Intellectual Property Rights and Efficient Firm Organization

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Introduction

Intellectual Property Rights

- Tool to promote innovation in 3 ways:
- 1. IP rewards inventors with monopoly profits, and this incentive should encourage investment in innovation.
- 2. The patent system promotes disclosure of inventions, which enables sequential innovation.
- 3. IP rights support the development of a market for information, raising the profitability of innovation and enabling the rise of specialized R&D firms.

Introduction

Viewing IP through a New Lens

- A shift in the focus of IP theory, where its rationale is not sought in incentives for innovation.
- Viewing IP rights through the same lens as property rights on physical assets may seem counter-intuitive, since knowledge assets are non-rival.
- The paper formally establishes that allocating and protecting ownership of intangibles, no less than tangibles, is necessary to enable manufacturers to run an efficient supply chain in a world of incomplete contracts.
- When instead the protection of IP is weak, efficient organization of production is hindered by the risk that a supply relationship could collapse into costly IP leakage.
- This problem is most relevant for multinationals that contemplate cost-minimizing outsourcing deals with partners in developing countries.
- It is pervasive throughout the manufacturing sector, not just concern of most innovative firms.

Introduction

New Balance

- Since 1990 outsourced production of some of its cheapest and simplest shoes to China, ran by Horace Chang.
- In 1999, Chang unilaterally quadrupled production for sale in China; New Balance then terminated their relationship.
- Chang continued selling the shoes in competition with New Balance, both under their brand and with his own knock-off Henkee brand, not only in China, but also in Europe and Japan.
- The breakdown of this relationship costs $10m for New Balance, it suffered not only competition from its former supplier, but also disruption of the supply chain, legal costs of a lawsuit in Chinese courts, dilution of its brand value as too many of its cheaper China-made models reached the market, tarnishing a corporate image that hinged on more advanced US-made range.
- These translate to efficiency losses. Profits from Chang's sales would have failed to compensate them even within the partnership, which is why New Balance vetoed their production hike.
- Further reduced: could no longer rely on value-added of official retail channels.

Introduction

Apple Inc.

- Extensive legal safeguards of IP rights underpin the efficient international supply chain organization of Apple Inc., by some measure the largest and most successful company in the world.
- The US multinational itself focuses on retailing and product development.
- It outsources manufacturing to specialized suppliers such as Foxconn and Pegatron Corp., which also manufacture its competitors' products.
- This arrangement optimally exploits Apple's core competencies in design and customer-relationship management, as well as its suppliers' competitive advantage in cost-minimizing manufacturing.
- Such efficient supplier relationship hinges upon the effective enforcement of patents covering Apple's technology, copyright covering its software, trademarks covering its brand, and the distinctive appearance of its products, and protected trade secrets covering its business strategy.

- The model shows that IP rights underpin the efficient organization of manufacturing firms and therefore generate static productivity gains, distinct from the dynamic benefits that would result from incentives to innovate.
- The paper abstracts from invention and assumes that intangible assets are given ex ante, instead focusing on the organizational structure following the property-rights theory of the firm.
- Specialized inputs can be either acquired from outside suppliers or produced internally.
- The supplier needs to make a relationship-specific investment.
- With incomplete contracts, his incentives are determined by asset ownership.

Introduction

Results Preview

- Assume that supplier's investment has 2 dimensions: (i) the amount of cost-minimizing effort; (ii) its objective, either to cooperate with his downstream partner (Foxconn/Apple) or to bypass her (Chang/New Balance).
- In equilibrium, the first best is attained iff IP rights are sufficiently strong. Then outsourcing is both stable and efficiency maximizing.
- Ownership of physical productive assets protects the supplier from being held up by the downstream partner.
- At the same time, ownership of intangibles protects the latter from being cut out by the supplier.
- If instead IP rights are weak, productivity falls. An outsourcing partnership may break down, leading to inefficient production by the supplier alone.
- To avoid this risk, vertical integration (VI) may be chosen, but then the supplier's incentives for cost-minimization are inefficiently blunted.
- Result: Efficienty is monotonically increasing in the enforcement of IP rights.

- Shows IP protection does not benefit only innovative entrepreneurs and specialized research outfits whose output consists of ideas.
- It is crucial to enable efficient outsourcing and sustain productivity for all firms that exploit any intangible asset in production, i.e. the entire modern manufacturing sector.
- IP rights turn ideas into assets whose ownership can be clearly allocated.
- This possibility enables their efficient use in production and thus increases the efficiency of manufacturing, no less and possibly even more than the productivity of innovation.

Introduction

Paper Value-Added 2

- The analysis accounts for the observed cross-country organization of the supply chains of multinationals.
- The model predicts that VI should be more prevalent in sectors and jurisdictions in which IP rights are less secure.
- Empirical evidence is consistent with this prediction showing that stronger patent protection makes manufacturing more likely to establish a supply relationship by outsourcing rather than FDI (Lee and Mansfield, 1996; Smith, 2001; Antràs, Desai and Foley, 2009).
- Dynamic extension: imperfect IP protection accounts for an organizational product cycle with endogenous changes in the supply chain over time: product first manufacturing by vertically integrated firm, once final good producer learns the appropriability of her technology, may be safe to spin off a supplier and reduce production costs.

Introduction

Summary of Insights

- Most important justification of IP rights may be not as a tool to promote the creation of intangible assets, but rather as a mechanism that allows existing intangibles to be exploited efficiently.
- Classical view tends to favor broad patents, provided they can be licensed by incremental innovators (Gallini and Scotchmer, 2002). Here, optimality of narrow patent breadth is shown in property-rights framework, even when licensing is possible *ex ante*.
- Efficiency is maximized when the supplier is deterred from leaving the partnership and becoming a competitor, but instead encouraged to pursue spin-offs that do not directly compete with the parent business.
- Such differential incentives require ownership of intangible assets to be narrowly defined to protect the use of IP in the owner's business, without extending his rights to non-competing novel applications.

The Model

Final Producer

- Two agents with complementary skills and two complementary assets cooperate to produce a profitable business venture.
- Final producer F exogenously endowed with a unique profitable idea: An intangible asset A_I that defines the characteristics of a final product whose potential sale revenues are normalized to unity.
- F can be thought of as a US multinational such as New Balance or Apple and A_I consists of manufacturing specifications of a product (New Balance Classics shoes or iPhone).

The Model

Specific Human Capital

- F is endowed with specific expertise that is indispensable to exploit the full revenue-generating potential of his idea. Without F's personal contribution, revenues are reduced to $1-\eta$.
- η denotes fraction of revenues accounted for by F's retail channel, after-sale customer service, ongoing refinement of product, etc. That is, value of an entrepreneur's human capital.
- η fully revealed during the operation of a partnership, but not precisely known in the beginning. It is perceived as a random variable with common-knowledge distribution $\Phi(\eta)$ on $[0,1]$.

The Model

Supplier

- Production of the final good requires a specialized input produced by a supplier S using a tangible asset A_T.
- S can be thought of as a Chinese manufacturer such as Chang or Foxconn, and A_T as the manufacturing plant in China.
- Ex-ante there is a competitive pool of potential suppliers. In order to produce the specialized input required by F, the selected partner S must make a relation-specific investment, which involves 2 decisions:
- 1. it must decide what specialization he wants to acquire.
- 2. it must exert effort to minimize the cost of manufacturing intermediate inputs using the tangible asset A_T.

- On the one hand, S can cooperate and learn how to produce the specific input that complements F's expertise.
- This input is worthless to anyone but F, but it allows her to produce the final good and sell it for its maximum unit revenue.
- On the other hand, S can choose to defect and learn how to become a substitute for F, producing a different input that is specialized to the intangible asset A_I but designed to bypass F's expertise.
- This defecting input can be turned into a final product identically by F or anyone else (S itself), but its sales revenues are reduced to $1 - \eta$.
- This captures value of specialization and the division of labor, reflected in the inevitable imperfection of S as a substitute for F.

The Model

Example

- In Chang's case, choice of defection took place when he made plans and procured material to produce large quantities of the Classics shoes for direct sale, instead of adhering to the production and distribution schedule agreed upon with New Balance.
- Chang quadropled production in his factory.
- New Balance did not want such a large quantity of shoes to be brought to market.
- Conversely, Chang became committed to selling his excess output.

The Model

Cost Minimization

- An ex ante investment of $e \geq 0$ yields an ex post cost $c(e)$, described by a positive, strictly decreasing and convex function with

$$c(e) > 0, \quad c\prime(e) < 0 \quad \text{and} \quad c\prime\prime(e) > 0 \quad \text{for all} \quad e > 0.$$

- Function $c(e)$ describes the cost of producing the specialized input selected through the first half of the investment decision, i.e. the cooperating or the defecting input.
- Regardless of this choice, S always retains the outside option of using A_T to produce generic intermediates.
- Generics cannot be used with A_I to produce the distinctive final good, but can be sold on their own for a market price $1 - \alpha$.
- The parameter $\alpha \in (0, 1 - \lim_{e \to \infty} c(e)]$ captures the value of IP in A_I (revenue lost by Chang when switching production from New Balance shoes to original Henkee models or difference between profitability if iPhones and that of other cell phones that Foxconn manufactures).

The Model

Supplier Investment

- Supplier's investment is strictly specific to the physical asset A_T and to his human capital: without either of them it is impossible to produce a specialized intermediate, and therefore to exploit the intangible asset A_I.
- This implies that F cannot compete with S if he has chosen to defect instead of cooperating because she cannot recruit an alternative supplier.
- The investment is also specific to S's relationship with F and A_I , but not as strictly. It generates unambiguously higher surplus within a cooperating partnership ($\alpha > 0, \eta > 0$), but it retains some value outside of it.
- Production cost $c(e)$ is identical for specialized and generic inputs.

- First-best investment requires S to invest in complementing F and to exert effort
$$e^* = \arg\max_e \{1 - c(e) - e\} \quad \text{such that} \quad |c\prime(e^*)| = 1.$$
- Investment cannot be governed by a complete contract because of the complexity and unpredictability of the supply relationship.
- Parties cannot directly contract on investment level as it is unobservable.
- Ex-post costs and profits cannot be part of an enforceable contract because they are unverifiable by courts.
- A long-term supply contract cannot be written because the precise characteristics of the specialized input are initially uncertain.
- Ex ante, the only incentive device available is the allocation of property rights.
- Ownership assigns complete control rights if granted effective legal protection.

- Enforcement of property rights over A_T is perfect.
- Enforcement of property rights over A_I depends on quality of the IP regime.
- If F owns A_I, S may nonetheless choose to defect and infringe upon her IP, as Chang did with New Balance.
- In this case, he is liable to pay F compensation with expected value σ.
- Parameter $\sigma \in [0, 1]$ measures the strength of IP protection in terms of lost profits damages (or reduced-form representation of legal remedies).

The Model

Timeline

- 1. F recruits S from the pool of potential suppliers. The parties negotiate the ownership of A_I and A_T.
- 2. The value of F's expertise η is realized and observed by both parties. S makes a non-contractible relationship-specific investment. He chooses his specialization (cooperating or defecting) and exerts effort e.
- 3. The intermediate input is produced. F and S bargain over its transfer price. The outcome of their negotiation is modelled by the Nash bargaining solution.
- 4. Property rights are enforced and payoffs are realized.

- Two parties are risk neutral, have symmetric information, form rational expectations concerning subsequent stages of the partnership game.
- Joint surplus within the partnership and outside options if the partnership breaks down depend on the allocation and enforcement of property rights in stage 1, as well as on the realization of F's expertise and on S's investment choices in stage 2.
- Let a_I and a_T be binary variables whether S owns A_I and A_T and can therefore use either asset if the partnership breaks down.
- Let supplier's specialization be $s \in [F, S]$, where $s = F$ denotes cooperation and $s = S$ defection.

- Under cooperation, the joint surplus in the partnership is

$$\Pi(\eta, e, F) = 1 - c(e).$$

- If partnership breaks down, F cannot produce the final good without a specialized input supplied by S, thus, his outside option is zero.
- S can also not produce the final good because he lacks access to F's expertise. Thus his outside option is zero if he does not own the tangible asset ($a_T = 0$).
- If instead S owns A_T, he can produce generic intermediates outside the partnership and earn profits $1 - \alpha - c(e)$.
- Nash bargaining solution implies that S's payoff is then

$$\pi_S(a_I, a_T, \eta, e, F) = \frac{1 + a_T}{2}[1 - c(e)] - \frac{\alpha}{2}a_T.$$

- If S has chosen to defect, joint surplus in the partnership is reduced.
- F's expertise can no longer be exploited, so the supplier must choose between producing a sub-par final good (losing revenue η) or a generic intermediate (losing revenue α).
- As long as S owns A_T its outside options expand. He can produce not only generics, but after defecting he can also produce specialized intermediates and the final good without F's expertise.
- If he does so without owning A_I ($a_I = 0$), however, he is liable to pay σ damages when IPR rights are enforced in stage 4.
- His outside option thus is

$$a_T[1 - \min\{\alpha, \eta + \sigma(1 - a_I)\} - c(e)].$$

- Since defection reduces joint surplus, it can be attractive only when it expands S's outside options, namely when $\eta + \sigma(1 - a_I) \leq \alpha$.
- The joint surplus is
$$\Pi(\eta, e, S) = 1 - \eta - c(e).$$
- S's outside option is $a_T[1 - \eta - \sigma(1 - a_I) - c(e)]$, while F's outside option is represented by the expected damages that he receives for infringement of his IP rights: $\sigma a_T(1 - \sigma(1 - a_I)$.
- Nash bargaining solution implies that S's payoff is then
$$\pi_S(a_I, a_T, \eta, e, S) = \frac{1 + a_T}{2}[1 - \eta - c(e)] - \sigma a_T(1 - a_I).$$

The Model

Stages 2 and 1

- Stage 2: S makes his investment choice anticipating these payoffs. He chooses specialization and effort that solve his unilateral optimization problem:

$$(e(a_I, a_T, \eta), s(a_I, a_T, \eta)) = \arg \max_{e \geq 0, s \in \{F,S\}} \{\pi_S(a_I, a_T, \eta, e, S) - e\}.$$

- Stage 1: division of bargaining ex ante is immaterial. Any efficient bargaining procedure (i.e. Nash bargaining solution) leads the parties to choose the asset allocation

$$(a_I^*, a_T^*) = \arg \max_{(a_I, a_T) \in \{0,1\}} \int_0^1 \Pi(\eta, e(a_I, a_T, \eta), s(a_I, a_T, \eta)) d\Phi(\eta).$$

Equilibrium Firm Structure

Lemma 1: Full IP Protection

- The productivity benchmark is a legal system that perfectly protects IP: $\sigma = 1$ so that compensation equals the full amount of lost revenues, removing any incentives to violate IP rights.
- *In a legal system that fully protects an agent's exclusive right to use intangible asset A_I so that $(\sigma = 1)$, the first best is achieved by a non-integrated partnership in which the final producer F owns A_I, while the input supplier S owns the physical capital A_T.*
- As long as IP is effectively protected, the optimum can be reached by using ownership of the two assets to provide separate incentives for the two dimensions of investment.

Equilibrium Firm Structure

Incentives for the Efficient Choice of Specialization

- Allocation of A_I incentivizes the efficient choice of specialization ($s = F$). Final good can only be produced if the owners of the two assets cooperate.
- It is pointless for S to try substituting for F's human capital as it would reduce potential revenues without removing the need to negotiate with F who controls the indispensable IP.
- S makes the efficient choice to complement F provided he doesn't own and cannot appropriate A_I.
- Apple can entrust Foxconn with the detailed specifications of its patented products, knowing that Foxconn will reliably produce them rather than developing competing imitations.
- The latter is unprofitable because Apple is aggressive and successful in pursuing the enforcement of its IP rights.

Equilibrium Firm Structure

Incentives for Cost Mimimizing Efforts

- Allocation of A_T incentivizes the provision of cost-minimizing effort e. If A_T belongs to S, he can use it to produce either a specialized or generic input at same cost $c(e)$.
- Since he can undertake generic production without F's consent, ownership of A_T is all S needs to internalize the full benefit of his investment.
- S exerts the efficient effort e^* provided he owns A_T.
- Foxconn is famous for the ruthless efficiency of its manufacturing operations. It invests in cost-minimizing management of its factories without fear of being help up by Apple, because the investment also pays off in its relationship with alternative customers such as Microsoft, Nokia, or Sony.

Equilibrium Firm Structure

Lemma 2: No IP Protection

- The opposite extreme is $\sigma = 0$, i.e. no protection of IP rights, the only asset to be allocated is A_T.
- *With no property rights protection over intangibles* $(\sigma = 0)$*, if final producer* F *owns* A_T*, the input supplier* S *efficiently invests in cooperating, but with suboptimal equilibrium amount of cost-reducing investment* $(e < e^*)$*. If* S *owns* A_T*, he provides first best effort* e^**, but with inefficient investment in substituting the final producer* F *whenever the value of her human capital is lower than her share of ex-post surplus* $(\eta < \alpha/2)$.
- With no IP rights, no party has exclusive rights over A_I. Failure to extend property rights to intangible assets makes A_T ownership the only incentive scheme.
- Costly trade-off that IP protection can avoid: Granting S ownership of A_T gives cost-minimization incentives, but weak IP increases temptation to defect. Impossible to induce optimal investment along both dimentions.

Equilibrium Firm Structure

Trade-off: If Final Firm Owns the Tangible Asset

- Owning A_T enables F to prevent S's defection by hiring him as an employee. When F has residual control over A_T, S needs to cooperate with her, or else he cannot produce anything and his investment is wasted.
- However, binding S to F as an employee also subjects him to the classic hold-up problem. After S's investment is sunk, F can appropriate part of its value in ex-post bargaining.
- Thus, S cannot internalize the full benefits of his own investment while he must bear its entire cost. Equilibrium effort is therefore suboptimal ($e < e^*$). The underinvestment has a cost

$$C = c(\bar{e}) + \bar{e} - c(e^*) - e^* > 0.$$

Equilibrium Firm Structure

Trade-off: If Supplier Owns the Tangible Asset

- If S owns A_T, his effort level is efficient, as in Lemma 1. His cooperation with F however is no longer assured.
- If he choses to defect, S can avoid sharing the ex-post surplus, at the cost of foregoing the gains from specialization and the value of F's human capital.
- From S's ex-ante perspective, specialization presents a trade off between reducing joint surplus and increasing his own share of it.
- When F's human capital (η) is relatively unimportant compared to the value of A_I (α), the supplier chooses defection.
- Chang chose to ramp up production and break away from New Balance to maximize his sales revenues, although joint surplus would have been higher in continued partnership that limited Chang's output to maximize brand value.
- Defection is always suboptimal from the ex-ante point of view of stage 1. Cost of distortion is a reduction of total surplus, while the ex-post advantage to S is purely distributional. However, contract incompleteness prevents S from committing to the efficient investment in complementarity.

Equilibrium Firm Structure

Determinants of Organizational Structure of Firm

- Lemma 2 implies that VI is optimal in the absence of IP protection ($\sigma = 0$) iff

$$C < \int_0^{\alpha/2} \eta d\Phi(\eta),$$

  namely if underinvestment due to the hold up problem costs less than the expected value of F's human capital wasted because of defection, making VI under F's leadership among equilibrium organizational forms.
- Equilibrium structure depends on appropriability of A_I, measured by η (possibility of using A_I without F's human capital), and on its legal protection measured by IP rights, σ.
- Ex ante, appropriability is only imperfectly predictable: η is realized in stage 2 but unknown in stage 1 when asset ownership is allocated.
- ensuing uncertainty gives rise to instances of partnership breakdown on the equilibrium path, such as the one involving New Balance and Chang.

Equilibrium Firm Structure

Proposition 1

- *Legal protection of IP is perfectly effective when the expected penalty for infringement is sufficiently large compared to the value of intangibles* ($\sigma \geq \alpha/2$). *Then the firm is organized as a non-integrated partnership and the supplier* S *exerts the optimal effort* e^*.
- *Legal protection of IP is completely ineffective if its strength* σ *falls below a minimum threshold* $\bar{\sigma} \in (0, \alpha/2 - C)$. *Then the firm is vertically integrated under the final producer* F, *and the supplier* S *exerts suboptimal effort* $(\bar{e})$.
- *When IP protection is partially effective* ($\bar{\sigma} < \sigma < \alpha/2$), S *owns the physical capital* A_T *and exerts optimal effort* (e^*). *Ex-post, the firm operates as a non-integrated partnership with probability* $p \in (0, 1)$. *With probability* $1 - p$, S *defects, prescinds from* F*'s expertise and produces as an integrated firm.*

Equilibrium Firm Structure

Interpretation

- First result is an extension of Lemma 1: By defecting, distorting his specialization, and substituting away from F's human capital, S gains his partner's share of the ex-post surplus $(\alpha/2)$ at the cost of an efficiency loss (η) and a legal cost (σ). Perfect enforcement obtained when expected damages are at least equal to F's profit share, so that S's temptation to defect is removed with probability 1.
- When IP enforcement imperfect, F must choose between relying on partial legal protection or self-protecting through the ownership of A_T.
- Second choice ensures production takes place within a high-quality, high-cost VI firm headed by F.
- First option involves ex-ante uncertainty: legal remedies and the value of F's contribution might prove sufficient to sustain the first-best non-integrated partnership. But S might find it profitable to break away and run his own low-quality, low-cost VI firm.

Equilibrium Firm Structure

Effectiveness of the IP regime

- The IP regime is ineffective when it is dominated by private self-protection. If legal protection is too weak ($\sigma < \bar{\sigma}$), firm organization and equilibrium outcome is the same as if it were nil.
- When legal protection is imperfect but preferable to costly self-protection ($\bar{\sigma} \leq \sigma < \alpha/2$), the eventual structure of the firm is realized only ex post.
- Letting S own A_T can lead either to a non-integrated partnership between S and F, or to autarkic production by S alone in an integrated firm that carries out internally production of both the specialized input and the final good.
- In this case, ex post F might license the intangible asset A_I to S at price σ, avoiding lawsuits but not the efficiency loss (η) that is irreversibly triggered by S's defection.

Equilibrium Firm Structure

Corollary 1: Prevalence of VI as a function of IP Protection

- *The probability that the firm operates as a non-integrated partnership is monotone increasing in the strength of IP protection* $(\partial p/\partial \sigma > 0)$ *and monotone decreasing in the value of intangibles* $(\partial p/\partial \alpha < 0)$.
- *The threshold* $\bar{\sigma}$ *of IP protection for which the probability of VI jumps to one is increasing in the value of intangibles* $(\partial \bar{\sigma}/\partial \alpha > 0)$ *and decreasing in the importance of the supplier's investment* $(\partial \bar{\sigma}/\partial C < 0)$.
- Intuitively, more valuable intangible assets are more difficult to protect. Thus, when control of A_I allows an agent to capture a greater share of profits IP rights must be stronger to have any effectiveness $(\partial \bar{\sigma}/\partial \alpha \geq 0)$.
- If an arm's length relationship is attempted, it is more likely to fall prey to defection when value of knowledge assets it exploits is higher $(\partial p/\partial \alpha < 0)$.
- Effective IP right threshold higher when self-protection by VI more efficient $(\partial \bar{\sigma}/\partial C < 0)$.
- If hold-up problem is mild and generates little underinvestment (low C) then VI under F attractive, marginal improvements to a weak IP regime unconvincing.

Equilibrium Firm Structure

Empirical Prediction

- The model suggests that VI should be more common in sectors and countries whose IP protection is weaker.
- Threat of IP leakage major concern for companies considering outsourcing to developing countries (Kahn, 2002).
- Consistent with Proposition 1, VI is a way to reduce risk of IP leakage (Lee and Mansfield, 1996).
- Consistent with Corollary 1, stronger IP rights in destination significantly increase licensing relative to affiliate sales and exports (Smith, 2001).
- Stronger patent rights associated with greater reliance on arm's length technology transfer rather than FDI, lower equity holdings in foreign affiliates, and a lower financing of their assets by parent company (Antràs, Desai and Foley, 2009): IP protection significantly predicts choice of outsourcing over VI.

Equilibrium Firm Structure

Corollary 2

- *The ex-ante expected value of the firm is increasing in the strength of IP protection ($\partial E\Pi/\partial\sigma \geq 0$). First-best efficiency is attained iff $\sigma \geq \alpha/2$.*
- Even in absence of R&D activities, productive efficiency is monotone increasing in IP protection strength ($\partial\Pi/\partial\sigma \geq 0$).
- Existing intangible assets can always be exploited securely through VI. But only a strong IP regime allows firms to outsource supply-chain operations to efficiency specialized subcontractors.
- Manufacturing productivity higher when supplier has keener incentives to exert cost-reducing efforts, but at the same time is deterred from wastefully and imperfectly duplicating the expertise of the final-good producer.
- When sustainability of an efficient arm's length relationship is uncertain ($\bar{\sigma} < \sigma < \alpha/2$), marginal strengthening of IP has immediate positive impact by raising (reducing) probability of cooperation (defection).

Equilibrium Firm Structure

Comparison of Findings with Classical IP Theory

- Corollary 2 established that better IP enforcement yields static productivity gains in contrast to classic IP theory that stresses dynamic benefits via innovation versus static losses from reduced competition.
- The two theories are contrasting but complementary.
- Here IP enforcement raises firm productivity implying that it hightens the value of the intangible asset A_I.
- This would foster higher investment in innovation if the model were extended to include costly creation of A_I.

Organizational Dynamics

Dynamics in the Product Cycle

- Boundaries of firm are rarely constant over time. Proposition 1 accounts for potential breakdown of arm's length partnerships.
- Organizational dynamics emerge when we analyze effect of gradual learning about appropriability (η).
- Consider 2-period repeated version of the model.
- First period (initial phase of product cycle): (i) F and S allocate property rights; (ii) η is realized and S makes investment decision; (iii) parties produce specialized input and final good, bargaining over shared surplus unless S has defected.
- Second period (product maturity) the 3 steps are repeated: (i) firm can be reorganized by transferring assets; (ii) S invests; (iii) production and bargaining take place.
- Difference is that realization of η is known since the beginning of period 2, so allocation of A_T and A_I property rights over and can be reoptimized taking this into account.

Organizational Dynamics

Proposition 2

- *Suppose legal protection of IP is so weak that the firm initially operates as a VI under final producer F ($\sigma \leq \bar{\sigma}$).*
- *With probability p the firm vertically disintegrates once product reaches maturity. Ownership of phytical asset A_T is transferred to S and the firm turns into the first-best efficient arm's-length partnership.*
- With probability $q \in (0,1)$ a buy-out occurs once product reaches maturity. *Ownership of both assets A_T and A_I is transferred to S,who assumes the leadership of the integrated firm.*
- With weak IP, firm initially seeks self-protection against S's defection through VI under F. This gives insurance against realization of appropriability. Arm's length is initially risky due to possible collapse. Once η known such insurance no longer necessary.

Organizational Dynamics

Appropriability and Reorganization

- If value of F's human capital η is high:
- S not subject to defection so safe and profitable to disintegrate.
- F retains ownership of A_I but sells A_T to S who can be fully trusted to invest in complementarity.
- This gives first-best, i.e. endogenous decline in production costs.
- If value of F's human capital η is low:
- first best unattainable because weak IP insufficient to protect highly appropriable intangible asset.
- Second-best is VI. Both assets owned by same agent, both stages of production performed within single firm.
- Optimal integrated firm however can be either led by F or instead owned and operated by S. Second part of Proposition 2 considers transition from F-integration to S-integration.

Organizational Dynamics

Corollary 3

- *The probability of vertical disintegration is decreasing in value of intangibles ($\partial p/\partial \alpha < 0$) and increasing in strength of IP protection ($\partial p/\partial \sigma > 0$). The probability of a buy-out is increasing in relative importance of supplier's investment ($\partial q/\partial C > 0$).*
- The efficiency-maximizing transformation from IV to arm's length takes place with same probability $p(\alpha, \sigma)$ that describes stability of a non-integrated partnership in Proposition 1.
- In both cases it is the probability that appropriability is sufficiently low (high η) for IP rights σ to protect an asset with value α. Naturally, it is higher when legal sanctions are stronger ($\partial p/\partial \sigma > 0$) and A_I less valuable ($\partial p/\partial \alpha < 0$).
- A buy-out instead is a switch from a high-cost configuration to a low-cost, low-quality alternative. It is more likely when cost of S's underinvestment is high and thus more likely to outweigh value of F's human capital in the cost-quality trade-off ($\partial q/\partial C > 0$).

Organizational Dynamics

Corollary 4

- *Reorganization leads an efficiency gain* $\Delta \geq 0$. *Ex ante, the expectation of this gain is increasing in the quality of legal enforcement* $(\partial E\Delta/\partial\sigma > 0)$, *decreasing in the value of intangible asset* $(\partial E\Delta/\partial\alpha < 0)$, *and increasing in the supplier's investment* $(\partial E\Delta/\partial C > 0)$.
- Both organizational changes engage an endogenous decrease in production cost, as the supplier increases his effort to the first-best level (e^*).
- The ensuing efficiency gains increase with cost of underinvestment $(\partial E\Delta/\partial C > 0)$, which is cost of VI under F in initial phase of the production cycle.
- Expected gain from reorganization is also higher when IP is less valuable $(\partial E\Delta/\partial\alpha < 0)$ because then a mature product is less likely to need VI to forestall defection. Same is true when legal remedies are more effective in deterring S's defection $(\partial E\Delta/\partial\sigma > 0)$.

Organizational Dynamics

IP rights and Efficiency Gains

- Just as Corollary 2 showed how IP rights underpin efficient firm organization at the beginning of product life cycle, Corollary 4 establishes that they enable efficient reorganization as the product reaches maturity.
- This reinforces findings that strengthening IP regime carries productivity benefits, whether or not it stimulates innovation.
- While marginal improvement to an ineffective IP regime ($\sigma < \bar{\sigma}$) do not raise efficiency at early life of a product, they have the potential to do so at its maturity.
- The model implies that manufacturing in countries and sectors with weak IP should take place within the boundaries of a VI firm at the beginning of the product life cycle. When market reaches maturity, instead, arm's-length supply relationships become more common.
- Predicted pattern of gradual outsourcing is broadly consistent with the real-world dynamics of multinational activity in developing countries

Organizational Dynamics

Anecdotal Evidence: Korea

- Rise of Korean electronic industry bears out the predicated switch from integration to outsourcing (Antràs, 2005).
- Sector entered international markets in late 1960's and early 1970's when US and Japanese companies set up subsidiaries in Korea.
- Affiliates typically fully owned, accounted for more than 70% of exports.
- As industry reached maturity, in 1980s domestic firms achieved greater prominence, mostly as licensees and subcontractors of foreign multinationals.

Organizational Dynamics

Anecdotal Evidence: China

- Chinese Semiconductor inudstry similarly took off in the 1990s through direct entry of foreign multinationals (Li, 2011).
- Sector was heavily regulated by Chinese government, which treated it as strategic priority and severely limited the establishment of wholly foreign-owned entities.
- Nonetheless, first successful fabrication plants were joint ventures run by NEC and Philips as captive subsidiaries supplying their foreign parents; while Intel and Motorola operated wholly-owned test and assembly facilities in China.
- Conversely, last decade has witnessed rise of domestic Chinese companies such as SMIC, now world's 5th largest semiconductor foundry.
- These enterprises operate as specialized contract manufactureres (pure foundries) that aggressively pursue licensing and outsourcing agreements with major foreign firms (e.g. Fujitsu and Infineon in case of SMIC).

Organizational Dynamics

Firm-level Evidence

- Suggestive evidence supports the prediction that companies first transfer technologies to their subsidiaries.
- They license externally only when it is more mature and thus, presumably, less valuable to the rest of the parent's company assets and expertise.
- Mansfield, Romeo and Wagner (1979): senior R&D executives at 30 US companies report that transfer to foreign subsidiary is dominant way of exploiting innovation internationally in the first 5 yeras since its commercialization.
- Mansfield and Romeo (1980): international technology transfer decisions of 31 US manufacturers show that lag between introduction of a technological innovation and its transfer is on average less than 6 years when the recipient is a subsidiary, but more than 12 years when it is an arm's length licensee.
- Davidson and McFetridge (1984,1985): 1376 technology transactions by 32 US multinationals indicate that internal transfers are more likely for newer and more innovative technologies.

Optimal Patent Breadth

Emergence of a Spin-off Idea

- The typical spin-off does not compete directly with parent company. Entrepreneurs who exploit derivative ideas usually aim at serving unexploited niche markets, avoiding head-on competition with the established incumbents they previously worked for.
- Assume that at time 1 a new opportunity arises for S with exogenous probability $\iota \in [0, 1]$.
- In addition to the relation specific investment e, he can make an investment $i \geq 0$ to develop a derivative idea.
- This idea exploits S's human capital and the intangible asset A_I to generate a new business that generates profits n.
- The probability that the development of the idea is successful is described by a concave function $v(i)$ with

$$v(i) \in [0, 1], v'(i) > 0 \text{ and } v''(i) < 0 \text{ for all } i > 0,$$

satisfying the Inada conditions $\lim_{i \to 0} v''(i) = \infty$ and $\lim_{i \to \infty} v''(i) = 0$, which ensures an interior solution.

Optimal Patent Breadth

The Spin-off and IP Protection

- The two investments e and i are not competing.
- The spin-off does not require the operation of A_T to produce special inputs, and it does not preclude S from producing them while simultaneously pursuing a derivative idea.
- The spin-off is a market that does not harm the profitability of the original firm.
- However, the derivative idea builds upon and leverages the original intangible asset A_I. It represents a case of cumulative innovation, whose legal standing hinges on the scope or breadth of IP protection (e.g., Scotchmer, 1991; Gallini and Scotchmer, 2002).
- If S developes spin-off without right to use A_I his derivative business may be found to infringe upon F's IP.
- S would then be forced to pay compensation. The expected value of the award equals ωn, with parameter $\omega \in [0, \sigma]$ providing a consice measure of patent breadth.

Optimal Patent Breadth

Licensing and Imitation

- In stage 1, when partnership is formed and ownership of assets decided, IP can also be licensed. If the owner of A_I chooses to grant a license for its use to the other party, then both can exploit it simultaneously, given the non-rival nature of intangible assets.
- If F owns A_I but her supplier S holds a license to use it, then he is free to develop a derivative idea without running the risk of being sued for infringement.
- All investments (i and e) are unobservable, so all revenues, costs and profits are unverifiable.
- The precise characteristics of the derivative idea are uncertain ex ante, and thus cannot be part of a contract until investment i is sunk, concerting the nature of the spin-off.
- Complexity of restrictive covenants makes them prohibitively costly, so ownership and licensing can only assign complete control rights. Hence, particular uses of assets cannot be contracted upon ex ante.
- Thus, if S is granted right to use A_I, he is equally entitled to use it to develop a derivative idea, and use it to produce a lower-quality imitation of the original product.

Optimal Patent Breadth

Proposition 3

- *Legal protection of IP is completely ineffective if its strength σ falls below a minimum threshold $\tilde{\sigma} \in [\bar{\sigma}, 1]$. Then the firm is VI under F, and employee S is granted a license to use the intangible asset A_I. He exerts suboptimal effort ($\bar{e} < e^*$) within the firm, but optimal effort (i^*) to develop a spin-off.*
- *When IP protection is effective ($\sigma > \tilde{\sigma}$), S owns A_T but does not hold a license to use A_I. He exerts optimal effort ($\bar{\imath} < i^*$) within the firm, but suboptimal effort (e^*) to develop a derivative idea. The efficient non-integrated partnership is preserved with probaiblity $p \in (0, 1]$.*

Optimal Patent Breadth

Intuition

- Key novelty here is that IP rights that are both sufficiently strong and sufficiently broad create a tension between the asset allocation that maximizes productivity in the original venture and the one that maximizes the probability of a successful spin-off.
- Investment in spin-off is sub-optimal if S does not hold a license to use A_I. But with incomplete contracts granting S a license ex ante means forfeiting legal protection against defection from an efficient arm's length partnership.
- Then F needs to protect his original idea using VI, at the cost of sub-optimal investment within partnership.

Optimal Patent Breadth

Optimal Firm Structure

- The second-best organization is the same that underpins the first best with an optimal IP system: the original firm is organized as an arm's length partnership, and to maximize its robustness S is denied a license ex ante.
- When enforcement is too weak, the firm resorts to VI.
- When it is stronger, a non-integrated partnership is attempted instead. It is sustained with same probability p as in the original proposition, reacing certainty if $\sigma \geq \sigma/2$.
- Minimum IP enfrocement required to induce an attempt at arm's length contracting rises ($\tilde{\sigma} > \bar{\sigma}$) because now VI as an advantage that partially countervails suboptimal investment ($\bar{e}$) in efficient production of specialized inputs.
- As an employee, the supplier cannot steal his employer's business because he doesn't control the tangible asset A_T.
- Thus he can be allowed instead to control the intangible asset A_I through a license, incentivizing at least efficient effort (i^*) in developing a spin-off.

Optimal Patent Breadth

Corollary 5: IP protection and Firm Structure

- *The threshold $\tilde{\sigma}$ of IP protection for which the probability of VI jumpts to one is increasing in the likelihood of a derivative idea ($\partial\tilde{\sigma}/\partial\iota \geq 0$), in the value of a spin-off ($\partial\tilde{\sigma}/\partial n \geq 0$), and in the breadth of IP rights ($\partial\tilde{\sigma}/\partial\omega \geq 0$), as well as decreasing in the importance of S's investment within the partnership ($\partial\tilde{\sigma}/\partial C \leq 0$), and increasing in the value of A_I ($\partial\tilde{\sigma}/\partial\alpha \geq 0$).*
- VI is more likely to be chosen when spin-offs are more important, either because derivative ideas are more likely to emerge ($\partial\tilde{\sigma}/\partial\iota \geq 0$) or because they are more valuable ($\partial\tilde{\sigma}/\partial n \geq 0$).
- Outsourcing also becomes less appealing when IP rights are broader, increasing the hold-up problem for spin-offs that are not covered by a license ($\partial\tilde{\sigma}/\partial\omega \geq 0$).
- Hence, the IP system deteriorates into uselessness not only as IP strength weakens, but also as IP scope broadens.

Optimal Patent Breadth

Corollary 6: Signifiance of Strength versus Breadth of IP Rights

- *The probability of a spin-off is decreasing in patent breadth ($\partial\bar{\iota}/\partial\omega < 0$). Aggregate value ($V$) of the partnership and its potential spin-off is monotone increasing in IP protection strength ($\partial V/\partial\sigma \geq 0$) and decreasing in its breadth ($\partial V/\partial\omega \leq 0$). The first best can be attained iff IP rights are simultaneosly perfectly strong ($\sigma \geq \alpha/2$) and perfectly narrow ($\omega = 0$).*
- IP rights must be strong to protect F's original business, but at the same time narrow to preserve S's incentives to develop derivative ideas.

Optimal Patent Breadth

IP Rights and Efficiency

- First best can be attained iff IP protection removes S's temptation to defect ($\sigma \geq \alpha/2$), also all chances for F to hold up profitable spin-off ($\omega = 0$).
- Weakening IP protection strength, also any broadening of its scope, has a negative impact on aggregate efficiency, captured by value V of the original partnership and its potential spin-offs ($\partial V/\partial\sigma \geq 0 \geq \partial V/\partial\omega$).
- Any marginal increase in IP breadth above the optimum destroys value by heightening the hold-up problem for derivative ideas. This friction reduces likelihood of a successful spin-off ($\partial\bar{\iota}/\partial\omega < 0 \Rightarrow \partial V/\partial\omega < 0$).
- Moreover, any marginal decline in IP strength below the optimum destroys value by making outsourcing more prone to collapse, thereby reducing partnership profits ($\partial p/\partial\sigma > 0 \Rightarrow \partial V/\partial\sigma > 0$).

Optimal Patent Breadth

Comparison with Conventional Wisdom

- Findings are in contrast with conventional analysis of optimal design of IP rights in the context of cumulative innovation.
- When IP rights are motivated by the goal of awarding innovations sufficiently large monopoly rents, mainstream view tends to favor broad patents (Gallini and Scotchmer, 2002).
- Underlying rationale is that the initial innovation should share in all the profits his idea enables. Wide patent scope is then particularly crucial when cumulative innovation dissipates the original innovator's own profits.
- Yet, the desirability of broad patents also emerges from models in which sequential innovation generate non-competing profits sources, as in the case considered here (Green and Scotchmer, 1995; Matutes, Regibeau, and Rockett, 1996; Schankerman and Scotchmer, 2001).
- Green and Scotchmer (1995) acknowledge that IP breadth can have the countervailing downside of creating a harmful hold-up problem ex post, but show that this drawback is removed by ex-ante licensing.

Optimal Patent Breadth

Double Role of IP Rights

- Same mechanism is at work here: investment in derivative innovation is suboptimal with ex-post bargaining ($\bar{\imath} < i^*$), but optimal with ex-ante licensing (i^*).
- Yet, once we see IP as an instrument to alleviate problem of contract incompleteness, conclusion is overturned.
- Broad IP rights are ineffective blunt tools that can only solve one hold-up problem by creating another (achieving e^* but $\bar{\imath} < i^*$ or i^* but $\bar{e} < e^*$).
- Thus scope of IP should be narrowly defined to cover a specific business opportunity, so it can be protected without holding up sequential innovators.
- In fact, narrower scope of IP rights here increases rather than reducing ex-ante value accruing to original entrepreneur F.

Optimal Patent Breadth

Concluding Discussion

- In stage 1, F controls access to unique intangible asset A_I as in Rajan and Zingales's (2001) analysis of defection and Boldrin and Levine's (2008) model of imitation.
- Ex ante she can therefore not only reap profits she can derive from A_I but also internalize the value that S can create through a spin-off after working with A_I.
- So F's ex ante value V increases with her partner's incentives for value creation, and thus falls with the likelihood that he will be held up due to the breadth of her IP rights ($\partial V/\partial \omega \leq 0$).
- These preferences are not time consistent for F, who ex post would instead prefer a broadening of his IP right and the ability to hold up S after his investment is sunk.

Optimal Patent Breadth

Evidence from the Software Industry

- Bessen and Meurer (2008) show evidence on US software industry, where patents since their introduction in mid-1990s have a broad and vague scope.
- Consistent with ex-ante expectations of inefficiency, from 1960s to 1990s prominent companies in the sector opposed software patents.
- Bessen and Meurer (2008) advance the legal argument that patents (especially software) should have much clearer and sharper boundaries.
- Their limits should be defined precisely at the time of filing, and patent should provide unambiguous notice to subsequent entrants.
- Here according to Proposition 3, patents should only protect the market that the patent owner is currently serving.
- For an innovation to be deemed infringing, it should be proven to be simultaneously derivative of a patented one and materially competing with the original product.