Intellectual Property Rights Enforcement in Imperfect Markets

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Abstract

We analyze intellectual property rights (IPR) enforcement in a developing country where information asymmetry between a foreign multinational and domestic consumers gives rise to the need for signaling by the multinational. The signaling distorts the multinational's entry decision even when IPR enforcement is perfect. Our analysis derives implications consistent with empirical observations: better IPR enforcement encourages the multinational's entry but exhibits an inverse U-shaped relation with their incentives to develop new technologies. Compared with perfect enforcement, moderately weak IPR enforcement, which does not fully deter copycats from stealing the multinational's technology, can benefit both the host country and the multinational. Our analysis thus sheds new light into IPR policies in developing countries and cautions policy implications drawn from empirical studies.

Keywords: intellectual property rights, market imperfection, asymmetric information, signaling, licensing

JEL Code: D82, F10, F12, F23

1 Introduction

As per conventional wisdom, stronger intellectual property rights (IPR) enforcement in developing countries can help protect the profits of foreign multinationals, which in turn encourages technology transfer that ultimately benefits developing countries themselves. This argument is based on an implicit premise. That is, once developing countries perfect their IPR enforcement, there is nothing else to obstruct technology transfer by foreign companies. Such a premise is, of course, miles away from the reality of developing countries where many forms of market imperfections

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are present besides weak IPR enforcement. More often than not, these market imperfections prevent multinationals from entering a country regardless of its IPR enforcement strength.

Examples abound where foreign firms withheld from entering a developing country until their copycats found much success in the market. In fact, such a pattern often leads to contention between developing countries and multinationals about the loss of multinationals as a result of IPR violation: Multinationals would maintain that products and services provided by copycats amount to loss of profitable opportunities; developing countries argue that these products and services would not have been offered in the market had there not been copycats. A case in point is Starbucks. Starbucks did not begin operation in mainland China on a large scale until 2000, when it filed a lawsuit against a copycat, *Xing Ba Ke*, a Chinese chain of coffee shops, which by the time of the lawsuit had enjoyed great success in Shanghai, the largest metropolitan city in China.[1]

Thus comes the question of whether conventional wisdom remains valid in such a second best environment where the market is imperfect. When market imperfection prevents a multinational from entering a market, the vacuum creates a potential for efficiency gain, which can be materialized if local firms can make use of the technology by, say, stealing it. While this seems to justify weak IPR enforcement that allows IPR violations, without addressing three questions, the argument remains shallow and is in no position to refute conventional wisdom. First, how will the presence of a copycat affect the foreign multinational's behavior in the market? If the copycat causes a further retreat by the multinational, there certainly will be a loss of social welfare as stealing a technology is likely to be a less efficient form of technology transfer than, say, licensing. Second, if there is efficiency gain to be realized under weak IPR enforcement, why cannot such a gain be captured under strong IPR enforcement by means of contracting between the multinational and its copycats?[2] In the Starbucks case, why could not have Starbucks licensed its China business to *Xing Ba Ke*? Finally, how will the profits of the multinational be affected by the presence of a copycat? Even if stealing generates efficiency gains, it may do so at the expense of the multinational. As conventional wisdom rightly suggests, if multinationals' interest cannot be protected, developing countries may stand to lose as well.

This paper thus revisits the issue of IPR enforcement in developing countries by addressing the three questions in a setting with some form of market imperfection. We show that by allowing copycats, weak IPR enforcement indeed forces a further retreat by a multinational from a developing country; however, the social gains from having a copycat serving the otherwise unserved market always outweigh the social loss of the further retreat by the multinational. We also demonstrate that the very form of market imperfection that causes a multinational to withhold its entry may also

[1] Judging by the success of *Xing Ba Ke*, Chinese urban consumers apparently have the appetite as well as the wallet for coffee, to which Starbucks did not respond initially. Starbucks' lack of response cannot be accounted for by the lax IPR enforcement in China. Given the nature of the coffee shop business, it is hardly believable that the sheer presence of a copycat would have exhausted all profitable opportunities. Neither can it be argued that Starbucks withheld from the Chinese market to protect its business secret, as its business model was copied despite its absence. The Starbucks case thus clearly points to some form of market failure. And Starbucks is just one of many examples of delayed entry by multinationals into China. Colgate did not enter China until 1991, a whole 13 years after China started its economic reform. Haagen-Dazs entered China in 1996, nine years later than Nestle, which sells ice cream of much lower prestige.

[2] Much of the existing literature on IPR enforcement avoids this question by simply assuming away the possibility of contracting.

discourage it from contracting with a local copycat regardless of the enforcement strength. As a result, the efficiency gain attained under weak IPR enforcement cannot be replicated by contracting under strong IPR enforcement. Finally, we show that the gains brought by copycats can be shared by the multinational and, as a result, moderately weak IPR enforcement may benefit the multinational as well.

The particular form of market imperfection that we assume in our model, which we deem to be especially relevant for a developing country, is information asymmetry between local customers and foreign firms with regard to the quality of foreign products. Take China for example. While some well-established international brands such as Coca Cola, Ford, and Seiko have long been household names, many others have been virtually unknown to most Chinese until recently, and even more still remain outside Chinese customers' knowledge. Starbucks was certainly a no-name among most Chinese before it filed the lawsuit against *Xing Ba Ke*. Chinese consumers do not recognize either eBay or Amazon, according to a publication from China's Ministry of Commerce.[3] A recent survey conducted by MasterCard Worldwide showed that while an increasing number of luxury brands have become popular in China, some local brands enjoyed more recognition than more prestigious global brands.[4]

With this particular form of market imperfection in mind, we tell the following story. A multinational contemplates entering a developing country with a technology of two possible qualities, which is *a priori* unknown to local consumers. The multinational can choose two ways to enter: direct investment by itself or licensing through some local firms. While direct investment allows the multinational to maintain its product quality, due to limited technological capacity of local firms, licensing can only deliver low quality products even if the quality of the technology is high. Applying the story to emerging markets where we think our analysis is most relevant, we envision a growing economy over two periods. The market size was initially small and grows only some time later, making direct investment profitable only in the second period. Given the information asymmetry, the multinational has a concern for its reputation in choosing its first period action that will shape consumers' perception of its product quality in the second period. While a low-quality multinational will license to the entire market, a high-quality multinational licenses to only part of the market in an attempt to signal its type, leaving the remaining part unserved.[5]

Depending on the strength of IPR enforcement, the vacuum left by the high-type multinational may then be filled by local firms through stealing. With positive probability, which represents the strength of IPR enforcement, the stealing is caught, in which case the copycat must turn over all its revenues to the multinational. Thus, local firms will not steal when the enforcement probability surpasses a certain threshold (hence strong), but will do so when the

[3] *China International Business*, June 2007, available at http://www.cibmagazine.com.cn/features/showatl.asp?id=128.

[4] According to an article in *Forbes*, Feb. 21, 2008 (http://www.forbes.com/2008/02/21/china-luxury-survey-markets-equity-cx_jc_0221markets02.html), more top spenders in China identify Chow Tai Fook, a Hong Kong jewelry retailer, than they do Cartier.

[5] While in theory firms may signal their qualities through advertising, they are not always able to do so in reality. Producers of lower quality products can often launch a large and equally impressive advertising campaign. A case in point is Amway, a U.S. based direct sale company which has been selling nutrient supplements, cook ware, cosmetics and personal care products in China. Judging by the scale of its advertising campaign on its nutrient products as compared to that made by Centrum, a firm specializing in multivitamin supplements with better quality, local Chinese consumers can hardly differentiate Anway from Centrum quality-wise.

probability falls below (hence weak). Although it withholds from entering some part of the market regardless of the enforcement strength, the multinational enters the market more aggressively under strong IPR than under weak IPR. Compared with strong enforcement, weak enforcement thus presents the multinational with the following trade-off. On the one hand, the multinational must give up a larger part of the market and face competition from local imitation in the part of the market it does enter. On the other, it can benefit from stealing in the part of the market that it chooses to ignore, as IPR enforcement imposes a transfer from the copycat with positive probability.[6] Our analysis shows that when the enforcement is moderately weak, the multinational earns more profits than it does under strong enforcement. However, the trade-off goes the other way and the multinational earns less profits when the enforcement becomes excessively weak.

Our analysis has the implication that should it be costly for the multinational to develop a technology for the developing country in the first place, the multinational's propensity to develop such a technology will be reduced when the enforcement becomes excessively strong or excessively weak, hence an inverted U-shape relation between IPR enforcement in the South and the development of technology in the North that is specifically targeted at the South. This is consistent with empirical studies by Scherer (1967) and Aghion, et al. (2005), who demonstrate an inverted U-shape relation between innovation and competition (or imitation). Meanwhile, our analysis also suggests that stronger IPR enforcement encourages entry, which is consistent with the works by Maskus and Penubarti (1995), Branstetter, et al (2006), Branstetter, et al (2007) and Du, et al (2008), who show that countries with better IPR enforcement, as well as regions with better IPR enforcement within a country, tend to attract a larger scale of entry and technology transfer by foreign multinationals. Thus, one of the key contributions of this paper is to offer a coherent analysis that helps tie the two sets of empirical evidence.

The implication of our analysis, that some imitation is good for innovation, resonates that of Aghion, et al (2001) and Aghion, et al (2005), but our argument works through a different mechanism. In those two papers, imitation may encourage innovation because incumbent firms try to "escape competition". Stronger imitation (due to weaker IPR enforcement, for example) increases incremental profits of innovation even though it reduces the absolute profits of incumbent firms. In our paper, imitation encourages outside firms to innovate by increasing both the incremental and the absolute profits. In this respect, our analysis is better positioned in explaining the aforementioned entry phenomena of foreign multinationals into developing countries.

Bessen and Maskin (2007) also stress the importance of market failure in understanding the role of IPR enforcement. They demonstrate that if technologies display externalities that cannot be internalized through contracts, strong

[6] Compensations made by copycats can be substantial. In June 2007, China's Supreme People's Court awarded Japan's Yamaha Motor Co damages of 8.3 million yuan (US$1.16 million) for a trademark infringement by Zhejiang Huatian, one of the largest Chinese motorcycle makers. In June 2003, General Motors accused Chery, a Chinese car manufacturer, of copying a model manufactured by its Korean subsidiary, GM Daewoo, and asked for a total of 80 million yuan (US$10 million) for damages and costs. In another case, Toyota filed a lawsuit against Geely, another fast-growing Chinese car maker, for trademark infringement and unfair competition. Toyota asked for a total of 14 million yuan (US$1.77 million) for damages.

IPR protection can slow down rather than facilitate technological progress. Such an observation offers a powerful explanation of why certain sectors, such as the information technology industry, have been able to flourish in developed countries without resorting to strong IPR protection. Insightful as it is, the argument is less applicable for understanding IPR enforcement in the South, which has highly asymmetric technological competence. In this regard, our work, focusing on a different form of market failure which we deem particularly relevant for developing countries, complements Bessen and Maskin (2007). Furthermore, different from their model, we allow for contracting despite market failure.

Helpman (1993) also argues that weak IPR protection in the South can be welfare enhancing. His argument focuses on division of labor between the North and the South. Enabled by weak IPR enforcement, imitation allows the South to make use of technologies developed in the North, which in turn allows the North to concentrate its resources in innovation rather than in production. One implicit assumption in Helpman's analysis, however, is that technology transfer is infeasible through either licensing or direct investment.[7] To make a clear distinction from this line of literature, we choose a partial equilibrium approach, thus leaving aside the reallocation effect completely. Our emphasis is not on how imitation in all or most Southern countries can raise the overall level of innovation in the North. Instead, we focus on how such imitation, enabled by relatively weak IPR enforcement in a single developing country, has the potential of increasing profitability of Northern firms that specifically target the Southern country itself. In doing so, our analysis is able to match the aforementioned empirical evidence from country-level studies. There are two additional differences between our paper and this literature. First, instead of allowing either investment or licensing, our analysis incorporates both actions as possible modes of entry by a foreign multinational. Second, we do not exogenously impose a cost on contracting.

The rest of the paper is organized as follows. In the next section, we set up our two-period model. Section 3 analyzes the second period outcome, followed by Section 4 that analyzes the first period and establishes the equilibrium. In Sections 5 and 6, we provide two extensions to relax some of the assumptions in the main model. Section 7 provides our conclusions.

2 Model

Consider a market in a developing country that consists of a continuum of segments of s measure. Each segment is inhabited by one domestic firm (D) and unit mass of consumers, who have unit demand for a product in each of two periods. A foreign multinational (M) possesses the technology to deliver the product. There are two types

[7] Following Helpman's work, a number of studies (for example, Lai 1998, Yang and Maskus 2001, Glass and Saggi 2002) became involved in the debate of whether imitation in the South can facilitate innovation in the North. While these studies make various assumptions about either licensing or direct investment, they share their focus on the resource reallocation effect as highlighted in Helpman (1993).

of M differentiated by the quality of the technology: high (M_h) and low (M_l). The quality of the final product, however, depends on the entry mode. In each segment and in each period, M_i ($i = h, l$) can enter either through direct investment or by licensing its technology to D. If M_i enters through direct investment, it is able to deliver the product in its genuine quality, in which case a consumer will derive a utility u_i with $u_h > u_l$. If M_i enters through licensing, the product quality is always low due to limited technological capacity of D and, as a result, a consumer will derive a utility u_l regardless of M_i's type.[8]

Although yielding higher utility to consumers, direct investment can be more costly than licensing. To capture the idea that direct investment by a foreign multinational may be too costly at the early stage of economic development, we introduce a market-wide fixed cost in the case of direct investment. For expositional simplicity, we assume that the fixed cost equals k per period for both types of M. Although this fixed cost may include advertising for brand recognition, we do not model it as an expenditure that can differentiate M's type. Although it seems reasonable to envision a higher fixed cost when the multinational enters the country for the first time, doing so will not affect the qualitative results of our analysis and we therefore assume a constant fixed cost across the two periods. To further simplify our model, we assume that once the fixed cost is incurred, M_i pays zero extra cost in serving each segment. To capture the idea that M's entry choice matters for the future, we assume a growing economy so that direct investment becomes profitable in the second period:[9]

$$s^1 u_h < k < s^2 u_l, \tag{1}$$

in which s^j is the market size in period j ($j = 1, 2$). The first inequality says that it is not profitable for M_h (let alone for M_l) to invest in the first period, whereas the second states that it is indeed profitable for M_l (and hence for M_h as well) to invest in the second period.

To allow for maximal contracting possibility, we assume that there is no market-wide fixed cost in licensing and hence M_i is able to license segment by segment regardless of the scale of its entry. Nevertheless, to manage licensing in each segment, M_i has to incur a cost c_i. We think of c_i as the expenditure needed for negotiating and administering the technology transfer. Because M_i has to divert its company resources, it is reasonable to assume that c_i represents a larger opportunity cost for M_h than for M_l, i.e., $c_h > c_l$, even though their final product quality is the same. Although it will be crucial to our analysis in the current setting, this assumption can be relaxed without altering any of our major

[8] While the assumption that licensing delivers the same product quality regardless of M's technology is a simplifying assumption, the assumption that licensing may not deliver the genuine quality is realistic. In the recent scandal in China about milk products tainted with melamine, an industrial chemical that causes kidney problems, both local brands (Sanlu, Mengniu, Yili and Bright) and foreign brands produced in China (Nestle, M&M) have been found to contain the chemical. For foreign companies, the problem of product quality is less severe in direct investment than in licensing or joint ventures (*The Economist*, Sept.25, 2008, "The poison spreads"): "Foreign companies have been concerned about the possibility of such a scandal for some time. Unilever dumped its joint ventures years ago, to ensure it had full control of all domestic Chinese operations. McDonald's has created its own closed supply chain, spanning beef, fries, bread and pickles. Coca-Cola imposes stringent rules on suppliers of sugar, water and carbon dioxide."

[9] This assumption, together with the assumption that licensing delivers the same low quality, ensures a reputation-building story to be told here. That is, it is the second-period price, not the first-period price, that M's first-period action is designed to influence.

results when we use a slightly different set-up.[10]

There are two ways by which D may obtain M's technology: licensing and stealing. Aside from the licensing fee, D incurs no extra cost in producing and delivering the product if it obtains the technology through licensing. In the case of stealing, however, D has to expend a stealing cost d in order to acquire the know-how and D is able to steal whether or not M enters the market.[11] As in the case of licensing, we assume that the product quality is always low in stealing regardless of the quality of the technology. To make sure that stealing can be profitable but at the same time is a less efficient form of technology transfer, we assume that

$$u_l > d > c_h. \tag{2}$$

Together, the first inequality of condition (1) and the second inequality of condition (2) imply that licensing is the most efficient form of making use of M_i's technology in the first period. The next assumption suggests that in the second period when the market size grows large enough, direct investment has the potential (when M_i enters all segments) to become the most efficient form of utilizing M_i's technology:

$$k < s^2 c_l. \tag{3}$$

The sequence of moves is as follows. First, Nature determines M's type. The *a priori* probability that $M = M_h$ is ρ^0. Afterwards, in each period and in each segment, M moves first by choosing between direct investment, licensing, or withholding (i.e., staying away from the segment). If it chooses licensing, M gives D a take-it-or-leave-it offer, which allows D to use the technology at a fee, f. After M's choice, D moves. Facing a licensing offer, D may accept and commit to not stealing (in that period). Alternatively, D may reject the offer, in which case M can no longer take up investment in that period.[12] Whenever D is not a licensee (i.e., when M invests, withholds, or offers a licensing contract that is rejected), D may steal M's technology. When both D and M operate in a segment, they engage in Bertrand competition.

Whether or not D steals depends, among other things, upon the strength of IPR enforcement, which is carried out at the end of each period. The enforcement strength is embodied in γ, the probability that D is caught for stealing. We allow γ to differ across the two periods. Once caught, D must transfer to M its revenue from stealing. D and M are

[10] For example, if M_h can make use of information from the first-period activities to adapt its technology while M_l is not able to do so due to its inferior technology, the qualitative results of our analysis hold even when $c_h = c_l$. Alternatively, the cost c_h and c_l can be incurred by D rather than by M. In that case, the interpretation for $c_h > c_l$ is that the local firm has to exert a larger effort and expenditure in order to learn a more sophisticated technology.

[11] As the Starbucks case illustrates, local firms in a developing country are often able to steal foreign multinationals' technologies before the latter enter their market.

[12] Maybe because investment has to be done at the beginning of each period.

risk neutral with a common time discount factor δ. Hence, stealing in period j ($j = 1, 2$) gives D a maximal (when it does not face competition from M's investment) expected payoff of $(1 - \gamma^j)u_l - d$ in that period. To simplify our analysis, we assume that enforcement is independent across the two periods; that is, catching D stealing in the first period will not prevent it from stealing again in the second. Accordingly, D will steal in period j only if

$$\gamma^j < \gamma_0 \equiv 1 - \frac{d}{u_l}.$$

The enforcement in period j is said to be strong if $\gamma^j > \gamma_0$ and weak otherwise.

With full information, i.e., M's type is known to all parties, the following will happen in equilibrium. In the first period, M_i will license to D in each segment at a fee of u_l if $\gamma^1 > \gamma^0$ and $\gamma^1 u_l + d$ if $\gamma^1 \leq \gamma^0$, which is accepted by D. In the second period, M_i will invest in each segment and set the price of its product at u_i if $\gamma^2 > \gamma^0$ and at $(u_i - u_l) + d$ if $\gamma^2 \leq \gamma^0$, and D will not steal in either case. No stealing takes place in equilibrium. Weakening IPR enforcement will not affect social surplus, but it reduces the multinational's payoff, which inevitably dampens innovations. Conventional wisdom is justified in such a setting.

Things will be different when information is asymmetric. As motivated in the Introduction, consumers in a developing country are often unaware of the quality of a foreign multinational's technology. Our model thus assumes that M's type is unknown and its licensing cost is unobservable. Except these two, everything else is observable to consumers.[13] Based on their observations, consumers update their beliefs concerning M_i's type *a la* Bayesian. We denote ρ_i^1 as consumers' belief in the first period that M_i ($i = l, h$) is the high type, and ρ_i^2 as the corresponding belief in the second period.

The rest of our analysis focuses on the comparison between weak and strong IPR enforcement under such information asymmetry. To highlight this comparison, we fix the second period enforcement to be strong while analyzing two scenarios, in which the first period enforcement is either strong or weak. Whenever possible, we apply the intuitive criterion to refine the equilibrium. In case of multiple equilibria that are Pareto rankable, we assume that players will coordinate on the Pareto dominant equilibrium.

3 Second Period: Strong IPR Enforcement

Throughout the entire paper, we assume that enforcement in the second period is strong ($\gamma^2 > \gamma^0$). Given that D never steals in the second period, if M_i invests, its revenue is $\rho_i^2 u_h + (1 - \rho_i^2)u_l$ in each segment where it invests. If M_i licenses, it sets the license fee at $f = u_l$ and earns $u_l - c_i$ in each segment. Suppose that M_i invests in x_i^2 segments

[13] M's type is irrelevant to D. Our analysis remains the same even if D observes M's type.

and licenses to y_i^2 segments ($x_i^2 + y_i^2 \leq s^2$). Its second-period profit is

$$\pi_i^2 = x_i^2[\rho_i^2 u_h + (1-\rho_i^2)u_l] - k + y_i^2(u_l - c_i).$$

Lemma 1 *In the second period, both types of M invest in all segments regardless of what happens in the first period.*

The lemma implies that the two types of M would take the same action in the second period and therefore M_h is unable to signal its type using the second period's action. If the two types of M are already separated by the end of the first period, there is no need to distort their second-period choices, so both invest in all segments. If they are not separated by the end of the first period, it is impossible for M_h to signal its type by distorting its second-period choice. The reason is as follows. The high type's investment in the second period is more valuable than the low type's, so the high type has an incentive to differentiate itself from the low type. Recall that the undistorted choice for both types in the second period is to invest in all segments. If M_h wants to signal its type, it can do so only by withholding or by switching to licensing in some segments. Because M_h and M_l differ only in their costs of licensing, withholding does not work. Because it is more costly for M_h to license than for M_l to do so, if M_h finds it profitable to signal its type by switching to licensing in some segments, it must be even more profitable for M_l to do the same thing and pretend to be the high type. Therefore, the two types must remain pooled. In fact, there exists a continuum of pooling outcomes in which both types invest in some segments and license in some or all of the remaining segments. The Pareto efficient outcome is for both types to invest in all segments, which, by our equilibrium selection criterion, is the equilibrium outcome.

Lemma 1 implies that consumers' second-period belief must remain the same as their first-period belief, i.e., $\rho_i^2 = \rho_i^1$. Thus, we can rewrite M_i's profit in the second period as:

$$\pi_i^2 = s^2[\rho_i^1 u_h + (1-\rho_i^1)u_l] - k. \tag{4}$$

Note that if the two types are separated in the first period, $\rho_h^1 = 1$ and $\rho_l^1 = 0$.

4 First Period: Strong versus Weak IPR Enforcement

4.1 Strong Enforcement

We now move back to the first period. In this subsection we consider the case in which IPR enforcement in the first period is strong ($\gamma^1 > \gamma_0$). The alternative case of weak enforcement will be analyzed in the next subsection. Recall that investment is unprofitable in the first period, and that M_h and M_l differ only in their licensing costs. Therefore, if M_h wants to signal its type, it will do so by switching from licensing to withholding (in some segments), and not by investment. Accordingly, M_i has only one choice to make in the first period: license in y_i^1 ($\leq s^1$) segments and hence withholding from the remaining $s^1 - y_i^1$ segments. As explained in the previous section, when IPR enforcement is strong, M_i's license payoff is $u_l - c_i$ per segment. Consider a possible pooling equilibrium in which both types of M license in $y^1 \leq s^1$ segments in the first period. M_i's two-period total profit is

$$\pi_i(y^1, \rho_i^1) = y^1(u_l - c_i) + \delta\{s^2[\rho_i^1 u_h + (1-\rho_i^1)u_l] - k\}. \tag{5}$$

Proposition 1 *Suppose that IPR enforcement in the first period is strong. If*

$$\frac{s^1}{s^2} > \delta\frac{u_h - u_l}{u_l - c_l}, \tag{6}$$

there exists a unique equilibrium where, in the first period, M_h withholds from some segments ($y_h^1 = s^1 - \frac{\delta s^2(u_h - u_l)}{u_l - c_l} < s^1$) while M_l licenses to all segments ($y_l^1 = s^1$) and, in the second period, both types invest in all segments.

Proposition 1 says that when the second-period market size is not very large, M_h withholds from entering some segments in the first period while M_l licenses in all segments. The intuition is as follows. As per Lemma 1, signaling is possible only in the first period, and it takes the form of withholding from entering some segments. The signaling works because withholding imposes a larger cost to the low type ($u_l - c_l$ per segment) than to the high type ($u_l - c_h$ per segment). By withholding from a right measure of segments, M_h can garner the benefit of being regarded as the high type in the second period without being mimicked by M_l. Note that M_l does not mimic M_h only when the benefit of being regarded as the high type is not very large, and hence the condition that the second-period market size should not be too large.

By Proposition 1, M_h's entry in the first period will not be complete if the market does not grow too fast. Recall that efficient entry requires both types of M to license in all segments in the first period. Incomplete entry reduces social welfare, which provides room for possible welfare improvement when stealing takes place under weaker IPR enforcement. Furthermore, because M_h can recover some of the lost income in the withheld segments through IPR enforcement, it may also benefit from weak IPR enforcement. This will be analyzed next.

4.2 Weak Enforcement

Now suppose that the first-period IPR enforcement is weak ($\gamma^1 \leq \gamma_0$). Stealing then becomes profitable for D, which affects M_i's payoffs and hence optimal choices. In the first period, if M_i stays away from a segment, D will steal and M_i's expected profit is $\gamma^1 u_l$. If M_i licenses to D, M_i has to leave enough surplus for D lest it steals, i.e., $(1-\gamma^1)u_l - d = u_l - f$, which means $f = \gamma^1 u_l + d$. M_i's payoff is therefore $\gamma^1 u_l + d - c_i$. Since $d > c_i$, licensing dominates withholding. Recall that withholding dominates investment in the first period under strong enforcement. When enforcement is weak, the return to withholding increases (from zero to positive), whereas the return to investment decreases because M_i has to lower its price to compete with D.[14] Thus, withholding continues to dominate investment in the first period under weak enforcement, which again implies that investment will not be used.

Consider a possible pooling equilibrium in which both types of M license in y^1 segments in the first period. M_i's two-period total profit is

$$\begin{aligned} \pi_i(y^1, \rho_i^1) &= y^1(\gamma^1 u_l + d - c_i) + (s^1 - y^1)\gamma^1 u_l + \delta\pi_i^2 \\ &= y^1(d - c_i) + s^1\gamma^1 u_l + \delta\{s^2[\rho_i^1 u_h + (1-\rho_i^1)u_l] - k\}. \end{aligned} \tag{7}$$

Compared with expression (5), which is M_i's profit under strong enforcement, (7) has d in place of u_l in the first term and has an extra fixed term $s^1\gamma^1 u_l$ that does not affect the choice of y^1. By similar proof as in Proposition 1, which is omitted, we have:

Proposition 2 *Suppose that IPR enforcement in the first period is weak. If*

$$\frac{s^1}{s^2} > \delta\frac{u_h - u_l}{d - c_l}, \tag{8}$$

there exists a unique separating equilibrium where, in the first period, M_h withholds from some segments ($y_h^1 = s^1 - \frac{\delta s^2(u_h - u_l)}{d - c_l} < s^1$) while M_l licenses to all segments ($y_l^1 = s^1$) and, in the second period, both types invest in all segments.

Proposition 2 is similar to Proposition 1. Note that condition (8) implies condition (6). That is, whenever M_h can separate itself from M_l under weak enforcement, it can also do so under strong enforcement.

[14] If M_i invests in a segment, it will compete with D *a la* Bertrand. D's expected profit will be $(1-\gamma^1)q - d$ when it is able to sell its product at price q, and D breaks even when $q \geq \frac{d}{1-\gamma^1}$. For any belief ρ_i^1, M_i enjoys (weak) quality advantage ($\rho_i^1 u_h + (1-\rho_i^1)u_l \geq u_l$) over D, but its cost is higher than D ($\frac{k}{s^1} > u_h > \frac{d}{1-\gamma^1}$). Therefore, either M_i is able to price p_i low enough to force D out of the market, or D is able to force M_i out of the market. In the former case, M_i will charge a price p_i such that consumers are indifferent between M_i's and D's products: $\rho_i^1 u_h + (1-\rho_i^1)u_l - p_i = u_l - \frac{d}{1-\gamma^1}$. Since $u_l - \frac{d}{1-\gamma^1} > 0$, we have $\rho_i^1 u_h + (1-\rho_i^1)u_l > p_i$. That is, M_i's per-segment investment revenue in the first period under weak enforcement, which is p_i, is smaller than that under strong enforcement, which is $\rho_i^1 u_h + (1-\rho_i^1)u_l$.

4.3 Strong versus Weak Enforcement: The Comparison

We are now ready to compare weak enforcement with strong enforcement in the first period while maintaining strong enforcement in the second period. The performance of four variables will be discussed: scale of entry, social surplus, multinational's payoff, and the incentive to innovate. We focus on the case in which the equilibrium is separating under both strong and weak enforcement, i.e., condition (8) is satisfied, which we assume for the remainder of the paper.[15] Given this condition, the IPR strength in the first period does not affect either type's entry choice, payoff or social surplus in the second period.

■ Scale of first-period entry

From Propositions 1 and 2, M_l enters all segments in the first period regardless of the enforcement strength, while M_h enters more segments under strong enforcement (the withholding is $\frac{\delta s^2(u_h-u_l)}{u_l-c_l}$) than under weak enforcement (the withholding is $\frac{\delta s^2(u_h-u_l)}{d-c_l}$). The reason for M_h's behavior is as follows. The scale of withholding is chosen to prevent M_l from mimicking; as such it is inversely related to M_l's per-segment opportunity cost of withholding. Under strong enforcement, the opportunity cost is $u_l - c_l$, which is M_l's profit in each licensed segment. Under weak enforcement, the opportunity cost is reduced, as M_l's licensing profit is lower and it receives some compensation from D. More specifically, M_l loses the licensing profit $\gamma u_l + d - c_l$ but gains γu_l through D's stealing payment. The net loss is $d - c_l$, which is smaller than $u_l - c_l$. Because M_l's opportunity cost of withholding is smaller under weak enforcement than under strong enforcement, M_h has to withhold from more segments under weak enforcement.

The conclusion that better enforcement encourages entry and technology transfer roughly matches empirical observations (Maskus and Penubarti, 1995; Branstetter, et al, 2006; Branstetter, et al, 2007; and Du, et al, 2008). Two caveats are noted, however. First, the empirical findings can be a combined result of the entry/transfer decisions of multinationals for any given technology they have already developed, and their decisions to develop these technologies in the first place. Both decisions should be affected by IPR enforcement in the developing country. The above match ignores the second effect, which will be discussed explicitly later in this subsection. Second, the theoretical prediction matches empirical observations only roughly, as the comparison is between the strong and weak enforcement regimes. Within each regime, M_h's entry scale remains the same regardless of the value of γ^1. An analysis that better matches the empirical findings should yield a first-period entry by M_h that is increasing in γ^1 even within the regime of weak and strong enforcement. Such an analysis will come later in Section 5.

■ Social surplus

Although our analysis generates positive predictions consistent with the empirical findings, its normative implication differs from conventional wisdom, which is often believed to be supported by these empirical observations. Under strong enforcement, the high type withholds from $\frac{\delta s^2(u_h-u_l)}{u_l-c_l}$ segments, which are not served by the local firm. Thus,

[15] When condition (8) is not satisfied, there will be pooling equilibrium in which both types of M withhold in the first period. We can show that the welfare comparison between strong and weak enforcement still holds, while the payoff comparison holds under some conditions.

the loss of social surplus in each of these segments is $u_l - c_h$, and the total loss (as compared with the first best of licensing in all segments) is

$$\delta s^2(u_h - u_l)\frac{u_l - c_h}{u_l - c_l}.$$

Under weak enforcement, the segments that M_h withdraws from are now served by D through stealing, so the per-segment loss of social surplus becomes $d - c_h$, which is smaller than that under strong enforcement. However, the scale of withholding under weak enforcement, $\frac{\delta s^2(u_h-u_l)}{d-c_l}$, is larger. Thus, there appears to be a trade-off between weak and strong enforcement. It turns out, however, that weak enforcement always yields a smaller loss. To see this, note that the total loss of social surplus under weak enforcement is

$$\delta s^2(u_h - u_l)\frac{d - c_h}{d - c_l},$$

which is evidently smaller than the loss under strong enforcement. The intuition is as follows. The total loss of social surplus is the per-segment loss of social surplus (i.e., society's opportunity cost of withholding) multiplied by the scale of withholding, which is inversely related to M_l's per-segment opportunity cost of withholding. When enforcement changes from strong to weak, society's opportunity cost and M_l's opportunity cost are both reduced, but since society's opportunity cost (related to c_h) is always smaller than M_l's opportunity cost (related to c_l), the reduction has a larger impact on society's opportunity cost than on M_l's opportunity cost. The net effect is that the total loss of social surplus is reduced.

Proposition 3 *Weak enforcement in the first period generates more social surplus than does strong enforcement in the first period.*

On the surface, the conclusion that weak enforcement generates more social surplus seems trivial. After all, IPR protection is supposed to be a cost that society has to pay (in the form of monopoly power in the product market) in order to provide sufficient incentive for technology innovation. Such a monopoly power is typically distortionary under downward-sloping demand and an inability to perfectly price discriminate. If a technology has already been invented, weakening IPR protection undermines the technology owner's monopoly power in the product market and should consequently lead to higher social surplus. In our model, however, the demand function is assumed to be perfectly inelastic. Hence, monopoly power by itself does not hurt social welfare. If information is symmetric, multinationals will never withhold from any segment. The first best outcome will always be achieved regardless of IPR strength, and there is no way that weak IPR enforcement can strictly increase social surplus. Withholding arises when information is asymmetric, and IPR enforcement strength matters because it affects both the scale of withholding and the social surplus in each withheld segment.

■ Multinational's payoff

To complete the picture, we need to not only consider the impact of IPR enforcement on social welfare given technology development, but we also need to examine how IPR enforcement affects the multinational's decision for developing such a technology in the first place. To do so, we first consider the multinational's first-period payoff (the second-period payoff does not depend on the enforcement strength in the first period). The impact of enforcement strength on technology development will be discussed subsequently.

M_l always licenses in all segments in the first period. When the enforcement changes from strong to weak, it has to lower the license fee in each segment from u_l to $\gamma^1 u_l + d$, so that M_l earns less under weak enforcement: $\pi_l^1(s) = s^1(u_l - c_l) > s^1(\gamma^1 u_l + d - c_l) = \pi_l^1(w)$. For M_h, it earns

$$\pi_h^1(s) = \left[s^1 - \frac{\delta s^2(u_h - u_l)}{u_l - c_l}\right](u_l - c_h)$$

in the first period under strong enforcement, and

$$\pi_h^1(w) = \left[s^1 - \frac{\delta s^2(u_h - u_l)}{d - c_l}\right](d - c_h) + s^1\gamma^1 u_l$$

under weak enforcement. Note that $\pi_h^1(s)$ does not depend on γ^1, whereas $\pi_h^1(w)$ is a linear, increasing function of γ^1. We can further show that $\pi_h^1(s) > \pi_h^1(w)$ when $\gamma^1 = 0$ and $\pi_h^1(s) < \pi_h^1(w)$ when $\gamma^1 = \gamma_0$.

Proposition 4 *When the first-period enforcement changes from weak to strong, M_l earns more profit, whereas M_h earns less profit if and only if $\gamma^1 \in [\gamma^*, \gamma_0)$ for some $\gamma^* \in (0, \gamma_0)$.*

Proposition 4 highlights one of the key results of this paper, that is, the gains in social surplus brought about by weak IPR enforcement can be shared by the high type multinational (but not the low type). When IPR enforcement is strong, M_h withholds from some segments and therefore loses profits there. When IPR enforcement is weak, M_h withholds from more segments and earns less in a licensed segment, as it has to charge a lower license fee to D in order to prevent it from stealing. However, M_h's payoff in a withheld segment is increased, as it receives some compensation for D's stealing. Within the regime of weak enforcement, M_h's payoff increases with the strength of IPR enforcement (γ^1), i.e., it prefers IPR enforcement to be (marginally) stronger. Across the regimes of weak and strong enforcement, though, M_h's payoff is higher under weak enforcement than under strong enforcement if the strength of weak enforcement is sufficiently strong. Consider the case in which γ^1 is slightly below γ_0. By the definition of γ_0, D can expect to earn almost zero from stealing. This means that M_h's profit in a licensed segment is not reduced. The comparison of M_h's payoff then boils down to a tradeoff between larger per-segment loss of profit under strong enforcement and larger withholding scale under weak enforcement. Given that D (and consumers) is receiving zero surplus, M_h's per-segment profit equals social surplus in the segment. Therefore, the conclusion is the same as with social surplus: M_h's first period payoff is higher under weak enforcement.

■ Innovation and technology portfolio

Conventional wisdom, which is in favor of strong IPR enforcement in developing countries, maintains that strong enforcement provides multinationals with incentives to develop technologies and products that will ultimately benefit developing countries. The argument is based on the premise that multinationals' profits will be lower when IPR enforcement becomes weaker. This may be the case in a conventional setting without any market imperfection. However, as shown above, when there is some form of market imperfection such as information asymmetry, weaker IPR may generate not only more surplus for society but also more profit for the (high type) multinationals. Moreover, because IPR enforcement strength affects the two types of multinationals differently, the technology portfolio facing the developing country may also change in response to the enforcement strength.

Imagine that after Nature determines its type, the multinational has to choose the likelihood that its technology will be successfully developed, $v_i \in [0,1]$, at a cost of $\phi\frac{v_i^2}{2}$, where ϕ is some large constant that ensures an interior solution for the optimal choice, v_i^*. Let $\pi_i^j \equiv \pi_i^1(j) + \delta\pi_i^2(j)$ be type i's two-period total profits under enforcement regime j, where $i = h, l$ and $j = s, w$. Then, M_i chooses v_i to maximize $v_i\pi_i^j - \phi\frac{v_i^2}{2}$, and the optimal choice is $v_i^* = \frac{\pi_i^j}{\phi}$. Let $\rho > 0$ be the probability that $M = M_h$ by Nature's choice. Then the probability that a technology is developed at all is $\rho\frac{\pi_h^j}{\phi} + (1-\rho)\frac{\pi_l^j}{\phi}$ under regime j. Hence, strong IPR enforcement is more likely to generate a technology suitable for the developing country than weak enforcement if and only if

$$\rho\frac{\pi_h^s}{\phi} + (1-\rho)\frac{\pi_l^s}{\phi} > \rho\frac{\pi_h^w}{\phi} + (1-\rho)\frac{\pi_l^w}{\phi},$$

or

$$(1-\rho)(\pi_l^s - \pi_l^w) > \rho(\pi_h^w - \pi_h^s).$$

Since $\pi_h^w - \pi_h^s = \pi_h^1(w) - \pi_h^1(s) > 0$ for $\gamma^1 \in [\gamma^*, \gamma_0)$ while $\pi_l^s - \pi_l^w = \pi_l^1(s) - \pi_l^1(w) = 0$ when $\gamma^1 = \gamma_0$, we conclude:

Corollary 1 *Weak enforcement is more likely to generate technologies for developing countries than strong enforcement if and only if*

(a) $\gamma^1 > \gamma(\rho)$ *for some* $\gamma(\rho) \in [\gamma^*, \gamma_0)$ *for any given* ρ*; and likewise*

(b) $\rho > \rho(\gamma^1)$ *for some* $\rho(\gamma^1) \in (0,1]$ *for any given* $\gamma^1 \in (\gamma^*, \gamma_0)$.

Corollary 1 brings forward two important implications in contrast to conventional wisdom. The first part of the corollary suggests that regardless of the value of ρ, that is, regardless of how likely the multinational is a high type to begin with, there always exists some moderately weak form of IPR enforcement more likely to develop a technology suitable for the developing country than strong IPR enforcement. The second part implies that moderately weak enforcement is more likely to develop a technology for the developing country than strong enforcement, provided that the likelihood of the multinational being the high type is large enough.

We can now reinterpret ρ^0, the aforementioned *a priori* probability that $M = M_h$, as the conditional probability of the multinational being a high type given that it has developed a technology for the developing country. In accordance, ρ^0 reflects the *ex ante* reputation of the multinational anticipated by local consumers and can therefore be endogenously determined as

$$\rho^0 = \frac{\rho\pi_h^j}{\rho\pi_h^j + (1-\rho)\pi_l^j}$$

under enforcement regime j. The multinational enjoys better initial reputation under strong enforcement if and only if $\frac{\pi_l^w}{\pi_l^s} > \frac{\pi_h^w}{\pi_h^s}$. Because $\pi_h^w > \pi_h^s$ for $\gamma^1 \in [\gamma^*, \gamma_0)$ while $\pi_l^s > \pi_l^w$ for any $\gamma^1 \leq \gamma_0$, it is apparent that the multinational enjoys better *ex ante* reputation when the weak strength γ^1 is in the range of $[\gamma^*, \gamma_0)$ than when enforcement is strong. Moreover, since both $\frac{\pi_l^w}{\pi_l^s}$ and $\frac{\pi_h^w}{\pi_h^s}$ are linear and increasing in γ^1, we can further conclude:

Corollary 2 *There exists $\gamma^{**} \in [0, \gamma^*)$ such that the multinational enjoys a better* ex ante *reputation, i.e., a higher ρ^0, under weak enforcement than under strong enforcement if and only if the weak strength satisfies $\gamma^1 > \gamma^{**}$.*

Corollary 2 suggests that upon entering the developing country, the multinational will be endowed with a better reputation under weak enforcement even when the weak enforcement hurts the incentive for technology development for both types (i.e., when $\gamma^1 \in (\gamma^{**}, \gamma^*)$). This is because weak IPR enforcement hurts the low type's incentive more than it hurts the high type. Hence, conditional on the multinational entering the market with a technology, it is more like to be the high type under weak enforcement than under strong enforcement.

5 Enforcement Cost

So far we have developed a simple model of IPR enforcement under information asymmetry. While our theoretical results roughly correspond to empirical evidence found in the existing literature, the match is imperfect because within the weak and strong enforcement regime, the scale of entry and the level of social surplus are constant regardless of the enforcement strength. To generate theoretical predictions that better match empirical observations, we extend the main model by introducing the cost of enforcement and allowing such a cost to vary across segments.

In the main model, enforcement, while imperfect, is assumed to be costless. In this section, we assume instead that the multinational has to incur a positive cost in order to initiate the IPR enforcement process. The cost reflects resources the multinational has to engage, including time, money, paperwork and personnel, in order for the legal authority to launch an investigation. Once an investigation is launched, the probability of successfully convict the copycat and obtain the compensation remains to be γ. Furthermore, we assume that the enforcement cost may differ across segments. This may be the case when the cost and competency of local lawyers or the level of government red tape differs from city to city. Without loss of generality, we assume that the enforcement cost in segment j, ω_j, is increasing in j. We also assume for simplicity that the cost is independent of M's type, that newly emerging segments in the second period are indexed higher than the first period segments, and that $\gamma_0 u_l > \omega_{s^2}$. The last assumption ensures that when the enforcement is strong, M would be willing to incur the enforcement cost in any segment should stealing take place there. As in the main model, the enforcement in the second period is assumed to be strong and accordingly no stealing takes place in the second period. Our ensuing analysis focuses on the first period.

When stealing takes place in the first period in segment j, M will start the enforcement process if and only if $\gamma^1 u_l \geq \omega_j$. Let $\underline{j}$ be the segment in which M is indifferent between starting the enforcement process or not. Note that $\underline{j}$ depends on the strength of enforcement, γ^1. Since ω_j is increasing in j, we have $j \in [0, \underline{j})$ as an enforceable segment and $j \in [\underline{j}, s^1]$ as an unenforceable segment. If M_i chooses to enter an enforceable segment, it offers the technology to D at a licensing fee of $\gamma^1 u_l + d$ and earns a payoff that equals $\gamma^1 u_l + d - c_i$. If M_i chooses to enter an unenforceable segment, it has to offer the technology to D at a lower licensing fee of d and thus earns a payoff of $d - c_i$. In such a segment, the effective enforcement strength becomes zero. If M_i decides to withhold from a segment, its expected payoff is $\gamma^1 u_l - \omega_j$ if the segment is enforceable and 0 if it is unenforceable.

The following result describes the entry choices made by the two types of M in the first period.[16]

Proposition 5 *There exists a separating equilibrium, in which during the first period,*

(a) M_l licenses in all segments while M_h licenses in some segments and withholds from the remaining segments;

(b) M_h withholds from all unenforceable segments before it withholds from any enforceable segment;

(c) M_h withholds from an enforceable segment with a smaller enforcement cost before it withholds from an enforceable segment with a larger enforcement cost.

As in the main model, condition (8), which we continue to assume, ensures that no pooling equilibrium exists. In a separating equilibrium, M_l enters all segments, even in those where M_l will not be willing to start the enforcement process should stealing take place. This is simply because licensing is more efficient than stealing ($d > c_l$) and, therefore, M_l will offer a licensing contract attractive enough for D to accept and hence to give up stealing, in which case the enforcement cost becomes irrelevant.

To differentiate itself from M_l, M_h has to withhold from some segments. Proposition 5 highlights the order of M_h's withholding, which is non-monotonic in the enforcement cost. M_h first withholds from unenforceable segments, i.e., those segments where the enforcement cost is so high that M_h will not seek enforcement after stealing takes place.

[16] The equilibrium is not unique only when all withholding happens among unenforceable segments and it is only because M_h is indifferent as to the identity of withheld segments (the measure of withheld segments remains unique).

In each of these segments, D steals and gets away unpunished. Should withholding from these segments be insufficient to signal its type, M_h further withholds from enforceable segments, where it will battle against D for IPR infringement.

The reason that M_h first withholds from unenforceable segments is as follows. Withholding from an unenforceable segment reduces the payoff of M_h by $d - c_h$ and that of M_l by $d - c_l$. Withholding from an enforceable segment, j, reduces the payoff of M_h by $\gamma u_l + d - c_h - (\gamma u_l - \omega_j) = d - c_h + \omega_j$ and that of M_l by $d - c_l + \omega_j$. In other words, withholding from an enforceable segment involves a larger opportunity cost for M_h (which is bad for M_h), as well as a larger opportunity cost for M_l (which is good for M_h because it reduces the scale of withholding) than withholding from an unenforceable segment. As before, M_h prefers a situation in which both opportunity costs are smaller, i.e., withholding from unenforceable segments first.

Among enforceable segments, M_h first withholds from those with lower enforcement costs. This can be similarly explained: the per-segment opportunity cost of withholding for M_i is $d - c_i + \omega_j$, and M_h prefers lower opportunity cost, namely smaller ω_j.

Whether M_h withholds from unenforceable segments only or from some enforceable segments as well depends, among other things, upon the strength of enforcement, γ^1. It is easy to show that when $s^1 - \underline{j}(\gamma^1) \geq \delta s^2 \frac{u_h - u_l}{d - c_l}$ (i.e., when γ^1 is very small), it is sufficient for M_h to withhold only from unenforceable segments. Otherwise, M_h has to withhold from some enforceable segments as well. As an increase in γ^1 increases $\underline{j}$ and shrinks the measure of unenforceable segments, M_h starts to withhold from enforceable segments. Because the opportunity cost of withholding from an unenforceable segment for M_l is smaller than from an enforceable segment, the increase in the scale of withholding from enforceable segments must be smaller than the reduction in the measure of unenforceable segments. With sufficient improvement in IPR enforcement, all segments become enforceable while stealing continues in any segment that M_h chooses to withdraw from. Further improvement, i.e., when $\gamma^1 \geq \gamma_0$, deters D from stealing. By the assumption that $\gamma_0 u_l > \omega_{s^2}$, it can be shown that the scale of withholding by M_h when all segments are enforceable is bounded below when the enforcement becomes strong. The next proposition summarizes this implication.

Proposition 6 *Suppose that $\gamma_0 u_l > \omega_{s^1}$. As the strength of IPR enforcement improves, M_h enters (weakly) more segments, and strictly so when γ^1 satisfies the condition $s^1 - \underline{j}(\gamma^1) < \delta s^2 \frac{u_h - u_l}{d - c_l}$.*

The implication highlighted in Proposition 6 differs from the prediction obtained from the main model, which suggests a constant level of entry by M_h as long as enforcement remains weak. Proposition 6 therefore better matches empirical findings in the literature (Maskus and Penubarti (1995), Branstetter, et al (2006), Branstetter, et al (2007), and Du, et al (2008)). Notice that in Proposition 6, better IPR enforcement encourages entry not because it provides more incentives for technology development by the multinational. Instead, given a technology, M_h decides to make the technology legally available (via licensing) in (weakly) more segments when IPR enforcement is improved. Hence the driving force for the phenomenon is the need for signaling: a larger γ^1 allows M_h to withhold from fewer segments in its attempt to separate itself from M_l.

Despite the expansion of entry, improved IPR enforcement does not lead to an increase in social welfare, in contrast to what conventional wisdom would suggest. When the enforcement is sufficiently weak, that is, when $s^1 - \underline{j}(\gamma^1) \geq \delta s^2 \frac{u_h - u_l}{d - c_l}$, M_h will not withhold from any enforceable segment. In this case, a small improvement in IPR enforcement has no impact on the scale of withholding and hence on social welfare, since in any segment that M_h withholds from, M_h will not incur an enforcement cost. As improved enforcement turns unenforceable segments into enforceable segments and induces M_h to increasingly withhold from enforceable segments, the social surplus diminishes. To see this, note that the withholding from an unenforceable segment gives rise to a social cost of $d - c_h$, or the cost difference between stealing and licensing. Withholding from an enforceable segment, j, however, induces a social cost of $d - c_h + \omega_j$. The additional cost, ω_j, is incurred because M_h will resort to the enforcement mechanism to claim its share from the copycat. When the improved enforcement reduces the measure of withholding from unenforceable segments by y, M_h will increase the measure of withholding from enforceable segments by, say, x. Let X represent the additional enforceable segments that M_h withholds from. The change in social surplus is therefore:

$$(y - x)(d - c_h) - \int_X \omega_j dj.$$

However, in order to separate itself from M_l, M_h must choose X, and hence x, in such a way that M_l has no incentive to mimic. This turns out to require:

$$(y - x)(d - c_l) - \int_X \omega_j dj = 0.$$

Since $c_h < c_l$, the resulting change in social surplus due to an improvement in enforcement is negative.

Proposition 7 *Social surplus under weak enforcement is weakly decreasing in γ^1.*

Furthermore, in the case when $s^1 - \underline{j}(\gamma^1) \geq \delta s^2 \frac{u_h - u_l}{d - c_l}$ and hence M_h withholds from unenforceable segments only, no enforcement cost is incurred in equilibrium. As a result, the scale of withholding by M_h in this case is the same as in the main model when there is no enforcement cost. Recall Proposition 3, which states that (without enforcement cost) weak enforcement generates more social surplus than strong enforcement. Applying the result here, we can then conclude that even with enforcement cost, social surplus generated under weak enforcement (if it is sufficiently weak) is higher than under strong enforcement.

When enforcement is still weak but close to strong (i.e., when γ^1 is close to γ_0), we know from the analysis above that the scale of withholding by M_h is bounded below by that under strong enforcement, as the cost of enforcement is assumed to be bounded above by $\gamma_0 u_l$. In fact, it can be shown that the scale of withholding by M_h approaches the lower bound when the enforcement cost in each segment approaches the upper bound. This implies that when the enforcement cost in each segment approaches its upper limit, the social surplus generated under moderately weak enforcement can fall below that under strong enforcement. On the other hand, if the enforcement cost in each segment is sufficiently small, we again know from the analysis of the main model that the social surplus thus obtained must be higher than that under strong enforcement.

We therefore conclude:

Proposition 8 *Suppose that $\gamma_0 u_l > \omega_{s^1}$. Compared to that under strong enforcement, social surplus under weak enforcement*

(a) is higher when γ^1 satisfies the condition $s^1 - \underline{j}(\gamma^1) \geq \delta s^2 \frac{u_h - u_l}{d - c_l}$;

(b) is higher (lower) when γ^1 is sufficiently close to γ_0 if ω_j is sufficiently small (large) for all $j \in [0, s^1]$.

Together, Propositions 6, 7, and 8 bring caution to the policy implications to be derived from empirical findings in the literature. Even if better IPR enforcement promotes multinationals' entry into developing countries, this may not serve as evidence in support of IPR improvement in an economy that suffers from various forms of market imperfection.

While Propositions 7 and 8 appear to paint a rather grim picture regarding IPR enforcement, it should be noted that both results are obtained under the condition that the multinational has already developed a technology for the market. To properly evaluate the effect of IPR enforcement, we once again need to look at its impact on the multinational's payoff.

Proposition 9 *Suppose that $\gamma_0 u_l > \omega_{s^1}$. Then,*

(a) the payoff of M_l is (weakly) increasing in $\gamma^1 \in [0, 1]$;

(b) the payoff of M_h is (weakly) increasing in γ^1 if $s^1 - \underline{j}(\gamma^1) \geq \delta s^2 \frac{u_h - u_l}{d - c_l}$;

(c) compared to that under strong enforcement, the payoff of M_h is lower when $\gamma^1 = 0$ and there exists $\gamma^{**} \in (0, \gamma_0)$ such that the payoff of M_h is higher when $\gamma^1 \in [\gamma^{**}, \gamma_0)$.

As in the main model, the payoff of M_l increases when the enforcement is improved. Recall that M_l licenses in all segments, earning $\gamma^1 u_l + d - c_l$ in an enforceable segment and $d - c_l$ in an unenforceable segment. It gains from improved enforcement for two reasons. First, the measure of enforceable segments is enlarged, and M_l earns more in an enforceable segment than in an unenforceable segment. Second, in an enforceable segment, M_l enjoys a larger profit because it can charge a higher license fee to D due to the improved enforcement.

Improved IPR enforcement also increases M_h's payoff when M_h withholds only from unenforceable segments. In such a case, a marginal improvement of enforcement does not affect the scale of withholding; it only expands the measure of enforceable segments. Accordingly, M_h gains from both the enlarged measure of enforceable segments and the higher licensing fee in any given enforceable segment, just like in the case of M_l.

When M_h begins to withhold from enforceable segments, better enforcement has an additional effect: it allows M_h to reduce the scale of its withholding. This turns out to be costly for M_h. The reason is as follows. The withholding by M_h has to satisfy the incentive compatibility constraint such that M_l does not mimic the withholding. The cost of withholding from an enforceable segment is $d - c_l + \omega_j$ for M_l and is $d - c_h + \omega_j$ for M_h, so M_h enjoys a cost advantage in withholding over M_l by the amount of $c_h - c_l$, which is turned into M_h's profit in a withheld segment. Accordingly, conditional on M_l not mimicking M_h, M_h's payoff is reduced in the withheld segments due to the decreased scale of withholding. Of course, in licensed segments and in segments that are turned from withholding to licensing, M_h's profit still increases due to improved enforcement. The net effect is unclear.

Nevertheless, it remains true that M_h has a higher payoff under moderately weak enforcement (and a lower payoff under extremely weak enforcement) than under strong enforcement. Under moderately weak enforcement (when γ^1 approaches γ_0 from below), all segments become enforceable. In the main model with zero enforcement cost, we know that M_h makes more profit under moderately weak enforcement than under strong enforcement. The comparison therefore must remain true when enforcement costs are sufficiently small. When enforcement costs approach their upper limit, the scale of withholding gets close to that under strong enforcement, as suggested earlier. In each segment where M_h offers licensing, M_h earns $\gamma^1 u_l + d - c_h$, which approaches $u_l - c_h$ when γ^1 approaches γ_0. In each segment where M_h withholds, M_h earns $\gamma^1 u_l - \omega_j$. When ω_j approaches its upper limit, the earning by M_h in such a segment approaches that under strong enforcement as well. Therefore, the total profit for M_h when the enforcement cost approaches its upper limit approaches that under strong enforcement. Since the equilibrium payoff of M_h is decreasing in enforcement costs in withheld segments, M_h will make more profits under moderately weak enforcement than under strong enforcement.

6 Competing Domestic Firms

One of our assumptions in the main model is that the multinational can contract with the single local firm, which is also the only potential copycat, in each segment. While allowing such a contract helps explain the fundamental question of why welfare gains achieved under weak IPR enforcement cannot be replicated under strong enforcement, it may also invite questions as to whether contracting is possible at all under weak enforcement. To examine the issue, we return to the main model and assume zero enforcement cost in all segments. Instead of a single domestic firm in each segment, however, we now assume many domestic firms in each segment. These firms all have the capability to steal the multinational's technology and compete in the product market *a la* Bertrand. We assume that the multinational is able to identify, and hence contract with, only one local firm in each segment.[17] This alternative setting obviously

[17] This is equivalent to a setting in which a domestic firm from a segment can sell its product to another segment when the technology is stolen. We choose the current setting for expositional simplicity.

better reflects the reality in a developing country. We want to investigate how this alternative assumption alters the qualitative results we obtained earlier.

As before, a domestic firm which steals the technology can expect to earn $(1-\gamma)q-d$ if it charges price q. The break-even price is therefore $q=\frac{d}{1-\gamma}$. When $\gamma>\gamma_0\equiv 1-\frac{d}{u_l}$, $q>u_l$, i.e., the break-even price is beyond the consumers' willingness to pay. Hence, as in the main model, a domestic firm can never sell the product for a profit and hence will not steal when enforcement is strong. In such a case, both M and domestic firms earn zero in a segment in which M withholds. In a segment where M_i licenses to a domestic firm, since the licensee does not face competition from other domestic firms, it will charge a price of u_l in the product market. As a result, M_i will charge a license fee that equals u_l, and M_i's payoff is u_l-c_i while the licensee's payoff is zero. As both parties' payoffs are the same as in the main model, Proposition 1 holds.

When the first period IPR enforcement is weak ($\gamma^1\leq\gamma_0$), in a segment where M_i withholds, Bertrand competition among domestic firms implies that all domestic firms will charge a price equal to $\frac{d}{1-\gamma^1}$ and expect to earn zero profit. Since each segment has a unit demand, the total earning made by all of these domestic firms equals $\frac{d}{1-\gamma^1}$, which is transferred to M_i with probability γ^1 through IPR enforcement. Hence, M_i's expected payoff is $\frac{\gamma^1 d}{1-\gamma^1}$ in such a segment. In a segment where M_i identifies a domestic firm and licenses to it the technology, the licensee will set its price equal to $\frac{d}{1-\gamma^1}$ to weed out competition from other domestic firms who may steal the technology. The licensee can certainly opt to refuse the license and instead steals M_i's technology, in which case it will make zero profit as a result of Bertrand competition against other domestic firms. Accordingly, the licensee's outside option has a value of zero. Realizing this, M_i will charge a license fee that equals $\frac{d}{1-\gamma^1}$, earning an expected payoff of $\frac{d}{1-\gamma^1}-c_i$. Therefore, M_i's two-period total profit is

$$\begin{aligned}\pi_i(y^1,\rho_i^1) &= y^1\left(\frac{d}{1-\gamma^1}-c_i\right)+(s^1-y^1)\frac{\gamma^1 d}{1-\gamma^1}+\delta\pi_i^2 \\ &= y^1(d-c_i)+s^1\frac{\gamma^1 d}{1-\gamma^1}+\delta\{s^2[\rho_i^1 u_h+(1-\rho_i^1)u_l]-k\}.\end{aligned}$$

Comparing the expression with equation (7) when there is only one domestic firm in each segment, we note that the only difference is in the term $s^1\gamma^1\frac{d}{1-\gamma^1}$ in the case of multiple domestic firms as opposed to $s^1\gamma^1 u_l$ in the case of a single domestic firm. The term, however, does not affect the choice of y^1 by either M_h or M_l. Therefore, Proposition 2 continues to hold.

In other words, the number of potential copycats in a market has no effect on the equilibrium choice of entry by the multinational. As a result, the social welfare comparison (Propositions 3) remains the same as before. The presence of competition among copycats under weak enforcement only reduces the equilibrium payoffs of both M_h and M_l by $s^1\gamma^1(u_l-\frac{d}{1-\gamma^1})$. Notice that this payoff reduction is small when enforcement is moderately weak (i.e., when γ^1 is close to γ_0). In such a case, all competing domestic firms will charge a price close to what a single domestic firm will charge without competition. When the enforcement becomes extremely weak (i.e., when γ^1 is close to zero), the payoff reduction is also small because the multinational can hardly expect any transfer from copycats whether there is one or many copycats.

Turning now to the comparison of the multinational's payoff between weak and strong enforcement, we note that as in the case of a single domestic firm in each segment, M_l is always hurt by the weak enforcement. In fact, competition among domestic firms only compounds the damage of weak enforcement on M_l, as we have highlighted above. As for M_h, although the competition among copycats also reduces its payoff under weak enforcement, it remains true that there exists some range of weak enforcement under which M_h earns more than under strong enforcement.[18] Therefore, the qualitative result of Proposition 4 continues to hold.

Although competition among copycats does not alter the qualitative results of most of our previous results, by reducing the equilibrium payoffs of both M_h and M_l by the same amount, the competition changes the technology portfolio. In particular, it becomes less likely that the multinational, whether the high type or the low type, is able to bring a technology to the developing country. The impact on ρ^0, the initial reputation that the multinational is endowed with when it enters the market, is less straightforward. It can be verified that $\pi_h < \pi_l$ whether the first period enforcement is strong or weak. As the competition reduces the equilibrium payoff of both M_h and M_l by the same amount, it can be shown that $\frac{\pi_h}{\pi_l}$ decreases, implying that the incentive of technology development is damaged more for M_h than for M_l and, as a result, the multinational will begin with a worse reputation in the first period.

7 Concluding Remarks

We have demonstrated in this paper that, when a country suffers from some forms of market failure, perfect IPR enforcement may serve the interest of neither the country nor the foreign multinationals transferring technology to that country. Instead, moderately weak enforcement can do better for both parties. However, extremely weak enforcement benefits the country at the expense of the foreign multinationals and is therefore likely to hurt the country ultimately when the incentives of technology development by foreign multinationals are taken into account. Although the normative results of our analysis depart from conventional wisdom that often advocates more stringent IPR enforcement in developing countries, the positive results of this paper match well with empirical observations that have been thought to support conventional wisdom. This not only makes our analysis relevant, but also raises doubts as to whether

[18] M_h's first-period payoff under weak enforcement becomes

$$\pi_h^1(w) = \left[s^1 - \frac{\delta s^2(u_h - u_l)}{d - c_l}\right](d - c_h) + s^1 \frac{\gamma^1 d}{1 - \gamma^1},$$

which is increasing γ^1 with $\pi_h^1(s) > \pi_h^1(w)$ at $\gamma^1 = 0$ and $\pi_h^1(s) < \pi_h^1(w)$ at $\gamma^1 = \gamma_0$.

the right policy implications have been drawn upon empirical facts when it comes to enforcing IPR in a developing country.

The particular form of market imperfection we have focused on is information asymmetry between foreign multinationals and local consumers concerning the quality of the former's technology. We have stressed in the Introduction the pertinence of this form of market imperfection to a developing country. Focusing on this particular form of market imperfection allows our analysis to be more efficient—we can simultaneously explain why the Pareto gains achieved under moderately weak enforcement cannot be attained under strong enforcement through a contractual arrangement. It will be useful to think of other forms of market imperfection that may prevent foreign multinationals from entering a developing country even under strong enforcement. However, it is likely to be challenging to simultaneously address why weak enforcement brings welfare gains and why such gains cannot be replicated under strong enforcement through contracting.

According to our analysis, information asymmetry, and hence the need for signaling, induces foreign multinationals with better technologies to partially delay their entry into developing countries. The delay is driven by the assumption that initial entry is more costly, and therefore withholding is less costly, for a multinational with better technologies. As explained earlier, we deem the assumption realistic. More importantly, the qualitative results of our analysis hold even without such an assumption. Should we alternatively assume that multinationals with better technologies gain more from maintaining their images, we would arrive at same conclusions even when the licensing cost is the same across types of multinationals.

Finally, we have assumed that second-period IPR enforcement is always strong. While the assumption is adopted to simplify the exposition of our analysis, it is more realistic to assume some form of weak enforcement in the second period as well. While it will be interesting to discuss, for example, the dynamic implications of better IPR enforcement using this alternative assumption, such an exercise will not change our analysis qualitatively and we choose to not incorporate it here.

Appendix

Proof of Lemma 1

If the two types are separated in the first period, they will choose their first best action in the second period, which is to invest in all segments. If the two types are not separated in the first period, we show below that they cannot separate in the second period, either. Suppose the contrary is true, i.e., the two types take different actions in the second period. Given Assumption 3 ($k < s^2 c_l$), M_l can do no worse by investing in all segments. Hence, $x_l^2 = s^2$

and $x_h^2 < s^2$. The following incentive compatibility conditions must hold

$$\begin{aligned} s^2 u_l &\geq x_h^2 u_h + y_h^2(u_l - c_l), \\ s^2 u_l &\leq x_h^2 u_h + y_h^2(u_l - c_h). \end{aligned}$$

Since $c_h > c_l$, these two conditions cannot hold simultaneously.

Meanwhile, a pooling equilibrium where both types invest in all segments ($x_l^2 = x_h^2 = s^2$) clearly exists. There does not exist any deviation (x^*, y^*) with the corresponding (off-equilibrium) belief ρ^* such that it would be profitable for the high type to deviate but not for the low type to do so. This is because, should

$$s^2[\rho^2 u_h + (1-\rho^2)u_l] \leq x^*[\rho^* u_h + (1-\rho^*)u_l] + y^*(u_l - c_h)$$

hold, we have

$$s^2[\rho^2 u_h + (1-\rho^2)u_l] \leq x^*[\rho^* u_h + (1-\rho^*)u_l] + y^*(u_l - c_l)$$

as well, given that $c_l < c_h$.

In fact, there exists a continuum of pooling equilibria with $x^2 \leq s^2$. They are supported by the off-equilibrium belief that only M_l deviates. Given this belief, either type must do no worse than invest in all segments and be regarded as the low type. That is,

$$x^2[\rho^2 u_h + (1-\rho^2)u_l] - k + y^2(u_l - c_i) \geq s^2 u_l - k$$

for $i = h, l$. Given our equilibrium selection criterion, the two types choose the most efficient pooling outcome, namely $x_l^2 = x_h^2 = s^2$. *Q.E.D.*

Proof of Proposition 1

We first show that a pooling equilibrium does not exist. Suppose there is a pooling equilibrium. Then either type of M can do no worse than licensing in all segments in the first period and investing in all segments (and being regarded as the low type) in the second period. In particular, $\pi_l(y^1, \rho^0) \geq \pi_l(s^1, 0)$. Define $\tilde{y}^1$ such that $\pi_l(\tilde{y}^1, 1) = \pi_l(y^1, \rho^0)$. Then, $\pi_l(\tilde{y}^1, 1) \geq \pi_l(s^1, 0)$, which means $\tilde{y}^1 > 0$ given that $\frac{s^1}{s^2} > \delta \frac{u_h - u_l}{u_l - c_l}$. $\tilde{y}^1$ is a deviation that gives M_l its equilibrium payoff should consumers assign an off-equilibrium belief that $\rho^1(\tilde{y}^1) = 1$.

Totally differentiating the profit $\pi_i(y^1, \rho_i^1)$ in (5) with respect to y^1 and ρ_i^1, we have $\frac{d\rho_i^1}{dy^1} = -\frac{u_l - c_i}{\delta s^2(u_h - u_l)}$. Since $c_h > c_l$, we have

$$\left|\frac{d\rho_h^1}{dy^1}\right| < \left|\frac{d\rho_l^1}{dy^1}\right|.$$

Therefore, the iso-profit curves of M_h and M_l satisfy the single-crossing property. As a result, there exists $\epsilon > 0$ with $\tilde{y}^1 - \epsilon > 0$ such that $\pi_l(\tilde{y}^1 - \epsilon, 1) < \pi_l(y^1, \rho^0)$ whereas $\pi_h(\tilde{y}^1 - \epsilon, 1) > \pi_h(y^1, \rho^0)$. In other words, there exists a feasible deviation $\tilde{y}^1 - \epsilon$ from which M_l can never profit even if consumers assign the most favorable belief following such a deviation, whereas M_h can profit under some posterior belief of consumers. Accordingly, the pooling equilibrium does not meet the intuitive criterion.

Now, consider the possibility of a separating equilibrium. By the usual argument, M_l licenses in all segments in the first period and invests in all segments in the second, thus earning a profit

$$\pi_l(s^1, 0) = s^1(u_l - c_l) + \delta(s^2 u_l - k).$$

M_h licenses in y_h^1 segments in the first period and invests in all segments in the second period. For M_l not to mimic M_h, we must have $\pi_l(s^1, 0) \geq \pi_l(y_h^1, 1)$, or

$$s^1(u_l - c_l) + \delta(s^2 u_l - k) \geq y_h^1(u_l - c_l) + \delta(s^2 u_h - k),$$

from which we find $y_h^1 = s^1 - \frac{\delta s^2(u_h - u_l)}{u_l - c_l} < s^1$. Given (6), $y_h^1 > 0$. *Q.E.D.*

Proof of Proposition 4

Note that $u_l - c_h > d - c_h$ and so $s^1 - \frac{\delta s^2(u_h - u_l)}{u_l - c_l} > s^1 - \frac{\delta s^2(u_h - u_l)}{d - c_l}$. Thus, when $\gamma^1 = 0$, $\pi_h^1(s) = \left[s^1 - \frac{\delta s^2(u_h - u_l)}{u_l - c_l}\right](u_l - c_h) > \left[s^1 - \frac{\delta s^2(u_h - u_l)}{d - c_l}\right](d - c_h) = \pi_h^1(w)$. Also note that $\frac{d - c_h}{d - c_l} < \frac{u_h - c_h}{u_l - c_l}$. Hence, when $\gamma^1 = \gamma_0$, $\pi_h^1(w) = s^1(u_l - c_h) - \delta s^2(u_h - u_l)\frac{d - c_h}{d - c_l} > s^1(u_l - c_h) - \delta s^2(u_h - u_l)\frac{u_l - c_h}{u_l - c_l} = \pi_h^1(s)$. *Q.E.D.*

Proof of Proposition 5

We begin by showing that no pooling equilibrium exists under condition (8). Suppose pooling in the first period with both types withdrawing from $L_e \subseteq [0, \underline{j}(\gamma^1))$ enforceable segments and $L_n \subseteq [\underline{j}(\gamma^1), s^1]$ unenforceable segments. M_i's two-period payoff is then

$$\begin{aligned} \pi_i(L_e, L_n, \rho^0) &= (\underline{j} - \|L_e\|)(\gamma^1 u_l + d - c_i) + \int_{L_e} (\gamma^1 u_l - \omega_j) dj + (s^1 - \underline{j} - \|L_n\|)(d - c_i) \\ &\quad + \delta[s^2(\rho^0(u_h - u_l) + u_l) - k] \\ &= \underline{j}\gamma^1 u_l + s^1(d - c_i) - \int_{L_e} (d - c_i + \omega_j) dj - \int_{L_n} (d - c_i) dj + \delta[s^2(\rho^0(u_h - u_l) + u_l) - k], \end{aligned}$$

where $\|L\|$ is the measure of L. This equilibrium exists only if

$$\pi_i(L_e, L_n, \rho^0) \geq \pi_i(\emptyset, \emptyset, 0).$$

The equilibrium must also satisfy the intuitive criterion, that is, there does not exist $L'_e \subseteq [0, \underline{j})$ and $L'_n \subseteq [\underline{j}, s^1]$ such that

$$\pi_l(L_e, L_n, \rho^0) \geq \pi_l(L'_e, L'_n, 1)$$

while at the same time there exists $\rho^1(L'_e, L'_n)$ such that

$$\pi_h(L_e, L_n, \rho^0) \leq \pi_h(L'_e, L'^1_n(L'_e, L'_n)).$$

When condition (8) holds, there exists L'_e, L'_n, with $L'_e \supseteq L_e$, $L'_n \supseteq L_n$, and $L'_e \cup L'_n \neq [0, s^1]$, such that

$$\pi_l(L_e, L_n, \rho^0) = \pi_l(L'_e, L'_n, 1).$$

To see this, note that when M_l withdraws from all enforceable segments, its payoff under the belief $\rho^1 = 1$ equals:

$$\begin{aligned}
\pi_l([0, \underline{j}), [\underline{j}, s^1], 1) &= \underline{j}\gamma^1 u_l + s^1(d - c_l) - \int_0^{\underline{j}} (d - c_l + \omega_j) dj - (s^1 - \underline{j})(d - c_l) + \delta(s^2 u_h - k) \\
&= \underline{j}\gamma^1 u_l - \int_0^{\underline{j}} \omega_j dj + \delta(s^2 u_h - k),
\end{aligned}$$

which is less than

$$\pi_l(\emptyset, \emptyset, 0) = \underline{j}\gamma^1 u_l + s^1(d - c_l) + \delta(s^2 u_l - k),$$

given condition (8). Since $\pi_l([0, \underline{j}), [\underline{j}, s^1], 1) < \pi_l(\emptyset, \emptyset, 0)$ and since $\pi_l(\emptyset, \emptyset, 0) \leq \pi_l(L_e, L_n, \rho^0)$, there exists L'_e, L'_n, with $L'_e \supseteq L_e$, $L'_n \supseteq L_n$, and $L'_e \cup L'_n \neq [0, s^1]$, such that

$$\pi_l(L_e, L_n, \rho^0) = \pi_l(L'_e, L'_n, 1),$$

or

$$\delta s^2(1 - \rho^0)(u_h - u_l) = (\|L'_e\| + \|L'_n\| - \|L_e\| - \|L_n\|)(d - c_l) + \int_{L'_e} \omega_j dj + \int_{L_e} \omega_j dj.$$

Since $L'_e \supseteq L_e$, $L'_n \supseteq L_n$, $\|L'_e\| + \|L'_n\| - \|L_e\| - \|L_n\| > 0$. Hence,

$$\delta s^2(1-\rho^0)(u_h - u_l) > (\|L'_e\| + \|L'_n\| - \|L_e\| - \|L_n\|)(d - c_h) + \int_{L'_e} \omega_j dj + \int_{L_e} \omega_j dj.$$

That is, there exists $\rho^1(L'_e, L'_n)$ such that

$$\pi_h(L_e, L_n, \rho^0) < \pi_h(L'_e, L'^1_n(L'_e, L'_n)).$$

Contradiction.

We now turn to a separating equilibrium. It is evident that in such an equilibrium, M_l enters all the segments and earns a two-period payoff of $\pi_l(\emptyset, \emptyset, 0)$. In correspondence, M_h withdraws from, say, $L_e \subseteq [0, \underline{j})$ enforceable segments and $L_n \subseteq [\underline{j}, s^1]$ unenforceable segments. The L_e and L_n are chosen to

$$\max_{L_e, L_n} \pi_h(L_e, L_n, 1) = \underline{j}\gamma^1 u_l + s^1(d - c_h) - (\|L_e\| + \|L_n\|)(d - c_h) - \int_{L_e} \omega_j dj + \delta(s^2 u_h - k)$$

subject to the constraint that $\pi_l(\emptyset, \emptyset, 0) \geq \pi_l(L_e, L_n, 1)$, or

$$(\|L_e\| + \|L_n\|)(d - c_l) + \int_{L_e} \omega_j dj \geq \delta s^2(u_h - u_l).$$

It is straightforward to show that the constraint above must be binding for the optimal choice of L_e and L_n. We thus rewrite the constraint as

$$(\|L_e\| + \|L_n\|)(d - c_l) + \int_{L_e} \omega_j dj = \delta s^2(u_h - u_l). \tag{9}$$

Substituting (9) into M_h's objective function, we can rewrite the constrained optimization problem as

$$\max_{L_e, L_n} \pi_h(L_e, L_n, 1) = \underline{j}\gamma^1 u_l + s^1(d - c_h) - \delta s^2(u_h - u_l) + (\|L_e\| + \|L_n\|)(c_h - c_l) + \delta(s^2 u_h - k) \tag{10}$$

subject to (9). The following feature becomes apparent from the constrained optimization problem: Provided that $L_e \subset [0, \underline{j})$ and $L_n \subseteq [\underline{j}, s^1]$ satisfies the constraint, M_h prefers $L_e \cup L_n$ to be as large as possible.

This feature implies that $L_e = \emptyset$ if $L_n \subset [\underline{j}, s^1]$. That is, M_h must first withdraw from unenforceable segments before withdrawing from enforceable segments. To see this, suppose $L_e \neq \emptyset$ and $L_n \subset [\underline{j}, s^1]$. Then M_h can reduce

L_e slightly while keeping (9) binding by increasing L_n by a larger size. Doing so increases $\|L_e\| + \|L_n\|$ and hence makes M_h better off. Contradiction.

The feature also implies that, when $L_e \neq \emptyset$ (i.e., when $L_n = [\underline{j}, s^1]$), among enforceable segments, those with the lowest enforcement costs are the first to be withdrawn from. To see this, suppose the contrary is true. Then M_h can replace a given measure of enforceable segments with a larger measure of enforceable segments with lower enforcement costs while maintaining constraint (9). Doing so increases $\|L_e\|$ and in turn makes M_h better off. Contradiction.

Finally, the feature implies the possibility of a continuum of separating equilibria. In particular, when $\underline{j}$ satisfies

$$(s^1 - \underline{j})(d - c_l) \geq \delta s^2(u_h - u_l),$$

M_h withdrawing from any subset of unenforceable segments with $\|L_n\|(d - c_l) = \delta s^2(u_h - u_l)$ while M_l entering all segments in the first period constitutes a separating equilibrium. *Q.E.D.*

Proof of Proposition 6

As argued in the proof of Proposition 5, when $\gamma^1 \leq \gamma_0$ and $(s^1 - \underline{j})(d - c_l) \geq \delta s^2(u_h - u_l)$, M_h withholds only from unenforceable segments with $\|L_n\|$ satisfying constraint (9). In this case, a marginal increase in γ^1 has no effect on the scale of withholding.

When $\gamma^1 \leq \gamma_0$ and $(s^1 - \underline{j})(d - c_l) < \delta s^2(u_h - u_l)$, an increase in γ^1 forces L_n to shrink. Then, from constraint (9), it is evident that $\|L_e\|$ must expand in correspondence but by a smaller magnitude. Hence, the total scale of withholding decreases.

When γ^1 increases to a level such that all segments become enforceable, constraint (9) is reduced to

$$\|L_e\|(d - c_l) + \int_{L_e} \omega_j dj = \delta s^2(u_h - u_l).$$

Since ω_j is increasing in j and since it is assumed that $\omega_{s^2} < \gamma_0 u_l$, $\|L_e\|$ is bounded below by l_e, where

$$l_e(d - c_l) + l_e \gamma_0 u_l = \delta s^2(u_h - u_l).$$

Since $\gamma_0 u_l = u_l - d$, $l_e = \delta s^2 \frac{u_h - u_l}{u_l - c_l}$, which equals the scale of withholding when $\gamma^1 > \gamma_0$. *Q.E.D.*

Proof of Proposition 9

Parts (a) and (b) are straightforward from the constrained optimization problem (10). Part (c) is obtained by making use of the following observations. First, provided that $L_e \subset [0, \underline{j})$ and $L_n \subseteq [\underline{j}, s^1]$ satisfy constraint (9), π_h is increasing in $\|L_e\| + \|L_n\|$ (see (10)). Second, when $\gamma^1 = \gamma_0$, $\underline{j} = s^1$, $\|L_n\| = 0$, whereas $\|L_e\|$ is bounded below by l_e obtained in the proof of Proposition 6. Substituting $\|L_e\|$ with l_e, M_h's payoff is then

$$\begin{aligned}\pi_h &= s^1(\gamma^1 u_l + d - c_h) - \delta s^2(u_h - u_l) + \delta s^2 \frac{u_h - u_l}{u_l - c_l}(c_h - c_l) + \delta(s^2 u_h - k) \\ &= s^1(\gamma^1 u_l + d - c_h) - \delta s^2(u_h - u_l)\frac{u_l - c_h}{u_l - c_l} + \delta(s^2 u_h - k).\end{aligned}$$

One can verify that π_h equals the payoff of M_h under strong enforcement. *Q.E.D.*

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