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IPRs and Tariff Policies: East-West Joint Ventures

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Abstract

I develop a two-period two-country model of joint ventures and technology transfer. A multinational enterprise (MNE) transfers advanced technology to a local firm through a joint venture. Based on the transferred technology, the local firm may invest in R&D to invent the next period technology. I investigate the incentives for recipient countries to strengthen intellectual property rights (IPRs) and how stronger protection affects the local-partner R&D investments. I also study how IPRs and tariffs interact in this competition.

In the model, the initial IPRs level, local bargaining power, and local innovation ability jointly determine the optimal IPRs policy of the local government. With weak initial IPRs, developing countries would prefer to establish even lower protection. When IPRs are stronger than a threshold level, both source (developed) countries and recipient (developing) countries would prefer even stricter protection. When the local joint-venture partner has low bargaining power and high innovation ability the recipient government would favor low IPRs protection. However, under high bargaining power and inefficient innovation, strengthening IPRs would be the ideal policy. I also find that at different tariff rates these payoffs to stronger IPRs would change. Two nations with the same IPRs but unequal tariffs may have opposing opinions about the gains from stricter rights, with more open economies preferring laxer protection.

1 Introduction

Because new ideas and knowledge are an increasingly important part of trade, intellectual property rights (IPRs) play a growing role in the process of technology transfer. However, there is a long history of sharp debates on IPRs between developed countries and developing countries and this divide may be growing. Many developed countries, especially the United States, insist that developing countries must adopt higher standards to reduce significant imitation of new technologies. Some developing countries, such as Brazil and India, resist such pressure and argue that strengthening IPRs largely would transfer more rents abroad and increase the monopoly power of multinational enterprises (MNEs).

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To some extent this divide was bridged by the adoption in 1995 of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), reached at the World Trade Organization (WTO). Under TRIPS developing countries must adopt certain minimum standards of protection and enforcement over a period of time. An interesting aspect of this agreement is that its inclusion in the WTO indicates the global belief that IPRs are related to trade and trade policy.

In this paper I investigate two questions. First, I consider whether it is true that developing countries, as technology recipients, and developed countries, as technology sources, always have conflicting views about the need to strengthen global IPRs. I find circumstances under which both groups may prefer to see tighter regimes. Second, I study the relationships between IPRs and tariff policy in providing incentives for technology transfer. In the international arena both lower tariffs and stronger IPRs are generally considered "good" policies. I examine whether both push trade and technology transfer together in a complementary fashion. In particular I am interested in whether changing tariff policy affects innovation and technology transfer in developing nations.

I develop a two-period, two-country model to investigate the effects of stronger IPRs when technology is transferred through joint ventures. I assume that a developing country can only acquire certain products through either imports or joint-venture production. If a joint venture is established, profit shares are decided through bargaining. The local firm may choose to undertake its own R&D expenditures, for a successful innovation threat would improve its bargaining position in the joint venture. However this behavior would violate the contract of the joint venture and would therefore be punished under intellectual property laws. Note that since exports are the other choice MNEs have for serving the recipient market, IPRs and trade policies together determine the mode of technology transfer and the welfare levels of both nations.

I find that without considering the tariff, developing countries with low initial IPRs are likely to prefer even lower protection. When IPRs rise beyond some threshold, stronger rights would be preferred by both developed countries and developing countries. However, the tradeoff is that stronger IPRs change the early-stage payoffs in joint ventures. This provides the governments of developing countries an advantage in affecting technology transfer through IPRs policy. The bargaining power of the local joint-venture partner and its innovation capacity also play an important role in the effects of stronger IPRs. With low bargaining power and high innovation ability, the local government favors weak IPRs. If local firms have high bargaining power and relatively inefficient innovation, strengthening the IPRs level would be a better policy for the recipient government. Adding tariff policy, these results still hold, but only for a nation with relatively low initial tariffs. When the tariff gets highly restrictive, it becomes more likely that developing countries would prefer strong IPRs. The tariff not only affects local investments in innovation and profit shares, it also affects the payoff to the recipient country of changing IPRs policy and the perceptions of source nations regarding the gains from stronger protection.

The remainder of the paper proceeds as follows. Section 2 gives the related literature. Section 3 provides a sketch of the model's building blocks and also presents the results with zero tariff both theoretically and through simulation. In Section 4 I discuss the interaction between tariff and IPRs on local innovation and profit shares in the joint venture. In Section 5 I investigate the policy implications. Section 6 contains a brief conclusion.

2 Literature

The technology transfer from developed countries to developing countries can take several channels. First, technology holders can export the goods directly. Second, they can set up its own subsidiary and control the production process itself. Third, they can choose to license its technology to LDCs. Finally, they can form a joint venture with a host firm under a joint production and technology-sharing agreement. Totally, technology transfer can happen through five channels: imitation, exports, foreign direct investment(FDI), license, and joint ventures. Economists have done research extensively on the effects of strengthening IPRs on technological innovation, technology transfer rate, and world distribution of income between developed countries and LDCs. The answers are not clear, which all depend on the assumptions of technology transfer channel.

In models with imitation as the only channel of technology transfer to LDCs, the rate of imitation declines when IPRs are strengthened, which leads to slower loss of technological advantages and higher profits per innovation. Also reallocation of manufacturing towards developed countries crowds out labors from innovation activities. Both results reduce innovating firms' efforts in research and development(R & D). Helpman(1993) argues that the innovation rate declines in the long term and welfare is also reduced in developed countries when imitation is not high. This is contrary to what developed countries always believe that tighter IPRs can bring higher benefits to them. Lai (1998) finds similar results. Stronger IPRs lower the rate of innovation, rate of technology transfer, and relative wage of LDCs when imitation is the only channel of technology transfer.

To exploit rents of technology innovations, multinational enterprizes(MNEs) can choose to invest directly in developing countries. FDI often embodies advanced technologies or intangible advantages. Lai (1998) finds that product innovation and technology diffusion are strengthened under tighter IPRs if FDI and imitation exist at the same time. Stronger IPRs increase the economic returns to innovation and further encourage technology transfer through FDI. Markusen (2001) takes a strategic-behavior approach to the same general problem. Both MNEs' profits and host-country welfare are improved if stronger IPRs lead to a shift from exporting to production within the host economy.

Licensing is another channel of technology transfer. Licensing advantaged technology to LDCs can make higher instantaneous profits due to lower wages there. However, licensing incurs contracting costs and monitoring costs of the enforcement of contracts. The licensor also has to give up some rents to the licensee to deter imitation. Stronger IPRs in LDCs create an improved legal framework which reduces the costs associated with establishing and enforcing the contract. Efficient leagal enforcement also allows the licensor to deter imitation by giving up a smaller share of licensing rents. Yang and Maskus (2001, 2002) find if IPRs are strengthened in LDCs, both the rate of innovation in developed countries and the extent of licensing to LDCs would increase.

The results of the effects of stronger IPRs on developing countries and technology transfer are mixed, depending on different channels of technology transfer. There is one other technology transfer channel that I are particularly interested in: joint ventures. Joint ventures represent one of the most fascinating developments in international business and also are an important channel in technology transfer, especially when the transfer happens from developed countries to LDCs. In pursuing policies to encourage foreign investment and technology transfer, LDCs are in favor of joint ventures. First LDCs prefer joint ventures because they believe joint ventures can help them set up their own industry. To protect fledgling local competitors from larger, better-funded, and longer-established foreign competitors, some developing country governments impose restrictions on foreign ownership. If a MNE wants to enter a developing country and produce locally, it has to find a local partner to form a joint venture. In a joint venture between a MNE and a developing country partner the MNE usually provides the superior technology that developing countries always desire.

Second, joint production and intensive training is more appropriate for the transfer of some forms of knowledge. Hedlund(1994) distinguishes among three forms or knowledge: cognitive knowledge, skills, and knowledge embodied in products and well defined services. Cognitive knowledge and knowledge embodied in products are relatively easy to transfer, either through written documents or sales of machineries. Skills, such as complex engineering processes, are highly embedded in organizational routine and therefore, are difficult to extract from another firm(Inkpen and Beamish, 1997). The tacit aspect of skills can only be transferred through personal interaction and cooperations, which can be achieved by joint ventures, but not licensing, FDI, or arm-length trade.

One other reason is that the scope of joint venture technology transfer is more profound than other less permanent contracts. The effective technology transfer, which refers to the technology learning process, includes three steps: transfer, transformation, and harvesting (Beamish and Berdrow, 2003). Transfer is the migration of knowledge from technology holders to technology receivers. The traditional FDI is to focus on this aspect only. Transformation is the potential new knowledge through interpretation, cooperative production process, and interaction of creating individuals. Harvesting refers to the flow of transformed and newly created knowledge from joint ventures back to the partners' parent firms. When technology holders use licensing, knowledge migrates and technology transfer happens on the first level. Joint ventures provide the possibility of transformation and harvesting, which facilitates more effective and profound technology transfer.

Joint ventures are an important channel of technology transfer for LDCs. However, there is little literature exploring the effects of IPRs assuming that technology transfer happens through joint ventures. One of the papers that focus on this aspect is by Panpiemras(2003). Panpiemras uses a dynamic model of two quality levels to demonstrate that stronger IPRs in the South promote innovations in the North and also enlarge the scope of high quality technology transferred in joint ventures. South can benefit from higher relative wage and the world consumption is higher at the same time. This supports TRIPs by showing both Southern countries and the world can benefit from stronger Southern IPRs protection. By comparing the rents the North can get, he also shows that licensing contracts are more preferred than joint ventures in case of low-quality technology transfer. Marjit and Mukherjee(2001) also compare licensing and joint ventures in international technology transfer when the quality of the technology is private information and imitation may happen under licensing but not under joint ventures. High quality technology holders are more likely to choose joint ventures as an entry mode to extract more surplus. When imitation cost is low, technology sellers also favor joint ventures over licenses.

Unlike the models in Panpiemras(2003) and Marjit and Mukherjee(2001) which compare license and joint ventures, I assume exports and joint ventures are two alternatives to choose from. Our model uses a two-period bargaining process, which is more suitable for joint venture framework. The life cycle of a joint venture is usually short, especially with east-west joint ventures.(Beamish, 1984; Killing, 1983; Franko, 1971). Two-period model is more appropriate than a dynamic model which may take a long time to reach equilibrium. Negotiations and contracts are important building blocks in a successful joint venture in practice and I incorporate these as an important feature in our model. Marjit and Mukherjee investigate the problem in a static scenario and do not consider possibility of future technological innovation. Our model assumes that local partner cannot imitate and deviate in the current period, but the transferred technology will facilitate the local innovation activity to get next period technology.

The other group of literature is about the relationship between trade and IPRs, especially tariff and IPRs. Maskus and Penubarti(1995), Smith(1999), Connolly(2004), Kabiraj and Yang(2001), Zigic(2000), Qiu and Lai(2004), and Vishwasrao etl.(2004) are among this group. The effects of stronger IPRs on trade volume are ambiguous. Stringent IPRs enhance market-power of exporters, which leads to lower exporting volume. However, at the same time demand is increasing with less imitation from importing countries. The tradeoff between these two effects makes the final results ambiguous(Maskus and Penubarti, 1995). Through empirical study Maskus and Penubarti find that countries with stronger IPRs do have significantly larger imports. The impact is stronger in larger countries. The empirical work of Smith(1999) shows how U.S. exports respond to the changing of IPRs in importing countries. He finds that weak patent rights are a barrier to U.S. exports, but only with countries that pose a strong threat of imitation. Connolly and Valderrama(2004) use a dynamic quality ladder model assuming trade facilitating imitation by reverse-engineering. When trade liberalization happens, its effects on the South and the North welfare depend on the regime of IPRs. If IPRs enforcement increases through rasing compensation to the North, welfare increases unambiguously in both transition and steady state for the North and the South. However, if IPRs regime is to limit the sale of South imitated products, less competition from the South leads to welfare declining for both areas.

While there are many literature focused on the effects of IPRs on trade, paper exploiting trade policy effects on innovation or technology transfer is relatively scant. Kabiraj and Yang(2001), Zigic(2000), Qiu and Lai(2004), and Vishwasrao etl.(2004)investigate this aspect. Kabiraj and Yang focus on how trade policy can affect the licensing and local innovations in a game between a local firm and a foreign firm. The common belief is that under liberalization environment, competitive forces will generate sufficient incentives for the LDCs to do innovative activities. However, they find when local innovation ability is high, on the contrary protectionism promotes local innovations and free trade leads to licensing only. Zigic analyzes the optimal tariff of the North with varying degrees of IPRs in the South. In his model when the South imitates the technology from the North, it can export the products back and compete in the North market. The optimal tariff for the North in his model is higher than the simple duopoly model without imitation. The tariff here serves not only as a profit shifting device, but also as an instrument to deter imitations in the South and restore the incentive for investing in R & D. Qiu and Lai, however, focus on tariff both in the South and in the North. Through a partial equilibrium model they find that rasing IPRs in either the South or the North can encourage innovation. However, changing tariff policy in the South or the North has opposite effects. Rasing tariff in the North encourages innovation while rasing tariff in the South discourages innovation. They argue that free trade policy in the South ambiguously improve world welfare, however, tariff barriers in the North may benefit the world economy. Northern tariff protects not only profits but also innovation and thus supplements weak IPRs protection as a second best policy. Vishwasrao etl.(2004) study a developing country's choice of optimal tariff and patent length. Their work is the closest to our paper in that both focus on developing countries' tariff and IPRs policies. In their model high tariff is used to induce FDI. However, in pre-FDI period high tariff is detrimental to the development country's welfare. Increasing the length of patents and lowering tariff can compensate the loss in pre-FDI period and still attract FDI into developing countries. Lower tariff and higher IPRs can increase developing countries' welfare.

3 IPRs Policy in Joint Ventures

3.1 Model Setup

3.1.1 Basic Framework

Our model has two firms: a MNE and a local firm l. The MNE is headquartered in a developed country and firm l is in a developing country. If both agree to set up a joint venture, they will produce the goods jointly in the developing country. I assume wholly-owned subsidiaries are not the option here.

There are three potential reasons why joint ventures are the channel instead of wholly-owned subsidiaries, licenses or other forms of technology transfer. First, joint ventures are formed under government regulations in LDCs. A study of 66-firm sample of joint ventures in LDCs reveals that about 57% of the joint ventures are formed under some level of government restrictions(Beamish, 1985). Through interview with almost seventy joint ventures in six developing countries Miller et al. (1996) find investment regulations requiring a local link is one of the most obvious reasons that a MNE enters a joint venture in LDCs. Secondly, even if the requirement of a joint production is not expressed explicitly in laws or regulations, sometimes barriers to wholly-owned subsidiary are so big that it is not feasible to produce locally without a local partner. Japan, for example, is widely cited for its protectionist policies. The frustration with Japan is that the barriers are often not explicitly regulatory but arise from difficulty in gaining access to the highly inefficient Japanese distribution system and in understanding Japanese customers(Murray and Siehl, 1989). Even without implicit or explicit investment restrictions, a MNE may still choose joint ventures over wholly-owned subsidiaries to explore local partners' comparative advantages, which include distribution channel, knowledge of labor conditions, knowledge of the legal system and government regulations, and familiarity with local customs and conventions.

In this model, I assume that if the MNE sees the host country as a potentially attractive market it can only choose between exports and joint ventures, either because of explicit or implicit barriers to wholly-owned local productions, or because of local partner's highly evaluated comparative advantages. In this section to simplify the model I also assume that the host country adopts a free trade policy which sets tariff at zero. I will add tariff into the model in the next section.

Figure 1 shows the whole game tree. The model has two-periods without discounting. At the beginning of period 1, the MNE decides the mode of entering the developing country market.

If the MNE chooses to export, it can enjoy monopoly profits in the host country market. If it decides to enter through a joint venture, the two firms will form a joint venture under a profit and technology sharing agreement. In the joint venture the local production has a lower marginal cost than the production in the developed country. Since one of the reasons that the MNE decides to enter a joint venture is the huge host country market, it is reasonable for us to assume that products from the joint venture are all sold in the local market. So the profit to share in the joint venture is the host country monopoly profit under local production.

The MNE and firm l reach the profit sharing agreement through bargaining. The technology aspect of the contract is equity participating technology collaboration, which means the MNE supplies its technology without any charge, but in exchange for a profit share in the joint venture(Marjit and Mukherjee, 1998). The prevailing technology is T1 in period 1. Firm l's technology is inferior to T1. For simplicity, I assume with any technology inferior to the prevailing one brings zero profit. T1 is transferred right away from the MNE to firm l after the joint venture is established in period 1. It is impossible for the MNE to hold back the technology with joint production.

The prevailing technology in period 2 is T2. The technology advancement here is production process improvement. Improved technology lowers marginal cost in the production. To get a favorable position in the joint venture, based on the transferred technology T1 firm l will do local innovation itself in period 1 to get T2 for the next period. Firm l can choose innovation inputs I. The success probability of getting technology T2 is $\phi(I)$, which is an increasing function in I. The MNE can develop technology T2 certainly and costlessly. This assumption can be justified on the ground that the MNE is operating in an international market. The innovation is targeting the whole world market with relatively fixed R&D costs and does not bring additional costs when used in the local market(Sinha, 2001). There are no other firms in the host country that can imitate without forming a joint venture because of the complexity of the technology.

Local firm l tries to invent the next period technology T2 based on existing technology T1. Some papers discuss this type of local innovation behaviors which happen after acquiring advanced technology from developed countries. When licensing is feasible, there are three scenarios in developing countries: license only, local innovation after license, and local innovation without license (Kabiraj and Yang, 2001). The choice is made based on developing countries' innovation ability. Sinha (2001) also points out that local firms' innovation after technology transfer is one of the factors that lead to instable joint ventures in his model.

This local innovation is different than pure imitation which is just replicating the most advanced technology in the market. However, it has some properties that are similar to imitation. Since imitators use resources just to get the technology that has already been available for use, pure imitation is a waste of resources from the point view of the world welfare. In our model the MNE can invent T2 certainly and costlessly. So firm l's innovation is also a drain on the world resources even though firm l may tilt the balance of profit share towards itself through local innovation.

3.1.2 Contract

Contract between cooperation partners in the joint venture is critical in governing each partner's behavior and solving disputes. Before introducing the whole game in details, I will give some assumptions of how the contract is constructed.

IPRs Protection in Contracting When the MNE decides to enter a joint venture with firm l, it has two options to protect its intellectual property. One is to use patents and the other is to keep the technology as trade secrets. Whether to seek patent protection or to maintain the invention as a trade secret is a decision considering many factors. The factors include if the technology can be reversed engineered, if the innovation is patentable, if the innovation's life is compatible with patent scope–not too long or too short, etc.

Here I assume the MNE uses trade secrets to protect its technology. In our previous assumption, the technology the MNE has is relative complex and there is no reverse engineering under export mode. Without reverse engineering it is possible to protect the innovation as trade secrets. And also due to the disadvantages of patents such as time and money consuming application process, publicly disclosed information upon issuance of the patent, and short protection duration, the MNE chooses trade secrets over patents.

Once the MNE decides to use trade secrets to protect its technology, it will sign non-disclosure and non-competition agreements with its partner firm l. The agreements include clauses of a good description of the trade secret, limits on where the technology is used, the terms and conditions of its use, limits on how the joint venture can utilize it, a duty of confidentiality, and a remedy for non-compliance with the agreement. The violation of the agreement will bring an action before courts. The compensation is decided by IPRs protection level in the developing country.

IPRs and Contract Enforcement The actual IPRs protection has two aspects. The first is the framework of laws and regulations. This is related to questions like term of patents, scope of patents, if a country has trade secret law, etc. The other aspect is the enforcement of IPRs, which may be consistent with the strength of IPRs or not. In many countries, courts are slow, inefficient, and even corrupt. In this case even a country can have complete and advanced written regulations and laws, but the actual legal protection is low. China has the copy right law that is comparable to most Northern countries, however, it is still the target of complains for its surging amount of pirated DVDs and CDs. Huge profits, lack of enforcement force and corrupted bureaucrats in China lead to much lower IPRs protection than stated by laws and regulation. When measuring IPRs protection, some literature use the length of patents by local laws. But this is only the first aspect of actual IPRs protection. In our paper I use fine for contract breach to measure IPRs level. Since the fine is decided by both the existence of applicable law and the enforcement of it, it reflects the actual protection of IPRs. This fine counts for both the length from the plaintiff files the lawsuit in court until the moment of actual payment and the associated costs which include court fees, attorney fees, other payments to accountants, etc.

In our paper intellectual property is protected as trade secret by contracts between two partners. The amount of fine from law suits represents IPRs protection level in the local country.

IPRs level here is actually represents a more general problem, the degree of the enforceability of joint venture contracts. However, IPRs in joint venture framework and enforceability of contracts here are not two unrelated questions, instead they contain each other. The contract enforcement problem is more broad in the sense that it is critical to any legal contracts between two business cooperation partners, which include joint venture contracts, supplier contracts, license contracts etc. Some of these contracts are about technology transfer, so the enforcement of these contracts represents the protection levels of IPRs. In this paper I use IPRs to present the enforceability of joint venture contracts since the critical part of the contracts is technology transfer and trade secret protection.

Dispute Resolution and Applicable Law Usually there are two common ways of resolving disputes between business partners: arbitration and resort to a court. Many contracts of joint ventures contain arbitration clause which obligates the parties to submit their disputes to an agreed arbitrator. Arbitration can be final and an alternative to resorting to a court. Arbitration can also be an initial step in a dispute, which if not resolved, can then be submitted to a court of the relevant jurisdiction. With arbitration and resort to a court combined together I can have arbitration only, resort to a court only or arbitration before going on a court.

In many developing countries there is a certain resistance to a dispute resolution clause that just flatly provides for final and binding arbitration of all disputes. Usually arbitration combined with court as the last resort is more popular in a joint venture contract. Since arbitration is the initial step and not binding, judgement from courts is final and fine enforced by the courts forms the threat point of the MNE in negotiation. That is why in our model fines from lawsuits affect the reserved payoffs of both firms, which change bargaining results in the joint venture.

With resorting to a court as a common clause in a joint venture agreement, the other question is that if one party brings the breaching of contracts to a court, which law should be applied. A joint venture contract must also set out the legal jurisdiction under which the agreement shall be governed and constructed. In all cases, there must be a rational reason for the choice of law. Usually a joint venture agreement intended to be implemented in a particular country should be subject to the law of its jurisdiction. While it may be possible to have a foreign law as the applicable law in a joint venture agreement, it is not a sensible option for local interests for the joint venture agreement to be interpreted in another country. There is nothing more confusing than operating under the law of one jurisdiction and seeking recourse to the law of another to resolve conflicts. In the absence of very compelling reasons, the law of the situs of the international joint venture should be the applicable law to regulate all questions including solving disputes.

Even with arbitration it is wise to chose a local arbitrator instead of through an international group such as the International Chamber of Commerce, because there are no substantial advantages to this approach and many inconveniences. When the two parties seek the resolution of conflicts by a forum outside the jurisdiction where the joint venture is established, it is unrealistic and far from the site of proofs. Compelling the attendance of unwilling witnesses is often an unsurmountable obstacle. The further away the forum from the applicable jurisdiction, the less likely it is that the atmosphere in which the conflict emerged will be understood.

If two parties in a joint venture can construct their contract freely, local arbitration and local jurisdiction are the wise choice for disputes resolution. Some developing countries have laws governing behaviors of international joint ventures which may even stipulate specifically that local arbitration and local laws should be applied to solve any disputes. For example, in China joint ventures are governed by Law of the People's Republic of China on Chinese-Foreign Equity Joint Ventures(hereafter I call it Equity JVs Law) and Law of the People's Republic of China on Chinese-Foreign Contractual Joint Ventures(hereafter I all it Contract JVs Law). In Equity JVs Law it stipulates that "...the dispute shall be settled through conciliation or arbitration conducted by an arbitral institution of China, or through arbitration by another arbitral institution agreed upon by the parties to the venture. The parties to an joint venture may submit the disputes to the People's court, if the parties neither stipulated any arbitrations clause in the joint venture contract nor reach such written arbitration clause after the occurrence of disputes." Contract JVs Law has similar stipulation about dispute resolution: "The Chinese or foreign party may bring a suit in a Chinese court, if no arbitration clause is provided in the contractual joint venture contract and if no written agreement is concluded afterwards."

Two Contracting Ways of Profit Shares Since the game has two periods with uncertain local innovation for the second period, it is hard to reach a stable two-period contract at the beginning of period 1. There are two ways of constructing a contract under this circumstance. The first is to state the first period share only and renegotiate before period 2 starts. The second is contracting on both periods. By giving up a higher second period share to firm l, the MNE can prevent firm l from taking the local innovation.

In the first contracting way, the MNE and firm l bargain for the first period share and put this into contract. The second period profit sharing is not stipulated in the contract. However, because the MNE knows that firm l will invent around and take higher share in the second period, it combines this information into the contract in the first period negotiation also. This contract protects the MNE from the local innovation in two aspects. First both the MNE and firm l have complete information about innovation probability function, cost function, and IPRs. If firm l will have a higher expected payoff in the future period due to lower IPRs or other factors, the MNE tries to bargain for a higher profit in the current period. The MNE uses rising early stage share to prevent possible future low profits. The second way to protect itself from such potential loss is that the MNE will ask to include in the contract the prohibition of misuse of $T1$ by the local partner. The technology here is treated as a trade secret. Under the contract, the MNE can get compensations from lawsuits for any local partner violations. The amount of compensation depends both on the protection level of IPRs in the local country and losses the violation brings to the MNE. Even though this contracting way can not eliminate the local innovation, it can protect the MNE at some level through these two ways.

The second contracting way is to contract for both periods. The second period share will also be included in the contract. The MNE has to give up some rents to deter the local firm from inventing around. The share in period 2 in the contract must be no less than the expected profit firm l can get through taking local innovation, otherwise local innovation and renegotiation still happen.

Under both contracting ways the expected profit share each firm can get is the same. The only difference is that under the first contract local innovation still exists but the second eliminates it and gives a stable share for each firm. With the assumptions of risk-neutral agents and relatively efficient local innovation the difference between the two contracting methods is trivial. In the following section I assume the contract is constructed using the first method.

3.1.3 First Period

The local demand of the products is $D(p)$ and the production cost is $f + mD(p)$. m is marginal cost and f is fixed cost. f happens only when a new facility is set up. Table 1 gives the payoff for different strategies of the MNE and firm l in period 1. In period 1 if both firms agree to establish a joint venture, m is m_1 with local production and technology T1. Fixed cost f is greater than zero. The production cost of the joint venture is $f + m_1 D(p)$. The joint venture acts as a monopolist in the local market with profit π_1. The MNE and firm l use bargaining to decide profit shares. Bargaining process leaves profit share π_{1m} for the MNE and π_{1l} for firm l , with $\pi_{1m} + \pi_{1l} = \pi_1$. After the joint venture is set up and technology $T1$ is transferred, firm l will decide the innovation inputs I.

If the MNE chooses exports over joint ventures and still produces in its own country, f is zero. With zero tariff the marginal cost is λm_1. With more expensive labor and less efficient marketing channel, the marginal cost is greater than that of the local production, which means $\lambda > 1$. The MNE earns monopoly profit π_{1e} in the local market, but π_{1e} is lower than π_1 when the fixed cost is not extremely high. Under export mode local firm l gets zero profits.

3.1.4 Second Period

If there is no joint venture formed in period 1, the MNE still produces in its own country with T2 in the second period. The marginal cost is λm_2, with $m_2 < m_1$. The corresponding monopoly export profit is π_{2e}. If joint venture is the mode both firms choose in period 1, the marginal cost now is m_2 in period 2. There is no fixed cost if the joint venture is stable. The total cost of local production is $m_2 D(p)$ and the monopoly profit is π_2. Table 2 gives the payoff for different strategies for the MNE and firm l in period 2.

With incomplete agreement in period 1 the MNE and firm l will rebargain for period 2 share. At the beginning of period 2, there are two scenarios. The first scenario is that firm l fails in the local innovation and the other is firm l succeeds in inventing technology T2. If firm l fails in acquiring T2 itself, the profit agreement through rebargaining gives the MNE and firm l π_{2mf} and π_{2lf} respectively, with $\pi_{2mf} + \pi_{2lf} = \pi_2$. The joint venture is stable and the MNE and firm l still produce jointly using technology $T2$. If they cannot reach an agreement or either party deviates, the payoff for firm l is zero and the payoff for the MNE is the monopoly profit through exports minus exit cost E from the breaking up, $\pi_{2e} - E$. This exit cost only happens to the MNE, which includes all costs related to moving resources and personnel back to its parent firm.

With firm l succeeding in the local innovation the MNE and firm l will rebargain for the profit share also, but the share is π_{2ms} and π_{2ls} instead, different from when the local innovation fails. I also have $\pi_{2ms} + \pi_{2ls} = \pi_2$. If they cannot reach a new agreement and break up in period 2, firm l uses T2 to produce locally and compete with the MNE in the domestic market, with cournot payoff π_{2ld}. The MNE has to return back to exporting to compete with firm l which brings payoff

$\pi_{2md} - E$.

The second scenario is not what the MNE desires. The MNE will be at a disadvantage in the rebargaining if firm l has acquired T2 through local innovation. However, in this case the MNE can sue firm l for the local innovation behavior, which violates the joint venture contract. The compensation from the lawsuit is related to the IPRs in the local country. It is

$$F = [\pi_{2mf} - (\pi_{2md} - E)]R \tag{1}$$

. R represents IPRs level of the host country, which is from zero to one: zero represents no IPRs at all and one represents perfect protection for IPRs. π_{2mf} is the profit share for the MNE in period 2 as if there is no local innovation or the local innovation fails. $\pi_{2md} - E$ is the cournot payoff for the MNE through exports if firm l succeeds in innovation and deviates. F is a fraction of the profit difference for the MNE between a stable joint venture without successful local innovation and breaking up when innovation succeeds. Without any IPRs F is zero and breaking up with firm l leaves the MNE π_{2md} and also some exit cost E in period 2. When there is perfect protection, $F = \pi_{2mf} - (\pi_{2md} - E)$. Even if firm l deviates, through the compensation the MNE still can realize the same payoff π_{2mf} as when the local firm fails in acquiring T2. With the strengthening of IPRs, the payoff from the lawsuit is increasing for the MNE. Here I assume as the cost function is a common knowledge for both parties, courts can verify the profit information. Neither party can exaggerate or understate underlying profits. The MNE can only sue firm l when the local innovation succeeds. Without firm l using the newly developed technology $T2$, the MNE cannot verify such local innovation behavior on the courts.

3.2 Bargaining of Profit Shares

In both periods firm l and the MNE bargain for their profits ahres in the joint venture. To solve the game I assign specific forms to both the demand function and the local innovation probability function. I assume the demand function is linear in price.

$$D(p) = a - bp \tag{2}$$

Local innovation probability function is

$$\phi(I) = 1 - e^{-(vI)^{\frac{1}{2}}} \tag{3}$$

v is the efficiency factor representing the innovation ability of firm l, with $v \in (0, 1]$. The larger v is, the higher innovation ability firm l has. vI represents the efficient innovation inputs and I is the dollar amount of innovation inputs.

$\phi(I)$ has the following properties: $I \in [0, +\infty)$, $\phi(I) \in [0, 1]$, $\phi'(I) \geq 0$, $\lim_{I \to 0} \phi'(I) = +\infty$, $\lim_{I \to +\infty} \phi'(I) = 0$, and $\phi''(I) \leq 0$.

3.2.1 Bargaining Powers

Bargaining power is an important determinant in this game and it decides the share of surplus each firm gets in the joint venture. Which firm has a higher bargaining power in this game, the MNE or local firm l? In a bilateral negotiation with a developed country a developing country generally faces the problem of unequal bargaining power. Developed countries have greater market power and more advanced commercial intelligence networks, which are the two key sources deciding bargaining power(Drahos, 2003). However, when negotiations happen on industrial level, developed country firms may not always have higher bargaining power. The bargaining power in negotiations comes from the ability to withhold resources that the other party wants. By conducting a survey with four U.S. joint ventures in different industries in China, Yan and Gray(1994) find that in two of the four joint ventures bargaining power is approximately equally shared between partners. In the other two joint ventures much more bargaining power is accruing the U.S. partner. The four ventures included in this study represent the three industrial sectors in which about 50% of all U.S.-China manufacturing joint ventures, while manufacturing ventures represent 69% of U.S.-China joint ventures. From their survey I cannot say foreign partners always have a higher bargaining power or the other way around.

In our game the bargaining powers of the MNE and firm l depend on the specific characteristics of each firm. Firm l 's bargaining power lies in the large and growing national market, valuable local resources, efficient marketing channel , and good relationship with local government. The MNE bargaining power is decided by its inimitable and scarce supply – sophisticated technology. The relative evaluation of each other's specific advantages is the underlying determinant of potential bargaining power in each negotiation (Eden et.al, 2004). If firm l is the only firm that has the advantages the MNE desires and the national market is extremely attractive, firm l has relatively larger bargaining power in the negotiation. If the MNE is the absolute technology leader in the industry and firm l doesn't have any other alternatives, the MNE has higher bargaining power and takes greater profit shares in the joint venture. The bargaining power of the MNE may or may not be greater than that of firm l. With θ_1 as firm l 's and $1-\theta_1$ as the MNE's first period bargaining power, I have $\theta_1 \gtreqless 1-\theta_1$.

At the beginning of period 2 the MNE and firm l have already entered the joint venture, their specific advantage is not as obvious as before the joint venture is established. The MNE is more familiar with the local market. Firm l also has at least the second best technology T1 and more solid base in the industry, with which firm l can find other alternative foreign partners more easily. Their bargaining powers tend to converge. Beamish(1997) argues one of the reasons that bargaining power shifts is the learning of partners in joint ventures. Foreign partners acquire knowledge provided by local partners during the cooperation, such as domestic distribution and personnel management. Local partners have the opportunity to learn expertise and technology from foreign partners. Substantial knowledge acquisition by one partner compared to the other partner can shift the partner's bargaining power and sometimes eliminate its dependency on its partner. Here without much loss of generality I assume the foreign and local partners learn each other's advantage at the same rate. Bargaining powers in period 2 are equalized, $1-\theta_2=\theta_2=\frac{1}{2}$.

3.2.2 Second Period Bargaining

I assume complete information about the game. If both partners are completely informed as to cost conditions, market opportunities, and so on, I may expect the Nash bargaining solution will be negotiated in a cooperative manner(Darrough and Soughton, 1989). I use Nash bargaining to find profit shares in this game. Table 3 gives the bargaining profit shares of firm l and the MNE under different scenarios.

In period 1, the MNE and firm l agree on the profit share π_{1m} and π_{1l}. Both parties know this agreement cannot guarantee a stable joint venture in period 2. At the beginning of period 2 they will renegotiate on the new profit share. However, the renegotiation results depend on if firm l has succeeded in inventing T2. If the local innovation fails, the generalized Nash bargaining solutions for the renegotiation are

$$\pi_{2lf} = \theta_2[\pi_2 - (\pi_{2e} - E)] \tag{4}$$

$$\pi_{2mf} = \pi_{2e} - E + (1 - \theta_2)[\pi_2 - (\pi_{2e} - E)] = \pi_2 - \theta_2[\pi_2 - (\pi_{2e} - E)] \tag{5}$$

. Each firm's share is equal to the reserved payoff plus part of the surplus. The reserved payoff for firm l is zero for firm l. If firm l deviates from the joint venture, with only T1 it cannot compete with the MNE. But the MNE can still return back to exports with reserved payoff $\pi_{2e} - E$. The total surplus from a constant joint venture is $\pi_2 - (\pi_{2e} - E)$, the difference between the monopoly profit from a stable joint venture and total payoff of the two firms if the joint venture breaks up. θ_2 and $1 - \theta_2$ represent the bargaining power of firm l and the MNE in period 2 respectively, which are also their shares of the surplus. Firm l's payoff π_{2lf} is equal to its reserved payoff zero plus θ_2 time the surplus from the joint venture; the MNE's profit share π_{2mf} is equal to its reserved payoff $\pi_{2e} - E$ plus $1 - \theta_2$ of the surplus .

If the local innovation succeeds, firm l has the advanced technology for period 2. The generalized Nash bargaining solutions are

$$\pi_{2ls} = \pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] \tag{6}$$

$$\pi_{2ms} = \pi_{2md} - E + [\pi_{2mf} - (\pi_{2md} - E)]R + (1 - \theta_2)[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] \tag{7}$$

. If break-up really happens, the MNE and firm l will compete as duopoly and at the same time the MNE will sue firm l for violating the contract. The reserved payoff in the renegotiation for the MNE is $\pi_{2md} - E + [\pi_{2mf} - (\pi_{2md} - E)]R$, the duopoly profit plus compensation from the law suit; the reserved payoff for firm l is $\pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R$, the duoploy profit minus fine for breaking the contract. The two firms share the surplus from a constant joint venture, $\pi_2 - (\pi_{2ld} + \pi_{2md} - E)$, difference between a constant joint venture and breaking up.

In both scenarios with a moderate exit cost E a constant joint venture brings higher total payoff than breaking up. Firm l and the MNE share the surplus through negotiation such that each can enjoy higher profit than its reserved payoff. Constant joint venture is always the result in period 2 with negotiation.

With the local innovation success rate $\phi(I^*)$ the expected second period payoff from the two scenarios for the MNE and firm l are

$$\pi_{2m} = \phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf} \tag{8}$$

$$\pi_{2l} = \phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}. \tag{9}$$

I^* is the optimal innovation input of firm l. As the MNE knows the local innovation probability function $\phi(I)$, I^* is a public information for both parties. I will derive I^* and discuss the innovation behavior in Section 3.3.

3.2.3 First Period Bargaining

Bargaining Results Before the joint venture starts, both the MNE and firm l know that the joint venture exists for two periods. They are concerned with the total two-period payoff they can get from the joint venture. If there is no local innovation or uncertainty in period 2, the generalized Nash bargaining solutions of two-period payoffs for firm l and the MNE are

$$\widetilde{\Pi_l} = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] \tag{10}$$

$$\widetilde{\Pi_m} = \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] \tag{11}$$

. θ_1 and $1 - \theta_1$ are bargaining powers of firm l and the MNE in period 1 respectively. θ_1 may or may not be equal to θ_2. The reserved payoff is zero for firm l since its profit is zero with inferior technology if the MNE does not enter into the joint venture. The MNE has reserved payoff $\pi_{1e} + \pi_{2e}$, two-period profits from exporting. They share the surplus of establishing a joint venture,$\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})$ according to the bargaining powers.

If the contract is complete, the joint venture is stable for both periods and firm l and the MNE get constant two-period profit share $\widetilde{\Pi_l}$ and $\widetilde{\Pi_m}$ surely. But with the possibility of local innovation and uncertain period 2 profit, contract is incomplete to guarantee profits in both periods and renegotiation is inevitable. At the beginning of the joint venture only the first period profits can be contract. In the negotiation in period 1 the MNE knows firm l will try to invent around $T1$ to get $T2$ and realizes the uncertainty of period 2 payoff. It also expects the renegotiation in period 2 and combines this knowledge into period 1 negotiation. So the true period 1 profit share also depends on the possible outcome of period 2 and the two-period payoff each firm expects to get from the joint venture. With equations (8) (9), (10), and(11), period 1 payoff $\widetilde{\pi_{1l}}$ and $\widetilde{\pi_{1m}}$ are

$$\widetilde{\pi_{1l}} = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}] \tag{12}$$

$$\widetilde{\pi_{1m}} = \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}] \tag{13}$$

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Period 1 payoff for each firm is equal to their two-period profits in the joint venture in equation (10) and (11) minus period 2 expected payoff. Period 2 expected payoff, however, is contingent on the innovation behavior of firm l. If the MNE' share of profits is low in period 2 because of weak IPRs and active local innovation behavior, it will try to grab more profits in period 1 to protect its benefit in the joint venture. I expect that MNE bargains for a higher first period profit share $\widetilde{\pi_{1m}}$ with weak IPRs, and correspondingly firm l 's first period share $\widetilde{\pi_{1l}}$ is decreasing when IPRs protection deteriorates.

Bargaining Results with Financial Constraints One of the reasons that the local country does not choose license but uses joint ventures to channel technology transfer is financial constraints. Most developing countries do not have sufficient capital, nor do they have the advantage in accessing financial markets. In the International Financial Corporation survey of around seventy joint ventures in developing countries, two-thirds mention that financing is one of the most important contributions to be expected from the industrial country partner (Miller et al., 1996).

The first period negotiated profit share for firm l in equation(12) can be negative. But since firm l is at a disadvantage in financing, it is reasonable to put a non-negative financial constraint on period 1 local profit share. Firm l does not pay the MNE in the joint venture even with negative $\widetilde{\pi_{1l}}$ from equation (12). The true first period payoffs become

$$\pi_{1l} = max\{0, \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}]\} \tag{14}$$

$$\pi_{1m} = min\{\pi_1, \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}]\} \tag{15}$$

. If period 1 profit share for the MNE in equation (13) is greater than π_1, the largest profit the MNE can get in period 1 is the monopoly profit π_1. In this case firm l gets zero profit in the early stage of the joint venture and its profit comes from period 2 only.

Because of the financial constraint, the true two-period profits for firm l and the MNE are different than those in equation (10) and (11). Each firm gets the first period profit under financial constraint in equation (14) and (15) plus their expected payoff in period 2 respectively. With equations (8), (9), (14), and (15), the true two-period profits for firm l and the MNE from the joint venture are expressed in the following equations:

$$\Pi_l = max\{\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}, \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]\} - I^* \tag{16}$$

$$\Pi_m = min\{\pi_1 + [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}], \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]\} \tag{17}$$

. Since (12) is increasing in IPRs, the financial constraint is binding when IPRs are weak enough. If the financial constraint is binding, firm l's total profit from the joint venture is only the expected second period profit minus the innovation cost. The MNE gets all the monopoly profit π_1 in period 1 plus its second period expected payoff. If IPRs are higher than some threshold level, the financial constraint is not binding. The total two-period payoffs from the joint venture are equal to $\widetilde{\Pi_l}$ and $\widetilde{\Pi_m}$ for firm l and the MNE respectively, which are constant in IPRs for each firm, though the partition between period 1 and period 2 varies with IPRs level.

3.3 Local Innovation

3.3.1 Optimal Local Innovation Inputs

Bases on the transferred T1 in the first period, firm l does local innovation trying to invent T2 independently. Firm l chooses innovation inputs I^* to maximize its net payoff from the innovation,

$\phi(I)\pi_{2ls}+(1-\phi(I))\pi_{2lf}-I$. Assuming constant and exogenous IPRs the optimal local innovation input I^* solves

$$\phi'(I^*)(\pi_{2ls}-\pi_{2lf})=1 \tag{18}$$

The right hand side is the marginal cost of doing the local innovation and the left hand side represents the marginal benefit. The marginal cost is constant, while the marginal benefit is positively related to the marginal success rate of the local innovation and the net payoff from successful innovation, difference between π_{2ls} and π_{2lf}. Using equations (4) and (6), I can transform (18) to

$$\phi'(I^*)=\frac{1}{\pi_{2ld}-[\pi_{2mf}-(\pi_{2md}-E)]R+\theta_2[\pi_2-(\pi_{2ld}+\pi_{2md}-E)]-\theta_2[\pi_2-(\pi_{2e}-E)]} \tag{19}$$

. With innovation probability function form $\phi(I)=1-e^{-(vI)^{\frac{1}{2}}}$ in equation (3) the first order condition changes to

$$\frac{2e^{(vI)^{\frac{1}{2}}}(vI)^{\frac{1}{2}}}{v}=\pi_{2ld}-[\pi_{2mf}-(\pi_{2md}-E)]R+\theta_2[\pi_2-(\pi_{2ld}+\pi_{2md}-E)]-\theta_2[\pi_2-(\pi_{2e}-E)] \tag{20}$$

3.3.2 Positive Local Innovation Condition

The incentive to do the local innovation is to get in a more favorable position in the renegotiation in period 2. To satisfy this condition the expected net payoff from local innovation must be greater than that without any local innovation activity. Otherwise, firm l will not do the innovation and both parties share the joint venture profit with certainty. The condition to have positive local innovation inputs is

$$\phi(I^*)\pi_{2ls}+(1-\phi(I^*))\pi_{2lf}-I^*>\pi_{2lf} \tag{21}$$

3.3.3 Effects of IPRs on I^*

If firm l succeeds in local innovation, it can obtain a better position in the renegotiation, but this advantage deteriorates with stronger IPRs. Higher IPRs bring harsher punishment to the local innovation success for breaking the contract, which decreases firm l's incentive to innovate. I expect that I^* is decreasing in IPRs.

To observe the effects of IPRs on I^*, differentiate equation (20) with respect to IPRs:

$$\frac{dI^*}{dR}=\Psi[\pi_{2mf}-(\pi_{2md}-E)] \tag{22}$$

$(\Psi=\frac{1}{\{\pi_{2ld}-[\pi_{2mf}-(\pi_{2md}-E)]R+\theta_2[\pi_2-(\pi_{2ld}+\pi_{2md}-E)]-\theta_2[\pi_2-(\pi_{2e}-C)]\}^2[-\frac{1}{4}e^{-(vI)^{\frac{1}{2}}}v^{\frac{1}{2}}I^{-\frac{3}{2}}(1+v^{\frac{1}{2}}I^{\frac{1}{2}})]})$

Whether higher IPRs increase innovation or not depends on if the marginal benefit outweighs the marginal cost. I can tell that Ψ in equation (22) is negative and $\frac{dI^*}{dR}$ is negative also. When IPRs are strengthened, firm l reduces its innovation inputs. With stronger IPRs the success of the local innovation will not bring as much excess payoff as before because of the increasing compensation from the lawsuit. Stronger IPRs lead to decreasing I^*.

If IPRs are so strong such that they are over some threshold level $\widetilde{R}$, the local innovation can not bring any excess payoff. The positive innovation inputs condition in equation (21) does not hold. Firm l chooses not to innovate at all and enjoys constant share π_{2lf} in period 2. The optimal innovation I^* is always zero when I have IPRs $R > \widetilde{R}$.

Proposition 1: *When $R < \widetilde{R}$, the local innovation input I^* is decreasing in IPRs; when $R > \widetilde{R}$, I^* is zero and does not change in IPRs.*

3.3.4 Critical IPRs Level: $\overline{R}$ and $\widetilde{R}$

Since both the financial constraint in period 1 and the positive local innovation condition are related with IPRs, in this section I will investigate the two critical IPRs levels: $\overline{R}$ that makes the financial constraint binding and $\widetilde{R}$ that eliminates local innovation.

In period 1 the financial constraint may be binding or not. If the Nash bargaining result of equation (12) is greater than zero, firm l and the MNE both get positive profit share in the joint venture and the financial constraint is not binding. Intuitively low IPRs increase the payoff from successful local innovation and the expected second period payoff for firm l. In this case the MNE bargains for a better share in the first period. When the expected payoff of firm l in period 2 is so high such that firm l's first period payoff in equation (12) is less than zero, the financial constraint is binding. $\overline{R}$ solves the following equation:

$$\pi_{1l} = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - \{\phi(I^*(\overline{R}))\pi_{2ls}(\overline{R}) + [1 - \phi(I^*(\overline{R}))]\pi_{2lf}\} = 0. \tag{23}$$

. I expect that if IPRs are low enough, the local firm can not get positive profit in period 1 negotiation. $\overline{R}$ is the critical value of IPRs below which the financial constraint is binding. If $R > \overline{R}$, firm l can get positive profit in period 1 in the joint venture. When IPRs are lower than $\overline{R}$, financial constraint is binding. Firm l gets zero profit and the MNE gets the whole share in the first period.

I have shown that I^* decreases in IPRs level and there should be another threshold $\widetilde{R}$ such that equation (21) does not hold and I^* is zero. Firm l is indifferent in doing the innovation when $R = \widetilde{R}$, which gives us the following equation for zero I^*:

$$\phi(I^*)\pi_{2ls}(\widetilde{R}) + [1 - \phi(I^*(\widetilde{R}))]\pi_{2lf} - I^*(\widetilde{R}) = \pi_{2lf} \tag{24}$$

. The expected payoff from doing the local innovation is the same as that from giving up efforts of innovating around. Since I^* is decreasing in R, any IPRs higher than $\widetilde{R}$ eliminate the local innovation. If IPRs are lower than $\widetilde{R}$, the optimal innovation inputs are greater than zero.

3.3.5 Simulation Results

From this section on I will demonstrate the effects of R on I^* and firm l and the MNE profit shares through simulation. In the simulation I assume different values for parameters a, b, f, and E. The values are assigned such that all the profit types in Table 3 are positive and there is positive surplus from setting up a joint venture compared to exports. Optimal innovation I^* and profit shares are endogenous. By changing values of R, I find the corresponding I^*, π_{1l}, π_{1m}, Π_l, and Π_m.

The benchmark case I use is $\theta_1 = \theta_2 = \frac{1}{2}$, which means the MNE and firm l have equal bargaining powers in both periods. Without loss of generality I also assume $v = 1$, which means one dollar of input equals on unit of efficient input. In the benchmark case I also assume zero tariff to isolate the effects of IPRs. By solving equations (23) and (24), the two critical IPRs value $\overline{R}$ and $\widetilde{R}$ are 0.764 and 0.868 in the simulation respectively.

Figure 2 gives the simulation results of I^* in IPRs. The local innovation first decreases in IPRs. When IPRs are higher than the threshold level $\widetilde{R}$, here at 0.868, I^* stays at zero just as Proposition 1 shows. If IPRs are high enough firm l gives up innovation and both parties can get a definite share from the joint venture without any uncertainty. In the simulation the $\widetilde{R}$ over which the local innovation is deterred is 0.868, less than perfect level. I can say that the IPRs level does not have to be at the highest possible level to protect the MNE. As long as IPRs are high enough such that $R > \widetilde{R}$, the joint venture share is stable and local innovation is eliminated. Any IPRs higher than that are not necessary.

3.4 First Period Profit Share

3.4.1 First Period Profit Share in IPRs

With the definition of $\overline{R}$ and equation(14), firm l's profit can be written into two parts.

$$\begin{aligned}\pi_{1l} &= 0,\ when\ R < \overline{R} \\ &= \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}], when R > \overline{R}\end{aligned}$$

Similarly, equation (15) can be written into two parts also.

$$\begin{aligned}\pi_{1m} &= \pi_1,\ when\ R < \overline{R} \\ &= (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}],\ when\ R > \overline{R}\end{aligned}$$

If $R < \overline{R}$, both π_{1l} and π_{1m} are constant at zero and π_1 respectively. When $R > \widetilde{R}$, there is no uncertainty in period 2, first period payoffs are stable in IPRs also. If R is higher than $\overline{R}$ but still lower than $\widetilde{R}$, $\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}$ decreases in IPRs and this leads to higher period 1 profit share for firm l and lower share for the MNE. I can get the following proposition.

Proposition 2:

$$\begin{aligned}
\frac{d\pi_{1l}}{dR} &= 0, \; when\ R < \overline{R}\ or\ R > \widetilde{R} \\
\frac{d\pi_{1l}}{dR} &> 0, \; when\ \overline{R} < R < \widetilde{R} \\
\frac{d\pi_{1m}}{dR} &= 0, \; when\ R < \overline{R}\ or\ R > \widetilde{R} \\
\frac{d\pi_{1m}}{dR} &< 0, \; when\ \overline{R} < R < \widetilde{R}
\end{aligned}$$

If $R < \overline{R}$, firm l gets zero and the MNE gets the whole share π_1. Both are invariant in IPRs. When $R > \widetilde{R}$, there is no local innovation and profit shares are constant in IPRs. However, when IPRs are in the middle range, $\overline{R} < R < \widetilde{R}$, both firms get positive shares from the joint venture in period 1. Firm l's first period payoff is increasing in IPRs and the MNE's is decreasing in IPRs.

3.4.2 Simulation Results

Figure 3 shows that when IPRs change from zero to one, both firm l's and the MNE's first period profits are first constant. But if IPRs are strengthened beyond some threshold level $\overline{R}$, in the simulation 0.764, the local innovation activity is less intensive and the MNE demands profit share lower than π_1. Firm l can get a positive profit in period 1 now. The higher IPRs, the less first period share the MNE demands in the bargaining as they can get higher expected second period payoff. In Figure 3 I can see when R is beyond $\overline{R}$, firm l 's first period profit is increasing in IPRs while the MNE's is decreasing IPRs. However, when IPRs exceed another threshold level $\widetilde{R}(0.868)$, the profit share is constant again. With Firm l finds local innovation unattractive because of the high punishment from lawsuits. Both firms' profits shares in the first period are constant in IPRs and solely decided by other factors.

Generalizing the above results, when a developing country has poor IPRs , local firms get nothing in the early stage of cooperation in joint ventures. When IPRs are strengthened, local firms are more likely to get a positive share in early stage and this share increases with stronger IPRs. In the business co-operations between a developing country and a developed country, usually the developed country firm exploits most of the early period profits. Developing countries always complain about this situation and think they are "robbed". Our model gives one explanation for this phenomenon. With low IPRs in developing countries, developed country firms do not have much protection in their future profit and they have to grab profit as early as they can in the bargaining. If IPRs are too low, sometimes the cooperation even leaves local partners zero profit. While complaining their disadvantage in the cooperation local firms have to be aware that with low IPRs protection they have to sacrifice some early benefit to exchange for future prosperity.

3.5 Two-Period Expected Payoff

3.5.1 Two-Period Expected Payoff in IPRs

The two-period expected payoff from the joint venture for firm l and the MNE are given in equations (16) and (17) respectively. With the definition of $\overline{R}$ equations (16) and (17) can also be written as:

$$\begin{aligned}\Pi_l &= \phi(I^*)\pi_{2ls} + (1-\phi(I^*))\pi_{2lf} - I^*, when\ R < \overline{R} \\ &= \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - I^*, when\ R > \overline{R}\end{aligned}$$

and

$$\begin{aligned}\Pi_m &= \pi_1 + \phi(I^*)\pi_{2ms} + (1-\phi(I^*))\pi_{2mf}, when\ R < \overline{R} \\ &= \pi_{1e} + \pi_{2e} + (1-\theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] when\ R > \overline{R}\ .\end{aligned}$$

The effects of IPRs on two-period payoffs of firm l and the MNE are showed in Proposition 3.

Proposition 3:

$$\begin{aligned}\frac{d\Pi_l}{dR} &< 0,\ if\ R < \overline{R} \\ \frac{d\Pi_l}{dR} &> 0,\ if\ \overline{R} < R < \widetilde{R} \\ \frac{d\Pi_l}{dR} &= 0,\ if\ R > \widetilde{R} \\ \frac{d\Pi_m}{dR} &> 0,\ if\ R < \overline{R} \\ \frac{d\Pi_m}{dR} &= 0,\ if\ R > \overline{R}\end{aligned}$$

When R is lower than $\overline{R}$, Π_l only comes from the second period. Strengthening IPRs decreases the expected payoff in the second period, so Π_l is lower in R. Since what firm l gains is what the MNE loses in the joint venture. MNE's total profit share approximately moves in the opposite direction in IPRs to that of firm l's. Π_m increases in IPRs with $R < \overline{R}$. If IPRs are greater than $\overline{R}$ but still less than $\widetilde{R}$, the financial constraint is not binding and local innovation exists. The MNE can use first period bargaining to leverage to get total share of $\pi_{1e} + \pi_{2e} + (1-\theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$, which leaves firm l constant two-period expected payoff $\theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$. Both are invariant in IPRs. However, as long as $R < \widetilde{R}$, stronger IPRs decrease firm l's inputs in I^*. Π_l increases in R due to the savings on I^*. When I have $R > \widetilde{R}$, the local innovation activity stops. Firm l gets a constant profit $\theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$ and the MNE gets $\pi_{1e} + \pi_{2e} + (1-\theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$. Both Π_1 and Π_m are constant in R.

3.5.2 Simulation Results

The simulation results in Figure 4 show that Π_l first decreases in IPRs until $\overline{R}(0.764)$. Then it increases with stronger IPRs, but this upward trend is not obvious since innovation inputs I^* change on a much smaller scale compared to Π_l. And finally Π_l keeps constant when IPRs are higher than $\widetilde{R}(0.868)$.

What firm l gains is what the MNE loses in the joint venture. In Figure 4 MNE's total profit share approximately moves in the opposite direction in IPRs to that of firm l's. Π_m increases in IPRs with $R < \overline{R}(0.764)$ and constant with $R > \widetilde{R}(0.,868)$. However, there is one exception when $\overline{R} < R < \widetilde{R}$. Π_m is constant in IPRs, while Π_l increases in IPRs. When IPRs are in this range, both firms have constant share from the joint venture through bargaining. But firm l's total payoff is its hare from the joint venture minus its innovation inputs, which is decreasing in IPRs. Firm l has higher total payoff with stronger intellectual protection because of the saved innovation inputs, while the MNE's profit does not vary with IPRs when $\overline{R} < R < \widetilde{R}$.

Whether developing countries benefit from stronger IPRs or not depends on its existing IPRs level. When a developing country has a relatively low IPRs, stronger intellectual protection lowers its profits from joint ventures. This is consistent with the reality. It is always those countries which have poor IPRs and low GPD that are against improving IPRs the most. When IPRs are over some threshold, developing countries are not totally against and sometimes even strongly appraise raising their intellectual protection. New industrial or fast developing countries like Chile, Mexico, Korea, and Taiwan are those countries which put great efforts in improving IPRs.

3.6 Heterogeneous Bargaining Power

3.6.1 Bargaining Power and $\widetilde{R}$ and $\overline{R}$

Bargaining power is one of the key factors that decide the share of each partner in the joint venture. Throughout this paper I assume the MNE and firm l have equal arguing power in period 2. When both firms have already entered the joint venture, common knowledge through cooperation and exit cost tend to make their arguing power converge. However, this may not be the case for period 1. The arguing powers θ_1 and $1 - \theta_1$ in period 1 depend on the relative strength of the advantages of each firm.

I expect that different values of θ_1 in the negotiation affect payoffs and may also change the level of $\overline{R}$ and $\widetilde{R}$. Differentiate (23) and (24) with respect to θ_1, I have

$$\frac{d\overline{R}}{d\theta_1} = \frac{\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})}{(\pi_{2ls} - \pi_{2lf})p'(I^*)I^{*\prime}(R)} < 0 \tag{25}$$

$$\frac{d\widetilde{R}}{d\theta_1} = 0 \tag{26}$$

. θ_1 does not enter into equation(26) since the innovation input is only related to factors that affect the expected payoff in period 2, not in period 1. $\widetilde{R}$ is invariant in the first period bargaining power θ_1 and $1-\theta_1$. $\overline{R}$ decreases in firm l's first period arguing power θ_1. $\overline{R}$ is the critical IPRs level that sets firm l's first period payoff $\theta_1[\pi_1+\pi_2-(\pi_{1e}+\pi_{2e})]-[\phi(I^*)\pi_{2ls}+(1-\phi(I^*))\pi_{2lf}]$ equal to zero. If firm l's bargaining power is getting stronger, the first part of the above expression will be higher. To get zero first period payoff firm l's period 2 expected payoff should be higher, which means IPRs are lower. Stronger position of firm l in the negotiation in period 1 brings down $\overline{R}$.

3.6.2 Simulation Results

Low θ_1 By observing Equation (23) which decides the level of $\overline{R}$, I find that if θ_1 is low enough, I may always have zero first period payoff for firm l for any values of R. If θ_1 is low enough, the first part of the equation, the total profits from the joint venture, is small. Even with the lowest possible value of the second part, π_{2lf}, firm l still has zero payoff in period 1. In the simulation when θ_1 is less than 0.383, π_{1l} is zero for any IPRs level and financial constraint is always binding. I always have $R<\overline{R}$ and the ranges of IPRs only include $R<\widetilde{R}$ and $R>\widetilde{R}$. Unless IPRs are over $\widetilde{R}$, more stringent IPRs decrease Π_l and do not change π_l. When IPRs are greater than $\widetilde{R}$, the local country may be indifferent in stronger IPRs.

It shows that when a country is at a much weaker position during the bargaining with a developed country, it will always prefer lower IPRs no matter what the existing IPRs level is. When a developing country firm has less bargaining powers, the benefits the developing country firm can get from the negotiation are limited. It would take advantage of weak IPRs to grab more profits in the joint venture. This is true in the real business world. It's always those much under-developed countries not new industrial countries insist on taking weaker domestic intellectual protection. Because with better infrastructure and larger consumption ability new industrial countries tend to have higher bargaining powers compared to those under-developed countries. They don't have to always rely on local innovation behaviors to benefit more from the cooperation. For countries which have poor bargaining powers they use weaker IPRs to compensate for their disadvantaged positions during cooperations with developed countries.

Moderate θ_1 Figure 5 gives the simulation results of $\overline{R}$ and $\widetilde{R}$ when $\theta_1 \in [0.383, 1]$. Just as equations (26) and (27) show, $\overline{R}$ is decreasing and $\widetilde{R}$ is constant in θ_1. The range between $\overline{R}$ and $\widetilde{R}$ is increasing when firm l has a higher bargaining power in the first period. When $\theta_1 = 0.5$, the range is [0.764, 0.868]. However if firm l has all the bargaining power in period 1 with $\theta_1 = 1$, the range expands to [0.552, 0.868]. From Proposition 3 I know that Π_l decreases in IPRs when $R<\overline{R}$ and increases in IPRs when $\overline{R}<R<\widetilde{R}$. When a country has a higher bargaining power, it would be more possible for the country's IPRs falling in the range between $\overline{R}$ and $\widetilde{R}$, which means it's more likely for the country to favor strengthening IPRs. Countries with higher bargaining powers like industrial countries would endorse stronger IPRs.

3.7 Innovation Ability

3.7.1 Different Innovation Ability

The local innovation ability of firm l in our model is represented by parameter v in the innovation probability function. In the benchmark case I assume that the efficient factor v takes the highest possible value 1. If firm l's innovation ability decreases, same amount of dollar inputs I brings lower probability of success and dampens the incentive to take local innovations. I expect this will reduce the second period payoff, but may increase the first period profits for firm l. I use simulation to see if our speculation is correct.

3.7.2 Simulation Results

$\overline{R}$ and $\widetilde{R}$ In the simulation I find that $\overline{R}$ increases and $\widetilde{R}$ keeps constant in the innovation efficiency factor v. Figure 6 shows that the range between $\overline{R}$ and $\widetilde{R}$ is shrinking with higher v.

When firm l is more efficient in innovation, it has higher incentive to input I. At the same time higher v in probability function $1-e^{-(vI)^{\frac{1}{2}}}$ means increasing success rate even with the same I. The second period expected payoff for firm l increases with more efficient innovation, which leaves firm l lower payoff in the first period bargaining. To enhance the bargaining share for firm l in period 1 $\overline{R}$ should be higher with more efficient local innovation. However, $\widetilde{R}$ is constant in v. $\widetilde{R}$ is the threshold level that makes firm l give up local innovation. The marginal decision to do local innovation or not depends on the difference of profits between two scenarios, π_{2lf} and π_{2ls}. π_{2lf} and π_{2ls} are independent of factor v. $\widetilde{R}$ is the same even when a country's innovation ability changes.

When local firms' innovation ability is enhancing, the developing country's IPRs level is less likely to fall in the range between $\overline{R}$ and $\widetilde{R}$, and more likely below $\overline{R}$. Which means the developing country may prefer lower IPRs with more efficient innovation.

Innovation, First Period ,and Two-Period Payoffs Figure 7 compares the simulation results when innovation efficiency factor v is 1 and 0.1 respectively. In Figure 7(a) innovation inputs I are lower when the innovation is less efficient. If a country does not have basic R & D ability, even with low IPRs protection, the innovation is not active.

If a local firm has lower innovation ability, as shown by graphs with $v = 0.1$, it tends to have lower two-period expected payoff but higher early stage profit. Higher efficiency in innovation leads to higher expected second period payoff, which reduces firm l's bargained profits in period one. But the increasing second period payoff more than compensates the loss in the first period. Higher innovation ability leads to higher total payoff in the joint venture.

4 IPRs and Tariff Policies in Joint Ventures

In the previous section I assume tariff rate is zero. If tariff is positive instead, it affects the reserved payoff of both the MNE and firm l. Bargaining results in the joint ventures vary with different tariff rates. IPRs and tariff decide welfare of the MNE and firm l jointly. When the tariff rate is no longer zero, $\widetilde{R}$ and $\overline{R}$ change in tariff also. $\widetilde{R}$ and $\overline{R}$ in the Proposition 1, 2 and 3 are the corresponding $\widetilde{R}(t)$ and $\overline{R}(t)$ respectively.

According to how tariff decides profits of the MNE in different modes, I can divide tariff rate into three ranges: $t < t_d$, $t_d < t < t_{2e}$, and $t > t_{2e}$. When $t > t_{2e}$, tariff is prohibitive and even with T2 exports are still not feasible for the MNE. Export profits are zero for both periods, $\pi_{1e} = \pi_{2e} = 0$. If $t_d < t < t_{2e}$, the MNE can choose export mode in period 2. However, when firm l succeeds in local innovation and deviates from the joint venture, the tariff is so high such that the MNE cannot compete with firm l as duopoly. $\pi_{2md} = 0$ and $\pi_{2ld} = \pi_2$. When $t < t_d$, tariff is such that both duopoly and export profits for the MNE are positive. With the assumptions of cost and demand function forms, I can get $t_d = \frac{a-2b\lambda m_2+bm_2}{2b}$ and $t_{2e} = \frac{a-\lambda m_2 b}{b}$.

4.1 Critical IPRs Level

4.1.1 $\overline{R}$ and $\widetilde{R}$ in Tariff

Both $\widetilde{R}$ and $\overline{R}$ are functions in tariff. They are critical in deciding firm l's innovation behavior and also each firm's profit share from the joint venture. I are interested in investigating how tariff policy affects these two thresholds. Totally differentiate equations (23) and (24), I can get

$$\frac{d\overline{R}}{dt} = -\frac{-\theta_1[(\pi_{1e})'_t + (\pi_{2e})'_t] - [\phi(I^*)(\pi_{2ls})'_t + (I^*)'_t + (1-\phi(I^*))(\pi_{2lf})'_t]}{-\phi(I^*)(\pi_{2ls})'_R - (I^*)'_R} \tag{27}$$

$$\frac{d\widetilde{R}}{dt} = -\frac{\phi(I^*)[(\pi_{2ls})'_t - (\pi_{2lf})'_t]}{\phi(I^*)(\pi_{2ls})'_R} \tag{28}$$

.

Since $\overline{R}$ is the threshold level of IPRs that sets firm l's 1st period payoff at zero, how $\overline{R}$ changes in t depends on how IPRs and tariff together decide π_{1l}. If both tariff and IPRs increase π_{1l}, with higher tariff $\overline{R}$ has to be lower to balance π_{1l} back to zero. If tariff and IPRs change π_{1l} in the opposite direction, $\overline{R}$ increases with higher tariff. The denominator $-\phi(I^*)(\pi_{2ls})'_R - (I^*)'_R$ in equation(27) gives the effect of IPRs on π_{1l}, which is always positive as indicated by Proposition 2. When IPRs are higher, firm l decreases innovation input and its expected payoff in period 2 is lower. The MNE would give up more share in the first period bargaining and leaves firm l higher share. The numerator of equation (27) represents the response of π_{1l} to changing tariff. The first term $-\theta_1[(\pi_{1e})'_t + (\pi_{2e})'_t]$ is the effect of tariff on the agreed total payoff of both periods for firm l, which is positive. The second term $[\phi(I^*)(\pi_{2ls})'_t + (I^*)'_t + (1-\phi(I^*))(\pi_{2lf})'_t]$ is the effect of tariff on the expected payoff in period 2 for firm l , which may be increasing or decreasing in tariff. Whether π_{1l} increases with tariff or not is ambiguous. If the numerator is positive, increasing tariff leads to higher first period payoff. The threshold $\overline{R}$ should be lower to leverage the effect of rising tariff to get zero first period payoff for firm l. $\overline{R}$ decreases in tariff. If the numerator is negative, $\overline{R}$ increases with rising tariff. In Proposition 4 I demonstrate how $\overline{R}$ changes in tariff. For most of the cases the sign of $\frac{d\overline{R}}{dt}$ is not clear. In the following section I assign specific values to parameters and use simulation to show how $\overline{R}$ changes in tariff.

Proposition 4:

For tariff $t > t_{2e}$, $\frac{d\overline{R}}{dt} = 0$.

For tariff $t_d < t < t_{2e}$, *the sign of* $\frac{d\overline{R}}{dt}$ *is ambiguous.*

For tariff $t < t_d$, *the sign of* $\frac{d\overline{R}}{dt}$ *is ambiguous.*

Proof: see Appendix 1

$\widetilde{R}$ is the IPRs level that keeps net payoff from the innovation at zero such that firm l is indifferent in doing local innovation. If tariff and IPRs change the net payoff from the innovation in the same direction, the sign of equation(28) is negative. $\widetilde{R}$ should be lower with increasing tariff such that their effects are cancelled out and net payoff from innovation stays at zero. If tariff and IPRs work in different directions, IPRs must be also higher to eliminate local innovation with raising tariff. The denominator of equation (28) is the effect of IPRs on net payoff for the local innovation, which is negative. More stringent IPRs protection lowers the incentive for firm l to do the local innovation. Whether $\widetilde{R}$ increases or decreases in tariff depends on the numerator, the effects of tariff on expected payoff from innovation, $\pi_{2ls} - \pi_{2lf}$. If tariff increases $\pi_{2ls} - \pi_{2lf}$, $\widetilde{R}$ should also increase in tariff to leverage the payoff to zero; if net payoff from innovation decreases in tariff, higher tariff leads to lower $\widetilde{R}$. Equation (28) has the same sign as $(\pi_{2ls})'_t - (\pi_{2lf})'_t$, which can be illustrated by Proposition 5:

Proposition 5:

For tariff $t > t_{2e}$, $\frac{d\widetilde{R}}{dt} = 0$;

For tariff $t_d < t < t_{2e}$, $\frac{d\widetilde{R}}{dt} < 0$;

For tariff $t^* < t < t_d$, $\frac{d\widetilde{R}}{dt} > 0$;

For tariff $t < t^*$, *when* $\widetilde{R} < R^*$, $\frac{d\widetilde{R}}{dt} > 0$;

when $\widetilde{R} > R^*$, $\frac{d\widetilde{R}}{dt} < 0$.

$(t_{2e} = \frac{a-\lambda m_2 b}{b}; t_d = \frac{a-2b\lambda m_2+2bm_2}{2b}; t^* = \frac{4a-20b\lambda m_2+16m-2b}{20b}; R^* = \frac{3(a-b\lambda m_2-bt)}{7a-23b\lambda m_2-23bt+16bm_2})$

Proof: see Appendix 1 It is obvious that $\widetilde{R}$ is constant in t beyond prohibitive tariff. When tariff is high but under t_{2e}, $\widetilde{R}$ decreases in t. If tariff is not so high, unless low tariff and high IPRs exist at the same time, $\widetilde{R}$ increases with tariff rate. I will also demonstrate this trend with simulation.

4.1.2 Simulation Results

As Proposition 4 and Proposition 5 indicate, the effect of tariff on $\widetilde{R}$ and $\overline{R}$ are not straightforward. I can use simulation to demonstrate the signs of equations (27) and (28). Tariff $t \in [0, 6.5]$, with $t_d = 2.49$ and $t_{2e} = 5.34$. The upper bound 6.5 is higher than t_{2e}, the prohibitive tariff.

Figure 8 gives simulation results of $\overline{R}$ and $\widetilde{R}$ under different tariff rates. $\overline{R}(t)$ always decreases in tariff in our simulation. When tariff is higher than 3.5, $\overline{R}(t)$ becomes negative. That means when tariff is high, even in countries without any IPRs protection the financial constraint is not binding and firm l can always share some profits in period 1. $\widetilde{R}$ is U-shaped when tariff is relatively low, then stays at approximately one when tariff is higher than 2.7 in the simulation. In Proposition 5 $\widetilde{R}$ should first decrease then keep constant when tariff $t > t_d$. However in Figure 8 this trend is not obvious since $\widetilde{R}$ only varies in the sixth digit place. Figure 8 shows when tariff is at the lower end of tariff, the R-t space can ge divide into three ranges: $R < \overline{R}(t)$, $\overline{R}(t) < R < \widetilde{R}(t)$, and $R > \widetilde{R}(t)$. With tariff increases, the range between $\overline{R}$ and $\widetilde{R}$ is getting larger and finally any IPRs level falls in the rang of $[\overline{R}(t), \widetilde{R}(t)]$.

4.2 Local Innovaiton I^*: IPRs and Tariff

4.2.1 Effects of Tariff on I^*

Tariff also changes the innovation behavior of firm l because it affects the reserved payoffs of both firms, which decide each firm's share in the joint venture. This in turn affects the net payoff of firm l's innovation. Totally differentiate optimal innovation input I^* in equation (20) with respect to tariff t, I can get the following equation:

$$\frac{dI^*}{dt} = \Psi[(\pi_{2ls})'_t - (\pi_{2lf})'_t] \tag{29}$$

$$(\Psi = -\frac{1}{\{\pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] - \theta_2[\pi_2 - (\pi_{2e} - C)]\}^2[-\frac{1}{4}e^{-I^{\frac{1}{2}}}I^{-\frac{3}{2}}(1 + I^{\frac{1}{2}})]})$$

. Ψ is positive in equation(29). Whether higher tariff leads to higher I^* or not depends on how it affects the innovation payoff $\pi_{2ls} - \pi_{2lf}$.

$$\pi_{2ls} - \pi_{2lf} = (1 - \theta_2)\pi_{2ld} + \theta_2(\pi_{2e} - \pi_{2md}) - [(1 - \theta_2)\pi_2 + \theta_2(\pi_{2e} - E) - (\pi_{2md} - E)]R \tag{30}$$

$$(\pi_{2ls})'_t - (\pi_{2lf})'_t = (1 - \theta_2)\frac{d\pi_{2ld}}{dt} + \theta_2(\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt}) - (\theta_2\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})R \tag{31}$$

The effect of tariff on $\pi_{2ls} - \pi_{2lf}$ in equation (31) is not clear, which can be divided into two parts. The first is simply how tariff affects the difference of profit shares from the joint venture between two scenarios assuming there is no IPRs protection at all, which is the first two terms of equation (31), $(1 - \theta_2)\frac{d\pi_{2ld}}{dt} + \theta_2(\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})$. I call it payoff effect. The second effect is IPRs effect. This is how tariff affects the compensation firm l has to pay the MNE under IPRs jurisdiction, which is $-(\theta_2\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})R$. In Appendix 2 I prove the following proposition:

Proposition 6:

If $R > \widetilde{R}(t)$, $\frac{dI^*}{dt} = 0$.

If $R < \widetilde{R}(t)$,

For tariff $t > t_{2e}$, $\frac{dI^*}{dt} = 0$;

For tariff $t_d < t < t_{2e}$, $\frac{dI^*}{dt} < 0$;

For tariff $t^* < t < t_d$, *I always have* $\frac{dI^*}{dt} > 0$;

with $t < t^*$ *and* $R < R^*$, $\frac{dI^*}{dt} > 0$;

with $t < t^*$ *and* $R > R^*$, $\frac{dI^*}{dt} < 0$.

$(t_{2e} = \frac{a-\lambda m_2 b}{b}; t_d = \frac{a-2b\lambda m_2+2bm_2}{2b}; \; t^* = \frac{4a-20b\lambda m_2+16m-2b}{20b}; \; R^* = \frac{3(a-b\lambda m_2-bt)}{7a-23b\lambda m_2-23bt+16bm_2})$

Proof: see Appendix 2

Proposition 6 can be demonstrated by Figure 9. With $t > t_{2e}$, tariff is so high such that it is prohibitive for the MNE to export in both periods. Also due to high tariff the MNE cannot compete with firm l if firm l grasps T2 independently. I have $\pi_{1e} = \pi_{2e} = 0$, $\pi_{2ld} = \pi_2$, and $\pi_{2md} = 0$. Both payoff effect and IPRs effect are zero. The net payoff from innovation is invariant in tariff when $t > t_{2e}$, and $\frac{dI^*}{dt} = 0$.

When tariff $t_d < t < t_{2e}$, if the MNE chooses to export instead of joining a joint venture , it can earn positive profits in the second period, $\pi_{2e} > 0$. But if joint venture is chosen and firm l succeeds in innovation, tariff is still high enough such that deviating from the joint venture brings firm l the whole market and the MNE zero share, $\pi_{2ld} = \pi_2$ and $\pi_{2md} = 0$. The payoff effect now is $\theta_2 \frac{d\pi_{2e}}{dt}$ and IPRs effect is $-\theta_2 \frac{d\pi_{2e}}{dt} R$. The payoff effect is negative while the IPRs effect is positive. With IPRs $0 \leq R \leq 1$ payoff effect always dominates IPRs effect. Higher tariff reduces the fine from lawsuit which leads to stronger incentive of local innovation, but always not as much as it dampens the share from the joint venture. Higher tariff unambiguously decreases the net benefit $\pi_{2ls} - \pi_{2lf}$ from innovation. Firm l chooses to do less local innovation with higher tariff.

If $t < t_d$ the MNE can compete as duopoly when firm l grasps the new technology and deviates in period 2, $\pi_{2ld} > 0$ and $\pi_{2md} > 0$. $\pi_{2ls} - \pi_{2lf}$ may increase or decrease in tariff. With assumptions of linear demand and equal bargaining powers in period 2, I can prove that payoff effect is always positive in tariff. Without considering IPRs protection higher tariff enhances the bargaining position of firm l in both scenarios, but firm l's payoff increases more when the innovation succeeds. Firm l has incentive to input more in the local innovation with increasing tariff because it can get better payoff in the joint venture. However, I find IPRs effect may be positive or negative in tariff. When tariff is higher than some threshold level t^*, I have either positive IPRs effect or payoff effect dominating IPRs effect. In both cases firm l inputs more in local innovation with rising tariff. If tariff is lower than t^*, payoff effect is not strong enough to dominate the IPRs effect for all IPRs level. IPRs play a role in deciding the effects of tariff on I^*. As shown in Figure 3, when IPRs are less than a threshold level, R^*, payoff effect dominates the IPRs effect. The total effect is positive and local innovation inputs increase in tariff. When $R^* < R$, higher IPRs increase the negative IPRs effect. IPRs effect dominates and local innovation inputs are decreasing in tariff, $\frac{dI^*}{dt} < 0$.

Figure 9 shows the effect of tariff on the innovation activity I^* keeping IPRs constant. When tariff changes, both existing levels of IPRs and tariff decide the movement of I^*. As Line 1 indicates, when a country with high IPRs increases tariff from zero to prohibitive tariff t_{2e}, I^* first keeps constant at zero, then increases, decreases, and finally gets constant again after t_{2e}. Line 2 shows if a country has moderate IPRs, from tariff zero to t_{2e}, I^* is U-shaped first, then decreases, and finally gets constant. However, if a country has poor IPRs protection as line 3, higher tariff always increases its local innovation activity until t_d after which I^* decreases then stays invariant in tariff after t_{2e}.

From Figure 9 I know that for high trade-barrier countries ($t > t_d$) tariff affects local innovation in the same way. As long as tariff is not prohibitive, liberalizing trade may increase local innovation. With a relatively closed economy, freeing trade brings higher local innovation. Lowering tariff has the same effect as relaxing IPRs policy. If a developing country has relatively free trade policy($t < t_d$), the effect of lowering tariff further also depends on its IPRs level. For countries with liberal trade but poor IPRs, more liberal trade decreases I^*. Lower tariff can have the same effects as strengthening IPRs. For a country which has low tariff and already high IPRs, the change of tariff may not affect the local innovation behavior. However, for country with moderate IPRs decreasing tariff may decrease I^* first, but when tariff is low enough already, I^* gets higher with more free trade policy.

4.2.2 Simulation Results of I^*

Figure 10 gives the simulation results of I^* in tariff and IPRs. To give a better illustration how IPRs affect I^* at different tariff rates, tariff is kept constant at 1.635 in Figure 10(b1) and at 4.55 in Figure 10(b2). In both cases I^* decreases, then reaches zero when IPRs are beyond some threshold level, just as Proposition 1 suggests. But the threshold level $\widetilde{R}$ that eliminates local innovation varies with tariff. $\widetilde{R}$ is around 0.87 when $t = 1.635$, but with $t = 4.55$ I^* approaches zero only when IPRs are close to one. If tariff is moderate or small, any IPRs higher than $\widetilde{R}$, not necessarily perfect protection can stop the local innovation. But only perfect IPRs can eliminate the local innovation when tariff is high.

In Figure 10(c1), (c2), and (c3) IPRs are kept constant at 0.1, 0.4, and 0.95 and the graphs show how the optimal local innovation changes in tariff. In all three figures after $t > t_d$, the dynamic movement of I^* is independent of IPRs level. This justifies Proposition 6 in which I^* decreases between t_d and t_{2e} and constant when t is beyond the prohibitive tariff t_{2e}. However when tariff is lower than t_d, how tariff affects I^* also depends on different IPRs. With low IPRs protection as in figure 10(c1), I^* is always higher with more closed trade policy. However in Figure 10(c2) when IPRs are moderate at 0.4, I^* is U-shaped in tariff. When IPRs are high in figure 10(c3), I^* starts at zero, then increases in tariff.

If tariff is high enough, greater than t_d but still lower than t_{2e}, either increasing tariff or strengthening IPRs can dampen the local firm innovation inputs. If a high trade-barrier country lowers its tariff, its local innovation behavior will be more active even with the same IPRs level. With a relative low tariff usually increasing t tends to enhance the local innovation activity with two exceptions. The first is that the local country has extremely low tariff and high IPRs protection. In this situation tariff has no effect on I^* since R is high enough to eliminate the local innovation. The other exception is that the local country has extremely low tariff and moderate IPRs. Increasing tariff in this case may dampen the local innovation first since higher tariff means more compensation paid by firm l in the contract breaching lawsuit.

4.3 First Period and Two-Period Expected Profit Share: Tariff and IPRs

In our model tariff has two effects. The first is its effect on the reserved payoff of both partners such that the resulting profit shares in period 1 and 2 and optimal innovation inputs change. I call this direct effect. The other effect is indirect effect. Since the two threshold levels $\overline{R}$ and $\widetilde{R}$ are functions in tariff, changing tariff changes relationship of current IPRs and $\overline{R}$ and $\widetilde{R}$. This in turn changes the attitude of the local country towards IPRs policy. Figure 11 demonstrates the indirect effect. I can divide R-t space into three regions. Region 1 is $R > \widetilde{R}(t)$, region 2 is $\overline{R}(t) < R < \widetilde{R}(t)$, and region 3 is $R < \overline{R}(t)$. From Proposition 2 and 3 I know that in region 1 local innovation is zero and π_{1l}, π_{1m}, Π_l , and Π_m are all invariant in IPRs. Both firms are indifferent to the changes of IPRs. In region 2 π_{1l} and Π_l increases in IPRs, while π_{1m} decreases and Π_m keeps constant in IPRs. In this region firm l may have incentives to strengthen its IPRs protection. In region 3 local innovation is positive, π_{1l} is zero and Π_l decreases in IPRs. Both π_{1m} and Π_m increase with more stringent IPRs protection. This is the case that firm l and the MNE have conflicting benefits concerning strengthening IPRs.

To demonstrate the indirect effect of tariff I assume that a developing country is currently in region 3. Keeping its IPRs constant the local country starts increasing the tariff rate. If the tariff increase is not dramatic, it is still in region 3. The effect of tariff is direct effect only. When tariff keeps increasing, the local country may shifts from region 3 to region 2. The local country has different attitudes towards stronger IPRs in region 3 and region 2. In region 3 higher IPRs do not change first period payoff of firm l but decreases its total payoff from the joint venture. The local government prefers lower IPRs. But in region 2, stronger IPRs increases both first period and total payoff. The local government may not be against stringent IPRs policy. The increasing tariff shifts the attitudes of local countries towards IPRs policy and this is the indirect effect of tariff. Since in this paper I are more concerned with the interaction of tariff and IPRs policy, I will focus more on the indirect effect of tariff.

4.3.1 Simulation Results of First Period Payoff

The simulation results in Figure 12 and 13 show the first period profit for firm l and the MNE respectively. Since the sum of the two firms' profit is equal to the monopoly profit π_1, which is invariant in tariff and IPRs, tariff and IPRs must have opposite effects on firm l and the MNE.

In Figure 12(b1) and 13(b1) I fix tariff rate at 1.635 and observe the effects of IPRs only. Both firm l's and the MNE's first period profits are constant when IPRs are low. With the strengthening of IPRs, π_{1l} increases and π_{1m} decreases in IPRs and finally keeps constant again when IPRs are high. This is exactly what Proposition 2 suggests and the two IPRs levels are $\overline{R}$ and $\widetilde{R}$, which are 0.34 and 0.89 respectively. When IPRs change from zero to one, it moves from region 3 to region 2 to region 1. Correspondingly π_{1l} and π_{1m} are constant in region 3 and region1. But in region 2 π_{1l} increases and π_{1m} decreases in IPRs. In Figure 12(b2) and 13(b2) the tariff rate increases to 4.55, and $\overline{R}$ and $\widetilde{R}$ are -0.15 and 0.99. Now any IPRs level are between $\overline{R}$ and $\widetilde{R}$, which is in region 2. Firm l always has higher and the MNE has lower first period payoff when IPRs are strengthened. When tariff changes from 1.635 to 4.55, the region shifting effect is the tariff indirect effect. Low IPRs countries shift from region 3 to region 2 and high IPRs country shifts from region 1 to region 2. When tariff jumps from 1.635 to 4.55, a low IPRs country will change from against to appraising increasing IPRs if it is really concerned with its early stage profit. A high IPRs country which used to be indifferent to more stringent IPRs now may favor stronger protection.

Figure 12(c) and 13(c) show how period 1 payoff changes in tariff keeping IPRs constant at 0.4. The figure of period 1 payoff for firm l also has three parts: first constant, then increasing, and finally constant again in tariff. Since the whole "Pie" firm l and the MNE sharing is constant, the MNE's profit share is first constant, then decreasing, and finally constant in tariff. When tariff is low, $R = 0.4$ is in region 3 in which firm l and the MNE have constant profit at zero and π_1 respectively. As tariff hits around 1.24, now $R = 0.4$ shifts from region 3 to region 2 and π_{1l} is no longer zero. π_{1l} is increasing and π_{1m} is decreasing in tariff in this range because higher tariff lowers the MNE reserved payoff in the bargaining. If tariff keeps increasing such that it's higher than the prohibitive level t_{2e}, tariff is not a factor influencing bargaining results any more. Period 1 payoff is constant again for both firm l and the MNE.

Generalizing the above results, when a developing country has poor IPRs and relatively open trade policy, local firms get nothing in the early stage of cooperation in joint ventures. Moderate change in tariff or IPRs will not affect period 1 payoff. If a country has both strong IPRs protection and high tariff, local firms almost surely can have a positive share in joint ventures. That's because high tariff rate reduces reserved payoffs for MNEs and stronger IPRs reduce incentives of MNEs to grab more profits in the first period share. Both increases profits shares for local firms in the bargaining in period one. For some developing countries that are neither of the above two cases, profit in period 1 generally increases in tariff and also increases in IPRs.

4.3.2 Simulation Results of Two-Period Expected Payoff

Since I assume two agents without discounting, firm l and the MNE are more concerned with their total two-period expected payoffs. Figure 14 and 15 demonstrate the simulation results of Π_l for firm l and Π_m for the MNE respectively. Tariff is fixed at 1.635 in Figure 14(b1) and 15(b1) and at 4.55 in 14(b2) and 15(b2). When tariff $t = 1.635$, Π_l first decreases, then increases, and at last keeps constant in IPRs, while Π_m increases then gets constant in IPRs. This trend satisfies Proposition 3. When IPRs change from zero to one, R-t moves from region 3 to region 2 and finally in region 1. If a developing country has relatively low tariff and also poor IPRs protection(as in region 3), it may desire even lower IPRs to grab more profits from the joint venture. With the same low tariff but IPRs beyond a threshold level(as in region 2), the local government may find that stronger IPRs can benefit firm l more. With tariff equal to 4.55 in Figure 14(b2) and 15(b2), Π_l is always increasing and Π_m is constant in IPRs. If a developing country has relatively low IPRs, increasing tariff from 1.635 to 4.55 shifts R-t from region 3 to region 2. Even with the same IPRs level, after raising the tariff the local government may change from against to endorsing stronger IPRs policy.

In Figure 14(c) and 15(c) IPRs are fixed at 0.4. Π_l is increasing and Π_m is decreasing in tariff as long as $t < t_{2e}$, the prohibitive level. Higher tariff decreases the export profit if the MNE deviates from the joint venture. Firm l is in a better position in the bargaining and gets higher profits share in the joint venture. This is the direct effect of tariff. Generally higher tariff increases firm l's payoff and decreases the MNE's payoff in the joint venture.

5 Policy Implications

5.1 IPRs Policy–Bargaining Powers, Innovation Ability, Discounting Factors, and Risk Neutrality

Once a country decides to adopt policies facilitating foreign investments in joint ventures, it should find out how IPRs can affect local welfare and innovation inputs. There is no single rule whether a developing country should adopt high or low IPRs, since the optimal IPRs level depends on the existing IPR level, tariff rate, local bargaining power, and local innovation ability.

Since I assume all products from the joint venture are sold in the local market, the local country's welfare is its consumer surplus plus Π_l. The consumer surplus is invariant in tariff and IPRs, therefore I focus on how Π_l changes under different policies. The welfare of the MNE for the developed country is Π_m. Without considering tariff I find that if a developing country's existing IPRs are low, it prefers even lower IPRs protection. But for developing countries with moderate IPRs, they should strengthen IPRs to improve payoff. This means there is a trap in IPRs. Low IPRs countries in this trap love lower intellectual property protection and high IPRs countries out of the trap prefer higher intellectual right protection.

If a local firm has lower bargaining power and high innovation ability, it's more likely the local government prefers low IPRs protection such that it can help local firms seek a higher profit in joint ventures. If a local firm has high valued advantages and higher bargaining power, and also at the same time its innovation is not so efficient, high IPRs protection may be preferred to the local government.

I assume no-discounting and risk neutral agents. If these two assumptions are unlikely to hold, policy implications for local governments and developed countries reaction may also change. If the local government values early stage profits more than the profits from period 2, the local government should improve its IPRs protection. The higher IPRs level can persuade the MNE to give up more share in the early stage since the MNE knows that its expected payoff in the second period enhances with stronger IPRs. When the MNE is risk neutral, as long as $R > \overline{R}$, it can use bargaining to leverage to get constant expected share. The MNE only presses the local government to raise its IPRs over $\overline{R}$. However, a more realistic assumption towards risk attitudes is that the MNE is risk averse and firm l is risk seeking rather than risk neutral. If this is the case, the MNE would want the local innovation activity to be as less as possible and may be eliminated totally. The MNE may insist that IPRs must be over $\overline{R}$, even up to $\widetilde{R}$. At the same time firm l is more active in taking uncertain innovation activities. With risk averse developed country partners and risk seeking local partners conflicts of strengthening IPRs are more severe. The local government is under higher pressure to increase IPRs than with risk neutral partners.

5.2 IPRs and Tariff Policies

Both IPRs and tariff policies are important in deciding each firm's payoff in the joint venture and in shaping local innovation activities. If the local government is free in choosing both tariff and IPRs level, it may select the combination that brings the highest payoff to local firm. However, the local government usually is relatively restricted in choosing its desired levels of both policies, especially with tariff. Tariff is less flexible than IPRs policy since most countries are in one or more trade treaties and they have to adjust the tariff according to clauses in these treaties. Even with agreements and organizations like TRIPS and World Intellectual Property Organization(WIPO), IPRs are still more flexible compared to tariff. I investigate how the local government uses the other policy to achieve the same goal.

In our model higher tariff usually increases firm l's profit in the joint venture. If there are no restrictions from trade treaty, the local country may set the tariff rate as high as the prohibit level t_{2e}. If tariff can be set at t_{2e}, the optimal IPRs will be as high as possible also. Since with high tariff the local country is always in region 2, higher IPRs increase the saving on local innovation and bring higher payoff to firm l. But usually the local government's hands are tied in freely changing tariff policy. Free trade is the world trend. If a country raises tariff unilaterally, it may cause tariff retaliation from other countries. Compared to tariff, the local government is more free in changing IPRs level. The more realistic question would be under current tariff rate, what IPRs policy is ideal for its own welfare, the two-period expected payoff. I will focus on the low and moderate tariff range to see how IPRs and tariff affect local innovation intensity I^* and joint venture payoffs.

If the local country has moderate or low tariff, IPRs lower than one will be enough to eliminate local innovation behavior. However, if it has relatively high tariff rate, only perfect protection may be deemed enough. Developed countries prefer less or no local innovation such that their firms can get a more stable profit form joint ventures, which means local IPRs should be higher than $\widetilde{R}$. I assume two countries A and B with the same level of IPRs R_{AB}, but different moderate tariff rate t_A and t_B, with $t_A > t_B$. It is possible country B's IPRs are higher than its $\widetilde{R}(t_B)$, while country A's IPRs are lower than its $\widetilde{R}(t_A)$. In country B the local innovation does not exist, while local firms in country A have positive innovation inputs. Also the MNE perceives that the two countries have different IPRs protection. One is more efficient than the other in eliminating local innovation.

Changing IPRs decreases I^* and also affects profit shares of firm l and the MNE in the joint venture. On the one hand tariff can also directly affect I^*, π_{1l}, π_{1m}, Π_l and Π_m. On the other hand different tariff may change the attitudes of local countries towards IPRs policy and how developed countries perceive the IPRs level. IPRs policy and tariff policy interact with each other. I can use another example to observe the relationship between tariff and IPRs. I assume there are two countries A' and B' with the same level of IPRs $R_{AB'}$, but different tariff rate t'_A and t'_B, with

$t'_A > t'_B$. Higher IPRs may have opposite effects on local welfare. As $t'_A > t'_B$, it is possible ($R_{AB'}$,t'_A) is in region 2 and ($R_{AB'}$,t'_B) is in region 3. Let's assume this is the case. Changes in IPRs bring different effects on welfare in country A' and country B'. When both countries strengthen IPRs, country A's welfare is increasing while country B's welfare is decreasing. For country A' the financial constraint is not binding and it gets a constant two-period share minus the innovation inputs. Stronger IPRs decreases I^* only, which leads to higher local welfare. In country B', the financial constraint is binding. Strengthening IPRs will not change period 1 payoff but decrease period 2 expected payoff. From the perspective of the local government a relative closed country prefer better IPRs protection. High tariff brings more profit share in the joint venture already. The local government should strengthen IPRs to save inputs on local innovation. A more open local economy has less profit due to low tariff. It tends to take loose IPRs policy and encourages local innovation to grab more profits in period 2.

Different tariff rate also changes how the MNE perceives tariff and IPRs policies. To enter into the local market, the MNE firm prefers low tariff and high IPRs. But since country A' is in region 2, strengthening IPRs will not bring excess benefit to the MNE. So the dispute between the local government and developed countries will be focused on tariff. While for country B', strengthening its IPRs increases the MNE payoff from the joint venture. Developed countries argue that country B' doesn't have enough IPRs protection. Even with the same absolute IPRs level, country B becomes the focus of IPRs dispute between developing countries and developed countries, while country A's "problem" lies majorally in tariff instead of IPRs.

6 Conclusions

Information gained through technology transfer is becoming increasingly important in determining the productivity performance of developing countries. Thus, the governments of such countries have been adopting successively tighter IPRs regimes. In the model in this paper I identify two channels through which the local economy can gain from tighter technology protection. First is the savings from spending less on domestic innovation, a savings that is larger if local firms are inefficient in that task. Second is that even though stronger IPRs may decrease the local firm's second-period payoff, it may increase the early-stage profit. Depending on the discount rate, policymakers may prefer achieving that outcome through IPRs policy.

In this paper I consider the characteristics of developing countries that may affect attitudes toward IPRs policy. A country that has initially weak protection, low innovation capacity, and high bargaining power on the part of its local firm, it is more likely to view stronger IPRs as beneficial. This outcome is made more likely in countries with large markets. The dispute over stronger IPRs arises in nations with low initial IPRs, high innovation capacity, and low bargaining power. This situation would induce the domestic government to choose weak protection. Note that low bargaining power would arise in the context of technology provision by a single MNE or a few concentrated MNEs. Finally, for countries with high local innovation capacity, other things equal, the would tend to prefer weak IPRs to take advantage of access to advanced technology while using few resources in adaptation.

I also investigate the interaction between IPRs and tariff policy. I find that different tariff rates may affect the attitude of various nations toward their optimal IPRs regime. Countries with higher tariff rates would favor stronger IPRs, while more open countries may prefer laxer protection. The tariff also affects local R&D activity, though the direction depends on both the tariff and IPRs level.

Several extensions may be considered in future research. First, here I assumed that the benefits from joint ventures are always higher than from exports. However, if there are high fixed costs, low comparative advantage in the recipient country, and high exit costs, this ranking may not hold. In the latter situation tariffs and IPRs would both the reserved payoffs in the bargaining and the gains to MNEs from entering joint ventures. Here, recipient countries may have incentives to increase tariffs at the same time as strengthening IPRs. Second, in the model I only consider the profit share of the developing-country partner in joint ventures as a production gain. However, the motivation for most developing countries in requiring local participation in foreign investment is to enhance the technology and innovation capacity of local firms. If this is successful, there would be additional welfare gains from spillovers to other industries. Further research could focus on such spillovers from joint ventures.

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Appendix 1

$\frac{d\overline{R}}{dt}$ and $\frac{d\widetilde{R}}{dt}$

(A)$\overline{R}$ makes the following equation hold.

$$\theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}] = 0$$

Totally differentiate the above equation:

$$\{-\theta_1[(\pi_{1e})'_t + (\pi_{2e})'_t] - [\phi(I^*)(\pi_{2ls})'_t + \pi_{2ls}\phi'(I^*)(I^*)'_t + (1 - \phi(I^*))(\phi_{2lf})'_t - \pi_{2lf}\phi'(I^*)(I^*)'_t]\}dt$$
$$-\{\pi_{2ls}\phi'(I^*)(I^*)'_R + \phi(I^*)(\pi_{2ls})'_R - \pi_{2lf}\phi'(I^*)(I^*)'_R\}d\overline{R} = 0$$

With $\phi'(I^*)(\pi_{2ls} - \pi_{2lf}) = 1$, the above can be simplified as:

$$\{-\theta_1[(\pi_{1e})'_t + (\pi_{2e})'_t] - [\phi(I^*)(\pi_{2ls})'_t + (I^*)'_t + (1 - \phi(I^*))(\pi_{2lf})'_t]\}dt$$
$$-\{\phi(I^*)(\pi_{2ls})'_R + (I^*)'_R\}d\overline{R} = 0$$

$$\frac{d\overline{R}}{dt} = \frac{-\theta_1[(\pi_{1e})'_t + (\pi_{2e})'_t] - [\phi(I^*)(\pi_{2ls})'_t + (I^*)'_t + (1 - \phi(I^*))(\pi_{2lf})'_t]}{\phi(I^*)(\pi_{2ls})'_R + (I^*)'_R}$$

$(\pi_{2ls})'_t = (1 - \theta_2)\frac{d\pi_{2ld}}{dt} - \theta_2\frac{d\pi_{2md}}{dt} - [\theta_2\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt}]R$

$(\pi_{2lf})'_t = -\theta_2\frac{d\pi_{2e}}{dt}$

$(I^*)'_t = -\frac{(\pi_{2ls})'_t - (\pi_{2lf})'_t}{\{\pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] - \theta_2[\pi_2 - (\pi_{2e} - E)]\}^2\phi''(I^*)}$

Suppose $\Psi = -\frac{1}{\{\pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] - \theta_2[\pi_2 - (\pi_{2e} - E)]\}^2\phi''(I^*)}$ and we have $\Psi > 0$. Plug the above three expressions in $\frac{d\overline{R}}{dt}$:

$$\frac{d\overline{R}}{dt} = \frac{-\theta_1(\frac{d\pi_{1e}}{dt} + \frac{d\pi_{2e}}{dt}) - \{[\phi(I^*) + \Psi][(1 - \theta_2)\frac{d\pi_{2ld}}{dt} - \theta_2\frac{d\pi_{2md}}{dt} + \theta_2\frac{d\pi_{2e}}{dt} - (\theta_2\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})R] - \theta_2\frac{d\pi_{2e}}{dt}\}}{\phi(I^*)(\pi_{2ls})'_R + (I^*)'_R}$$

Denominator $\phi(I^*)(\pi_{2ls})'_R + (I^*)'_R$ is negative, so the sign of the numerator decides the sign of $\frac{d\overline{R}}{dt}$.

Suppose numerator is Ω.

$$\Omega = -\theta_1(\frac{d\pi_{1e}}{dt} + \frac{d\pi_{2e}}{dt}) - \{[\phi(I^*) + \Psi][(1 - \theta_2)\frac{d\pi_{2ld}}{dt} - \theta_2\frac{d\pi_{2md}}{dt} + \theta_2\frac{d\pi_{2e}}{dt} - (\theta_2\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})R] - \theta_2\frac{d\pi_{2e}}{dt}\}$$

Case 1: When $t > \frac{a-\lambda m_2 b}{b}$, the tariff is so high that MNE cannot sell its goods in the local market through exports even there is no competition from local firms.

$\pi_{2ld} = \pi_2;\ \pi_{2md} = 0;\ \pi_{2e} = 0;\ \frac{d\pi_{2ld}}{dt} = 0;\ \frac{d\pi_{2md}}{dt} = 0;\ \frac{d\pi_{2e}}{dt} = 0.$

$\Omega = 0$ and $\frac{d\overline{R}}{dt} = 0$. $\overline{R}$ doesn't change in tariff.

Case 2: When $\frac{a-2b\lambda m_2+bm_2}{2b} < t < \frac{a-\lambda m_2 b}{b}$, the MNE can not compete as duopoly in the second period if the local firm has the advanced technology but still can export if the local firm fails in inventing technology T2 .

$\pi_{2e} > 0;\ \pi_{2ld} = \pi_2;\ \pi_{2md} = 0;\ \frac{d\pi_{2e}}{dt} < 0;\ \frac{d\pi_{2ld}}{dt} = 0;\ \frac{d\pi_{2md}}{dt} = 0.$

$$\Omega = -\theta_1(\frac{d\pi_{1e}}{dt} + \frac{d\pi_{2e}}{dt}) + \theta_2\frac{d\pi_{2e}}{dt} - [\phi(I^*) + \Psi](1 - R)\frac{d\pi_{2e}}{dt}\theta_2$$

The first term and third term are both positive, but the second term is negative. It's most likely that Ω is positive. But without the assumption of the specific values of the parameters it is difficult to tell the sign of Ω.

Case 3: When $t < \frac{a-2b\lambda m_2+bm_2}{2b}$, the MNE still can compete with the local firm as duoploy in the second period even the local firm succeeds in the innovation on its own.

$\pi_{2ld} > 0;\ \pi_{2md} > 0;\ and\ \pi_{2e} > 0;$

$$\Omega = -\theta_1(\frac{d\pi_{1e}}{dt}+\frac{d\pi_{2e}}{dt})-\{[\phi(I^*)+\Psi][(1-\theta_2)\frac{d\pi_{2ld}}{dt}-\theta_2\frac{d\pi_{2md}}{dt}+\theta_2\frac{d\pi_{2e}}{dt}-(\theta_2\frac{d\pi_{2e}}{dt}-\frac{d\pi_{2md}}{dt})R]-\theta_2\frac{d\pi_{2e}}{dt}\}$$

Just as in Case 2, we cannot tell the sigh of Ω also when $t < \frac{a-2b\lambda m_2+bm_2}{2b}$.

Generalize the above results we can get the following conclusion:

For tariff $t > t_{2e}$, $\frac{d\overline{R}}{dt} = 0$.

For tariff $t_d < t < t_{2e}$, *the sign of* $\frac{d\overline{R}}{dt}$ *is ambiguous.*

For tariff $t < t_d$, *the sign of* $\frac{d\overline{R}}{dt}$ *is ambiguous.*

(B)$\widetilde{R}$ makes the following equation hold.

$$\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf} - I^* = \pi_{2lf}$$

Totally differentiate the above equation:

$$[\phi(I^*)(\pi_{2ls})'_t + \pi_{2ls}\phi'(I^*)(I^*)'_t - \phi(I^*)(\pi_{2lf})'_t - \pi_{2lf}\phi'(I^*)(I^*)'_t - (I^*)'_t]dt$$
$$+[\pi_{2ls}\phi'(I^*)(I^*)'_R + \phi(I^*)(\pi_{2ls})'_R - \pi_{2lf}\phi'(I^*)(I^*)'_R - (I^*)'_R]d\widetilde{R} = 0$$

With $\phi'(I^*)(\pi_{2ls} - \pi_{2lf}) = 1$, the above can be simplified as:

$$[\phi(I^*)(\pi_{2ls})'_t - \phi(I^*)(\pi_{2lf})'_t]dt + [\phi(I^*)(\pi_{2ls})'_R]d\widetilde{R} = 0$$

$$\frac{d\widetilde{R}}{dt} = \frac{\phi(I^*)[(\pi_{2ls})'_t - (\pi_{2lf})'_t]}{-\phi(I^*)(\pi_{2ls})'_R}$$

The denominator of $\frac{d\widetilde{R}}{dt}$ is positive and the sign of $\frac{d\widetilde{R}}{dt}$ is the same as $[(\pi_{2ls})'_t - (\pi_{2lf})'_t]$. Suppose $\Phi = [(\pi_{2ls})'_t - (\pi_{2lf})'_t]$. Use the formulas in Table 3 and $\theta_2 = 1 - \theta_2 = \frac{1}{2}$, we can get

$$\begin{aligned}\Phi &= \frac{d\pi_{2ld}}{dt} - (\frac{1}{2}\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})\widetilde{R} - \frac{1}{2}(\frac{d\pi_{2ld}}{dt} + \frac{d\pi_{2md}}{dt}) + \frac{1}{2}\frac{d\pi_{2e}}{dt}\\ &= \frac{1}{2}(\frac{d\pi_{2ld}}{dt} + \frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt}) - (\frac{1}{2}\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})\widetilde{R}\end{aligned}$$

.

Depending on different tariff rate t we can have the following three cases.

Case 1

When $t > \frac{a-\lambda m_2 b}{b}$,

$$\begin{aligned}\Phi &= \frac{1}{2}(\frac{d\pi_{2ld}}{dt} + \frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt}) - (\frac{1}{2}\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})\widetilde{R}\\ &= 0\end{aligned}$$

When t is prohibitive, $\widetilde{R}$ does not vary in tariff.

Case 2

When $\frac{a-2b\lambda m_2+bm_2}{2b} < t < \frac{a-\lambda m_2 b}{b}$,

$$\begin{aligned}\Phi &= \frac{1}{2}(\frac{d\pi_{2ld}}{dt} + \frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt}) - (\frac{1}{2}\frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{dt})\widetilde{R}\\ &= \frac{1}{2}\frac{d\pi_{2e}}{dt}(1-\widetilde{R})\\ &< 0\end{aligned}$$

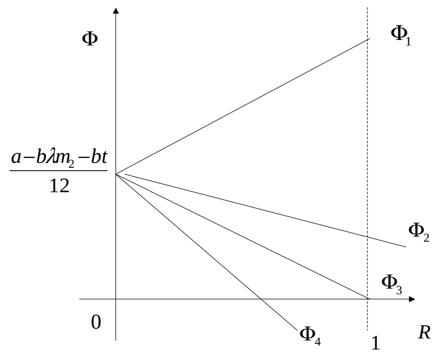


Figure A1: Φ when $t < \frac{a-2b\lambda m_2+bm_2}{2b}$
($\Phi_1 for\ t > \frac{7a-23b\lambda m_2+16bm_2}{23b}$; $\Phi_2\ for\ \frac{4a-20b\lambda m_2+16m_2b}{20b} < t < \frac{7a-23b\lambda m_2+16bm_2}{23b}$; $\Phi_3\ for\ t = \frac{4a-20b\lambda m_2+16m_2b}{20b}$; $\Phi_4\ for\ t < \frac{4a-20b\lambda m_2+16m_2b}{20b}$)

$\widetilde{R}$ decreases in tariff.

Case 3

When $t < \frac{a-2b\lambda m_2+bm_2}{2b}$,

$$\begin{aligned}\frac{d\pi_{2ld}}{dt} &= \frac{2(a-b(2m_2-\lambda m_2-t))}{9} > 0;\\ \frac{d\pi_{2md}}{dt} &= \frac{-4(a-b(2\lambda m_2-m_2+2t))}{9} < 0;\\ \frac{d\pi_{2e}}{dt} &= -\frac{a-b(\lambda m_2+t)}{2} < 0.\end{aligned}$$

$$\begin{aligned}\Phi &= \frac{1}{2}(\frac{d\pi_{2ld}}{dt}+\frac{d\pi_{2e}}{dt}-\frac{d\pi_{2md}}{dt})-(\frac{1}{2}\frac{d\pi_{2e}}{dt}-\frac{d\pi_{2md}}{dt})\widetilde{R}\\ &= (\frac{a-b\lambda m_2-bt}{12})-(\frac{7a-23bt-23b\lambda m_2+16bm_2}{36})\widetilde{R}\end{aligned}$$

We always have $\frac{a-b\lambda m_2-bt}{12} > 0$ under tariff $t < \frac{a-2b\lambda m_2+bm_2}{2b}$. The sign of Φ depends on the second term $(\frac{7a-23bt-23b\lambda m_2+16bm_2}{36})R$.

Figure A1 shows how Φ changes in IPRs.

If $t > \frac{7a-23b\lambda m_2+16bm_2}{23b}$, the slope of Φ in R is prositive, as showed by Φ_1 in Figure A1. We always have $\Phi > 0$.

If $t < \frac{7a-23b\lambda m_2+16bm_2}{23b}$, Φ is decreasing in IPRs, as showed by Φ_2, Φ_3, and Φ_4 . When the absolute value of the slope is small as Φ_2, we also have $\Phi > 0$ with any R. If the absolute value of the slope is large as Φ_4, the sign of Φ also depends on the value of R. Φ_3 has the slope such that for $R = 1$, Φ is exactly zero. For Φ_3 tariff $t = \frac{4a-20b\lambda m_2+16m_2b}{20b}$.

when $t < \frac{a-2b\lambda m_2+bm_2}{2b}$ we can get the following conclusions:

If $t > t^*$, $\frac{d\widetilde{R}}{dt} > 0$($\Phi_1$ and Φ_2 in Figure A1);

If $t < t^*$, when $\widetilde{R} < R^*$, $\frac{d\widetilde{R}}{dt} > 0$; when $\widetilde{R} > R^*$, $\frac{d\widetilde{R}}{dt} < 0$($\Phi_4$ in Figure A1).

($t^* = \frac{4a-20b\lambda m_2+16m_2b}{20b}$, $R^* = \frac{3(a-b\lambda m_2-bt)}{7a-23b\lambda m_2-23bt+16bm_2}$)

Generalize the above results: *For tariff* $t > t_{2e}$, $\frac{d\widetilde{R}}{dt} = 0$;

For tariff $t_d < t < t_{2e}$, $\frac{d\widetilde{R}}{dt} < 0$;

For tariff $t^* < t < t_d$, $\frac{d\widetilde{R}}{dt} > 0$;

For tariff $t < t^*$, *when* $\widetilde{R} < R^*$, $\frac{d\widetilde{R}}{dt} > 0$;

when $\widetilde{R} > R^*$, $\frac{d\widetilde{R}}{dt} < 0$.

($t_{2e} = \frac{a-\lambda m_2 b}{b}$; $t_d = \frac{a-2b\lambda m_2+2bm_2}{2b}$; $t^* = \frac{4a-20b\lambda m_2+16m_2b}{20b}$; $R^* = \frac{3(a-b\lambda m_2-bt)}{7a-23b\lambda m_2-23bt+16bm_2}$)

Appendix 2

$$\frac{dI^*}{dt} = -\frac{(\pi_{2ls})'_t - (\pi_{2lf})'_t}{\{\pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)] - \theta_2[\pi_2 - (\pi_{2e} - E)]\}^2[-\frac{1}{4}e^{-I^{\frac{1}{2}}}I^{-\frac{3}{2}}(1 + I^{\frac{1}{2}})]}$$

Proof:

In the second period we have $\theta_2 = 1 - \theta_2 = \frac{1}{2}$. The bargaining powers of firm l and the MNE are converging in the joint venture and without much loss of generality we assume they share the surplus equally.

As denominator is less than zero, the sign of the numerator decides the sign of the differentiation. We want to know if $(\pi_{2ls})'_t - (\pi_{2lf})'_t$ is positive or negative. In Appendix 1 we find that the sign of $\frac{d\widetilde{R(t)}}{dt}$ also depends on the sign of $(\pi_{2ls})'_t - (\pi_{2lf})'_t$. Similarly we can get the following proposition:

If $R > \widetilde{R}$, $\frac{dI^*}{dt} = 0$.

If $R < \widetilde{R}$,

For tariff $t > t_{2e}$, $\frac{dI^*}{dt} = 0$;

For tariff $t_d < t < t_{2e}$, $\frac{dI^*}{dt} < 0$;

For tariff $t^* < t < t_d$, $\frac{dI^*}{dt} > 0$;

with $t < t^*$ *and* $R < R^*$, $\frac{dI^*}{dt} > 0$;

with $t < t^*$ *and* $R > R^*$, $\frac{dI^*}{dt} < 0$.

$(t_{2e} = \frac{a-\lambda m_2 b}{b}; t_d = \frac{a-2b\lambda m_2+2bm_2}{2b};\ t^* = \frac{4a-20b\lambda m_2+16m_2 b}{20b};\ R^* = \frac{3(a-b\lambda m_2-bt)}{7a-23b\lambda m_2-23bt+16bm_2})$

Table 1: First Period Payoff

	Yes to a joint venture	No to a joint venture
MNE	π_{1m}	π_{1e}
Local Firm	$\pi_{1l} - I$	0

Table 2: Period Two Strategy and Payoff

		MNE	Local Firm
Local firm succeeds in innovation with probability $\phi(I)$	Joint Venture is constant	π_{2ms}	π_{2ls}
	Joint Venture Breaks Up	$\pi_{2md} - E$	π_{2ld}
Local firm fails in innovation with probability $1 - \phi(I)$	Joint Venture is constant	π_{2mf}	π_{2lf}
	Joint Venture Breaks Up	$\pi_{2e} - E$	0

Table 3: Profit Notations and Descriptions

Profit (with linear demand function)	Description
$\pi_1 = \frac{(a-m_1 b)^2}{4b} - f$	Monopoly profit for the joint venture in the first period
$\pi_2 = \frac{(a-m_2 b)^2}{4b}$	Monopoly profit for the joint venture in the second period
$\pi_{1e} = \frac{[a-\lambda m_1 b]^2}{4b}$	Monopoly profit for the MNE through exports in the first period
$\pi_{2e} = \frac{[a-\lambda m_2 b]^2}{4b}$	Monopoly profit for the MNE through exports in the second period
$\pi_{2md} = \frac{[a-(2\lambda m_2 - m_2)b]^2}{9b}$	Cournot profit for the MNE through exports in the second period
$\pi_{2ld} = \frac{[a-(2m_2 - \lambda m_2)b]^2}{9b}$	Cournot profit for the local firm through setting up its own production in the second period
$\pi_{2ms} = \pi_{2md} - E + [\pi_{2mf} - (\pi_{2md} - E)]R + (1-\theta_2)[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)]$	MNE profit share in the joint venture in the second period when the local innovation succeeds
$\pi_{2ls} = \pi_{2ld} - [\pi_{2mf} - (\pi_{2md} - E)]R + \theta_2[\pi_2 - (\pi_{2ld} + \pi_{2md} - E)]$	Local firm profit share in the joint venture in the second period when the local innovation succeeds
$\pi_{2mf} = \pi_2 - \theta_2[\pi_2 - (\pi_{2e} - E)]$	MNE profit share in the joint venture in the second period when the local innovation fails
$\pi_{2lf} = \theta_2[\pi_2 - (\pi_{2e} - E)]$	Local firm profit share in the joint venture in the second period when the local innovation fails
$\pi_{1m} = min\{\pi_1, \pi_{1e} + \pi_{2e} + (1-\theta_1)[\pi_1 + \pi_2 - (\pi_1 e + \pi_2 e)] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}]\}$	MNE profit share in the joint venture in the first period
$\pi_{1l} = max\{0, \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}]\}$	Local firm profit share in the joint venture in the first period
$\pi_{2m} = \phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}$	The second period expected profit share for the local firm
$\pi_{2l} = \phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}$	The second period expected profit share for the MNE
$\Pi_m = min\{\pi_1 + [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}], \pi_{1e} + \pi_{2e} + (1-\theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]\}$	Total payoff in the joint venture for the MNE
$\Pi_l = max\{\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}, \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]\} - I^*$	Total payoff in the joint venture for the local firm

Table 4: IPRs Effects on I^* and Payoffs

	$R < \overline{R}$	$\overline{R} \leq R < \widetilde{R}$	$R \geq \widetilde{R}$
Innovation input	$I^* > 0$; $\frac{dI^*}{dR} < 0$	$I^* > 0$; $\frac{dI^*}{dR} < 0$	$I^* = 0$; $\frac{dI^*}{dR} = 0$
First period payoff for the local firm	$\pi_{1l} = 0$	$\pi_l = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}] > 0$	$\pi_l = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - \pi_{2lf}$
	$\frac{d\pi_{1l}}{dR} = 0$	$\frac{d\pi_{1l}}{dR} > 0$	$\frac{d\pi_{1l}}{dR} = 0$
First period payoff for the MNE	$\pi_{1m} = 0$;	$\pi_{1m} = (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}]$	$\pi_{1m} = (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - \pi_{2mf}$
	$\frac{d\pi_{1m}}{dR} = 0$	$\frac{d\pi_{1m}}{dR} < 0$	$\frac{d\pi_{1m}}{dR} = 0$
Two-period payoff for the local firm	$\Pi_l = \phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf} - I^*$	$\Pi_l = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - I^*$	$\Pi_l = \theta_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$
	$\frac{d\Pi_l}{dR} < 0$	$\frac{d\Pi_l}{dR} > 0$	$\frac{d\Pi_l}{dR} = 0$
Two-period payoff for the MNE	$\Pi_m = \pi_1 + \phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}$	$\Pi_m = \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$	$\Pi_m = \pi_{1e} + \pi_{2e} + (1 - \theta_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$
	$\frac{d\Pi_m}{dR} > 0$	$\frac{d\Pi_m}{dR} = 0$	$\frac{d\Pi_m}{dR} = 0$

Figure 1: Game Tree

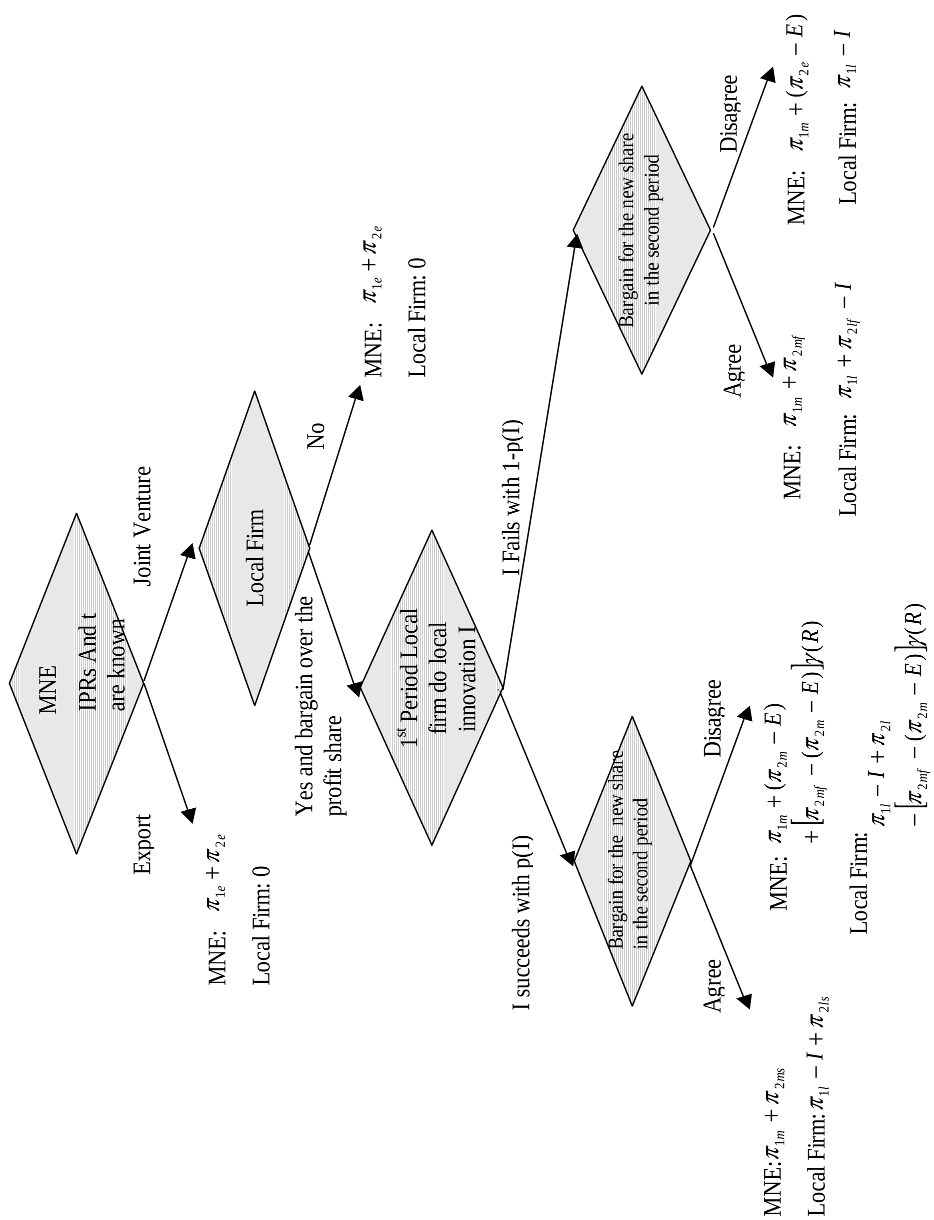


Figure 2: Optimal Local innovation,$R \in ([0,1]$

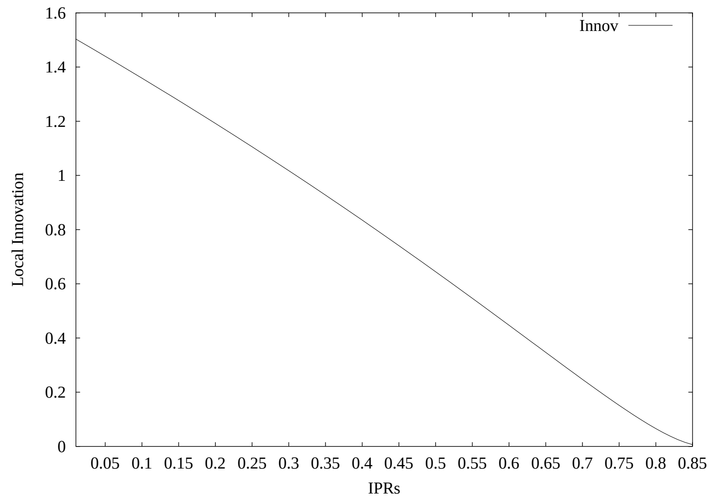


Figure 3: First Period Payoff in the Joint Venture,$R \in ([0,1]$

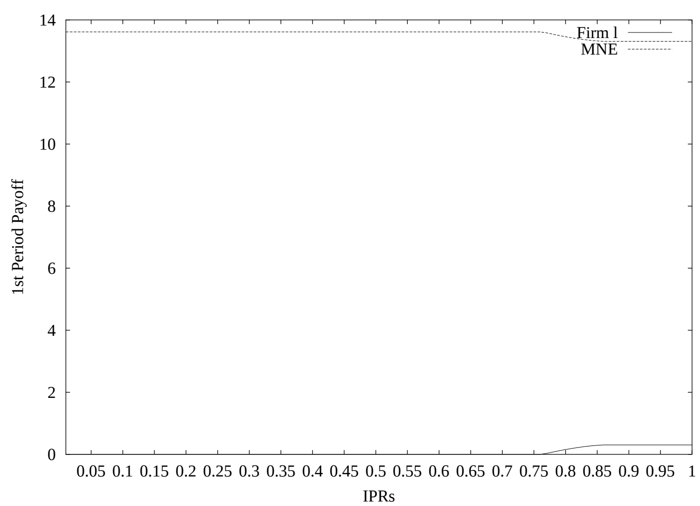


Figure 4: Two-Period Payoff in the Joint Venture,$R \in ([0, 1]$

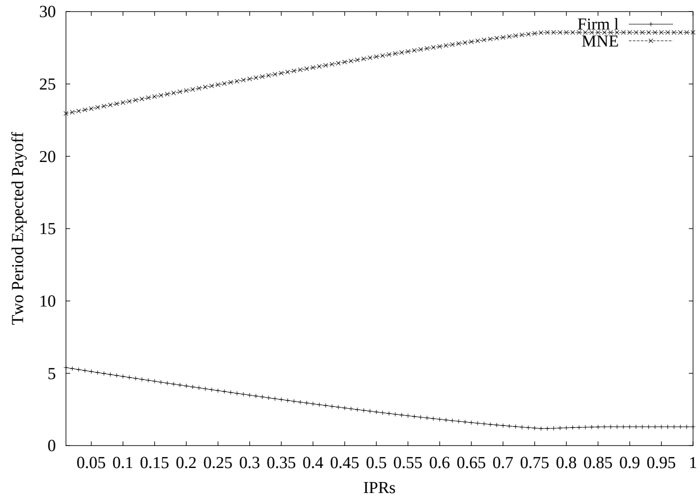


Figure 5: $\widetilde{R}$ and $\overline{R}$ with Different θ_1

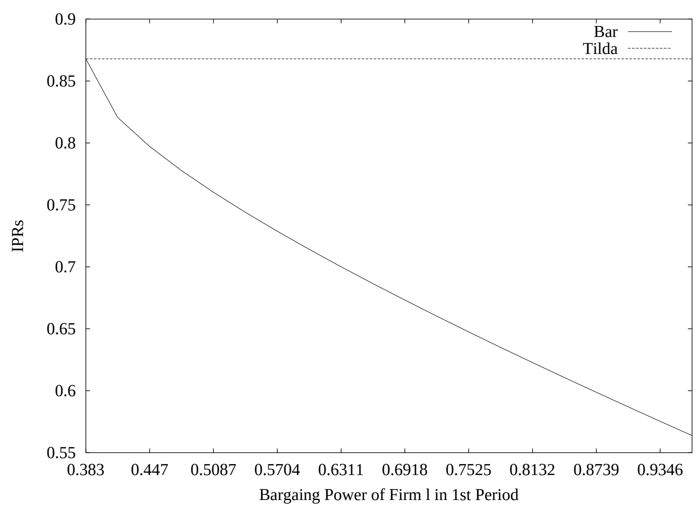


Figure 6: $\widetilde{R}$ and $\overline{R}$ with Different Innovation Ability v

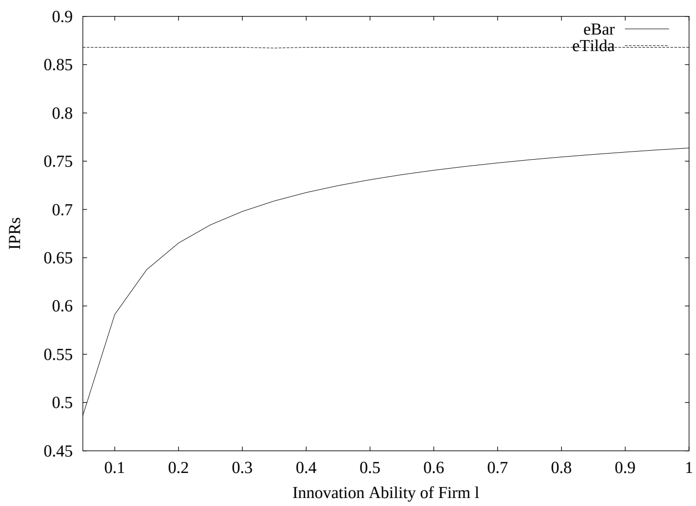
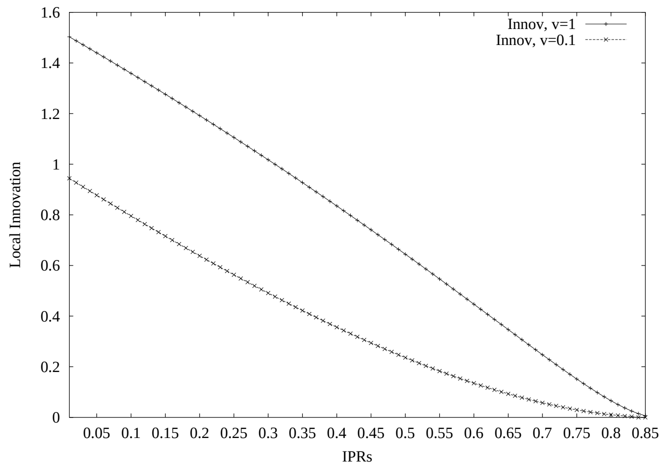
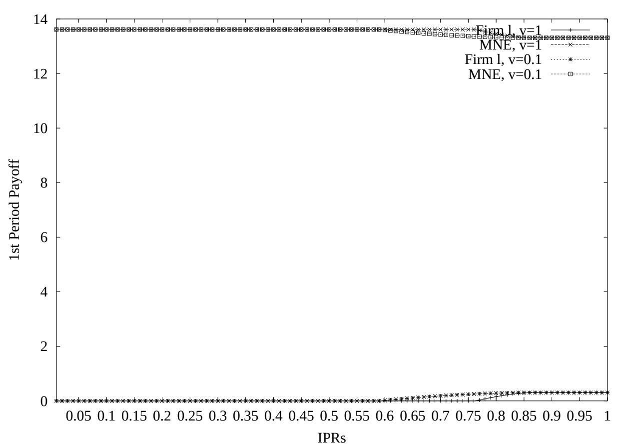
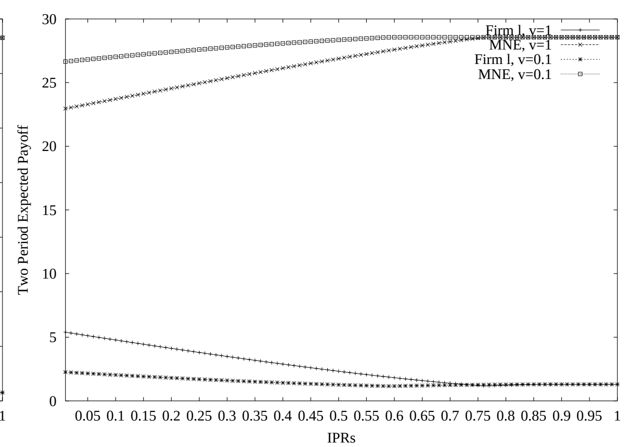


Figure 7: Innovation and First and Two-Period Payoff with Different Innovation Ability



(a)Innovation Inputs ($v = 1$ and $v = 0.1$)





(b)1st Period Payoff ($v = 1$ and $v = 0.1$)

(c)Two-Period Payoff ($v = 1$ and $v = 0.1$)

Figure 8: Critical IPRs Levels:$\overline{R}$ and $\widetilde{R}$

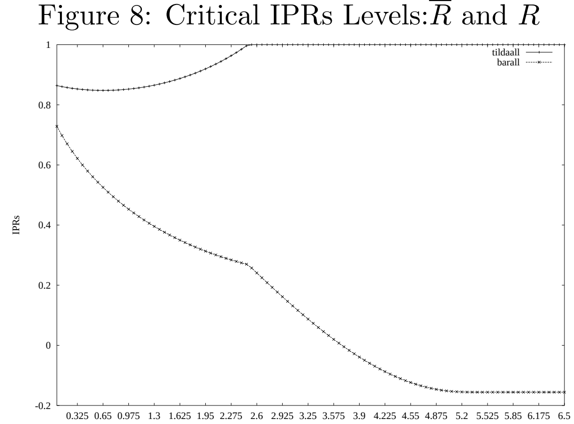


Figure 9: Effects of Tariff on I^*

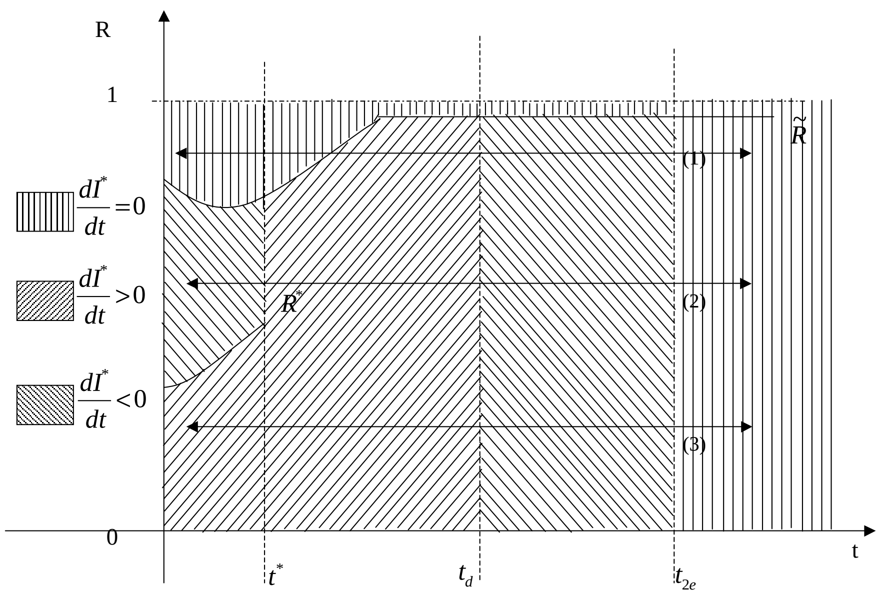
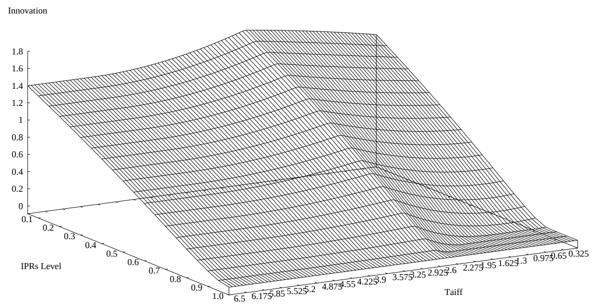
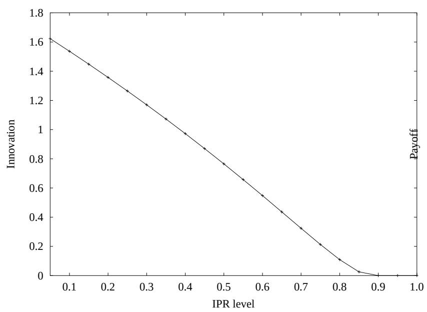


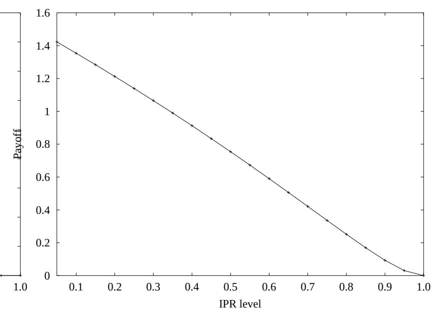
Figure 10: Optimal Local innovation,$t \in (0, 6.5]$ and $R \in ([0, 1]$



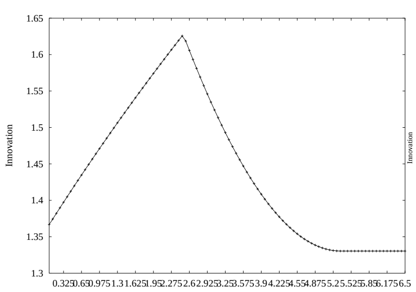
(a)Change with Tariff and IPRs



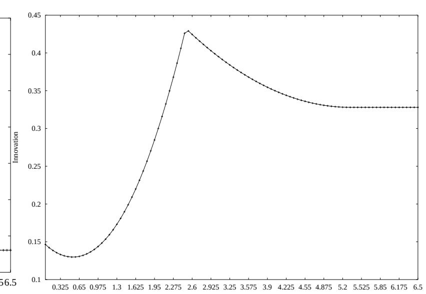
(b1)When $t = 1.635$



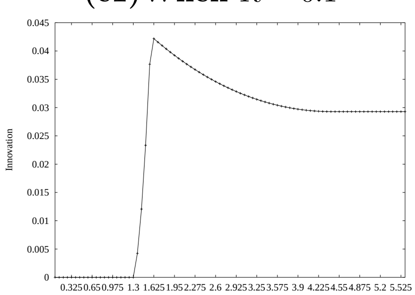
(b2)When $t = 4.55$



(c1)When $R = 0.1$



(c2)When $R = 0.4$



(c3)When $R = 0.95$

Figure 11: Indirect Effect of Tariff

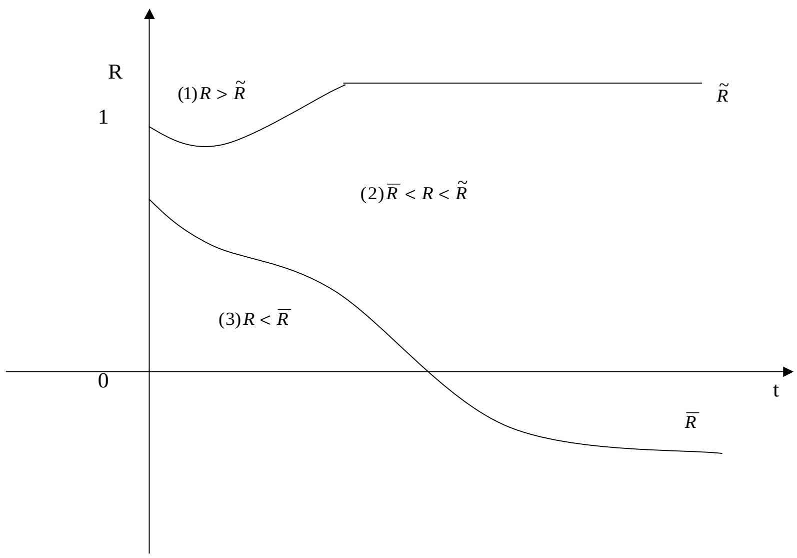
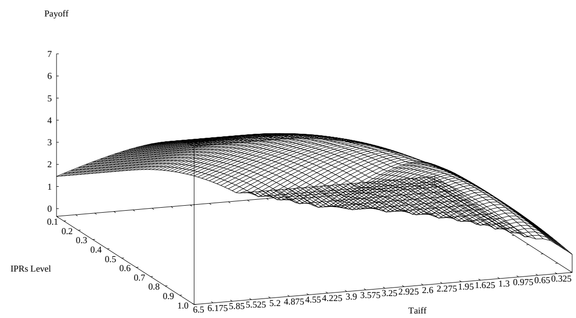
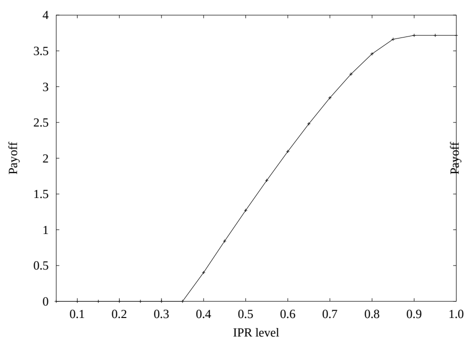
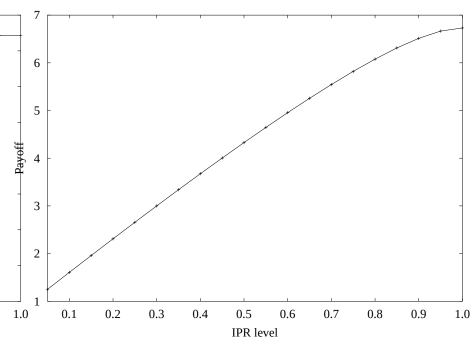


Figure 12: First Period Payoff of the Local Firm

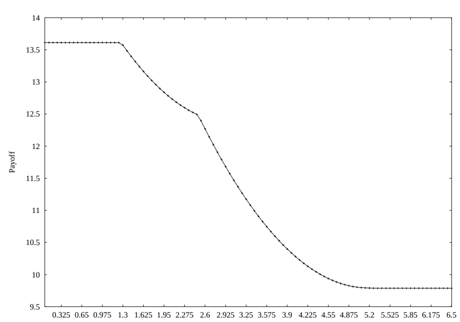


(a)Change with Tariff and IPRs



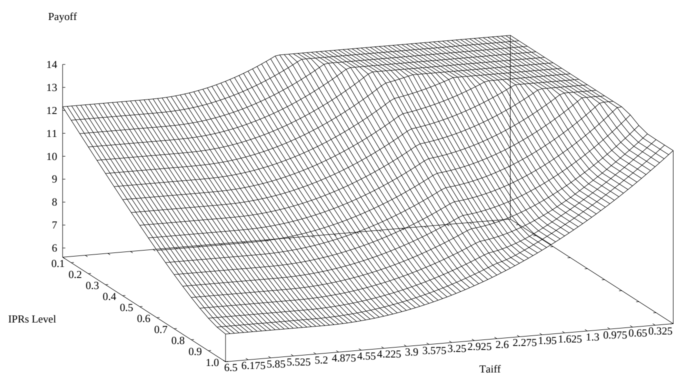


(b1)When $t = 1.635$ **(b2)When** $t = 4.55$

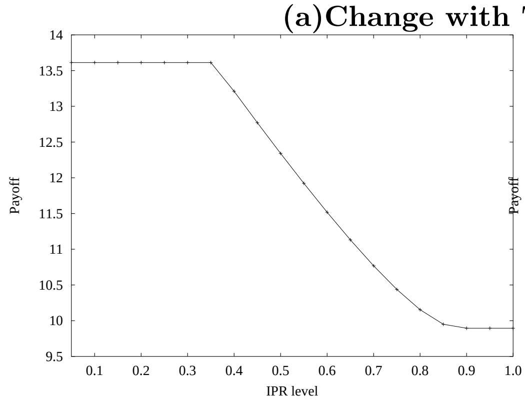


(a)When $R = 0.4$

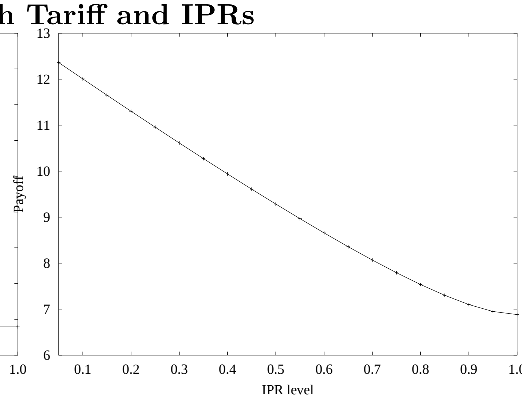
Figure 13: First Period Payoff of the MNE



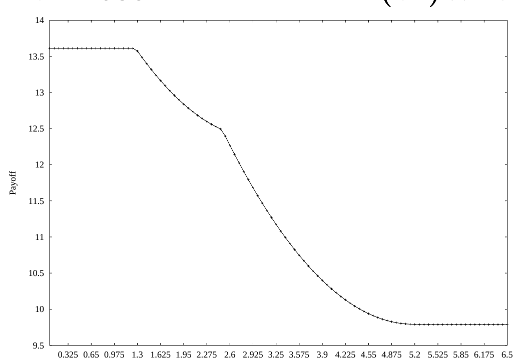
(a)Change with Tariff and IPRs



(b1)When t=1.635

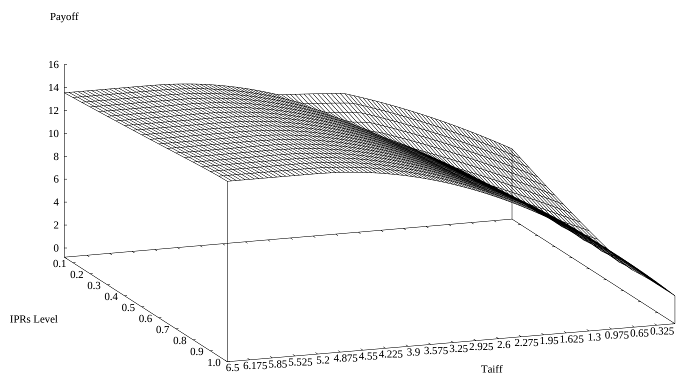


(b2)When $t = 4.55$

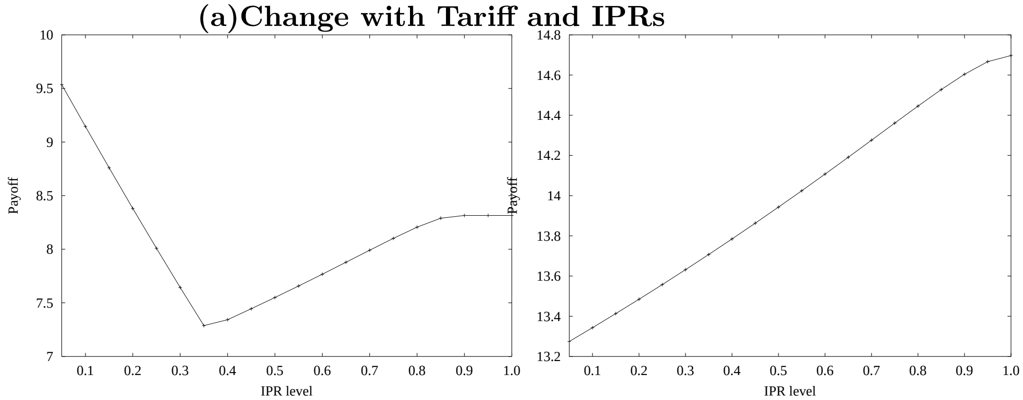


(c)When $R = 4$

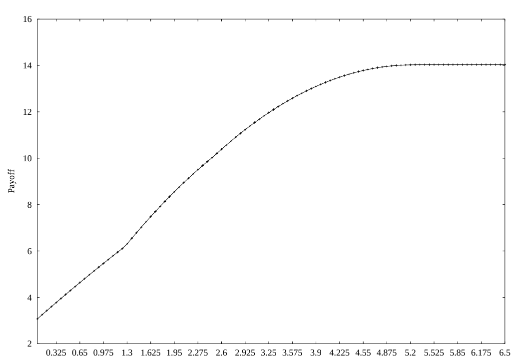
Figure 14: Two Period Payoff of the Local Firm



(a)Change with Tariff and IPRs

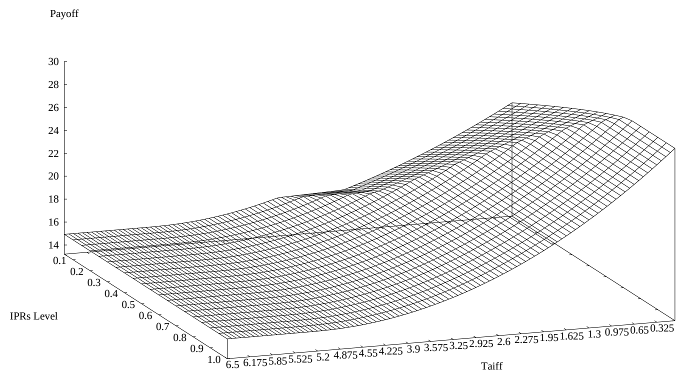


(b1)When $t = 1.635$ **(b2)When** $t = 4.55$

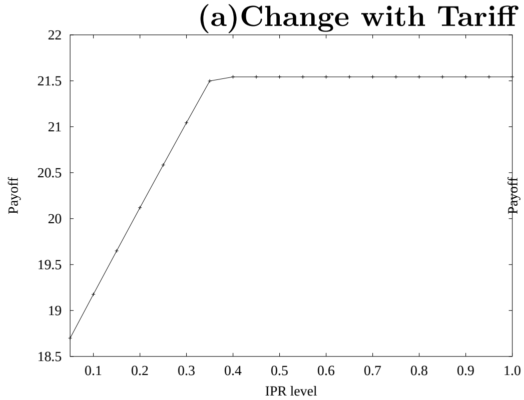


(c)When $R = 0.4$

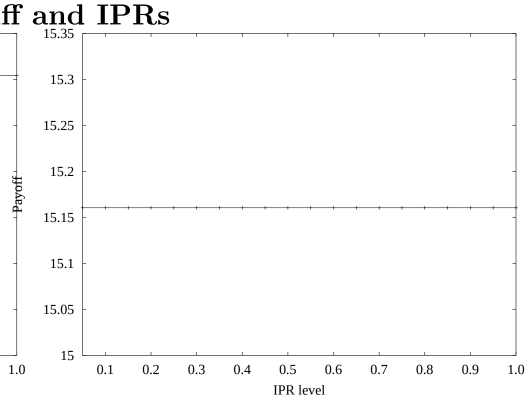
Figure 15: Two Period Payoff of the MNE



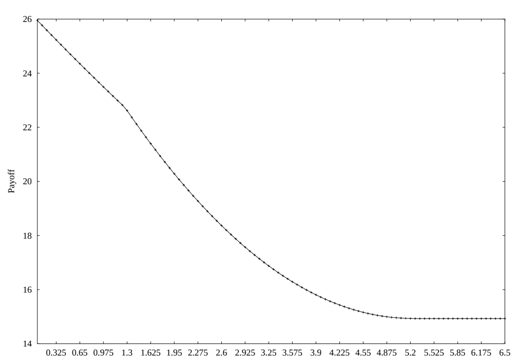
(a)Change with Tariff and IPRs



(b1)When $t = 1.635$



(b2)When $t = 4.55$



(c)When $R = 0.4$