensee firms may engage in "learning by doing", which may increase their firms' innovation efficiency, which is the last question we address here.

We address the above research question using a large and unique sample of patent licensing transactions provided by the ktMINE Patent License Agreement Database. ktMINE complies 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 transactions specifically listing the bundled patents. The ktMINE database also provides detailed information on transaction terms, types of intellectual properties involved, and associated licensing fees. This comprehensive dataset allows us to analyze both firm-level and patent-level dynamics.

Our empirical results can be summarized as follows. We first discuss the results of our analysis of our first set of research questions, namely, the characteristics of licensor and licensee firms and the determinants of the pairing between the two sets of firms. Our first empirical finding here is regarding the nature of firms that are likely to become licensors and licensees. We find that firms with a larger patent stock and larger number of citations per patent and higher R&D expenditures (relative to matched control firms) are more likely to become licensors. On the other hand, firms with declining patent productivity and citations per patent in the prior three years related to matched control firms are more likely to become licensee firms. We also find that product market competition and market power may also influence the licensing propensity for both licensor and licensee firms. Thus, higher market concentration increases the likelihood of firms being involved in patent licensing transactions. Our results suggest that if the market is highly competitive, licensors are less willing to license out their patents. From the licensees' perspective, when the market is more concentrated, licensing technology becomes a strategic move to quickly access new innovations without incurring the full costs and time associated with internal development, thereby gaining a competitive edge over existing firms. For licensors, their market power does not significantly impact their decision to license out their patents. However, for licensees, having less market power increases the likelihood of licensing new technology, providing a faster route to developing new products, helping the licensee firms to gain market power in the future.

Our second set of findings is regarding the determinants of the pairing between licensor and licensee firms. We document two findings here. First, as we hypothesized, we find that licensors are more likely to license patents to licensee firms if they are the downstream partners of licensor firms. This suggests that licensors take into account the indirect benefits of licensing, such as a potential increase in demand for their products from licensee firms. Second, we find that licensors are less likely to license patents to firms that are technologically more similar to them (as measured by the cosine similarity between their patent portfolios). This again is consistent with our hypothesis that licensors may take into account the potential of future product market competition from licensees when choosing which firms to license their patents to.

We now summarize the results of our empirical analysis addressing our second set of research questions. We document three findings. First, licensors retain patents that are closer in technological distance to their firms' current patent portfolio, while monetizing (either by selling or 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 patents 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 the licensor, licensee firms choose to license those patents closer in technological distance to their own patent portfolio. This is consistent with our hypothesis that an important reason for licensee firms to licensee patents is to build products around them, and it is less costly for them to build products close to their current line of business.

We now summarize the findings of our empirical analysis addressing our third set of research questions, namely, the consequences of licensing transactions for the licensor and licensee firms. Our first finding addresses the question of whether licensing transactions are efficient and the value created by such transactions, i.e., whether they create equity market value for the licensor and licensee firms. We answer this question in the affirmative, where value creation is measured using the Tobin's Q of licensor and licensee firms: we find that, following licensing transactions, both licensor and licensee firms have higher Tobin's Q than matched control firms. To establish causality, we make use of the National Technology Transfer and Advancement Act (NTTAA) of 1995, which arguably made the licensing of patents more efficient. Our DiD analysis around this Act comparing the Tobin's Q of firms engaging in licensing transactions with those of propensity score matched control firms before and after the passage of the NTTAA establishes that licensing transactions causally and significantly increase the Tobin's Q of both licensor and licensee firms.

We also delve into the channels through which licensing transactions increase the market value (Tobin's Q) of licensor and licensee firms. While such value creation may occur through numerous channels, we explore one channel each for the licensor and licensee. For the licensor, we explore the licensing fee as a potential channel: our split-sample analysis shows that firms receiving higher licensing fees (as measured by the royalty rate) have a higher Tobin's Q relative to matched control firms than those receiving lower licensing fees. For the licensee, we explore exposure to new technologies due to the licensed-in patents as a potential channel of value creation. Our split-sample analysis shows that licensee firms that obtained higher exposure to new technologies as a result of the licensing transactions had a higher Tobin's Q after the licensing transaction relative to matched control firms than those licensee firms that received only lower exposure to new technologies due to the licensing transaction.

We also explore the other consequences of licensing transactions for the licensor and licensee firms. For licensor firms, we analyze whether these firms are able to increase their R&D expenditures subsequent to the licensing transaction (potentially by making use of the licensing fees they receive as a result of licensing transactions). We find that this is indeed the case: the R&D expenditure of firms engaging in licensing transactions is greater subsequent to the transaction than that of matched control firms. Further, the difference in R&D expenditure between licensor firms and matched control firms is greater for the subsample of licensor firms receiving greater licensing fees (as measured by a higher royalty rate). Finally, we also find that the innovation productivity (as measured by number of patents produced) of licensor firms is also greater than matched control firms subsequent to licensing transactions, suggesting that the higher R&D expenditure of licensor firms that we documented above results in their being able to increase their innovation productivity subsequent to the licensing transaction.

Finally, we explore the other consequences of licensing transactions for licensee firms. We first analyze whether licensee firms are able to develop a larger number of products as a result of the licensing transaction. Consistent with this, we find that licensee firms have a larger average number of products compared to matched control firms over the three years after the licensing transaction. We next analyze whether making use of newly licensed patents allows licensee firms to increase their innovation efficiency through "learning by doing" using newly licensed patents. Consistent with this, we find that licensee firms have greater innovation efficiency compared to matched 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 describes the underlying conceptual framework 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 characteristics of licensor and licensee firms and the determinants of the pairing between licensors and licensees. Section 6 analyzes 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. Section 8 presents our analysis of the other consequences (beyond an increase in equity market value) of licensing transactions for the licensor and licensee firms. Section 9 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 that is 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 generating the innovation internally reduces the return for R&D. Akcigit et al. (2016) calibrate their model using data from the 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. (2016) do not explicitly analyze the role of licensing in the transfer of patents, which is our main focus here. We, however, make use of their measure of technological distance in our empirical analysis of the nature of patents that a licensing firm chooses to retain (and build products around) rather than to monetize through selling or licensing, and in our analysis of licensor's choice of patents to sell versus to license. As we discuss below, we also address several other novel research questions 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. 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. 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 propensity to license: see, e.g., Anand and Khanna (2000), Vonortas and Kim (2004), and Gambardella et al. (2007). Kim and Vonortas (2006) use a dataset of U.S. firms and study the determinants of technology licensing, and find that some important determinants are the stock of technological knowledge of the licensor, the licensor's prior exposure to licensing, the strength of

IPR protection, and the nature of the technology licensed. 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. Despite the existence of this large literature, ours is the first large sample study across industries to analyze the characteristics of licensees and the determinants of the pairing between licensors and licensees.

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 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.

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. (2022) 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.

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 three important research questions: the determinants of the pairing between licensors and licensees; the nature of patents that are retained by the licensor versus that monetized by selling or licensing as well as the patent characteristics that drive the choice between the selling and licensing; and the consequences of licensing transactions.

3 Conceptual Framework and Hypothesis Development

In this section, we develop a broad conceptual framework underlying patent licensing transactions, and then make use of this framework to develop testable hypotheses for our empirical analysis.

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 are allowed to 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 area of activity. The firms 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 (in return for financial rewards).

Each choice the firm makes regarding its patents has different costs and benefits. First, while the firm may benefit from building products around some of its patents, it may be prohibitively costly for it to develop products around patents that are far away from its main line of activity. It may therefore choose to monetize these patents by either selling some of these patents or by licensing them to other firms. However, selling a patent, while the firm may reap substantial financial rewards from the sale, requires the firm to relinquish control of the patent completely to the buying firm, which may eventually use it for uses that are detrimental to the interests of the firm developing the patent. An alternative to selling a patent which allows the firm to maintain some control of the patent while monetizing it to some extent is licensing: licensing enables the firm licensing the patent (the licensor) to obtain a periodic (quarterly, semi-annually, or annually) licensing fee from the firm licensing it (the licensee). Licensing allows the licensor to maintain more control of the patent than selling the patent outright since it allows the licensor to terminate the licensing contract after the initial licensing period.

Based on the above conceptual framework, we now develop testable hypotheses for our empirical analysis. We first develop testable hypotheses for our first research question: what determines the pairing between a licensor and a licensee? In determining which firm to licensee 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 non-pecuniary benefits and costs of licensing a patent to a particular firm. One non-pecuniary benefit of licensing a patent to a firm arises from the licensee firm buying the products of the licensor: i.e., the licensor and the licensee may 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 increasing the demand for the licensor's products from the licensee firm. This gives 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 first hypothesis that we test here (**H1**).

We now turn to the potential costs that may arise from a licensor licensing a patent to another firm. 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 it has licensed from the licensor to improve its own products, thereby obtaining a competitive advantage with aspect to the products of the licensor. This means that, if a licensor and a potential licensee are technologically similar, then the two firms are less likely to form a licensor-licensee relationship. This is the next hypothesis that we test here (**H2**).

We now turn to developing testable hypotheses for the second research question that we analyze in this paper, namely, a patent-level analysis of the type of patents that a licensor is likely to retain (and build products around) versus the type of patents it chooses to license or sell to another firm. As discussed earlier in this section, 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 build products around their current line of business. In other words, firms will retain those patents which are closer in technological distance (see Akcigit et al. (2016)) to their current patent portfolio, while monetizing (either by licensing or by selling) patents that are further away from their current patent portfolio. This is the next hypothesis that we test here (**H3**).

Further, if a firm chooses to monetize a patent, it has to decide how to monetize it: by licensing the patent to another firm or by selling it outright. On the one hand, licensing the 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 licensing fee. On the other hand, if the firm sells a given patent outright, it has no remaining control of the patent going forward, though 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 most far away from their current patent portfolio (which reflects their main line of business) while licensing those patents that are closer to their current patent portfolio. This is the next hypothesis that we test here (**H4**).

We now turn to the choice made by the licensee regarding a licensing transaction. Clearly, licensing transactions will not occur for a patent without a firm demanding to license that patent. 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 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 firm's current line of activity, since firms are more likely to build new products more closely related to their current patent portfolio. This leads to our next testable hypothesis, namely, that licensee firms are more likely to license patents closer to their current patent portfolio (**H5**).

We now turn to our third research question, namely, the value created as a result of the licensing transaction for the licensor and the licensee firms and the channel through which this value is created. The first question we ask here is: are licensing transactions efficient on average? In other words, are they value-creating for the licensor and licensee simultaneously? In particular, we hypothesize that the stock market valuation of the licensor and licensee firms increase simultaneously if the licensing transaction is viewed as being efficient by the equity market. This is the next hypothesis that we test here (**H6**).

We now turn to developing hypotheses about the specific consequence of licensing transactions for licensors and licensees and the channels through which they occur. First, we turn to the consequences of licensing transactions for the licensor. Clearly, an important benefit of a licensing transaction to a licensor firm is the stream of licensing fees they will receive over time from licensee firms. The licensor firm may be able to use a part of these fees to create further value for their firm by investing some of the cash flows received as licensing fees into increasing in R&D

expenditures. This is the next hypothesis that we text here (**H7**). As a result of the above increased R&D expenditures, the innovation productivity of the licensor firm may increase subsequent to the licensing transaction. This is the next hypothesis that we test here (**H8**).

We now turn to the consequences of licensing transactions for the licensee. As part of the licensing transaction, the licensee firm pays a stream of licensing fees to the licensor and in return, obtains legal access to use a patent that it had not developed by itself. An important consequence of this is that the licensee firm is able to develop new products, making use of the licensed patent subsequent to the licensing transaction. This is the next hypothesis that we test here (**H9**). Another advantage of the licensing transaction to the licensee firm is that, by making use of the newly licensed patent, the licensee firm is able to obtain exposure to new technology that it would not otherwise have been able to get exposure to. This is the next hypothesis that we test here (**H10**). Access to such new technology may lead to increases in the licensing firm's innovative efficiency, since it may engage in "learning by doing" making use of the licensed patent. This is the last hypothesis that we test here (**H11**).

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 the 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). In addition, since the majority of the database comes from the SEC firm disclosures, at least the filer of every patent licensing transaction has a unique identifier, CIK. This allows us to link this identifier to other standard databases (such as Compustat). As a result, our sample contains 7204 patent licensing transactions spanning from 1976 to 2022, while 1935 of these transactions 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 level and patent level.

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 (licensing, manufacturing, commercialization, distribution...), types of intellectual properties (IPs) involved,[1] detailed terms of every transaction, filing and effective dates of every transaction, and associated fees (in the forms of upfront fixed payment as well as royalty).

Generally, licensee firms pay two types of fees for each patent they wish to license. The first type is a fixed fee payment, which includes upfront payments, one-time license fees, or royalty payments that require licensee firms to pay licensor firms a predetermined amount on a regular basis, such as quarterly. The second type is a variable fee payment, which is based on the licensee firms' annual net sales or operations related to the licensed product. This type of payment is charged as a percentage of net sales or as a dollar value fee per unit of product. Within our sample, only three transactions exclusively use the fixed fee category, while the remaining over 7,000 transactions involve a combination of both fixed and variable payment types.

Upon getting access to the ktMINE Patent License Agreement Database, we link it 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 based on 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 1300 (1954) unique Compustat public firms that engage in patent licensing transactions as licensors (licensees) over the sample period.

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 integration from Hoberg-Phillips Data Library.[2] This data is originally developed by Frésard et al. (2020) and captures the degree

[1] Most of IPs involved are patents, but many transactions include other types of IPs, such as trademarks, copyrights, and brands, among others.

[2] The data is downloaded from: https://faculty.marshall.usc.edu/Gerard-Hoberg/FresardHobergPhillipsD

of vertical integration between a given pair of public firms. We report the firm- and patent-level summary statistics in Table 1. We trim all the continuous variables at 1% and 99% percentile levels to minimize the impact of outliers.

5 Licensor and Licensee Firms Characteristics and the Pairing Between the Licensor and the Licensee

In this section, we conduct various multivariate analyses to investigate the determinants of patent licensing transactions. Initially, we explore firm-level determinants to identify which firms are more likely to become licensors or licensees. Subsequently, we analyze the factors influencing the pairing between licensors and licensees.

5.1 An Analysis of Licensor and Licensee Characteristics

To start with, we explore the firm-level determinants of patent licensing transactions by asking the question: which firm is more likely to be a licensor or licensee in a patent licensing transaction? To answer this question, we use the following specification.

$$\begin{aligned} \textit{Licensor/Licensee}_{i,k,t} = \alpha + \beta_1 \textit{Firm Innovation Characteristics}_{i,k,t-1} \\ + \beta_2 \textit{Firm Characteristics}_{i,k,t-1} + \textit{Transaction FE}_k + \epsilon_{i,k,t} \end{aligned} \tag{1}$$

In specification (1), the dependent variable, *Licensor/Licensee Firm*$_{i,k,t}$, is a dummy variable that equals one if firm i is the licensor or licensee in licensing transaction k and zero otherwise. The main independent variable of interest, *Firm Innovation Characteristics*$_{i,k,t-1}$, includes a set of different innovation characteristics of firm i measured in year $t-1$ that proxy for the firm's innovation productivity or innovation quality. We also control for some firm-level fundamentals in *Firm Characteristics*$_{i,k,t-1}$, which include size, R&D, ROA, leverage, cash holdings, capital expenditures, and book-to-market ratio. Further, we include licensing transaction fixed effects, such that we are comparing an actual licensor (licensee) firm with its matched non-licensor (non-licensee) firms within a transaction.

ataSite/index.html.

For every patent licensing transaction, we match the actual licensor (licensee) firms with non-licensor (non-licensee) firms based on the industry and size measured as of the year prior to the licensing transaction year. Specifically, for each actual licensor (licensee) in 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 the 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 number of control firms in the same four-digit SIC industry, we gradually relax our industry classification to three-digit and then 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 (1), since the conditional logit model allows us to account for matching (Bena and Li (2014), Cunningham et al. (2021)).

We first examine which firms are more likely to become licensors. Table 2 presents coefficient estimates from the conditional logit regression in equation (1) to predict licensors. Column (1) uses the number of patents filed by a firm in the last three years up to a given year (*Num_Pat_3*) as a proxy for the firm's innovation productivity. Column (2) employs the firm's total number of lifetime citations received by patents filed in the last three years, scaled by the number of patents filed in the same period (*CPP_3*), i.e., citations per patent, as a proxy for innovation quality. Columns (3) and (4) use the change in *Num_Pat_3* and *CPP_3* as proxies for the growth rate of the firm's innovation productivity and innovation quality, respectively.

On average, a firm's innovation productivity and innovation quality have a positive and statistically significant effect on the probability of licensing out some of its patents. However, the growth rate of these two variables does not significantly predict the likelihood of becoming a licensor. Notably, across all specifications, the estimated coefficients of firms' previous years' R&D expenditure are positive and statistically significant. Overall, this evidence suggests that firms with greater innovation productivity, higher innovation quality, and higher R&D expenditure are more likely to license out their patents in patent transactions.

Next, we turn to the other side of patent transactions, namely, the licensees. We analyze which firms are more likely to become licensees in patent transactions. Table 3 presents coefficient estimates from the conditional logit regression in equation (1) to predict licensees. Columns (1) and (2) show that a firm's total number of patents filed and the total number of citations received in the last three years have a positive and significant relationship with the likelihood of becoming a licensee. Interestingly, Column (3) shows that the growth rate of innovation productivity is negatively and statistically significantly related to the probability of becoming a licensee. Additionally, Column (4) indicates that the growth rate of a firm's innovation quality also has a negative relationship with the likelihood of choosing to license in patents. Notably, a firm's lagged R&D expenditure has no effect on the probability of licensing in patents.

Taken together, our results suggest that both licensor and licensee firms tend to have large innovation stocks and high innovation quality. Licensor firms invest more in R&D expenses at the time of patent transactions. However, licensee firms might lack sufficient funds to invest in R&D, leading to a decline in their innovation output growth rate. Consequently, these firms are more likely to license patents from other firms rather than develop them internally.

In addition to a firm's innovation characteristics, product market competition and market power may also influence the licensing propensity for both licensor and licensee firms. Table 4 reports the coefficient estimates from the conditional logit regression predicting the relationship between product market competition or firm market power and the likelihood of becoming a licensor or licensee. We use the Herfindahl-Hirschman Index (HHI) for every three-digit SIC-year combination as a proxy for product market competition and the Lerner Index as a proxy for firms' market power.[3] Following Aghion et al. (2005), we construct the Lerner Index for each firm-year as the firm's operating income net of depreciation scaled by the firm's total sales in a given year.

Columns (1) and (3) in Table 4 report the relationship between product market competition in an industry and the likelihood of a firm becoming a licensor or a licensee, respectively. The estimated coefficients on the HHI are both positive and statistically significant, indicating that higher market concentration increases the likelihood of firms being involved in patent licensing transactions. In other words, if the market is highly competitive, licensors are less willing to license out their patents to protect their own technology and maintain a competitive advantage. From the licensees' perspective, when the market is more concentrated, licensing technology becomes a

[3] Lerner (1934) is known today as the source of the Lerner Index for monopoly power, and it has been widely used in other studies (see Nickell (1996), Aghion et al. (2005), Elzinga and Mills (2011)).

strategic move to quickly access new innovations without incurring the full costs and time associated with internal development, thereby gaining a competitive edge over existing firms.

Columns (2) and (4) show the relationship between firms' market power and the likelihood of being involved in patent licensing transactions. For licensors, market power does not significantly impact their decision to license out their patents. However, for licensees, having less market power increases the likelihood of licensing new technology. This approach provides a faster route to market for new products and helps them gain market power in the future.

5.2 The Pairing between Licensors and Licensees

In this section, we test Hypothesis 1, which examines the determinants of the pairing between a licensor and a licensee, using the following regression specification:

$$\begin{aligned} \textit{Actual\_Pair}_{i,j,k,t} = \alpha &+ \beta_1 \textit{Vertical\_Integrate}_{i,j,k,t-1} + \beta_2 \textit{Tech\_Similarity}_{i,j,k,t-1} \\ &+ \beta_3 \textit{Licensor Innovation Characteristics}_{i,k,t-1} \\ &+ \beta_4 \textit{Licensee Innovation Characteristics}_{j,k,t-1} + \beta_5 \textit{Licensor Characteristics}_{i,k,t-1} \\ &+ \beta_6 \textit{Licensee Characteristics}_{j,k,t-1} + \textit{Transaction FE}_k + \epsilon_{i,j,k,t} \end{aligned} \tag{2}$$

The dependent variable in specification (2), $\textit{Actual\_Pair}_{i,j,k,t}$, is equal to one if the firm pair *ij* is the actual licensor-licensee pair in licensing transaction k, and zero otherwise. The main independent variables of interest are $\textit{Vertical\_Integrate}_{i,j,k,t-1}$ and $\textit{Tech\_Similarity}_{i,j,k,t-1}$. $\textit{Vertical\_Integrate}_{i,j,k,t-1}$ is a dummy variable equal to one if firm i and j in licensing transaction k at time $t-1$ are vertically integrated, and zero otherwise. The data on firm pairs' vertical integration relationship are obtained from Frésard et al. (2020). Specifically, if the firm pairs have vertical-related scores in the top 10% of all pairwise scores in a given year, we assign $\textit{Vertical\_Integrate}_{i,j,k,t-1}$ a value of one.[4] Thus, this measure serves as a proxy for the product market relationship between the licensor and licensee and is directed. Therefore, in our sample, we designate the licensors as the upstream firms and the corresponding licensees as the downstream firms. A value of one for this variable

[4]We 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.

between a firm pair indicates a stronger linkage, with licensor firms acting as upstream suppliers to the licensee firms, or licensee firms acting as downstream distributors for the licensor firms. *Tech_Similarity*$_{i,j,k,t-1}$ is calculated as the cosine similarity between technology classes of patents in licensor firms and those in licensee firms. This measure ranges from zero to one, with values closer to one indicating greater similarity between the licensor firm's technology expertise and that of the licensee firm. All other variables are the same as specification (1).

We employ a methodology consistent with our previous approach for forming industry- and size-matched control samples. Specifically, for each actual licensor-licensee firm pair involved in our analysis, we pair the actual licensor with up to five pseudo-licensee firms that closely match. Similarly, we pair the actual licensee with up to five of the closest matches to the licensor firm. Consequently, for each actual licensor-licensee firm pair, we generate up to 35 matched licensor-licensee control pairs. This matching process ensures that the control groups are closely aligned with the actual pairs in terms of industry classification and firm size, thus allowing us to mitigate any potential impact between industry pairs on the likelihood of forming a licensor-licensee pair.

Table 5, Panel A, reports the regression results examining the relationship between the likelihood of becoming an actual licensor-licensee pair and the product market relation between the two firms. Column (1) presents univariate regression results without any controls, indicating that a higher degree of vertical integration between a firm pair increases the likelihood of forming a licensor-licensee pair. Column (2) includes controls for both the licensor's and licensee's innovation characteristics and firm characteristics, as well as transaction fixed effects to account for any time-invariant factors between the actual licensor-licensee pair and the pseudo pairs in each transaction. Even after controlling for various variables and fixed effects, the estimated coefficient for *Vertical_Integrate* remains positive and significant. Overall, the results in Panel A suggest that when deciding which firm to license patents to, licensor firms consider the non-pecuniary benefits and prefer to license patents to firms that are more likely to be their downstream partners. This strategy helps licensors increase demand for their products from their downstream partners. Therefore, the findings in Table 5 confirm the prediction of Hypothesis 1.

Table 5, Panel B, reports the regression results examining the relationship between the likelihood of becoming an actual licensor-licensee pair and the technology similarity between the two firms. Column (1) presents the univariate regression results without any controls, indicating that lower technology similarity between a firm pair increases the likelihood of forming a licensor-licensee pair. Column (2) includes the same control variables and fixed effects as in Panel A, and the estimated coefficient for *Tech_Similarity* remains negative and statistically significant. Overall, the results in Panel B suggest that there are potential costs for licensors in licensing out their patents. To retain their competitive advantage, licensors are more likely to license their patents to firms that are less technologically similar to themselves. Therefore, the findings in Table 5 Panel B confirm the prediction of Hypothesis 2.

6 The Nature of Patents Involved in Licensing Transactions

In this section, we use the following patent-level regression specification to address our second research question: What types of patents are more likely to be involved in patent licensing transactions?

$$Licensed\_Patent_{i,j,t} = \alpha + \beta Tech\_Dist_{i,j,t} + \boldsymbol{X_{i,t}}\gamma + \epsilon_{i,j,t} \tag{3}$$

The dependent variable in specification (3), $Licensed\_Patent_{i,j,t}$ equals one if patent i is licensed out by licensor j or licensed in by licensee j at year t, and zero otherwise. $\boldsymbol{X_{i,t}}$ is a vector of patent-level control variables for patent i in year t, including the number of backward citations, number of forward citations, 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 licensed in year t from firm j's patent portfolio. We follow Akcigit et al. (2016) to construct the measure of technological distance between a patent and a firm's existing patent portfolio.[5] Based on patent citation information, the technological distance between technology classes X and Y is defined as follows:

$$d(X,Y) = 1 - \frac{\#(X \cap Y)}{\#(X \cup Y)} \tag{4}$$

$d(X,Y)$ refers to the technological distance between technology classes X and Y. $\#(X \cap Y)$ represents the number of patents that cite patents from both technology classes X and Y simultaneously. $\#(X \cup Y)$ refers to the number of patents that cite patents in either technology classes X and/or Y. This symmetric measure suggests that among all the patents that cite patents in either technology

[5]This measure is widely used in other papers (e.g., Zhang (2020) and Han et al. (2022)).

class X and/or Y, if the number of patents that simultaneously cite patents in technology class X and Y is larger, then it indicates that the technology class X and Y is more proximate in the knowledge space, resulting in a $d(X,Y)$ value close to zero. Therefore, a higher value of $d(X,Y)$ indicates that X and Y are technologically more distant from each other.

Building on the measure of $d(X,Y)$, the technological distance between a patent p and the patent portfolio of firm f is calculated as follows:

$$d_\iota(p,f) = \left(\frac{1}{\parallel P_f \parallel} \sum_{p' \in P_f} d(X_p, Y_{p'})^\iota \right)^{\frac{1}{\iota}} \tag{5}$$

P_f denotes the set of patents of firm f prior to patent p and $\parallel P_f \parallel$ refers to the number of patents in the firm's patent portfolio. ι is a weighting parameter, where $0 < \iota \leq 1$. In this paper, we follow existing literature and set ι to 2/3.[6] Therefore, a higher value of $d_\iota(p,f)$ indicates that the patent is technologically more distant to the patent portfolio of firm f.

We start with the decisions made by licensors. There are two ways of technology transfer: selling the patents or licensing the patents. We test the relationship between a patent's technological distance from the owning firm and the probability of the patent being licensed out or sold. We run specification (3), where the dependent variable *Licensed_Patent*$_{i,j,t}$ equals to one if patent i is licensed out by firm j at year t, and zero if patent i is sold.[7]

Table 6 reports the empirical results. Column (1) includes firm and year fixed effects to account for any firm-specific factors and macroeconomic conditions that could potentially affect the probability of technology transfer. The negative and statistically significant coefficient suggests that a patent with a greater distance from the licensor's patent portfolio is less likely to be licensed out in a patent transaction. In other words, a firm is more likely to sell its patents that are technologically distant from its own patent portfolio and more likely to license patents that are technologically closer to its own portfolio. Column (2) controls for a set of patent-level variables that could potentially affect the patent transactions. In addition, Columns (3) and (4) account for technology class-specific factors varying over time that could potentially affect the probability of a patent being licensed or sold. Across all specifications, the coefficients of the main independent *Dist_to_Licensor*

[6] See Akcigit et al. (2016), Brav et al. (2018), Zhang (2020), Han et al. (2022), and Ma et al. (2022).

[7] We exclude firms that have both patent licensing and selling transactions.

remain negative and statistically significant. Therefore, when a firm chooses to monetize patents, it is more likely to sell patents that are furthest from its current patent portfolio while licensing those that are closer to its portfolio to maintain some control rights. Thus, the results in Table 6 support the prediction of Hypothesis 4.

Now we turn to the licensee's point of view. When licensees choose to license a patent, they might first consider which firms they could license a patent from. After selecting the licensor firms, licensee firms might decide which patents to license. To examine what kinds of patents licensee firms choose to license, we run specification (3) with $\textit{Licensed\_Patent}_{i,j,t}$ equals to one for the licensed patent i, and zero for other patents in the corresponding licensor's patent portfolio at transaction year t.[8] The independent variable $\textit{Tech\_Dist}_{i,j,t}$ in the specification (3) is now *Dist_to_Licensee*, calculated as the distance between each patent in the corresponding licensor's patent portfolio and the licensee's patent portfolio.

Table 7 reports the results on the relationship between a patent's distance from the licensee's patent portfolio and the probability of being licensed in by the licensee firm. Column (1) shows the results from a univariate regression. The coefficient on the technological distance variable is negative and statistically significant, indicating that the shorter distance between the patent and licensee's patent portfolio, the more likely the licensee will choose to license this patent. Column (2) includes technology-specific time-varying factors that could potentially affect licensee's decision to license this patent. Additionally, column (3) includes a vector of patent-level control variables, such as the number of backward citations, number of forward citations, number of claims, and a litigation dummy. Building on column (3), column (4) accounts for the time-invariant licensee firm-specific characteristics that could impact the licensee's choice. Across all specifications, the estimated coefficients remain negative and significant. Overall, the results in Table 7 are consistent with the prediction of Hypothesis 5, suggesting that licensee firms are more likely to license patents that are closer to their current patent portfolio.

In conclusion, our patent-level analyses find that for licensors, when choosing to monetize a patent by either licensing it to another firm or selling it outright, tend to sell patents that are most distant from their current patent portfolio and license those that are closer to. By engaging in

[8]Licensee firms may first consider which technology class they need to license a patent from and then choose a specific patent from this technology class. Thus, we also use a different control group, where the licensed patent equals one, and zero for other patents in the same technology class at the transaction year. The results continue to hold.

patent licensing transactions, licensors firms can facilitate technology transfer among firms while maintaining some controls over those patents. Similarly, licensee firms are more likely to license patents that are closer to their current line of business, as it would be more cost-effective for them to develop these patents internally.

7 Are Patent Licensing Transactions Efficient?

As we find above, patent licensing transactions can facilitate technology transfer among firms. Firms with higher levels of R&D expenditure are more likely to license out patents that are relatively distant from their current line of business, while licensee firms that have shown a prior decline in innovation productivity are more likely to license patents that better fit their main business. In this section, we empirically test whether this technology transfer, through patent licensing transactions, is efficient for both licensor and licensee firms.

7.1 Baseline Analysis

We first construct a control group for each licensor and licensee firm. Unlike in Section 5.1, where we selected five control firms from the same industry and with similar size for each licensor and licensee, here we use a propensity score matching method to construct the control group. In Section 5.1, our goal is to understand the factors that determine a firm becoming a licensor or licensee compared to other firms in the same industry and of similar size. In this section, we focus on the consequences of patent licensing transactions. Therefore, we need to find a control group with very similar characteristics to the licensor/licensee firms, where the only difference is that these control firms do not engage in patent licensing transactions. To some extent, This allows us to attribute the differences in outcomes between licensor/licensee firms and control firms to the patent licensing transaction.

To form the control group, we require that the control firms be in the same industry as the licensor/licensee firms. For each firm that becomes a licensor/licensee in year t, we match up to five control firms that, in year $t-1$, have similar size, R&D expenditure, ROA, leverage, cash, capital expenditure, total number of patents in the previous three years, and total number of citations per patent in the previous three years as the actual licensor/licensee firms.

We examine whether patent licensing transactions are efficient for both licensor and licensee firms using the following specification:

$$TobinQ\_1\_3_{i,t} = \alpha_j \times \alpha_t + \beta \textit{Licensor/Licensee}_{i,t} + \boldsymbol{X_{i,t}}\gamma + \epsilon_{i,t} \tag{6}$$

we use the equity market valuation, Tobin's Q, to measure a firm's performance. Specifically, the dependent variable in specification (6) is firm i's average Tobin's Q in the three years following year t. The independent variable of interest is *Licensor/Licensee*$_{i,t}$, which equals one if the firm is a licensor/licensee, and zero for the matched control firms. We control for a vector of firm-level variables, $\boldsymbol{X_{i,t}}$, including firm's number of patents, size, R&D expenditure, ROA, leverage, cash, and capital expenditure at year t, all of which could potentially affect a firm's Tobin's Q. We also include industry-by-year fixed effects to account for any industry-specific unobservables that vary over time. Robust standard errors are clustered at the industry level.

Table 8, Panel A, reports the regression results for licensors associated with specification (6). Column (1) shows the univariate regression results, where the coefficient for *Licensor* is positive and statically significant. Column (2) includes the industry-by-year fixed effects, and column (3) controls for a set of firm-specific characteristics. To further test whether patent licensing transactions indeed increase the subsequent Tobin's Q for licensor firms, column (4) controls for the Tobin's Q at the year of the patent licensing transactions. The estimated coefficients for the *Licensor* dummy remain positive and statistically significant. This suggests that, on average, three years after engaging in patent licensing transactions, licensor firms tend to have higher Tobin's Q than matched non-licensor firms. Panel B reports the regression results for licensee firms. The estimated coefficients in columns (1)–(4) are positive and significant, indicating that, compared to the matched non-licensee firms, licensee firms tend to have a higher Tobin's Q after patent licensing transactions.

Overall, our baseline results show that, after patent licensing transactions, both licensor and licensee firms have higher Tobin's Q than matched control firms. Through technology transfer, licensors can offload relatively redundant technology to licensee firms while receiving periodic licensing fees. These financial rewards can subsequently be utilized to create firm value. On the other hand, by accessing new technology more quickly, licensee firms also benefit from the licensed patents. Therefore, patent licensing transactions facilitate both licensor and licensee firms in utilizing assets more efficiently to create market value.

7.2 Identification: Difference-in-Differences Analysis

Our above matched-sample baseline regressions could potentially address the concern that firms with higher Tobin's Q, usually associated with higher growth potential, are more likely to engage in patent licensing transactions. However, there may still be unobservable factors that correlate with the main independent variable *Licensor/Licensee* and affect a firm's 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. This approach is based on the National Technology Transfer and Advancement Act (NTTAA) of 1995, which serves as a positive exogenous shock to firms' patent licensing transaction 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.

The NTTAA 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.

Therefore, based on these arguments, we utilize the passage of NTTAA as a positive exogenous shock to the licensing transaction for both licensor and licensee firms. We estimate the following

DiD framework using panel data of a five-year window around the year 1996:

$$TobinQ_{i,t} = \alpha_i + \alpha_t + \beta Licensor/Licensee_i \times Post_t + \boldsymbol{X_{i,t}}\gamma + \epsilon_{i,t} \tag{7}$$

where the dependent variable is firm i's Tobin's Q in year t. The independent variable of interest is the interaction term $Licensor/Licensee_i \times Post_t$, where $Licensor/Licensee_i$ equals one if firm i engages in patent licensing transactions during the ten-year window, and zero for the matched control firms. Here, we use the same matched control firms as in specification (6). $Post_t$ is a dummy variable that equals one if the observation is in the year 1996 and within five years after 1996, and zero if it is within five years before 1996. We control for firm-level characteristics as all our earlier specifications and include both firm and year fixed effects.

Table 9 reports our regression results using specification (7). Column (1) shows the 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 the matched non-licensor firms. Column (2) shows the regression results for $Licensee_i \times Post_t$. The estimated coefficient is also positive and statistically significant, suggesting that licensee firms similarly show an increase in their Tobin's Q five years following the NTTAA compared to the matched non-licensee firms. Overall, Table 9 suggests that patent licensing transactions causally create equity market value for both licensor and licensee firms and supports the prediction of Hypothesis 6.

The causal interpretation of the results relies on one central assumption that the parallel trend assumption required by the DiD approach should be satisfied. To empirically test this assumption, we estimate the following regression:

$$TobinQ_{i,t} = \alpha_i + \alpha_t + \sum_{t=-5, t\neq -1}^{5} \beta_t Licensor_i(or Licensee_i) \times Period_t + \boldsymbol{X_{i,t}}\gamma + \epsilon_{i,t} \tag{8}$$

Here, we examine the dynamics of the impact of NTTAA by replacing the time dummy ($Post_t$) in equation (7) with a set of dummies representing each annual period ($Period_t$). The dummy for the year when the NTTAA was signed into law (year 1996) is dropped to avoid the multicollinearity and served as the baseline group for comparison. Other variables are the same as those in specification (7). We plot the coefficients of β_t for the regression specification (8) in Figure 1. The upper panel shows the estimated coefficients for licensor firms, and the lower panel shows the coefficients for licensee firms.

Both panels in Figure 1 demonstrate no significant trend prior to the NTTAA enactment: all the coefficient estimates on $Licensor/Licensee_i \times Period_t$ are not 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 had a positive effect on both licensor and licensee firms' performance (as measured by their Tobin's Q). Thus, Figure 1 provides supporting evidence that the parallel trend assumption is not violated. Therefore, we argue that the patent licensing transactions are efficient for both licensor and licensee firms and do create value for these firms involved in the transactions.

7.3 Channels of Value Creation

Now we examine the channels through which patent licensing transactions create value for both licensor and licensee firms. For licensor firms, licensing out some of their patents results in financial rewards through periodic licensing fees. This financial inflow is expected to positively impact their equity market value. Therefore, we hypothesize that for licensor firms, the higher the licensing fees they receive, the higher their Tobin's Q following the patent licensing transactions. On the other hand, licensee firms gain access to new technologies by engaging in patent licensing transactions. This access allows them to leverage these technologies for innovation and competitive advantage, potentially enhancing their equity market value. Consequently, we hypothesize that for licensee firms, greater exposure to new technologies will correlate with a higher Tobin's Q following the patent licensing transactions.

We begin by testing whether receiving licensing fees is an important channel for licensor firms to achieve subsequent higher equity market valuation. We utilize the licensing fee data from ktMINE. As discussed in Section 4, each transaction involves several patents and various payment types. To obtain a firm-level measure of licensing fees, we first sum the fixed payments, average the variable payments related to sales, and aggregate the variable payments related to the unit price for each transaction. Consequently, each transaction is represented by a single observation that includes data from these three payment categories. Since the same licensors may be involved in multiple transactions, we aggregate the three types of payments at the licensor firm-year level. Summary statistics at the licensor level reveal that 99% of licensors receive zero in fixed payments, and 90% receive zero in variable payments based on sales. However, around 95% of licensors receive more than zero in variable payments based on unit sales. We divide the licensors into two groups based on the median value of the variable payment related to sales (7.5%): one group with above-median payments, labeled "High Royalty," and another group with below-median payments, labeled "Low Royalty."[9]

We split the licensor firms into two groups and combine the corresponding propensity score-matched non-licensor firms to run separate regressions based on specification (6). Table 10 shows the regression results. Column (1) and (4) indicate that firms receiving higher royalties (higher variable payments related to sales) exhibit higher subsequent Tobin's Q following the patent licensing transactions compared to non-licensor firms, even controlling for licensor firms' Tobin's Q at the year of patent licensing transactions. Column (2) and (5) show that licensor firms receiving relatively lower variable payments based on licensee firms' future sales do not have a higher equity market value following the patent licensing transactions compared to non-licensor firms. Column (3) and (6) present the difference between the estimated coefficients for licensor firms in the two regressions, with the positive and significant difference indicating that the distinction between the two groups is indeed significant. Therefore, Table 10 supports our prediction that licensing fees are indeed one of the channels leading to higher equity market valuation, making the patent licensing transactions more efficient for licensor firms.

To test whether exposure to new technology is a possible channel for licensee firms to gain higher equity market value, we split the licensee firms based on their degree of exposure to new technologies. Specifically, we utilize the cosine similarity between the licensee firm and the corresponding licensor firm's patent portfolio.[10] We then divide the licensee firms into two groups based on the technology similarity scores. The group with above-median technology similarity scores, indicating less exposure to new technology, is assigned to the "Less Exposure" group, and

[9] Detailed summary statistics are reported in Table 1.

[10] Although in this paper we focus on public firms, licensee firms can license patents from private licensors. Thus, we consider all licensee-licensor pairs in this analysis, including both public licensee-private licensor and public licensee-public licensor pairs.

the group with below-median technology similarity scores, indicating greater exposure to new technology, is assigned to the "High Exposure" group. For each group of licensee firms, we combine the corresponding propensity score-matched non-licensee firms and run two regressions based on specification (6).

Table 11 shows the results of the two regressions. Column (1) and (4) report the results for the licensee group with more exposure to new technology, with column (4) including the licensee firms' Tobin's Q at the year of patent licensing transaction as a control variable. The positive and statistically significant coefficient suggests that the greater the exposure of licensee firms to new technology, the higher their subsequent Tobin's Q following the patent licensing transactions compared to their matched control firms. In contrast, the coefficient in column (2) and (5) suggest that for licensee firms with less exposure to new technology, there is no significant difference in future equity market value between the licensee firms and the non-licensee firms. Column (3) and (6) present the difference between the estimated coefficients in "More Exposure" and "Less Exposure" groups, which are positive and significant. This indicates that the distinction between the two groups is meaningful, with licensee firms that have greater exposure to new technology experiencing a higher Tobin's Q following the patent licensing transactions compared to their counterparts with less exposure. Overall, Table 11 suggests that exposure to new technology enables licensee firms to better leverage these technologies for further innovation, thereby enhancing their equity market value.

8 Other Consequences of Patent Licensing Transactions

From the previous section, we conclude that patent licensing transactions are efficient and can create value for both licensor and licensee firms in the equity market. In this section, we explore whether there are other consequences associated with patent licensing transactions.

8.1 Consequences for Licensors

We first examine the consequences for licensor firms. After licensing out their patents, licensor firms receive licensing fees as a result of these transactions. These financial rewards can be substantial and provide an immediate boost to the firm's capital. With increased capital, licensor firms can reinvest in their R&D activities, enhancing their innovation capabilities. This reinvestment can lead to the development of new technologies and the creation of additional patents. Consequently, the firm's patent portfolio grows, which not only enhances the firm's market position but also increases its potential for future licensing opportunities. This cycle of innovation and reinvestment fosters a sustainable model of growth and technological advancement.

To empirically examine whether licensor firms have subsequent higher R&D expenditure and increased innovation productivity, we run a regression based on specification (6). The independent variable is $Licensor$ which equals one for licensor firms and zero for the propensity score-matched non-licensor firms. The dependent variables are $R\&D\_1\_3_{i,t}$ and $Num\_Pat\_1\_3_{i,t}$. $R\&D\_1\_3_{i,t}$ represents the average R&D expenditure for firm i over the three years following the patent licensing transaction year t, while $Num\_Pat\_1\_3_{i,t}$ represents the average total number of truncated patents for firm i over the three years following the patent licensing transaction year t.

Table 12, panel A, shows the results for the dependent variable $R\&D\_1\_3_{i,t}$. Column (1) reports the univariate regression results of the relationship between being a licensor and the subsequent R&D expenditure three years following the patent transaction, where we find a positive and significant coefficient. Column (2) includes industry-year fixed effects to account for time-varying industry-specific characteristics that could affect a firm's R&D expenditure. In addition to the industry-year fixed effect, column (3) controls for a set of firm characteristics that could influence a firm's decision on R&D expenditure over time. Across all the specifications, the estimated coefficients remain positive and statistically significant. Therefore, Panel A indicates that licensor firms have higher R&D expenditures compared to matched non-licensor firms in the three years following the patent licensing transactions. This finding further supports our prediction of Hypothesis 7, suggesting that the financial rewards from licensing fees are indeed reinvested into R&D.

We further split the licensor firms into two groups: those receiving an above-median royalty rate, the "High Royalty" group, and those receiving a below-median royalty rate, the "Low Royalty" group. We then combine each licensor firm's matched control group and assign a zero royalty rate to those control firms. Panel B reports the regression results. Column (1) shows that for the "High Royalty" group, there is a positive and statistically significant relationship between the licensor firms and the non-licensor firms' subsequent R&D expenditures three years following the patent licensing transactions. Column (2) indicates that there is no significant relationship between licensor firms receiving a lower royalty rate and the matched control firms regarding subsequent R&D expenditures. Column (3) reports the difference between the two estimated coefficients. Although the difference between the two groups is not statistically significant, Panel B suggests that licensor firms in the "High Royalty" group tend to have larger R&D expenditures than matched control firms three years following the patent licensing transactions. Overall, Table 12 provides thorough evidence that licensor firms benefit from receiving licensing fees, and the higher the licensing fees they receive, the more they will invest in R&D.

Table 13 reports the regression results for the dependent variable $Num\_Pat\_1\_3$. Across the three specifications, the estimated coefficients are positive and statistically significant, even after controlling for firm-specific characteristics and accounting for industry-year fixed effects. This robustness suggests that the positive relationship between patent licensing and subsequent innovation productivity is not driven by unobserved heterogeneity or time-varying industry conditions. The results in Table 13 indicate that, compared to matched non-licensor firms, licensor firms tend to generate a greater number of patents in the three years following the patent licensing transactions. This finding implies that the financial inflows from licensing fees are effectively utilized by licensor firms to invest in additional R&D activities, fostering the development of new technologies. Consequently, licensor firms exhibit higher innovation productivity relative to their counterparts who do not engage in patent licensing transactions. Therefore, Table 13 provides strong empirical support for Hypothesis 8.

Overall, for licensor firms, patent licensing transactions not only enhance their equity market valuation but also enable them to utilize licensing fees effectively for further investment in R&D activities and the pursuit of additional innovations. The ability to convert licensing revenues into increased R&D and innovation productivity demonstrates a significant value-creating mechanism for licensor firms. The results underscore the strategic importance of patent licensing as a means to not only monetize existing technology but also to reinvest in the firm's innovative capabilities.

8.2 Consequences for Licensees

We now examine the consequences for licensee firms. Licensee firms pay a stream of licensing fees to license in patents that they have not developed themselves. By engaging in patent licensing transactions, licensee firms gain access to new technologies and intellectual property. Thus, the infusion of external technology through licensing can complement and enhance the firm's existing R&D effort, leading to more efficient utilization of resources and greater overall new products.

In this section, we empirically test whether licensee firms increase the introduction of new products and improve innovation efficiency following patent licensing transactions. We run regressions based on specification (6). The independent variable is $Licensee$, which equals one for licensee firms and zero for the propensity score-matched non-licensee firms. The dependent variables are $Num\_Trademark\_1\_3$ and $Innovation\_Efficiency\_1\_3$. $Num\_Trademark\_1\_3$ represents the average number of new trademarks generated by firm i over the three years following the patent licensing transaction in year t, while $Innovation\_Efficiency\_1\_3$ represents the average innovation efficiency for firm i over the same period.

We follow Hirshleifer et al. (2013) to construct the proxy for innovation efficiency, defined as the ratio of patents granted to R&D capital ($Patents/RDC$). Specifically, $Patents/RDC$ is calculated as the ratio of firm i's patents granted in year t ($Patents_{i,t}$) scaled by its R&D capital, which is the five-year cumulative R&D expenses assuming an annual depreciation rate of 20%, in the fiscal year ending in year $t-2$:

$$\frac{Patents}{RDC} = \frac{Patents_{i,t}}{(R\&D_{i,t\text{-}2} + 0.8 \times R\&D_{i,t\text{-}3} + 0.6 \times R\&D_{i,t\text{-}4} + 0.4 \times R\&D_{i,t\text{-}5} + 0.2 \times R\&D_{i,t\text{-}6})} \tag{9}$$

where $R\&D_{i,t\text{-}2}$ 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.

Table 14 shows the regression results for the dependent variable $Num\_Trademark\_1\_3$. Column (1) reports the univariate regression results, column (2) accounts for the time-varying industry-specific characteristics, and column (3) also controls for a set of firm characteristics that could affect a licensee firm's capability of introducing new trademarks. Across all the specifications, we find a positive and statistically significant relationship between being a licensee firm and the subsequent number of new trademarks. This finding suggests that, compared to matched non-licensee firms, firms that choose to license in patents experience an increase in the number of new trademarks on average three years following the patent licensing transactions. Therefore, Table 14 provides strong support for our Hypothesis 9, demonstrating that patent licensing transactions facilitate the expansion of trademark portfolios for licensee firms. This highlights the strategic value of patent licensing as a mechanism for accessing new technologies and fostering product commercialization for licensee firms.

Table 15 presents the regression results for the relationship between being a licensee firm and its subsequent innovation efficiency. Utilizing similar specifications as before, we find that licensee firms tend to increase their innovation efficiency on average three years after licensing in patents compared to the matched non-licensee firms. Therefore, Table 15 supports Hypothesis 11, indicating that licensing in patents enables licensee firms to effectively leverage external innovations, which leads to an increase in overall innovation efficiency within these firms. By accessing new technologies through licensing agreements, licensee firms can enhance their innovation processes, resulting in a higher ratio of patents granted relative to their R&D expenditures.

Overall, we conclude that through patent licensing transactions, licensee firms gain access to new technologies that they have not developed themselves or would find more costly to develop internally. Access to advanced technologies enables licensee firms to introduce new products more efficiently, as evidenced by the significant increase in new trademark registrations. Additionally, the improvement in innovation efficiency indicates that licensee firms are able to maximize the output of their R&D investments by incorporating licensed technologies into their innovation frameworks.

9 Conclusion

In this paper, we make use of a large sample of patent licensing transactions from the ktMINE Patent Licensing Agreement database to conduct a large sample, cross-industry study to analyze the economics of patent licensing. We study three important research questions for the first time in the literature. First, what are the characteristics of licensors and licensees that drive the former set of firms to license out their patents to the latter set of firms? Second, what is the nature of patents that the licensor firms choose to retain and build products around versus that of patents that it choose to monetize by selling or licensing to other firms? Further, given that it has chosen to monetize a patent, what patent characteristics drive the choice of a licensor firm between selling a patent versus licensing it to another firm? Third, what are the consequences of patent licensing for licensor and licensee firms? In particular, are patent licensing transactions efficient in the sense that the equity market perceives such transactions as creating value for licensor and licensee firms?

Our empirical analysis allows us to develop a number of novel findings, which can be summarized as follows. First, we find that licensors are more likely to license patents to firms with whom they have a downstream relationship, suggesting that licensor firms take into account the indirect benefits from licensing patents (in addition to direct monetary benefits from licensing fees) when choosing firms to license their patents to. On the other hand, licensor firms are less likely to license patents to firms with technologically similar patent portfolios, suggesting that licensors may take into account the potential for future product market competition from licensee firms.

Second, our patent level analysis results suggest that licensors are likely to retain patents closer in technological distance to their current patent portfolio for their own use, while monetizing (either by selling or licensing) patents that are farther away. Further, among patents that licensor firms choose to monetize, licensors choose to license patents that are closer to their patent portfolio while selling those farther away. This is consistent with the notion that licensing allows the licensor firm to maintain some future control of the patents licensed, whereas selling a patent involves relinquishing complete control of the patent. Conversely, when choosing which patents to license, licensee firms choose patents closer in technological distance to their own patent portfolio, suggesting that they license those patents that are cheaper for them to build products around.

Third, our analysis of the consequences of patent licensing transactions for licensor and licensee firms provides us with the following findings. First, licensing transactions are efficient in the sense that these transactions increase the equity market value of both licensor and licensee firms (as measured by their Tobin's Q). We establish the causality of these baseline findings using a DiD analysis around the National Technology Transfer and Advancement Act of 1995. The results of our DiD analysis suggest that licensing transactions casually and significantly increase the Tobin's Q of both licensor and licensee firms. In terms of channels, our split-sample analysis suggests that licensor firms receiving higher licensing fees obtained greater increases in Tobin's Q relative to matched control firms compared to those receiving lower licensing fees. On the licensee side, our results suggest exposure to new technologies as a source of value increase for these firms: our split-sample analysis suggests that licensee firms that received greater exposure to new technologies as a result of the licensing transaction obtained greater increases in their Tobin's Q (relative to matched control firms) compared to those receiving a smaller extent of such exposure.

Our empirical analysis exploring other ("intermediate") consequences of licensing transactions for both licensor and licensee firms yielded the following findings. For licensor firms, we find that such firms increased their R&D expenditure and achieved greater innovation productivity (as measured by the number of patents produced) over the three years after the licensing transaction relative to matched control firms. Further, licensor firms receiving higher licensing fees (as measured by the royalty rate) increased their R&D expenditure to a greater extent. On the licensee side, we find that such firms produced a larger number of new products (as proxied by their number of new trademarks registered) over the three years subsequent to their licensing transaction relative to matched control firms. Further, while licensee firms did not increase their patent productivity, their innovation efficiency increased relative to matched control firms over the three years subsequent to their licensing transaction, suggesting a "learning by doing" effect (using their newly licensed patents).

References

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2005). Competition and innovation: An inverted-u relationship. *The Quarterly Journal of Economics 120*(2), 701–728.

Akcigit, U., M. A. Celik, and J. Greenwood (2016). Buy, keep, or sell: Economic growth and the market for ideas. *Econometrica 84*(3), 943–984.

Anand, B. N. and T. Khanna (2000). The structure of licensing contracts. *The Journal of Industrial Economics 48*(1), 103–135.

Arora, A., S. Belenzon, and J. Suh (2022). Science and the market for technology. *Management Science 68*(10), 7176–7201.

Arora, A. and M. Ceccagnoli (2006). Patent protection, complementary assets, and firms' incentives for technology licensing. *Management science 52*(2), 293–308.

Arora, A. and A. Fosfuri (2003). Licensing the market for technology. *Journal of Economic Behavior & Organization 52*(2), 277–295.

Bena, J. and K. Li (2014). Corporate innovations and mergers and acquisitions. *The Journal of Finance 69*(5), 1923–1960.

Brav, A., W. Jiang, S. Ma, and X. Tian (2018). How does hedge fund activism reshape corporate innovation? *Journal of Financial Economics 130*(2), 237–264.

Cunningham, C., F. Ederer, and S. Ma (2021). Killer acquisitions. *Journal of Political Economy 129*(3), 649–702.

Elzinga, K. G. and D. E. Mills (2011). The lerner index of monopoly power: origins and uses. *American Economic Review 101*(3), 558–564.

Figueroa, N. and C. J. Serrano (2019). Patent trading flows of small and large firms. *Research Policy 48*(7), 1601–1616.

Fosfuri, A. (2006). The licensing dilemma: understanding the determinants of the rate of technology licensing. *Strategic Management Journal 27*(12), 1141–1158.

Frésard, L., G. Hoberg, and G. M. Phillips (2020). Innovation activities and integration through vertical acquisitions. *The Review of Financial Studies 33*(7), 2937–2976.

Gambardella, A., P. Giuri, and A. Luzzi (2007). The market for patents in europe. *Research Policy 36*(8), 1163–1183.

Han, P., C. Liu, and X. Tian (2022). Does trading spur specialization? evidence from patenting. *Available at SSRN 3681360*.

Hirshleifer, D., P.-H. Hsu, and D. Li (2013). Innovative efficiency and stock returns. *Journal of Financial Economics 107*(3), 632–654.

Kim, Y. and N. S. Vonortas (2006). Determinants of technology licensing: the case of licensors. *Managerial and Decision Economics 27*(4), 235–249.

Lerner, A. P. (1934). The concept of monopoly and the measurement of monopoly power. *The Review of Economic Studies 1*(3), 157–175.

Ma, S., J. T. Tong, and W. Wang (2022). Bankrupt innovative firms. *Management Science 68*(9), 6971–6992.

Moreira, S., T. M. Klueter, and S. Tasselli (2020). Competition, technology licensing-in, and innovation. *Organization Science 31*(4), 1012–1036.

Moser, P. and A. Voena (2012). Compulsory licensing: Evidence from the trading with the enemy act. *American Economic Review 102*(1), 396–427.

Nickell, S. J. (1996). Competition and corporate performance. *Journal of political economy 104*(4), 724–746.

Serrano, C. J. (2010). The dynamics of the transfer and renewal of patents. *The RAND Journal of Economics 41*(4), 686–708.

Vonortas, N. and Y. Kim (2004). Technology licensing. *Patents, innovation and economic performance*, 181–199.

Zhang, J. (2020). Freeing up (burdened) resources: Empirical evidence from firms' secondary market patent transactions. *Available at SSRN*.

Table 1: Summary Statistics

This table reports the results of summary statistics for variables used in this paper. Panel A (Panel B) reports the summary statistics for the sample of licensors (licensees) and their 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 generated by a firm in the last three years up to a given year. CPP_3 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. 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 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 for both 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 and are measured in the year prior to a licensing transaction. 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
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
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
Panel D: Licensing Fees				
Licensor Firm Level:				
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
Transaction Level:				
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

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

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 industry-size matched non-licensor firms. Num_Pat_3 is the truncation-adjusted number of patents generated by firm i 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 generated by firm i 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			
	(1)	(2)	(3)	(4)
Num_Pat_3	0.975***			
	(0.175)			
CPP_3		0.117*		
		(0.062)		
ΔNum_Pat_3			-0.011	
			(0.015)	
ΔCPP_3				0.013
				(0.017)
R&D	0.556**	0.772**	0.907**	1.326**
	(0.220)	(0.318)	(0.447)	(0.565)
Size	0.351***	0.501***	0.701***	0.856***
	(0.070)	(0.077)	(0.099)	(0.128)
ROA	-0.389***	0.130	-0.626**	0.061
	(0.138)	(0.179)	(0.258)	(0.347)
Leverage	-0.398***	0.034	0.472*	0.585**
	(0.147)	(0.202)	(0.242)	(0.290)
Cash	0.309	0.551**	0.467	0.618
	(0.197)	(0.226)	(0.312)	(0.385)
B/M	-0.502***	-0.578***	-0.667***	-0.722***
	(0.139)	(0.152)	(0.191)	(0.212)
CAPEX	-4.451***	-3.127***	-2.110**	-1.533
	(1.161)	(1.215)	(1.404)	(1.449)
Transaction FE	Yes	Yes	Yes	Yes
Number of Obs.	4,727	3,759	2,858	2,341
Pseudo R^2	0.0718	0.0624	0.0955	0.1126

Table 3: Which Firms Are More Likely to Be Licensees?

This table reports the results on the relationship between a firm's innovation characteristics and the probability of the firm being a licensee in a patent licensing transaction. $Licensee$ is a dummy variable equal to one if firm i is an actual licensee firm who licenses in some patents in year t. This variable is equal to zero for industry-size matched non-licensee firms. Num_Pat_3 is the truncation-adjusted number of patents generated by firm i 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 generated by firm i 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.

	Licensee			
	(1)	(2)	(3)	(4)
Num_Pat_3	1.786***			
	(0.297)			
CPP_3		0.132**		
		(0.054)		
ΔNum_Pat_3			-0.042*	
			(0.024)	
ΔCPP_3				-0.044**
				(0.021)
R&D	-0.133	-0.133	0.049	0.274
	(0.188)	(0.335)	(0.493)	(0.545)
Size	0.297***	0.620***	0.989***	1.230***
	(0.061)	(0.090)	(0.104)	(0.125)
ROA	-0.860***	-1.020***	-1.367***	-1.330***
	(0.145)	(0.276)	(0.387)	(0.502)
Leverage	-0.122	-0.268	0.514*	0.927***
	(0.134)	(0.196)	(0.277)	(0.320)
Cash	0.532***	0.289	0.048	0.521
	(0.180)	(0.220)	(0.301)	(0.376)
B/M	-0.585***	-0.541***	-0.369***	-0.478***
	(0.106)	(0.126)	(0.142)	(0.152)
CAPEX	0.907	0.686	2.915**	3.050**
	(1.070)	(1.156)	(1.363)	(1.527)
Transaction FE	Yes	Yes	Yes	Yes
Number of Obs.	4,828	3,526	2,424	2,022
Pseudo R^2	0.0709	0.0669	0.1105	0.1434

Table 4: Product Market Characteristics and Licensing Propensity

This table reports the results on the relationship between product market characteristics and the probability of the firm being a licensor or licensee firm in a patent licensing transaction. $Licensor$ ($Licensee$) is a dummy variable equal to one if firm i is an actual licensor (licensee) firm who licenses out (in) some patents in year t. It is equal to zero for the industry-size matched non-licensor (non-licensee) firms. HHI is the sales-based Herfindahl-Hirschman Index constructed at the 3-digit SIC industry level. It is calculated by dividing the sales of each firm in the same industry by the total sales of that industry in a particular year, squaring the result, and summing the squared fraction across all the firms in the same industry. $Lerner\_Index$, constructed following Aghion et al. (2005), is defined as firm i's operating income net of depreciation (Compustat item: oibdp - dp) scaled by the firm's total sales in the year prior to a licensing transaction. 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)
HHI	7.282**		10.661***	
	(3.059)		(2.729)	
Lerner_Index		0.000		-0.003*
		(0.003)		(0.002)
Size	0.518***	0.550***	0.419***	0.430***
	(0.065)	(0.070)	(0.059)	(0.062)
R&D	0.560**	0.755***	-0.118	-0.408*
	(0.220)	(0.282)	(0.191)	(0.242)
ROA	-0.480***	-0.675***	-0.916***	-0.958***
	(0.138)	(0.170)	(0.150)	(0.186)
Leverage	-0.426***	-0.044	-0.127	0.067
	(0.148)	(0.172)	(0.135)	(0.145)
Cash	0.295	0.559**	0.525***	0.524**
	(0.200)	(0.230)	(0.180)	(0.210)
B/M	-0.548***	-0.495***	-0.633***	-0.570***
	(0.139)	(0.136)	(0.104)	(0.108)
CAPEX	-3.700***	-2.135*	1.267	1.636
	(1.120)	(1.139)	(1.040)	(1.036)
Transaction FE	Yes	Yes	Yes	Yes
Number of Obs.	4,795	4,427	4,865	4,380
Pseudo R^2	0.0654	0.0788	0.0656	0.0558

Table 5: Licensor-Licensee Pairing and Transaction Incidence

This table reports the results on the determinants of the pairing between a licensor and a licensee firm. Panel A reports the results on the relationship between the product market relation between licensor and licensee firms and the probability of them having an actual patent licensing transaction. Panel B reports the results on the relationship on the technology relation between licensor and licensee firms and the probability of them having an actual patent licensing transaction. $Actual\_Pair$ 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 industry-size matched firms of licensors and licensees. $Vertical\_Integrate$ is a dummy variable equal to one if a firm pair is vertically integrated. In other words, this variable is equal to one if licensees (matched pseudo licensees) have 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 generated 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. $Licensor\_CPP\_3$ ($Licensee\_CPP\_3$) is the number of truncation-adjusted lifetime citations per patent for patents generated 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. 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.

Panel A: Product Market Relation		
	Actual_Pair	
	(1)	(2)
Vertical_Integrate	0.328*	0.686*
	(0.168)	(0.392)
Licensor_Num_Pat_3		2.339***
		(0.455)
Licensee_Num_Pat_3		2.448***
		(0.482)
Licensor_CPP_3		0.409***
		(0.111)
Licensee_CPP_3		0.220*
		(0.116)
Licensor Firm Controls	No	Yes
Licensee Firm Controls	No	Yes
Transaction FE	No	Yes
Number of Obs.	28,294	5,427
Pseudo R^2	0.0006	0.0817

Panel B: Technology Relation		
	Actual_Pair	
	(1)	(2)
Tech_Similarity	-0.354***	-0.491**
	(0.100)	(0.219)
Licensor_Num_Pat_3		2.076***
		(0.499)
Licensee_Num_Pat_3		2.064***
		(0.488)
Licensor_CPP_3		0.488***
		(0.113)
Licensee_CPP_3		0.257**
		(0.126)
Licensor Firm Controls	No	Yes
Licensee Firm Controls	No	Yes
Transaction FE	No	Yes
Number of Obs.	28,374	5,229
Pseudo R^2	0.0028	0.0951

Table 6: 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. We construct this variable 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. 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	-1.0500*	-1.3128**	-1.3114**	-1.4130**
	(0.6052)	(0.6271)	(0.6698)	(0.6891)
Backward_Cite		0.3641***		0.3722***
		(0.1264)		(0.1246)
Forward_Cite		0.1349		0.1630**
		(0.0893)		(0.0745)
Num_Claim		0.0817		0.0533
		(0.1255)		(0.1376)
Litigate		0.9556**		0.8381**
		(0.4418)		(0.4212)
Firm FE	Yes	Yes	Yes	Yes
Filing Year FE	Yes	Yes	No	No
Tech Class $\times$ 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 7: 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. We construct this variable 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	-0.0152**	-0.0166**	-0.0152**	-0.0073***
	(0.0071)	(0.0074)	(0.0072)	(0.0015)
Backward_Cite			0.0035***	0.0010**
			(0.0012)	(0.0004)
Forward_Cite			0.0030***	0.0014***
			(0.0007)	(0.0003)
Num_Claim			-0.0006	-0.0004
			(0.0005)	(0.0003)
Litigate			0.0654***	0.0372***
			(0.0132)	(0.0091)
Firm FE	No	No	No	Yes
Tech Class $\times$ Filing Year FE	No	Yes	Yes	Yes
Number of Obs.	193,552	192,979	189,875	189,855
Adj. R^2	0.0038	0.0187	0.0305	0.5034

Table 8: Baseline Consequences of Patent Licensing Transactions: Firm Valuation

This table reports the results on the baseline consequences of patent licensing transactions for 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×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 generated by firm i 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***	1.093***	0.993***	0.865***
	(0.225)	(0.253)	(0.235)	(0.217)
Num_Pat			1.855	0.463
			(4.210)	(4.229)
Size			-0.110	-0.079
			(0.083)	(0.085)
R&D			0.869	0.007
			(0.608)	(0.656)
ROA			0.387	-0.020
			(0.377)	(0.427)
Leverage			0.186	0.272
			(0.883)	(0.853)
Cash			2.987***	2.018***
			(0.294)	(0.316)
CAPEX			5.414**	5.682***
			(1.604)	(1.396)
TobinQ				0.185***
				(0.033)
Industry × 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***	0.598***	0.801***	0.655***
	(0.106)	(0.092)	(0.123)	(0.119)
Num_Pat			4.477	3.631
			(3.462)	(2.488)
Size			-0.066	-0.052
			(0.045)	(0.031)
R&D			1.623***	-0.106
			(0.304)	(0.403)
ROA			0.852***	0.156
			(0.187)	(0.276)
Leverage			-0.363*	0.411
			(0.176)	(0.270)
Cash			2.695***	1.922***
			(0.356)	(0.208)
CAPEX			-4.523***	-2.105*
			(0.924)	(1.069)
TobinQ				0.233***
				(0.029)
Industry × 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 9: Difference-in-Differences (DiD) Analysis: The Impact of National Technology Transfer and Advancement Act of 1995 on Firms' Valuation

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×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. 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 generated by firm i 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 fixed effects 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	
	(1) Licensor	(2) Licensee
Licensor × Post	1.123**	
	(0.478)	
Licensee × Post		0.943**
		(0.392)
Num_Pat	2.237	2.513
	(2.283)	(2.889)
Size	-0.843***	-0.628***
	(0.212)	(0.170)
R&D	3.183***	3.146***
	(1.217)	(0.967)
ROA	-0.343	-0.438
	(0.769)	(0.628)
Leverage	0.198	-0.670
	(0.782)	(0.737)
Cash	3.906***	2.876***
	(0.747)	(0.618)
CAPEX	5.229**	3.979*
	(2.290)	(2.090)
Firm FE	Yes	Yes
Year FE	Yes	Yes
Number of Obs.	5,268	6,188
Adj. R^2	0.3418	0.3613

Table 10: Channel of Licensors' Performance Improvement: Rent Extraction

This table reports the results on the heterogeneous effects of licensing transactions on licensor firms' subsequent performance based on their ability to extract rents from transactions. The "High Royalty" denotes the sub-sample of licensor firms which charge above-median royalties for the patents they license out, while the "Low Royalty" denotes the sub-sample of licensor firms charging 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×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 generated by firm i 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 firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

	TobinQ_1_3			TobinQ_1_3		
	(1)	(2)	(3)	(4)	(5)	(6)
	High Royalty	Low Royalty	Difference	High Royalty	Low Royalty	Difference
Licensor	1.503***	0.635	0.868***	1.136***	0.614	0.522**
	(0.236)	(0.352)	(0.229)	(0.241)	(0.400)	(0.227)
Num_Pat	6.731	1.464		5.964	-0.519	
	(3.784)	(3.039)		(4.145)	(2.710)	
Size	-0.083***	-0.064		-0.059**	-0.038	
	(0.024)	(0.036)		(0.023)	(0.029)	
R&D	0.136	-0.130		-0.967	-0.768	
	(0.701)	(0.796)		(0.751)	(0.801)	
ROA	-0.206	-0.151		-0.651*	-0.376	
	(0.284)	(0.306)		(0.340)	(0.366)	
Leverage	-0.529*	-0.884***		-0.745**	-1.101***	
	(0.258)	(0.250)		(0.230)	(0.140)	
Cash	2.698***	2.274***		1.463***	1.433***	
	(0.720)	(0.552)		(0.420)	(0.317)	
CAPEX	7.254***	2.306**		7.529***	2.661*	
	(1.003)	(0.693)		(1.709)	(1.193)	
TobinQ				0.186***	0.164*	
				(0.051)	(0.076)	
Industry × 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 11: Channel of Licensees' Performance Improvement: Exposure to New Technologies

This table reports the results on the heterogeneous effects of licensing transactions on licensee firms' subsequent performance based on their exposure to new technologies from licensors. The "More Exposure" denotes the sub-sample of licensee firms which 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 which 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×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 generated by firm i's 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 firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

	TobinQ_1_3			TobinQ_1_3		
	(1)	(2)	(3)	(4)	(5)	(6)
	More Exposure	Less Exposure	Difference	More Exposure	Less Exposure	Difference
Licensee	1.403***	0.197	1.206***	1.139***	0.072	1.067***
	(0.230)	(0.213)	(0.348)	(0.270)	(0.190)	(0.316)
Num_Pat	4.120	5.642		2.856	4.541*	
	(5.145)	(3.593)		(4.141)	(2.443)	
Size	-0.154**	-0.063		-0.105**	-0.052	
	(0.056)	(0.052)		(0.039)	(0.036)	
R&D	1.489***	2.154***		0.016	0.373	
	(0.282)	(0.428)		(0.636)	(0.416)	
ROA	0.882***	1.273***		0.297	0.599*	
	(0.183)	(0.246)		(0.397)	(0.295)	
Leverage	-0.468**	-0.647**		0.534	0.256	
	(0.205)	(0.242)		(0.470)	(0.363)	
Cash	2.712***	2.996***		2.121***	2.262***	
	(0.422)	(0.368)		(0.219)	(0.184)	
CAPEX	-5.424***	-6.403***		-2.961***	-3.441*	
	(1.558)	(1.167)		(0.802)	(1.650)	
TobinQ				0.260***	0.248***	
				(0.023)	(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 12: 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 generated by firm i 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 firm 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***	0.040***	0.033**
	(0.011)	(0.011)	(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 × Year FE	No	Yes	Yes
Number of Obs.	2,324	2,324	2,203
Adj. R^2	0.0032	0.0511	0.4475

Table 13: 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 generated by firm i 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 generated by firm i 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 firm 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***	0.019***	0.004***
	(0.005)	(0.005)	(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 14: Licensees' Trademark Activity Following Licensing Transactions

This table reports the results on the effect of patent licensing transactions on licensee firms' introduction of new products after 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 generated by firm i 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 firm 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***	0.616***	0.431**
	(0.176)	(0.154)	(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

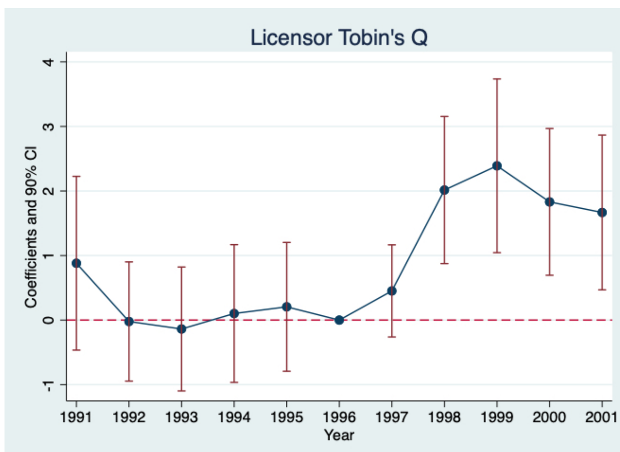
Table 15: Licensees' Innovation Efficiency Following Licensing Transactions

This table reports the results on 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) and is detailed in Eq. (9). $Licensee$ 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 generated by firm i 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 firm level and are reported in parentheses. *, **, and *** denote the 10%, 5%, and 1% significance levels, respectively.

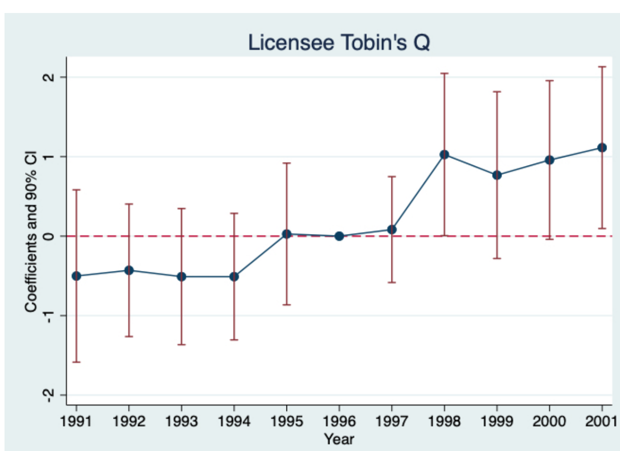
	Innovation_Efficiency_1_3		
	(1)	(2)	(3)
Licensee	0.036**	0.037**	0.036**
	(0.013)	(0.015)	(0.015)
Num_Pat			0.826***
			(0.091)
Size			-0.015***
			(0.003)
R&D			-0.037**
			(0.017)
ROA			0.007
			(0.006)
Leverage			-0.005
			(0.006)
Cash			0.049
			(0.030)
CAPEX			0.377
			(0.246)
Industry × Year FE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

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 (8). Panel A plots the coefficient dynamics for licensor firms, while Panel B plots for licensee firms. The dependent variable here is firm i's Tobin's Q in year t (Compustat item: (dlc+dltt+csho×prcc_f)/(dlc+dltt+ceq)). $Licensor_i$ and $Licensee_i$ are dummy variables equal to one if firm i is an actual licensor and licensee firm, respectively. 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. $Period_t$ 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, $Leverage$, $Cash$, 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.



(a) Licensor Tobin's Q



(b) Licensee Tobin's Q

Appendix to

The Economics of Patent Licensing: An Empirical Analysis of the Determinants and Consequences of Patent Licensing Transactions

A Variable Definition

This table displays 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