Master's Thesis

The factors influencing a contract payment structure in biotech licensing deals

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Abstract

There are many studies which try to identify and verify theoretically and empirically many factors influencing technology market's elements including rate of technology licensing, informational asymmetry, pricing of technology and so forth. In this study, based on conventional bargaining power's approach and signaling theory's perspective, I identified and verified empirically a couple of determinants influencing contract payment structure of licensing. Licensor's size and licensee's size has a positive impact on a share of fixed upfront payment in contract payment structure. Licensed technology's development phase has a positive impact on a share of fixed upfront payment in contract payment structure and licensing region has a negative impact on a share of fixed upfront payment in contract payment structure. There is significant moderation of technology development phase on direct effect of licensor's size and leverage on contact payment structure. Generally, in biotechnology industry, conventional bargaining power's approach is dominant over signaling theory's perspective. Total asset as a proxy for size is justified empirically compared to other size measures such as total revenue.

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1. Introduction

As licensing has been a growing phenomenon, understanding how the price of licensing deals and their payment structure are determined has become of significance to both technology management scholars and managers of technology firms. A dominant view in the licensing literature is to see patents or internally-developed technologies as a signal of a firm value. Similarly, many prior studies verified empirically that a potential licensor uses dual payment structure (fixed upfront payment and performance-based contingent payment) to signal the value of a technology under an information asymmetric condition of a market for ideas (Kotha et al., 2018).

Signaling theory is useful for describing behavior when two parties (individuals or organizations) have access to different information (Cornnelly, Certo, Ireland, and Reutzel, 2011). Signaling theory is fundamentally concerned with reducing information asymmetry between two parties (Spence, 2002). Signaling theory has demonstrated that certain financial or technological characteristics of firms can be regarded as credible indicators of the positive or negative attributes of a firm which tries to appeal its quality for capital and labor providers in factor input market, and certain actions pursued by firms can be construed as characteristics (value) of a technology or a product which are meant to be sold, thereby reducing information asymmetries and allowing potential buyers to make informed purchasing decision (Etzion and Pe'er, 2013). In capital and labor market, patents are often used to reduce information asymmetry between capital and labor providers and firms, which are patent holders (Ndofor and Levitas, 2004). In technology market, licensors' characteristics and dual payment structure of a licensing contract is used to signal the value of licensed technology to reduce information asymmetry and overcome patent's future performance uncertainty (Kotha et al. 2018, Ruckman and McCarthy, 2017).

Developed technologies can be used to indicate firm's potential value and expected future R&D performance, which results in a situation in which capital providers decide whether or not they provide a firm with their capital dependent on the firm's developed technologies' quality and amount. Especially a patent, codified technology and exclusive legal right to use the technology, serves a signaling function to reduce informational asymmetry in capital and labor market in reality (Ndofor and Levitas, 2004). By reducing informational uncertainty of new ventures, patents make venture capitalists do better financing decision based on a signal originated from new ventures' patents (Haeussler, Harhoff, and Mueller, 2009). Especially, if new ventures don't have any characteristics to be a signal to convey their own quality to capital providers, (i.e. reputations of their founders), importance of patents as a positive signal of the firm is amplified (Hsu and Ziedonis, 2013). There is also evidence of the relationship between firm's market value and patents. Albeit mentioned implicitly in a couple of papers, patents and patents' quality are also recognized empirically as valuable resources and a positive signal of a firm value in equity market (Griliches, 1981; Hall, Jaffe, and Trajtenberg, 2005).

If a firm developed a technology and patented successfully, the firm needs to decide whether a developed technology will be used internally for further development or licensed (Gans and Stern, 2003). There are many papers which identified and verified factors influencing the probability of licensing of developed technology instead of using internally. Gambardella et al. (2007) shows that licensor's size, patent breadth of licensor, patent protection, and other factors have an impact on the willingness to license. Fosfuri (2006) verified empirically that firm's decision to license depends on revenue effect and profit dissipation effect which derive from licensing. After a licensing deal is decided and during negotiation of contract terms, the most important problem which needs to be solved is a valuation of a technology to be licensed. There are several studies which try to identify a value of a technology, not in market context but in other aspects (Trajtenberg, 1990; Lerner, 1994; Gambardella et al., 2008). There are also a couple of papers which try to determine the factors influencing pricing of a patent in technology market.

Price of technology can be shown in two ways. The one representation is total deal size (aggregate price of technology). Lan (2016) shows empirically that licensing deals' characteristics and licensing environment influence the total price of licensed technology. The other representation consists of two components, upfront payment and contingent payment. Dual structure of total price (fixed upfront payment and performance-based contingent payment) is normally used to solve problems of future performance uncertainty of licensed technology and informational asymmetry inherent in a transaction itself (Gallini and Wright 1990). Sakakibara (2010) identifies and verifies empirically the factors that influence the royalty rate of patent licensing in conventional bargaining approach. In this study, Sakakibara estimates the upfront payment and running royalty as separate dependent variables on two equations by 3SLS regression and shows that running royalty is better proxy for a price of a technology. On the other hand, Kotha et al. (2018) treats upfront payment and running royalty in the context of dual contract payment structure, which means they show different aspects of a single total price. A result shows that variation in dual payment structure of price is used for a licensor to signal a value of licensed technology and to overcome informational asymmetry in a licensing deal.

In Sakakibara's and Lan's study, there isn't an attempt to treat fixed upfront payment and performance-based contingent payment in the context of dual payment structure. In Kotha et al.'s work, samples of research are limited to licensed technologies developed in university.

Following these research streams and trying to fill the gap, in this study, I tried to analyze empirically the influence of various factors associated with licensing on a contract payment structure under both conventional bargaining principle and signaling theory with the sample of licensing deals in biotechnology industry.

2. Theory

Technology market and innovator's decision to license technology

After a technology is developed, a technology holder needs to decide whether the technology will be used internally or licensed. At this foremost moment, it is better to describe the situation as whether the technology should be licensed or can be developed internally further for commercialization. There are many preconditions for an innovator to develop technology further internally. First is complementary asset. If a technology holder is a start-up or university lab, then, it is hard to imagine they own complementary assets to commercialize technology at the time of developing (George, 2005; Gans and Stern, 2003). Second is the access to financial market. If a technology holder is a new venture which has no reputation in terms of previous performance or a company in a hard financial condition, the technology holder has limited opportunity to access financial market and few capabilities to obtain complementary assets in exchange for loan to commercialize technology (David et al, 2008; Sakakibara, 2010; Hsu, and Ziedonis, 2013). Third is environmental factors surrounding technology transfer process. Negotiations in the market for ideas entails substantial risk, requiring costly search and disclosures that confer powers towards established firms (Gans and Stern, 2003). If a legal system to monitor market for ideas doesn't be formed or functioned well, a technology holder will be reluctant to transfer technology in a licensing deal because of knowledge spillover followed by licensee's imitation and decrease of appropriability from own-developed technology. If there are many other players who already have complementary assets for commercializing the technology, a start-up holding newly developed technology is more likely to use existing value chain to commercialize (Teece, 1986). Other environmental factor needed to be considered carefully is fragmented patents' ownership structure and litigation landscape in technology-related industry environment (Lan, 2016). Fragmented patent ownership structure, patent thicket, is a "dense web of overlapping patent rights that a company must hack its way through in order to actually commercialize new technology" (Shapiro, 2004). There have been researches examining the direct influences of patent thickets on the technology licensing strategy of firms (Lin, 2011; Cockburn et al., 2010). If there isn't an adequate system to treat this patent thicket, then, technology holder has no choice but to license for appropriating some of the rents derived from technology's reaching product market and because a technology holder who commercialize technology of its own accord may be litigated from other parties who own similar patent whose scope is related with the commercialized technology. If there is an active litigation landscape and it is easy to be embroiled in patent litigation, then, a new venture and a start-up must license a patent to an established market player to avoid possible patent disputes which require disputing parties' huge amount of financial resources. To solve these problems originating from patent thicket, cross-licensing and patent pooling, if properly applied, could function to reconcile potential disputes across a dense web of patents, prevent actual patent lawsuits from happening, and make market for ideas better and impartially functioned than previous situation (Shapiro, 2004; Choi, 2010).

If preconditions for internal development are satisfied and licensors can decide whether licensing or internally developing technology rather freely, they need to consider pros and cons of licensing and internal use with respect to possible rents to be appropriated and the circumstance or tendency of licensing in each technology sector. In the former respect, Arora and Fosfuri (2003) shows that a firm's rate of technology licensing can be explained by the interplay of two effects that licensing produces on the licensor's profit: profit dissipation effect and the revenue effect. Technology licensing forces a trade-off: licensing and royalty revenues net of transaction costs (the revenue effect) must be balanced against the lower price-cost margin and/or reduced market share implied by increased competition (the profit dissipation effect) from the licensee. In the latter respect, Anand and Khana (2000) identify and verify empirically the difference of rate of technology licensing in each technology sector (Broadly speaking, it can also be illustrated in the context of profit dissipation effect and revenue effect). In terms of profit dissipation and revenue effect, licensing will occur if profit dissipation effect is less than revenue effect or internal development will be chosen if profit dissipation effect is more than revenue effect (Fosfuri, 2006). When evaluating profit dissipation effect and revenue effect resulting from technology licensing, almost same criteria which are used to evaluate possibility of internal use of technology are utilized in evaluating the cost of internal development, which is closely associated with profit dissipation effect. It is rational to understand the fact that the cost of internal development reduces profit dissipation effect in licensing. When licensor doesn't have any complementary asset, if they want to commercialize technology, they need to buy complementary asset in capital good market. This increase fixed cost and decrease price-cost margin. Increasing cost of internal development deters technology holders from trying to develop technology of its own accord. When a licensor doesn't have any performance or reputation in the industry and assets to be collateralized and the licensor tries to get a loan for financing complementary assets to commercialize technology, financier will discount this licensor's bond more than established player in the market. This increased cost of internal development which reduces profit dissipation effect in licensing promotes licensing (Gambardella et al., 2007). If licensor's industrial sector is in a fragmented ownership structure and high litigation landscape, the possibility of intruding others' patent scope and being embroiled in litigation when a technology is developed internally means future expected losses, if this amount of expected losses and possibility of expected losses are substantial, then considerable expected cost in internal development promotes licensing of technology. Hitherto, rate of licensing is mainly explained by profit dissipation effect. The other important effect, revenue effect, also must be considered side by side carefully. When revenue effect is considered, the indispensable element is pricing of licensed technology. In addition, beyond revenue and profit dissipation effect framework, when trying to evaluate participation of licensing under whatever approach, a pricing of a technology to be licensed is the foremost one to be considered carefully.

Pricing of licensed technology and conventional bargaining approach

There is no public market for technology. The price of a technology is determined by a private negotiation between a licensor and a licensee (Sakakibara, 2010). This different characteristic compared to other general transaction causes the fact that a pricing of technology to be licensed is affected by characteristics of licensor, licensee, and other environmental factors apart from technology itself (Rey & Salant, 2012; Galasso, 2012). There are several aspects influencing the fact that pricing of licensed technology is hard to complete by means of traditional asset pricing approach. It is hard to estimate profitability, expected future cash flows, of licensed technology and it is also hard to find out a previous benchmark to compare to determine a price of licensed technology. This situation makes a pricing of licensed technology hard just based on commonly-used valuation methods. Another problem is informational asymmetry and costs involved in transaction itself. All licensing transaction involves a better-informed licensor and a less-informed licensee. If the licensee has enough resources to use for investigating and evaluating the technology properly, then the licensor and licensee can distribute revenue streams of licensed technology rather fairly under limited knowledge and expectation. After estimating expected revenue streams of licensed technology based on information in hand, the licensor and licensee need to decide how much part of income streams the licensor will take and the licensee will take, which implies licensor's revenue effect. The maximum price a licensor can potentially charge is the expected net present value of the patent for a licensee. The minimum price a licensor can accept is the transfer costs of licensed technology plus opportunity costs of licensing (Contractor, 1981).

There are a couple of commonly introduced factors which have influence on opportunity costs of licensing. A factor is whether a technology to be licensed is core or not. A core technology of licensor will ask more opportunity cost than non-core technology because of a possibility of spill-over and imitation of core technology on which licensors depend more than non-core technology for revenue generation (Sakakibara, 2010; Grandstrand et al., 1997; Gambardella et al., 2007; Palomeras, 2007). So, an increased profit dissipation effect and an opportunity cost of core technology licensing for a licensor increase a price of a deal.

Another factor is a distance between a licensor and a licensee in terms of their main industry sector (Sakakibara, 2010). If licensor's and licensee's main industry sectors are near, then, it is more likely that licensee's product market overlaps licensor's product market. This results in increased profit dissipation effect and more opportunity cost of licensing for the licensor, which increases a price of a deal. On the other hand, a licensor has a greater incentive to license and might accept a low price if a licensee is in a different industry and not likely to be a competitor as the result of licensing because the licensor does not have to be compensated for the reduced profit from intensified competition (Sakakibara, 2010; Arora and Fosfuri, 2003).

The other determinant for opportunity cost of licensing is product market share. If the licensor has a small market share, the rent dissipation effect is smaller because there is a lower loss from creating another competitor after licensing. By contrast, the licensor which has a large market share asks higher price because they have more to loss from licensing (Gambardella et al., 2007). Consequently, a price of licensed technology will fall between the maximum price and minimum price, depending on the bargaining powers of a licensor and a licensee.

As regards a pricing of technology, there is a thing to consider in addition to the total price mentioned hitherto, dual payment structure. Dual payment structure consists of fixed upfront royalty and performance-based contingent payment which is also separated into running royalty and other milestone payments/promises to be made later on should the predetermined conditions are met (Lan 2016). This dual structure solves the problem of market failure that can be derived from licensed technologies' future performance uncertainty and informational asymmetry between two parties. Technologies' uncertain future performance makes licensed technology risky asset. To share this inherent risk and to promote after-licensing collaboration to commercialize licensed technology properly, a licensee prefers contingent payment (Gallini and Wright, 1990; Macho-Stadler et al., 2008). On the other hand, economic theory predicts that based on risk aversion and financial constraints, the licensors will prefer fixed up-front payment for their licensed technologies (Crama et al., 2008; Kulatilaka and Lin, 2006). Consequently, in addition to a certain total price, structure of payment is decided by a negotiation depending on the degree of uncertainty of expected performance of licensed technology, informational asymmetry, and bargaining power of licensors and licensees. The higher degree of uncertainty of expected performance of licensed technology and informational asymmetry between both parties makes a licensing technology riskier asset, and it means that the amount of risk that should be shared by means of contingent payment increases. Following the process of measuring the amount of risk based on limited knowledge, this certain degree of risk (degree of uncertainty of future performance of licensed technology) should be shared between both parties by means of a payment structure, depending on their respective bargaining powers. There are several factors determining a licensor's and a licensee's bargaining powers. Basically, bargaining power is determined by how many choices a licensor or a licensee can choose instead of participating in this licensing compared to a counterpart (licensee for licensor, licensor for licensee) and how flexible they can decide to take part in several choices to extract similar revenue streams from the technology (so, the licensor has several choices to use internally developed technology and the licensee has a couple of choices to license similar technology or to invent around original technology. Several choices are rather indifferent with respect to risk and profitability under limited expectation.) (Arrow and Debreu, 1954). There are many papers identifying determinants of bargaining power and verifying empirically the fact that these determinants influence a price of licensed technology in an expected manner (Gambardella et al., 2007; Fosfuri, 2006; Kotha et al., 2018; Sakakibara, 2010; Lan, 2016).

Firm size is one of determinants of bargaining power of a licensor and a licensee. A large licensor is likely to possess complementary assets to successfully commercialize its innovation (Teece, 1986), or it can buy complementary assets quickly and more cheaply due to its access to the financial markets (Gambardella et al., 2007). These current and potential complementary assets a large licensor can access give it a strong bargaining power (Sakakibara, 2010). When it comes to a contract payment structure, a strong bargaining power derived from large licensors' size makes the licensor be able to extract more revenues in a form of fixed upfront payment, which results in a larger share of fixed upfront payment in a contract payment structure. Another aspect to consider is adverse selection of large licensors (Sakakibara, 2010). Katz and Shapiro (1985) and Rockett (1990) showed that small or lower quality inventions tend to be licensed, while major inventions (i.e. ones that afford the inventor an effective monopoly) tend not to be licensed. One would expect that this adverse selection would be more pronounced for large firms, because large firms have more alternative ways to generate and utilize their technological portfolio than do small firms (Jaffe and Lerner, 2004). Therefore, when a large firm does license its technology, it is likely that such technology has little value. A potential licensee faces choices between sourcing technology through licensing and developing the technology on its own (including inventing around) (Gans and Stern, 2003). It is hard for small licensees to develop the technology to invent around original technology supposed to be licensed, because of limited resources to be spent for R&D and limited access to capital market like the situation of small licensors (Sakakibara, 2010). These restricted choice sets make a small licensee have a weak bargaining power followed by higher price of a deal and higher upfront ratio in a contract payment structure. In addition to the bargaining power approach, based on information asymmetry inherent in licensing transaction, there is another explanation for the effect of a licensee's size on a price of deal. Large potential licensees have more resources to use to search for high quality technology which is fit to their strategy. This results in a condition in which large potential licensees can find out high quality and good strategic-fit technology among a variety of technologies in market and successfully license-in and commercialize than small potential licensees. This high quality technology requires the licensee to pay higher price compared to average price of technologies in the same industry sector, but it can generate much more revenues for a licensee after successful commercialization. Contrary to the adverse selection of a licensor in a licensing deal, this phenomenon can be termed as "lucrative selection" of a licensee in a licensing deal. In addition to the reasoning for total price, it can be stated that a large licensee who can find out and evaluate high quality technology accurately would try to appropriate rents from technology exclusively, followed by higher upfront ratio in contract payment structure.

Leverage of capital structure is another determinant of bargaining power. There are a couple of papers which verify the relationship between a company's leverage, R&D expenditure, and R&D performance (Greve H, 2003; Kochhar, 1996; O'Brien, 2003; David et al, 2008). When a company has additional resources in addition to the reserves to pay for debt, these additional resources may affect decisions to continue or discontinue R&D projects (Greve H, 2003). A couple of papers have verified empirically that debt and R&D intensity are negatively associated in a different reason to that of Greve (2003) (Balakrishnan & Fox, 1993; Long & Malitz, 1985; Vincente-Lorente, 2001). Vincente-Lorente (2001) shows that strong R&D intensity causes a firm to have a large proportion of intangible assets which is firm-specific (it is a technology, not a product for general consumer or not like financial instruments whose value is determined fairly in capital market.). In the case of financial distress, firm-specific assets will suffer large losses of value when the corporation is reorganized or liquidated. Thus, theory suggests that equity financing is optimal for assets whose value is sensitive to the financial condition of the firm (Myers, 1977; Williamson, 1988). Also, in lenders' perspective, since highly specific assets have a limited capacity to insure lenders against bankruptcy, bond holders will react by charging a risk premium to debt cost, enforcing an inverse relationship between specific resources and financial leverage. Based on these studies, the relationship between bargaining power of each parties and each one's leverage can be surmised (Choi and Triantis, 2012).

If a potential licensor's leverage is substantial, the licensor is hard to finance complementary assets with both equity and debt (because of reasons mentioned just before, lenders regard a specific technology as a poor-collateral and are reluctant to lend, and equity financiers are also reluctant to buy the potential licensor's issued equity either privately or publicly in a judgement based on the high leverage of the potential licensor which raises the possibility of credit event such as bankruptcy.) to commercialize a technology or develop the technology further instead of licensing, and this situation forces the potential licensor to license for generating revenue and results in weak bargaining power, which makes total price of licensing deal and fixed upfront ratio in contract payment structure lower. Similar explanation can be applied for potential licensees. If a potential licensee's leverage is considerable, it is hard for the licensee to invent around a technology meant to be licensed, owing to limited resources to be spent for R&D and limited access to capital market resulting from high possibility of credit event and more cost of a financing, which causes the licensee's bargaining power to be lower and makes total price of licensing deal and fixed upfront ratio in contract payment structure higher.

Traditionally, a technology development phase is regarded as a proxy for the degree of uncertainty of future performance of licensed technology. In addition to the increased uncertainty of future performance, when inventions are closer to science than technology, information asymmetry regarding their values between both parties increases (Heeley et al., 2007, Kotha et al., 2018). The licensee is less likely to have enough information to investigate the technology closer to science than to product market and licensor is less likely to have enough information to evaluate expected revenue streams from use of technology fairly and accurately, which results in increased informational asymmetry and uncertainty of expected cash flows followed by a high amount of risk to be shared between both parties. So, even if both technologies have same expected revenue streams based on limited information in hand, Science-like technology will be priced less than product-like technology because of more risk. This results in technology development phase positively associated with the value of technology. Consequently, science-like technology's possible value will be distributed in lower price region than a price distribution of product-like technology. In terms of the variance of distribution, science-like technology's price distribution is more dispersed than product-like technology's price distribution because of higher risk inherent in technology. This difference in price distribution results in a situation in which an impact of licensor's and licensee's bargaining power on pricing increases when a technology to be licensed is science-like (there is larger price range on which licensor's bargaining power can impact.). The structure of payment can also be affected by technology development phase. In a licensing deal involved in riskier science-like technology, higher risk that should be shared by both parties increases the share of contingent payment in the total price. In addition to the direct effect of risk on the contract payment structure, it can be predicted that science-like technologies' higher risk that should be shared by both parties compared to mature technology results in a situation in which an impact of licensor's and licensee's bargaining power on contract payment structure increases.

Regions in which a licensed technology can be commercialized are a commonly used indicator for markets for a product developed based on the licensed technology. From a common-sense point of view, the larger region in which a licensed technology can be commercialized, the higher the total price of licensed technology. Larger region means more product markets and target consumers in and for which the product can be sold and more revenue streams for licensees which should be distributed between both parties depending on the bargaining powers of both parties (Lan 2016). Licensing region can also moderate the impact of bargaining power of licensor on pricing. If a licensing region is broad, there are fewer potential licensees who can afford to commercialize licensed technology with complementary assets. Licensing in broader region will require the licensee to have more complementary assets to produce more products and broader distribution channel than licensing in smaller region. These fewer potential licensees who can commercialize the technology decreases the impact of licensor's bargaining power on the price of the deal. Also, like a technology development phase, licensing region can also impact the structure of payment. As explained just previously, broader licensing region implies fewer potential licensees with whom a potential licensor should negotiate a deal. This increases a bargaining power of licensee and decreases a bargaining power of licensor. The licensor prefers fixed upfront payment and the licensee prefers performance-based contingent payment. Increased bargaining power of licensee and decreased bargaining power of licensor results in larger share of contingent payment in total price.

Until now, I tried to explain the determinants of a pricing in licensing deal by conventional bargaining approach. There is the other approach that can explain the factors influencing a pricing of technology to be licensed rationally, signaling theory

Signaling to solve informational asymmetry

Information affects the decision-making processes used by individuals in households, businesses, and governments. Individuals make decisions based on public information, which is freely available, and private information, which is available to only a subset of the public. Stiglitz (2002) explained that information asymmetries occur when "different people know different things." Because some information is private, information asymmetries arise between those who hold the private information and those who could potentially make better decisions if they had it. So, the depth of theory lies in attributing costs to information acquisition processes that resolve information asymmetries in wide socio-economic phenomena (Corennelly et al., 2011).

Akerlof (1970) examines how the quality of goods traded in a market can degrade in the presence of information asymmetry between buyers and sellers, leaving only "lemons" behind. Spence (1974) demonstrated that in such markets, reestablishment of effective market could be achieved if above-average quality product sellers could engage in some costly effort to signal their quality to the market. Signals are "things one does that are visible and that are in part designed to communicate" (Spence, 2002: 407). Spence (1973) conceptualized an economic signal as a mechanism for credible information flow between economic agents with a great deal of accurate information (sellers) and those with little accurate information (buyers). Signals and signaling have the following characteristics: (1) Signaling occurs when the better-informed party (sender) moves first and provides an indication of the underlying quality to the uninformed party (receiver); (2) The signal is credible if the investment that is made by the sender is costly and irreversible; (3) The signal is informative if the magnitude of the cost to signal is dependent on the underlying quality of the sender (Spence, 1973; Kotha et al., 2018). The uninformed party receives the signal and enters into a contract that fits their assessment of the sender's underlying quality (Kotha et al., 2018). Accurate information can be delivered through signals when it is less costly for a provider of a high quality good to generate the signal than it is for a provider of a low quality good. When the cost of attaining a signal is sufficiently high to deter low quality actors from pursuing one, the resultant separation yields two clearly demarcated subpopulations: high quality actors that generate the signal, and low quality actors that do not. This grouping dependent on whether a signal is emitted or not from informed party to uninformed party participating in a transaction is called 'separation' (Spence, 2002). This separation between high quality actor and low quality actor can be dichotomized by a specific signal's existence or it can be continuous distribution, which implies the higher end representing high quality actor's strong signal and at the lower end representing low quality actor's weak signal.

In factor input markets, signaling research (Riley, 2001; Ndofor and Levitas, 2004) has established third-party affiliation, capital structure, and dividend policy as some of the most effective signals of a firm's knowledge endowment. Also, there are many studies which verified empirically firm's patent pools or firm's R&D expenditure can be good signals for capital providers' decision to finance a firm and what sort of finance (i.e. equity or liability) they will provide for the firm (Long, 2002, Heeley et al., 2007, Hsu and Ziedonis, 2013, Guo et al., 2005). Bhattacharaya and Ritter (1983) examined an important trade-off between the cost of publicly disclosing valuable information which reduces an informational advantage vis-à-vis rivals in similar industry and its benefit in signaling firm's value to the capital providers so that technology holder's financing cost will reduce. Long (2002) verifies theoretically that if an easily measurable firm's attribute such as patent counts is positively correlated with other less readily measurable firm's attributes such as knowledge capital, then patent counts can be used as a means of conveying information about these other attributes. Knowing this, firms may choose to obtain (instead of the use of technology in secrecy if they don't consider licensing.) and use a portfolio of patent rights to signal information about themselves that would be more expensive to do through other means in capital market. Similarly, a firm's patent portfolio signals to capital providers the firm's ability to convert R&D resources into new knowledge. It represents the firm's stock of cumulative innovation activities that provides the necessary absorptive capacity (Cohen and Levinthal, 1990). To get a patent, firms must go through a predefined process to obtain. In this scenario, high quality firms are more likely than low quality ones to go through this process successfully. Also, high quality firms are more productive in their use of R&D investments and thus have greater number of patents. As such, the patent pools of a firm can be an effective signal in providing an insight for capital providers to distinguish a high quality firm from a low quality one.

In a technology market, the relationship between a licensor and a licensee might be hindered by three major contractual hazards. Each one is a source of significant transaction costs in the transmission of knowledge (Marimont et al., 2010). First, since commercial ideas may contain tacit knowledge often hard to describe contractually but privately known by licensors, contracting is subject to asymmetric information. Second, the effort of the licensor during the development and commercialization of licensed technology after licensing may be difficult to verify (opportunism). Lastly, knowledge is a public good and, during the negotiation with a licensor, a licensee may infer and imitate (reverse-engineering) licensed technology and licensor's idea (an issue associated with the protection of property rights, also called spill-over) (Stiglitz 2000, Marimont et al., 2010). In a legal regime and an industry sector which uphold various degree of legal protection of property rights, to reduce and resolve informational asymmetry between both parties participating in a deal, a licensor signals the value of a technology to be licensed in two ways. The one is licensor's own characteristics including the size, capital structure, the number of star scientists, and licensor's patent portfolio which enhances and signals the licensor's own reputation and technological expertise in the relevant field (Ruckman K and McCarthy I, 2017). The other is a variation of dual payment structure in pricing a deal.

Firstly, there are many papers identifying and verifying theoretically and empirically which characteristics of a potential licensor is attractive to a potential licensee and why these characteristics make a potential licensor more attractive to a potential licensee and affect probability of a successful technology licensing positively. Audretsch and Stephan (1996) and Macro (2007) shows that a firm's reputation is based on the quality of its key productive resources such as star scientists in biotechnology firms and the quality of patent stocks. Allen (1984) verifies that past licensing performance enhances current licensing performance because past performance provides a signal of future invention quality to potential buyers. Sine et al. (2003) shows that universities with stronger research standings is more likely to license than their lower standing research counterparts. Arora and Gambardella (1990) shows that technological depth acts as a signal to others of their technical expertise in their relevant technological field. Ruckman and McCarthy (2017) identify and verify the reasons why a particular licensor's patent was licensed over all technologically similar patents held by other dissimilar licensors. They theorized and hypothesized based on psychological theory such as "halo effect" (Thorndike, 1920) and "Matthew effect" (Merton, 1968), and confirmed empirically that patents owned by licensors with reputation in relevant field, experience at licensing, and combined technological depth and breadth have a greater chance at being chosen by licensees compared to similar alternatives which are owned by other potential licensors who have less reputation, less experience at licensing, and shallow technological debt and narrow technological breadth. This work has special implication for signaling in technology market. In this work, a licensable patent is a unit of analysis, and they found out in case of patents similar to a patent to be licensed which are hold by different potential licensors, a licensee chooses to license-in a technology which is developed by the licensor with high quality, which implies a licensee values similar patents differently depending on signal emitted from a potential licensors' quality such as reputation. This result implies that in addition to a quality of licensed technology, signals which show a quality of the licensor influences a pricing of technology.

Dual payment structure of a price is the other element which is normally used as a signal to reduce information asymmetry in a licensing deal (Gallini and Wright, 1990; Marimont et al., 2010; Kotha et al., 2018). According to conventional bargaining approach, a risk-averse licensor prefers to reduce the share of performance-based contingent payment including running royalty and other milestone payment to minimize risk and a risk-averse licensee prefers to increase the proportion of contingent payment in total deal size to share risk with the licensor in a licensing deal (Gans and Stern, 2003). Consequently, a licensor with strong bargaining power compared to the bargaining power of a licensee will increase the share of fixed upfront payment and decrease the share of contingent payment. However, signaling theory predicts the resultant dual structure of price after completing the deal in a different manner. In the absence of any device to credibly disclose information of a licensed technology, contract design (structure of payment) is the only remaining tool to communicate information and quality of technology (Macho-Stadler and Perez-Castrillo, 1991). Accordingly, contracts are distorted to relax the informed licensor's incentive constraint. As a consequence, private information on the quality of a licensed technology requires licensors to take significant contingent payments (including royalty) in the project as a credible means of signaling. A high quality potential licensor signals themselves for a potential licensee by means of payment structure which a low quality potential licensor is hard to follow because of more uncertain future performance of licensed technology which causes the low quality licensor to be more reluctant to share risk by means of performance-based fee, and not enough internal resources to pay for both technology development cost and patent filing related cost makes a low quality licensor hard to wait for contingent payments based on future performance. This situation makes higher share of performance-based fee in total deal price an effective signal to separate a high quality licensor from a low quality licensor (Marimont et al., 2010). So, the ability to signal is different depending on licensors' quality. The need to signal comes from the degree of uncertainty of expected performance of licensed technology and licensee's information in hand about the technology. In their recent paper, Kotha et al. (2018) address an issue which is to integrate signaling ability and need into a unified framework to better understand how both parties agree on contract payment structure. The need for signaling is greater in more uncertain environments (Hsu and Ziedonis, 2013; Ozmel et al., 2013; Ramchander et al., 2012). Inventions at different stages of development, produced by different levels of inventor experience, or patent scope may influence the licensee's need for information about the invention. These conditions increase or decrease uncertainty about expected performance of licensed technology followed by increased or decreased need for signaling. However, not all signals such as reputation originated from licensor's own characteristics can be strengthened in the face of greater uncertainty than normal condition. Lack of other signaling devices in higher uncertain condition induces potential licensors to use contract payment structure to signal a value of a technology to be licensed. As explained above, a high quality licensor can signal a value of technology to be licensed by means of larger share of contingent payment in total price. In other words, a high quality licensor has the ability to signal by means of contract payment structure. When the need for signal increases in certain circumstances, the ability to signal by contract payment structure can meet the increased need for signal in uncertain environment, which results in increased share of contingent payment in total deal size (Kotha et al., 2018).

In case of the role of a signal (reputation) in pricing a technology to be licensed, there are a couple of studies including Ruckman and McCarthy (2017) which identifies and verifies empirically reputation related variable's effect on pricing of the licensed technologies. However, as for the role of the contract payment structure as a signal of a quality of a technology, there isn't enough research which analyzes empirically related phenomena. Recent research of Kotha et al. (2018) verified empirically related phenomena in the context of university technology licensing. Based on the previous researches, I tried to identify and verify empirically that the effect of licensor's quality as an ability to signal on a contract payment structure in different circumstances which need different levels of signal in the biotech licensing deals.

3. Hypotheses

Under both bargaining power's approach and signaling theory, I proposed the hypotheses to be tested.

Under conventional bargaining power's approach, as a licensor's size increases, licensor's bargaining power also increases, because already prepared complementary assets to commercialize a technology and easy access to capital market to finance further development or commercialize gives a potential licensor more choices to generate revenue by using the technology in either internal development or license-out (Sakakibara, 2010). This increased bargaining power of a licensor makes the upfront ratio in the contract payment structure higher. If there is some amount of risk to be shared between both parties by means of performance-based contingent payment, bargaining power's approach predicts that relative bargaining powers between a licensor and a licensee has a significant effect on the contract payment structure. As a licensors' size increases, risk-averse licensors who prefer fixed upfront payment can make contract payment structure have higher upfront ratio. Another aspect to consider is adverse selection of large licensors (Sakakibara, 2010). Katz and Shapiro (1985) and Rockett (1990) showed that small or lower quality inventions tend to be licensed, while major inventions (i.e. ones that afford the inventor an effective monopoly) tend not to be licensed. One would expect that this adverse selection would be more pronounced for large firms, because large firms have more alternative ways to generate and utilize their technological portfolio than do small firms (Jaffe and Lerner, 2004). Therefore, when a large firm does license its technology, it is likely that such technology has little value. From this reasoning of adverse selection, large licensors would license an inferior technology more than small licensors. As a consequence, large licensors may prefer fixed upfront payment anticipating licensed technologies' inferior future performance. Large licensor's tendency of licensing lower quality inventions makes the upfront ratio in the contract payment structure higher.

Based on above explanations, I proposed the following hypotheses:

H1: A licensor's size is positively associated with the share of fixed upfront payment in a total deal size.

In the same manner, as a licensee's size increases, licensee's bargaining power also increases. Large licensee has more complementary assets to invent around a technology which is supposed to be licensed, and it can access capital market more easily to finance R&D and related complementary assets and get a loan in a better condition than a small licensee. This makes large licensee's bargaining power increases (Gambardella et al., 2007). By using this increased bargaining power, a licensee can also change the contract payment structure to share more risk with the licensor, which implies increased share of contingent payment in payment structure. However, there is another approach, lucrative selection, to explain the relationship between a licensee's size and a contract payment structure. Based on lucrative selection assumption I made earlier, if a licensee has more resources to use to search for high quality technology and accomplish a deal successfully, it also implies that a licensee can better expect future performance of licensed technology and the licensee is willing to pay more fixed upfront payment in exchange for future performance-based contingent fees because the licensee doesn't want to divide expected future revenue streams with the licensor.

Based on above explanations, I proposed the following hypotheses:

H2: A licensee's size is negatively(positively) associated with the share of fixed upfront payment in a total deal size.

Leverage of potential licensors and licensees has also important and significant implications for bargaining powers of both parties (David et al., 2008). Higher level of leverage means higher cost of debt and equity financing and higher probability of credit event such as restructuring and bankruptcy filing. A potential licensor who has higher leverage capital structure compared to industry standard is hard to finance to commercialize internally developed technology, which results in a condition in which the potential licensor has no choice but to license-out to extract revenue. This means licensor's low bargaining power followed by decreased share of fixed upfront payment in contract payment structure compared to similar counterparts in terms of the other aspects except capital structure. Similarly, a potential licensee who has higher leverage compared to an industry standard is hard to finance R&D expenditure to invent around licensable technology, which results in a condition in which the potential licensee has no choice but to license-in to generate revenue. This means licensee's low bargaining power followed by decreased share of performance-based contingent payment compared to similar counterparts with respect to other aspects except capital structure. However, in a similar manner to the explanation based on lucrative selection of a potential licensee, it is hard for a potential licensee with higher leverage to overcome informational asymmetry and find out a lucrative technology because of limited resources to use to search for a technology to be licensed, and even if high leverage potential licensee succeeds in finding out lucrative technology, it is harder for the licensee to complete the deal because of financial constraint than lower leverage counterparts. This results in a failed lucrative selection followed by increased share of performance-based contingent payment.

Based on above explanations, I proposed the following hypotheses:

H3a: A licensor's leverage is negatively associated with the share of fixed upfront payment in a total deal size.

H3b: A licensee's leverage is positively(negatively) associated with the share of fixed upfront payment in a total deal size.

The technology development phase is normally considered a proxy for uncertainty of expected future performance of a technology (Bikard, 2014; Kotha et al., 2018). As a technology is developed further and closer to product market, the expected future cash flows are more certain because of more available information needed to expect them. This enhanced expectation and information about future performance of a technology makes technology less risky asset, so discount rate for future revenue streams from the technology is lower than riskier technology. Then, if future revenue streams are same as that of riskier technology, a technology in higher development phase is priced higher than technology in lower development phase. In statistical representation, average of a price distribution of a technology in high development phase is located at higher region than average of a price distribution of a technology in low development phase. In terms of the variance of the distribution, the variance of a price distribution of the technology in high development phase is lower than the variance of a price distribution of the technology in low development phase. This results from lower risk on a technology in high development phase, and less amount of risk to be shared between both parties. Less amount of risk to be shared implies that there is less need to share risk between both parties, which results in lower contingent payment and higher upfront payment.

Technology development phase can also be viewed as an environmental factor which affects the range of price in which a price can be chosen for licensing depending on the bargaining power of both parties. When technology is a mature one (closer to product market), price range that can be bargained over is narrower than that of more science-like technology, which results in reduced impact of bargaining power of licensor on a contract payment structure in licensing deal. As technology development phase increases, uncertainty of technology's future performance decreases, and this will result in a narrower price range on which licensor's bargaining powers can impact (resultant decreased licensor's bargaining power). This means if licensor's size increases in licensing deal involved in mature technology, increased licensor size has less impact on the total price of licensing deal. In perspective of same bargaining power's approach, if licensor's size and licensee's size change in licensing deal involved in mature technology, decreased licensor's and increased licensee's size has less impact on the payment structure, which implies less increase of share of performance-based contingent payment and less decrease of share of fixed upfront payment compared to licensing deal with science-like technology. A licensor's leverage and a licensee's leverage's impact on the contract payment structure also diminishes as bargaining power's impact decreases when licensing involves mature technology.

Based on above explanation, I proposed following hypotheses:

H4a: Technology development phase is positively associated with share of fixed upfront payment in licensing deal.

H4b: In case of higher technology development phase, the upfront payment increase and contingent payment decrease become less pronounced as licensor size increases.

H4c: In case of higher technology development phase, the upfront payment decrease and contingent payment increase become less pronounced as licensee size increases.

H4d: In case of higher technology development phase, the upfront payment increase and contingent payment decrease become less pronounced as licensor's leverage decreases and licensee's leverage increases.

Licensing region is also an important factor influencing pricing of a licensing deal (Lan, 2016). Broader licensing region implies more demand for commercialized product from licensed technology and this means more rents which can be extracted from selling products based on the licensed technology. As for licensee, it is harder to find out adequate licensee who can afford to commercialize broader licensing region. As licensing region is broader, more complementary assets and experience in foreign market are required to successfully commercialize the technology, which results in the lower number of appropriate licensees. Lower number of appropriate licensees implies higher bargaining power of licensees and lower bargaining power of licensors. Consequently, broader licensing region makes a deal more expensive and have larger share of performance-based contingent payment. Also, broader licensing region implies demand for commercialized product from various regions meaning various cultural aspects and different aptitudes of consumers, which implies increased uncertainty of future revenue streams of licensed technology. Increased risk to be shared between both parties in licensing deal involving broader licensing region amplifies the effect of licensor's bargaining power and licensee's bargaining power on contract payment structure.

Based on above explanation, I proposed following hypotheses:

H5a: Broadness of licensing region is positively associated with share of performance-based contingent payment in total deal size.

H5b: For broader licensing region, the upfront payment increase and contingent payment decrease become more pronounced as licensor size increases.

H5c: For broader licensing region, the upfront payment decrease and contingent payment increase become more pronounced as licensee size increases.

H5d: For broader licensing region, the upfront payment increase and contingent payment decrease become more pronounced as licensor's leverage decreases and licensee's leverage increases.

When explaining a licensing transaction under signaling theory, there are two types of signals which can be used to inform a potential licensee of the value of underlying technology. The one is path-dependent licensor's reputation which comes from licensor's size, patent counts, star scientists, and past performance of licensed technology, and various other characteristics. The other is path-independent and deal-specific dual payment structure to signal the value of underlying technology when there is no other means to signal a value of underlying technology or a potential licensor wants to signal the value more effectively.

Path-dependent licensor's reputation is closely associated with licensor's own characteristics such as size. The larger licensor's size, it is more probable that licensors have enough resources to spend for R&D expenditure and successfully develop high quality technology compared to counterparts which has lower reputation and smaller size. The higher licensor's leverage, it is more probable that licensors have not enough resources to spend for R&D expenditures because of debt-associated expenditure such as interest and principal and it is hard for licensors to access capital market to finance R&D projects in a timely manner, which results in developing low quality technology compared to counterparts which has lower leverage ratio. Beyond this explanation of the impact of licensor's reputation (characteristics) on an intrinsic value of a technology, even if the technologies to be licensed have similar characteristics and similar expected future revenues with similar probability under limited information in hand, a potential licensee will value a technology coming from a higher reputation's potential licensor higher than that of a lower reputation's potential licensor (Ruckman and McCarthy, 2017).

When it comes to dual contract payment structure, under signaling theory, important thing to consider is that the ability to signal is different depending on the licensors' quality. The need to signal comes from the degree of uncertainty of expected performance of licensed technology and licensee's information in hand about the technology (which implies the degree of information asymmetry). High quality licensors can emit a signal of the value of underlying technology by changing a contract payment structure in accordance with the degree of need to signal (Gallini & Wright, 1990; Martimort et al., 2010). Normally, a potential licensee wants to share more risk of licensed technology so that the licensee prefers larger share of contingent payment in the total deal size depending on the degree of uncertainty and informational asymmetry. This results in a situation in which high quality licensors can emit a signal by means of larger share of contingent payment in total deal size compared to low quality licensors who can't share risk fully to meet licensee's need perfectly because of their budget constraints and the other reasons which make low quality licensor have no choice but to extract some amount of rents by means of fixed upfront payment.

Based on above explanations, I proposed following hypotheses:

H6a: A licensor's size is negatively associated with the share of fixed upfront payment in a total deal size. (a large licensor implies high quality licensor).

H6b: A licensor's leverage is positively associated with the share of fixed upfront payment in a total deal size (a licensor with high leverage implies low quality licensor).

In signaling perspective, technology development phase and licensing region also have an impact on dual structure of payment. If a technology to be licensed is in a higher technology development phase (mature one), the degree of uncertainty of expected performance of licensed technology is lower and as a consequence, need to signal is lower and this results in a contract payment structure, which consists of relatively larger share of upfront payment and smaller share of performance-based contingent payment. In case of licensing region, the broadness of licensing region increases the uncertainty of expected performance of licensed technology. The broad licensing region implies that the licensee should get permission from many administrative authorities to sell products within many countries and if there is country or market-specific demand, the licensee also needs to meet the demand to adapt product to the one which reflects market-specific characteristics such as cultural element in that region. These elements which increase the uncertainty and needs to signal makes the contract payment structure have larger share of performance-based contingent payment in a total deal size.

Lower technology development phase and broader licensing region means higher uncertainty of future performance of technology and higher need for signal (Kotha et al. 2018). Confronting this higher need for signal, high quality licensors will transmit stronger signal by taking even less upfront and shifting more of the payment to royalties, to show their confidence in the invention's value and willingness to absorb more risk. By contrast, because of budget constraint and the other several reasons, low quality licensor is hard to transmit stronger signal to meet the higher need for signal originated from higher uncertainty.

Based on above explanation, I proposed following hypotheses:

H7a: Technology development phase is positively associated with the share of fixed upfront payment in a total deal size.

H7b: Licensing region is negatively associated with the share of fixed upfront payment in a total deal size.

H7c: In case of higher technology development phase, the upfront payment decrease and contingent payment increase become less pronounced as licensor's size increases and licensor's leverage decreases. (the effect of licensor's quality on contract payment structure decreases as licensing-involved technology matures.)

H7d: For broader licensing region, the upfront payment decrease and contingent payment increase become more pronounced as licensor's size increases and licensor's leverage decreases. (The effect of licensor's quality on contract payment structure increases as licensing region becomes broader.)

4. Data and variables

Sample

I tested my predictions using biotechnology licensing contracts' data from Lan (2016) (with his permission) with added information which I searched for by using WRDS database, an award-winning research platform and business intelligence toll for 50,000+ corporate, academic, government, and non-profit users at 450+ institutions in 35+ countries. There were in total 1332 licensing deals, 1288 of which had information of total price, 997 of which had information of upfront payment. Licensing deals without any information on price (in total 44) were removed from the analysis. Throughout the present study, empirical analysis was conducted at the level of technology licensing deal (Lan, 2016). Added to Lan's original data set, as the goal of this study is to identify and verify empirically the factors which have significant impacts on the contract payment structure of licensing deal, I searched for financial data of both licensors and licensees, and other relevant data of licensors and licensees which can be thought of as factors influencing payment structure in licensing contract.

Dependent Variable

My study examined the following dependent variables: upfront/contingent-payment ratio. To calculate the dependent variable, an essential element was a total price of a deal. Total price of a deal is the total deal size of a licensing transaction including all the relevant payments already made and expected to be made following the contract. Based on the total price of a deal, upfront fixed-fee payment and performance-based contingent payment can be calculated. Sum of upfront fixed-fee payment and performance-based contingent payment equals total price of a deal. When a licensing deal is completed, a licensee is supposed to pay fixed upfront payment for the successful licensing process and pay performance-based contingent payment to promote collaboration with a licensor for successful commercialization.

Originally, performance-based contingent payment is categorized into two separate components, the one is running royalty, and the other is mile-stone payments which depend on licensee's certain level of achievement of sales or other criteria. However, because of limited information, it is hard to separate these two components, so I just calculate contingent payment to use for calculating the dependent variable as:

Contingent payment = total price – fixed upfront payment

Based on above separation of total price into two components, I can calculate main dependent variable, upfront/contingent-payment ratio. This ratio variable is for direct comparison of the change of the dual payment structure dependent on the change of values of independent variables, controlling for total price. I followed the method of David et al. (2008). After calculating upfront ratio:

Upfront ratio = upfront payment/total price

As it is problematic for a dependent variable to be bounded between 0 and 1, I transformed it by taking the natural logarithm of upfront ratio divided by one minus upfront ratio. Before the transformation, values of 0 and 1 were replaced by 0.001 and 0.999, respectively.

Independent variables

Licensor's and licensee's size

There are many proxies for licensor's size: total asset, total revenue, total number of employees, total patent stock, and citation-weighted total patent stock (Hall, Jaffe, Trajtenberg, 2005; Gambardella, 2007; Sakakibara, 2010; Lan, 2016; Kotha et al., 2018). Some of the papers make firm size a qualitative variable to estimate more fitted regression results and get more statistically significant coefficient estimate (Gambardella, 2007; Sakakibara, 2010). In this study, I used total asset of a firm as a proxy for licensor's size and licensee's size. This decision was based on the other ratio variables, which is leverage ratio and standardized patent stock, as both ratio's denominator is total asset.

Licensor's and licensee's leverage

Firms' leverage is also normally used in many literature (Greve H, 2003; Kochhar, 1996; O'Brien, 2003; David et al, 2008; Balakrishnan & Fox, 1993; Long & Malitz, 1985; Vincente-Lorente, 2001). Normally, as firms' decision on whether to do a project or not, or which financing method is proper to get about a project is highly dependent on firms' leverage, as licensing transaction is. There are also many proxies for leverage: total debt-total asset ratio, total asset-total equity ratio (leverage ratio in Dupont analysis), total debt-total equity ratio, current debt-current asset ratio and slack variables which are normally used in the papers verifying the performance of R&D. Among these proxies for leverage, I used total debt-total equity ratio.

Technology development phase

Technology development phase is normally used as a proxy for the degree of uncertainty of future performance of a technology to be licensed. Higher technology development phase means a technology is closer to product market and there is more information to estimate future performance of a technology. At the time of signing the deal, if the licensed technology was at the pre-clinical trial stage, the deal had a dummy value of 0; if the licensed technology was at phase 1, the deal had a dummy value of 1; if the licensed technology was at phase 2, the deal had a dummy value of 2; if the licensed technology was at phase 3, the deal had a dummy value of 3; if the licensed technology had already passed the three basic phases of clinical trial, the deal had a dummy value of 4.

Licensing region

As licensing region is broader, more complementary assets and experience in foreign market are required to successfully commercialize the technology, which results in the lower number of appropriate licensees. This decreased number of adequate licensees increase bargaining power of potential licensees. Thus, the licensing region was included in the analysis as one of the independent variables. A licensing region of a deal was considered worldwide as long as it included all three major markets (North America, Europe and Asia). A license was considered regional if one of the three major markets was not included in the agreement. A worldwide license had a dummy value of 1, whereas a regional license had a dummy value of 0.

Interaction variables

To verify my hypotheses about moderating effect of technology development phase and licensing region on an impact of licensor's and licensee's size and leverage on variation of contract payment structure in both bargaining power's perspective and signaling theory, I formed eight interaction variables based on the cross-product of the licensor's and licensee's related variables with the above-explained two explanatory variables: technology development phase and licensing region.

Control variables

I accounted for a couple of characteristics of the licensor, licensee, licensed technology, and environmental factors as control variables whose value is likely to be relevant to the contract payment structure of licensed technology.

Standardized patent stock

I included standardized patent stock which is licensor's total patent stock divided by licensor's total asset to standardize licensor's total patent stock by licensor's total asset. This standardized ratio is meant to show the licensor's historical effective use of own asset to develop technologies and file for patents, which means that standardized licensor's patent stock could be seen as the degree of a licensor's bargaining power and a positive signal from reputation.

Proximity of a licensor and a licensee in terms of their respective market

If a licensor and a licensee is distant in terms of their respective markets, it is likely that products from commercialization of licensed technology don't overlap licensor's product market, which implies that licensor's opportunity cost of licensing and profit dissipation effect after licensing is lower than the other case in which both participant's markets overlap and are closely connected with each other. Lower profit dissipation effect and opportunity cost of licensing could require lower fixed upfront payment which affects contract payment structure of a licensing deal deeply. As a proxy for proximity of a licensor and a licensee with respect to their respective markets, I used same industry dummy following the method of Sakakibara (2010). For a licensor, we have a four-digit level standard industry classification code. We created dummy variable, which takes one when both a licensor and a licensee are in the same industry at the SIC four-digit level (Sakakibara (2010) used SIC two-digit level as a criterion, but in this study, almost all sample firms are in biotechnology industry, which fairly justifies my approach).

Deal type

The inclusion of business corporation (i.e. co-manufacturing; R&D cooperation) could potentially have a strong impact on the variation of dual payment structure of licensing deal. To control for this effect, I used a dummy variable scheme, where an IP-focused licensing deal had a dummy value of 0, and a business-associated technology licensing deal had a dummy value of 1 (Lan, 2016).

Exclusivity

An exclusive licensing is likely to have larger share of performance-based contingent payment in contract payment structure than non-exclusive one. For exclusive licensing, there are fewer adequate licensees who can afford to commercialize technology based on their complementary assets and this will result in increased licensee's bargaining power followed by increased share of contingent payment in contract. An exclusive license had a dummy value of 2; a semi-exclusive license had a dummy value of 1; a non-exclusive license had a dummy value of 0 (Lan, 2016).

Diversity index

Licensor's patent's stocks can be concentrated in one technological area or can be diversified away in several technological areas. It is important to know how much degree licensor's patent stocks are spread over various technological areas because it can impact minimum price of licensing in respect of profit dissipation effect and opportunity cost of licensing. In addition to the impact of diversity of licensors' patent's stocks on total price of a deal (Sakakibara, 2010), it can be surmised that diversity of licensor's patent stocks may also have an influence on a variation of contract payment structure.

Patent thicket

Patent thicket is an important environmental determinant of variation in contract payment structure. There are many papers identifying and verifying empirically patent thicket's influences on licensing deal in several aspects (Shapiro, 2004; Lan, 2016; Lin, 2011; Cockburn et al., 2010). Patent thicket, fragmented patent ownership structure in related industry, can be calculated in several way. In this paper, the proxy variable for patent thicket was obtained by computing the concentration ratio of the patent landscape of a technical domain as to the assignees of the patents. Herfindahl index (also known as Herfindal-Hirschman Index, or "HHI") was used for calculating the concentration ratio following methods disclosed in several papers including Clarkson and Dekorte (2006). HHI ranges from 1/N to 1, wherein N is the number of patent assignees inside the technical domain. A small HHI indicates a fragmented patent ownership in the technical domain, and an HHI closer to 1 indicates that most patents concentrate in the possession of a few assignees and there is no fragmentation as to patent ownership (Lan, 2016).

To control for year-specific characteristics such as macro-economic environment and firm-specific characteristics of licensors and licensees, I also included year fixed effect and licensors' and licensees' company fixed effects.

5. Method

In the empirical analysis, I conducted regression analysis (using STATA software) to identify and verify factors influencing the contract payment structure of licensing deal. My empirical specification followed Lan (2016) and Kotha et al. (2018).

To test Hypotheses about the factors influencing upfront ratio which is meant to describe share of upfront payment and contingent payment in a total price, removing the need to consider a change of the total price in a deal when considering change of the contract payment structure, I used the multiple regression to predict the dependent variable. Summary statistics of the data are presented in Table 1. The correlations of the variables are presented in table 2. All correlations that equal 0.064 and above are significant at a p value < 0.05. A positive and significant correlation existed between a main independent variable, licensor size, and the dependent variable (upfront ratio). Further, a positive and significant correlation existed between another main independent variable, licensee size, and the upfront ratio.

Table 1. Summary statistics of Variables

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
Upfront ratio(ln)	995	-0.984	3.288	-6.907	6.907
Year	1288	4.481	3.466	0.000	13.000
Licensors	1288	326.842	197.545	1.000	674.000
Licensees	1288	306.191	171.109	1.000	615.000
Standard patent stock	970	0.688	1.934	0.000	24.876
Same industry dummy	786	0.383	0.486	0.000	1.000
Dealtype	1288	0.741	0.438	0.000	1.000
Exclusivity	1026	1.729	0.660	0.000	2.000
Diversity index	1288	1.479	1.036	0.000	4.263
Patent thicket	1288	0.023	0.041	0.014	0.642
Licensor's size(ln)	972	4.986	2.280	0.156	13.420
Licensee's size(ln)	998	7.692	2.857	0.031	12.269
Licensor's leverage(ln)	950	0.841	16.490	-35.473	354.770
Licensee's leverage(ln)	980	0.131	3.342	-88.340	31.276
Tech development phase	1128	1.598	1.610	0.000	4.000
Licensing region	1030	0.754	0.431	0.000	1.000
Licensor's size x tech dev phase	866	8.740	10.162	0.000	44.329
Licensor's size x licensing region	767	3.843	2.964	0.000	12.181
Licensee's size x tech dev phase	886	11.403	13.182	0.000	46.155
Licensee's size x licensing region	805	6.205	4.206	0.000	12.269
Licensor's leverage x tech dev phase	846	0.380	5.564	-69.597	73.125
Licensor's leverage x licensing region	749	0.969	18.435	-35.473	354.770
Licensee's leverage x tech dev phase	873	0.302	1.395	-17.296	21.515
Licensee's leverage x licensing region	792	0.221	1.413	-10.428	31.276

Table 2. Correlation Table of Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Upfront ratio(ln)	1																						
Year	-.163	1																					
Licensors	.002	.007	1																				
Licensees	-.094	.026	.015	1																			
Standard patent stock	.041	.016	.020	.054	1																		
Same industry dummy	-.071	.036	-.057	.056	.031	1																	
Dealtype	-.239	-.074	-.021	.004	.032	.056	1																
Exclusivity	-.227	.151	-.011	.071	.012	.060	.169	1															
Diversity index	.098	.008	-.081	.013	.183	.018	-.070	.067	1														
Patent thicket	.044	-.102	-.032	.022	-.024	-.077	.015	-.077	-.023	1													
Licensor's size(ln)	.121	.069	-.023	-.025	-.264	.010	-.173	-.018	.493	-.044	1												
Licensee's size(ln)	-.199	.178	.006	.026	.006	-.022	.271	.048	-.132	-.016	-.319	1											
Licensor's leverage(ln)	-.013	.031	.090	.064	.034	-.043	.022	.030	.011	-.020	.001	.026	1										
Licensee's leverage(ln)	-.044	.036	.001	-.019	.010	.031	-.001	.071	-.029	-.102	-.011	.067	.000	1									
Tech development phase	.210	.198	-.017	.017	.009	.163	.016	.150	.181	-.051	.132	-.125	-.040	.018	1								
Licensing region	-.103	-.077	-.011	-.013	-.078	-.047	.016	-.156	-.040	.038	.048	.189	.023	.001	-.403	1							
Licensor's size x tech dev phase	.231	.175	-.035	-.021	-.131	.125	-.063	.134	.334	-.066	.562	-.243	-.029	.017	.826	-.299	1						
Licensor's size x licensing region	-.023	-.021	-.031	.032	-.163	-.034	-.125	-.096	.291	-.035	.614	-.105	.012	.003	-.242	.742	.042	1					
Licensee's size x tech dev phase	.151	.247	-.023	.021	.012	.137	.072	.144	.139	-.064	.050	.212	-.039	.019	.888	-.296	.695	-.221	1				
Licensee's size x licensing region	-.200	.061	.028	-.003	-.026	-.061	.192	-.041	-.152	.033	-.204	.685	.037	-.018	-.385	.795	-.395	.443	-.157	1			
Licensor's leverage x tech dev phase	-.061	.021	.020	.009	-.041	.067	.008	.025	.046	-.006	.074	-.012	.087	.002	.071	-.001	.105	.045	.074	-.036	1		
Licensor's leverage x licensing region	-.010	.030	.093	.068	.046	-.047	.026	.029	.009	-.026	-.004	.034	.997	-.007	-.053	.029	-.041	.017	-.053	.043	.030	1	
Licensee's leverage x tech dev phase	.044	.046	.049	-.062	.007	-.044	.026	.022	.015	-.016	-.023	.007	-.009	.158	.209	-.045	.112	-.010	.209	-.060	.022	-.014	1
Licensee's leverage x licensing region	-.040	-.020	.014	-.018	-.018	.026	.056	.067	-.027	-.162	.002	-.013	-.006	.937	-.057	.084	-.048	.070	-.049	.046	-.002	-.005	.307

Note: n=521 observations; all values of 0.064 and above are significant at p<0.05.

As expected, licensor's size is positively correlated with share of upfront payment in total deal size and licensee's size is positively correlated with share of contingent payment, implying that both parties' bargaining power strongly impact the dual payment structure of licensing deal. Neither leverage ratios appeared to have any significant correlation with the dependent variables. Technology development phase has significant correlation with all dependent variables, except the amount of contingent payment. Licensing region has significant correlation with all dependent variables, except the amount of upfront payment.

6. Analysis and Results

Multiple regression results are summarized in Table 3 (Upfront ratio as the dependent variable). In table 3, Model.a1 is the base model that includes all control variables and independent variables with moderators. The standardized coefficients (β) of all control variables were statistically insignificant, except year, deal type, and exclusivity. Significant coefficients are all negative. Year coefficient estimate is negative, which indicates that share of performance-based contingent payment increases and upfront payment decreases in total price. This implies a couple of facts. As time goes by, it is likely that licensor's and licensee's collaborations by means of contingent payment are enhanced, or it is likely that there are many licensing involving newly developed technologies about which it is hard to estimate future performance followed by increased share of contingent payment in licensing deal. Deal type coefficient estimate is also negative, which implies that the inclusion of business collaborations beyond simple technology transfer asks a licensor to do more for technology's successful commercialization. Exclusivity coefficient estimate is also negative. More exclusive licensing gives a licensee monopolistic use of technology which means the licensee should have complementary assets to commercialize technology for every consumers of the product. This implies there are fewer adequate licensees and in bargaining power's perspective, licensee's bargaining power increases followed by increased share of contingent payment.

The main independent variables, licensor's and licensee's total assets, were found to have significant impacts on a variation in the contract payment structure. Licensor's size has a positive and significant effect on a share of fixed upfront payment in contract payment structure, supporting bargaining power's approach against signaling theory (supporting Hypothesis 1 and rejecting Hypothesis 6a). Licensee's size also has a positive effect on a share of fixed upfront payment in contract payment structure, supporting licensee's lucrative selection against bargaining power's impact (Hypothesis 2). A licensee who has more resources than others can search for lucrative technologies in market fast and efficiently and negotiate a licensing deal successfully. Lucrative selection, not like the bargaining power's

Table 3. OLS Estimation (Upfront ratio)

	Model.a1		Model.a2		Model.a3	
Control variable						
Year	-0.172***	(0.034)	-0.163***	(0.034)	-0.171***	(0.034)
Licensors	0.001*	(0.001)	0.001*	(0.001)	0.001*	(0.001)
Licensees	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Standard patent stock	0.167	(0.124)	0.182	(0.123)	0.167	(0.124)
Same industry dummy	-0.201	(0.230)	-0.177	(0.229)	-0.203	(0.231)
Dealtype	-1.501***	(0.297)	-1.563***	(0.297)	-1.496***	(0.301)
Exclusivity	-0.768***	(0.248)	-0.768***	(0.247)	-0.768***	(0.249)
Diversity index	0.080	(0.160)	0.074	(0.160)	0.082	(0.161)
Patent thicket	0.551	(3.614)	0.210	(3.599)	0.534	(3.623)
Independent variable						
Licensor's size(ln)	0.280***	(0.072)	0.178	(0.187)	0.278***	(0.073)
Licensee's size(ln)	0.104**	(0.051)	0.098*	(0.052)	0.147	(0.133)
Licensor's leverage(ln)	0.002	(0.005)	0.002	(0.005)	0.002	(0.005)
Licensee's leverage(ln)	0.057	(0.067)	0.060	(0.067)	0.059	(0.068)
Moderator						
Tech development phase	0.409***	(0.082)	0.012	(0.228)	0.477*	(0.265)
Licensing region	-0.588*	(0.300)	-0.209	(0.811)	-0.317	(0.935)
Interaction						
Licensor's size x tech dev phase			0.079*	(0.042)		
Licensor's size x licensing region			-0.073	(0.145)		
Licensee's size x tech dev phase					-0.008	(0.031)
Licensee's size x licensing region					-0.036	(0.118)
Licensor's leverage x tech dev phase						
Licensor's leverage x licensing region						
Licensee's leverage x tech dev phase						
Licensee's leverage x licensing region						
Constant	-0.908	(0.869)	-0.422	(1.187)	-1.241	(1.281)
Obs	439		439		439	
R^2	0.235		0.246		0.235	

Table 3. (Continued)

	Model.a4		Model.a5		Model.a6	
Control variable						
Year	-0.170***	(0.034)	-0.174***	(0.034)	-0.163***	(0.034)
Licensors	0.001*	(0.001)	0.001*	(0.001)	0.001*	(0.001)
Licensees	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Standard patent stock	0.163	(0.123)	0.175	(0.124)	0.190	(0.123)
Same industry dummy	-0.193	(0.229)	-0.210	(0.231)	-0.172	(0.228)
Dealtype	-1.507***	(0.295)	-1.545***	(0.298)	-1.620***	(0.300)
Exclusivity	-0.756***	(0.246)	-0.748***	(0.248)	-0.734***	(0.246)
Diversity index	0.073	(0.159)	0.078	(0.161)	0.065	(0.160)
Patent thicket	0.687	(3.590)	0.524	(3.610)	0.309	(3.575)
Independent variable						
Licensor's size(ln)	0.287***	(0.072)	0.286***	(0.073)	0.130	(0.197)
Licensee's size(ln)	0.100*	(0.051)	0.105**	(0.051)	0.056	(0.141)
Licensor's leverage(ln)	0.030	(0.071)	0.002	(0.005)	0.024	(0.071)
Licensee's leverage(ln)	0.058	(0.067)	-0.235	(0.206)	-0.248	(0.210)
Moderator						
Tech development phase	0.417***	(0.082)	0.373***	(0.086)	-0.232	(0.421)
Licensing region	-0.584*	(0.301)	-0.706**	(0.309)	-0.668	(1.494)
Interaction						
Licensor's size x tech dev phase					0.096**	(0.045)
Licensor's size x licensing region					-0.034	(0.155)
Licensee's size x tech dev phase					0.015	(0.033)
Licensee's size x licensing region					0.018	(0.127)
Licensor's leverage x tech dev phase	-0.068***	(0.026)			-0.069***	(0.026)
Licensor's leverage x licensing region	-0.028	(0.071)			-0.021	(0.071)
Licensee's leverage x tech dev phase			0.119	(0.096)	0.148	(0.096)
Licensee's leverage x licensing region			0.302	(0.215)	0.311	(0.218)
Constant	-0.967	(0.865)	-0.789	(0.873)	0.266	(1.831)
Obs	439		439		439	
R^2	0.248		0.240		0.267	

Note: Clustered standard errors in parentheses. The dependent variable is upfront ratio (ln).

* p<0.1 ** p<0.05 *** p<0.01 (two-tailed test)

approach, implies that as a licensee's size increases, lower informational asymmetry and better search for a lucrative technology based on enough resources make the licensee willing to pay fixed amount at the initiation of licensing deal to extract expected revenue streams from commercialization of technology exclusively. Licensor's leverage and licensee's leverage have no significant effect on a variation of contract payment structure, rejecting Hypotheses 3a, 3b and 6b. This result indicates that not like both parties' size, leverage of both parties could not have significant effect on bargaining power of both parties and could not be positive or negative impact on the licensor's ability to signal by means of variation of contract payment structure. However, it can also be surmised that in case of licensor, leverage's impact on bargaining power and ability to signal is similar, so there is no significant impact of licensor's leverage on variation of contract payment structure (Impact of licensor's leverage on bargaining power cancels out impact of licensor's leverage on the licensor's ability to signal). This result can be explained by Modigliani-Miller theorem (Modigliani and Miller, 1958). M-M suggests that the value of a firm is unaffected by how that firm is financed. Value of a firm may be associated with several aspects such as expected revenues generated by firm's activity, firm's bargaining power in licensing transaction and ability to signal by the variation of contract payment structure.

Two moderators, technology development phase and licensing region, have significant direct effect on a variation in contract payment structure, as expected. Technology development phase has a positive impact on the share of fixed upfront payment (supporting Hypothesis 4a and 7a). Mature technology's expected performance is more certain than science-like technology, which implies less risk to be shared between both parties by means of performance-based contingent payment, which results in lower share of contingent payment. In signaling perspective, more certain future performance of licensed technology implies less need to signal, which results in lower share of contingent payment, same as the result of reasoning in the previous explanation. The other moderator, licensing region, has a negative direct effect on the share of fixed upfront payment (supporting Hypothesis 5a and 7b). This implies that as licensing region is broader, there are fewer adequate licensees who can commercialize the licensed technology followed by increased licensee's bargaining power. Increased bargaining power of licensee implies lower share of fixed upfront payment, because the risk-averse licensee prefers to share risk of future performance of licensed technology with the licensor. In signaling perspective, the broadness of licensing region increases the uncertainty of expected performance of licensed technology, which results in more need to signal followed by lower share of fixed upfront payment, same as the result of reasoning of bargaining power's perspective.

From model.a2 to model.a5, I added a couple of interaction terms pair by pair and found out there are two significant moderations on a direct effect on variation in contract payment structure. The one is the positive moderating effect of technology development phase on the direct effect of licensor's size on variation in contract payment structure. As licensed technology is more mature, licensor's size's positive impact on the share of fixed upfront payment becomes more pronounced, which rejects hypothesis 4b. This result is the opposite of the hypothesis's estimation. It can be surmised that as mature technology is licensed, a large licensor can extract more revenues in the form of fixed upfront payment because of lower uncertainty of future performance of licensed technology than small licensor. Lower uncertainty implies certain future cash flows and based on these certain expected CFs information, the large licensor can negotiate a deal with higher share of fixed upfront payment in contract payment structure than small licensor. Total deal size, net present value of CFs, is same, but a large licensor can extract more revenues in the form of upfront payment by using strong bargaining power. The other is the negative moderating effect of technology development phase on the direct effect of licensor's leverage on variation in contract payment structure. As licensed technology is more mature, licensor's leverage's positive impact on the share of fixed upfront payment becomes less pronounced, which supports hypothesis 7c. Hypothesis 7c is based on signaling theory, which illustrates that licensor's ability to signal have an impact on the variation in contract payment structure. A licensor with high leverage is the low quality licensor and their ability to signal is lower than counterpart, which results in the higher share of fixed upfront payment in contract payment structure. As licensed technology is more mature, there is less need to signal the quality of technology by means of contract payment structure, which results in less pronounced impact of licensor's leverage on variation in contract payment structure. In model.a6, I put all the interaction terms together into one estimation, and the result is same as expected.

Broadness of licensing region doesn't show any significant moderating effect on the impact of characteristics of licensor on contract payment structure. In case of licensee's characteristics' impact on variation of contract payment structure, there is no significant moderating effect of both moderators. This can be explained by the fact that licensee's size's impact on contract payment structure was verified empirically by means of lucrative selection, not bargaining power's approach, and moderating mechanism was explained by bargaining power's approach in building hypotheses.

In model.a2, there is a multicollinearity problem for licensor size, technology development phase, and licensing region. In model.a3, there is a multicollinearity problem for licensee size, technology development phase, and licensing region. In model.a4, there is a multicollinearity problem for licensor's leverage. In model.a5, there is a multicollinearity problem for licensee's leverage. In model.a6, there is a multicollinearity problem for all the independent variables and moderators.

I conducted robustness check to verify my finding. In the analysis, I replaced total asset of a firm with total revenue of a firm as both licensor's and licensee's size's proxy. As a size proxy, total asset is selected to match other related independent variables. Leverage of licensor and licensee is based on balance sheet data and standardized patent stock is calculated by dividing licensor's total patent stock by total asset. However, total revenue of a firm is more often used as a size measure in a couple of literatures including Sakakibara (2010).

Table 4. total revenue as a proxy for size of a firm

	Model.b1		Model.b2		Model.b3	
Control variable						
Year	-0.169***	(0.034)	-0.159***	(0.034)	-0.168***	(0.034)
Licensors	0.001*	(0.001)	0.001*	(0.001)	0.001*	(0.001)
Licensees	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Standard patent stock	0.111	(0.119)	0.128	(0.118)	0.114	(0.119)
Same industry dummy	-0.214	(0.231)	-0.186	(0.229)	-0.218	(0.231)
Dealtype	-1.435***	(0.300)	-1.551***	(0.300)	-1.415***	(0.303)
Exclusivity	-0.778***	(0.248)	-0.755***	(0.247)	-0.775***	(0.249)
Diversity index	0.117	(0.159)	0.129	(0.157)	0.121	(0.159)
Patent thicket	1.126	(3.635)	0.011	(3.622)	1.140	(3.644)
Independent variable						
Licensor's size(ln)	0.208***	(0.057)	0.125	(0.138)	0.206***	(0.057)
Licensee's size(ln)	0.095**	(0.044)	0.095**	(0.044)	0.129	(0.108)
Licensor's leverage(ln)	0.002	(0.005)	0.002	(0.005)	0.002	(0.005)
Licensee's leverage(ln)	0.076	(0.068)	0.069	(0.068)	0.075	(0.069)
Moderator						
Tech development phase	0.415***	(0.082)	0.166	(0.132)	0.401*	(0.212)
Licensing region	-0.552*	(0.298)	-0.185	(0.464)	-0.232	(0.711)
Interaction						
Licensor's size x tech dev phase			0.075**	(0.032)		
Licensor's size x licensing region			-0.098	(0.108)		
Licensee's size x tech dev phase					0.001	(0.026)
Licensee's size x licensing region					-0.048	(0.097)
Licensor's leverage x tech dev phase						
Licensor's leverage x licensing region						
Licensee's leverage x tech dev phase						
Licensee's leverage x licensing region						
Constant	-0.169	(0.789)	-0.020	(0.856)	-0.405	(1.041)
Obs	439		439		439	
R^2	0.232		0.249		0.233	

After multiple regressions with new size variables, I found out that regression results are almost same as previous one in which both parties' total asset is used as a proxy for size measure, which verifies that total asset of both parties is also a good proxy for a size measure as total revenue.

Table 4. total revenue as a proxy for size of a firm (continued)

	Model.b4		Model.b5		Model.b6	
Control variable						
Year	-0.166***	(0.034)	-0.170***	(0.034)	-0.158***	(0.033)
Licensors	0.001**	(0.001)	0.001*	(0.001)	0.001**	(0.001)
Licensees	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Standard patent stock	0.098	(0.118)	0.114	(0.119)	0.130	(0.118)
Same industry dummy	-0.207	(0.230)	-0.222	(0.231)	-0.182	(0.228)
Dealtype	-1.445***	(0.299)	-1.475***	(0.301)	-1.587***	(0.303)
Exclusivity	-0.767***	(0.247)	-0.759***	(0.249)	-0.718***	(0.246)
Diversity index	0.128	(0.158)	0.119	(0.159)	0.142	(0.157)
Patent thicket	1.179	(3.618)	1.095	(3.633)	-0.034	(3.603)
Independent variable						
Licensor's size(ln)	0.201***	(0.056)	0.210***	(0.057)	0.053	(0.152)
Licensee's size(ln)	0.090**	(0.044)	0.095**	(0.044)	0.035	(0.124)
Licensor's leverage(ln)	0.025	(0.071)	0.002	(0.005)	0.021	(0.071)
Licensee's leverage(ln)	0.076	(0.068)	-0.185	(0.207)	-0.250	(0.222)
Moderator						
Tech development phase	0.423***	(0.082)	0.381***	(0.086)	-0.191	(0.306)
Licensing region	-0.544*	(0.300)	-0.656**	(0.307)	-0.470	(1.079)
Interaction						
Licensor's size x tech dev phase					0.097***	(0.036)
Licensor's size x licensing region					-0.055	(0.122)
Licensee's size x tech dev phase					0.033	(0.030)
Licensee's size x licensing region					0.004	(0.112)
Licensor's leverage x tech dev phase	-0.061**	(0.026)			-0.055**	(0.026)
Licensor's leverage x licensing region	-0.022	(0.071)			-0.019	(0.071)
Licensee's leverage x tech dev phase			0.115	(0.096)	0.155	(0.098)
Licensee's leverage x licensing region			0.269	(0.215)	0.312	(0.229)
Constant	-0.193	(0.787)	-0.044	(0.796)	0.719	(1.360)
Obs	439		439		439	
R^2	0.243		0.237		0.268	

Note: Standard errors in parentheses. n = 439. * p < 0.10 ** p < 0.05 *** p < 0.01 (two-tailed test)

7. Discussions

My study focused on the impact of the factors associated with licensing contract on a variation of dual contract payment structure in a licensing deal. The main factors which were identified and verified empirically are licensor's characteristics such as both parties', a licensor and a licensee, size and leverage from financial statement, technological characteristic such as technology development phase, and contract-specific characteristic, licensing region. I tried to find out and explain the relationship between those factors just mentioned and a variation of dual contract payment structure in both bargaining power's perspective and signaling theory's perspective. For a licensor, Bargaining power's perspective dominates over signaling theory's perspective when it comes to prediction of the results. Empirical testing supports licensor's bargaining power's approach on a variation of contract payment structure in licensing. As a licensor's size increases, the share of upfront payment in total price increases. In addition to both perspectives, there are other reasons which are mentioned to support hypotheses in other aspect. These other reasons are adverse selection of a licensor and lucrative selection of a licensee. Prediction based on adverse selection was supported because adverse selection's prediction is in line with that of bargaining power's perspective, and prediction based on lucrative selection was supported as well. Especially, regression results show that licensee's lucrative selection dominates over a bargaining power's approach. As a licensee size increases, share of the upfront payment increases like the case of licensor size. When it comes to moderating effect, technology development phase shows significant moderating effect on the influence of licensor's variables on a variation of contract payment structure. Technology development phase positively and significantly moderates an impact of licensor's size on a variation of contract payment structure in a deal, which is consistent with the reasoning of bargaining power's perspective. This result is unanticipated and further research is required. In addition, technology development phase negatively and significantly moderates an impact of licensor's leverage on a variation of contract payment structure in a deal, which is consistent with the reasoning of signaling theory. Apart from moderation, there are significant and positive direct relationships between two factors, licensing region and technology development phase, and share of upfront payment in contract payment structure.

It is worth to mention several limitations in this study. One is that all licensing contracts come from bio-technology industry, and it is hard to conclude that these results can be applied to other industry sectors. Another limitation is the lack of technology-specific characteristics. It is hard to verify certain technology's intrinsic value by certain value-related criteria such as citation or patent scope.

This paper's logics and empirical processes were mainly based on earlier studies of Sakakibara (2010), Lan (2016), and Kotha et al. (2018). Bargaining power's approach, signaling theory, adverse selection of large licensors and lucrative selection of large licensees illustrate and verify empirically the technology market's phenomena. Mostly, bargaining power's approach dominates over signaling theory's approach. However, in part, signaling theory's approach also can illustrate a phenomenon in consistent manner. It would be interesting to investigate further what types of forces dominates over other forces to determine contract payment structure in other industry sectors.

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