DISCUSSION PAPERS IN ECONOMICS

Working Paper No. 05-08

IPRs and Tariff Policies:
East-West Joint Ventures

Xiaofei Vivian Yang
University of Colorado at Boulder
Boulder, Colorado

November 9, 2005

Center for Economic Analysis
Department of Economics

IPRs and Tariff Policies: East-West Joint Ventures

Xiaofei Vivian Yang[*]

November 9, 2005

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).

[*]Department of Economics, University of Colorado at Boulder, CO 80309. Please contact at xiaofei.yang@colorado.edu

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.

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

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 tari and patent length. Their work is the closest to our paper in that both focus on developing countries' tari and IPRs policies. In their model high tari

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 governing behaviors of international joint ventures which may even stipulate specifically that 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 I 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 I use bargaining to decide profit shares. Bargaining process leaves profit share π_{1m} for the MNE and π_{1l} for firm I , with $\pi_{1m} + \pi_{1l} = \pi_1$. After the joint venture is set up and technology $T1$ is transferred, firm I 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 I 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 I in period 2.

With incomplete agreement in period 1 the MNE and firm I will rebargain for period 2 share. At the beginning of period 2, there are two scenarios. The first scenario is that firm I fails in the local innovation and the other is firm I succeeds in inventing technology T2. If firm I fails in acquiring T2 itself, the profit agreement through rebargaining gives the MNE and firm I π_{2mf} and π_{2lf} respectively, with $\pi_{2mf} + \pi_{2lf} = \pi_2$. The joint venture is stable and the MNE and firm I still produce jointly using technology $T2$. If they cannot reach an agreement or either party deviates, the payoff for firm I 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 I succeeding in the local innovation the MNE and firm I 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 I 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 I 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.

ϕ

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

$$\pi_{2lf} = \mu_2[\pi_2 - (\pi_{2e} - E)] \tag{4}$$

$$\pi_{2mf} = \pi_{2e} - E + (1 - \mu_2)[\pi_2 - (\pi_{2e} - E)] = \pi_2 - \mu_2[\pi_2 - (\pi_{2e} - E)] \tag{5}$$

. 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. μ_2 and $1-\mu_2$ 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 μ_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 $1 - \mu_2$ of the surplus .

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

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

scenarios for the MNE and firm l are

$$¼_{2m} = Á(I^{¤})¼_{2ms} + (1 - Á(I^{¤}))¼_{2mf} \quad (8)$$

$$¼_{2l} = Á(I^{¤})¼_{2ls} + (1 - Á(I^{¤}))¼_{2lf}: \quad (9)$$

$I^{¤}$ is the optimal innovation input of firm l. As the MNE knows the local innovation probability function $Á(I)$, $I^{¤}$ 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 payo 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 payos for firm l and the MNE are

$$\widetilde{\Pi_l} = \mu_1[¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})] \quad (10)$$

$$\widetilde{\Pi_m} = ¼_{1e} + ¼_{2e} + (1 - \mu_1)[¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})] \quad (11)$$

. μ_1 and $1 - \mu_1$ are bargaining powers of firm l and the MNE in period 1 respectively. μ_1 may or may not be equal to μ_2. The reserved payo 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 payo $¼_{1e} + ¼_{2e}$, two-period profits from exporting. They share the surplus of establishing a joint venture,$¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})$ 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 payo. 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 payo each firm expects to get from the joint venture. With equations (8) (9), (10), and(11), period 1 payo $\widetilde{¼_{1l}}$ and $\widetilde{¼_{1m}}$ are

$$\widetilde{¼_{1l}} = \mu_1[¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})] - [Á(I^{¤})¼_{2ls} + (1 - Á(I^{¤}))¼_{2lf}] \quad (12)$$

$$\widetilde{¼_{1m}} = ¼_{1e} + ¼_{2e} + (1 - \mu_1)[¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})] - [Á(I^{¤})¼_{2ms} + (1 - Á(I^{¤}))¼_{2mf}] \quad (13)$$

.

Period 1 payo for each firm is equal to their two-period profits in the joint venture in equation (10) and (11) minus period 2 expected payo. Period 2 expected payo, 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 $\widetilde{¼_{1m}}$ with weak IPRs, and correspondingly firm l 's first period share $\widetilde{¼_{1l}}$ 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

$Á(I)¼_{2Is} + (1 - Á(I))¼_{2If} - I$. Assuming constant and exogenous IPRs the optimal local innovation input $I^{¤}$ solves

$$Á^{0}(I^{¤})(¼_{2Is} - ¼_{2If}) = 1 \tag{18}$$

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 payo from successful innovation, dierence between $¼_{2Is}$ and $¼_{2If}$. Using equations (4) and (6), I can transform (18) to

$$Á^{0}(I^{¤}) = \frac{1}{¼_{2Id} - \text{Rs§7.97Tcn/F1172i4f6isß}}$$

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 ¼$_{2lf}$

Proposition 2:

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

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

3.5.2 Simulation Results

The simulation results in Figure 4 show that Π_I first decreases in IPRs until power μ_1 and $1-\mu_1$. $\overline{R}$ decreases in firm l's first period arguing power μ_1. $\overline{R}$ is the critical IPRs level that sets firm l's first period payoff $\mu_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1-\phi(I^*))\pi_{2lf}]$ 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 μ_1 By observing Equation (23) which decides the level of $\overline{R}$, I find that if μ_1 is low enough, I may always have zero first period payoff for firm l for any values of R. If μ_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 μ_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 μ_1 Figure 5 gives the simulation results of $\overline{R}$ and $\widetilde{R}$ when $\mu_1 \in [0.383, 1]$. Just as equations (26) and (27) show, $\overline{R}$ is decreasing and $\widetilde{R}$ is constant in μ_1. The range between $\overline{R}$ and $\widetilde{R}$ is increasing when firm l has a higher bargaining power in the first period. When $\mu_1 = 0.5$, the range is [0.764, 0.868]. However if firm l has all the bargaining power in period 1 with $\mu_1 = 1$, 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.

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 of rising tariff to get zero first period payoff for firm I. $\overline{R}$ 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

$\widetilde{R}$

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:

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

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

Proposition 6:

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

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

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

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

For tari $t^{¤} < t$ TD[(=) -277 (0)]B1n81[53ln0t TD[(=) -277 (0)]B1n81[53ln0t 86]B1n83,4165853ln0t 8

7.3 -13.24 0 T

d284317.7714Tf14.413.76 0 TD[(<)]TJ/F 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^*

dstari@2ulatio9 25F37.97.0.093.96875,64(lo)--359(i827(derate)]TJ/F37.97685.653.963TD[(25F37.97Tf5.653.96=en)]TJ4D[(I)]TJ/F37.971

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 $¼_{1l}$ and $¼_{1m}$ are constant in region 3 and region1. But in region 2 $¼_{1l}$ increases and $¼_{1m}$ decreases in IPRs. In Figure 12(b2) and 13(b2) the tariff rate increases to 4.55, and $\overline{R}$ and $\widetilde{R}$

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 (pro8u3B22ilit71(stage)r-371(gof3e)-342acf3e)-ment vo61(gof3e 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,

$t_A^0 > t_B^0$. Higher IPRs may have opposite e effects on local welfare. As $t_A^0 > t_B^0$, it is possible (R_{AB^0}, t_A^0) is in region 2 and (R_{AB^0}, t_B^0) is in region 3. Let's assume this is the case. Changes in IPRs bring di erent e ects 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 payo but decrease period 2 expected payo . From the perspective of the local government a relative closed country prefer better IPRs protection. High tari 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 tari . It tends to take loose IPRs policy and encourages local innovation to grab more profits in period 2.

Di erent tari rate also changes how the MNE perceives tari and IPRs policies. To enter into the local market, the MNE firm prefers low tari 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 tari . While for country B', strengthening its IPRs increases the MNE payo 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 tari 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 successre ad7(et5(IPs)]T(not)n378(p--2358ssre)-3ue-333(tacet).s)s ss rates may affect the attitude of various nations toward their optimal IPRs regime. Countries

, V93(1ol.)-444(37,)-M94.“Bar3(T)83(ec)27(h.93TD6(Mi85i53,)485.96Aimin,)-395(.93ic)5ang,PoretiP“In Propert0

Marjit, Tsugata , and Arijit Mukherjee, 1998. “Collaboration and Foreign Equity Participation: A Theoretical Analysis” *Review of International Economics*, Vol. 6, 1998

Marjit, Tsugata , and Arijit Mukherjee, 2001 “Technology Transfer under Asymmetric Information: The Role of Equity Participation” *Journal of Institutional and Theoretical Economics* 157, 2001, 281-300

Markusen, James R., 2001. “Contracts, Intellectual Property Rights, and Multinational Investment in Developing Countries” *Journal of International Economics*, Vol. 53, 2001, 189-204

Maskus, Keith E., 1998. “The Role of Intellectual Property Rights in Encouraging Foreign Direct Investment and Technology Transfer” *Duke Journal of Comparative and International Law*, Vol. 9 1998, 109-161

Miller, Robert R., Jack D. Glen, Frederick Z. Jaspersen, and Yannis Karmokolias, 1996. “International Joint Ventures in Developing Countries, Happy Marriages” *International Finance Corporation discussion paper* 29, 1996

Panpiemras,Jirawat, 2003. “International Joint Ventures under Imperfect Protection of Intellectual Property Rights and Asymmetric Information” *Working paper No. 03-15, University of Colorado at Boulder*

Sinha, Uday Bhanu, 2001. “Imitative innovation and international joint ventures: a Dynamic Analysis” *International Journal of Industrial Organization*, Vol.19, 2001, 1527-1562

Yan, Aimin, and Barbara Gray, 1994.“Bargaining Power, Management Control, and Performance in United States-China Joint Ventures: a Comparative Case Study” *Academy of Management Journal*, Vol. 37, No. 6, 1994, 1478-1517

Guifang, Yang, and Keith E. Maskus, 2001. “Intellectual Property Rights, Licensing, and Innovation in an Endogenous Product-Cycle Model” *Journal of International Economics*, Vol. 53, No. 1, 1(and)5333(No.)-444(1,)-334D3, e5333faryT16.93-144.93TD6(Mi85i53,)445i52Aimin, .933382ang,w1998

Appendix 1

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

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

$$\mu_1[¼_1 + ¼_2 - (¼_{1e} + ¼_{2e})] - [Á(I^{¤})¼_{2ls} + (1 - Á(I^{¤}))¼_{2lf}] = 0$$

Totally di erentiate the above equation:

$$\{-\mu_1[(¼_{1e})_t^0 + (¼_{2e})_t^0] - [Á(I^{¤})(¼_{2ls})_t^0 + ¼_{2ls}Á^0(I^{¤})(I^{¤})_t^0 + (1 - Á(I^{¤}))(Á_{2lf})_t^0 - ¼_{2lf}Á^0(I^{¤})(I^{¤})_t^0]\}dt$$
$$-\{¼_{2ls}Á^0(I^{¤})(I^{¤})_R^0 + Á(I^{¤})(¼_{2ls})_R^0 - ¼_{2lf}Á^0(I^{¤})(I^{¤})_R^0\}d\overline{R} = 0$$

${}_{2e})_t^0] - [Á(II$[(ß$_{2ls}$)1̃9()]TJ/F910.91Tf4.240TD[(I)1

With $Á^0(I^{¤})(¼_{2ls} - ¼_{2lf}) = 1$, the above can be simplified as:

$$\{-\mu_1[(¼_{1e})_t^0 + (¼_{2e})_t^0] - [Á(I^{¤})(¼_{2ls})_t^0\ ))($$ 2.0310.91Tf44-7.2TD[(t)]TJ/F510.91Tf5.9240TD[(I)]

$\frac{d¼_2}{dt_2}$

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

$¼_{2ld} = ¼_2;\ ¼_{2md} = 0;\ ¼_{2e} = 0;\ \frac{d¼_{2ld}}{dt} = 0;\ \frac{d¼_{2md}}{dt} = 0;\ \frac{d¼_{2e}}{dt} = 0:$

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

Case 2: When $\frac{a ¡ 2b ¸m_2 + bm_2}{2b} < t < \frac{a ¡ ¸m_2 b}{b}$, 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 .

$¼_{2e} > 0;\ ¼_{2ld} = ¼_2;\ ¼_{2md} = 0;\ \frac{d¼_{2e}}{dt} < 0;\ \frac{d¼_{2ld}}{dt} = 0;\ \frac{d¼_{2md}}{dt} = 0:$

$$\Omega = -\mu_1(\frac{d¼_{1e}}{dt} + \frac{d¼_{2e}}{dt}) + \mu_2\frac{d¼_{2e}}{dt} - [Á(I^¤) + \Psi](1 - R)\frac{d¼_{2e}}{dt}\mu_2$$

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 di□cult to tell the sign of Ω.

Case 3: When $t < \frac{a ¡ 2b ¸m_2 + bm_2}{2b}$, 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.

$¼_{2ld} > 0;\ ¼_{2md} > 0;\ and\ ¼_{2e} > 0;$

$$\Omega = -\mu_1(\frac{d¼_{1e}}{dt} + \frac{d¼_{2e}}{dt}) - \{[Á(I^¤) + \Psi][(1-\mu_2)\frac{d¼_{2ld}}{dt} - \mu_2\frac{d¼_{2md}}{dt} + \mu_2\frac{d¼_{2e}}{dt} - (\mu_2\frac{d¼_{2e}}{dt} - \frac{d¼_{2md}}{dt})R] - \mu_2\frac{d¼_{2e}}{dt}\}$$

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

Totally dierentiate the above equation:

$$[Á(I^{¤})(¼_{2Is})'_t + ¼_{2Is}Á'(I^{¤})(I^{¤})'_t - Á(I^{¤})(¼_{2If})'_t - ¼_{2If}Á'(I^{¤})(I^{¤})'_t - (I^{¤})'_t]dt$$
$$+[¼_{2Is}Á'(I^{¤})(I^{¤})'_R + Á(I^{¤})(¼_{2Is})'_R - ¼_{2If}Á'(I^{¤})(I^{¤})'_R - (I^{¤})'_R]d\widetilde{R} = 0$$

With $Á'(I^{¤})(¼_{2Is} - ¼_{2If}) = 1$, the above can be simplified as:

$$[Á(I^{¤})(¼_{2Is})'_t - Á(I^{¤})(¼_{2If})'_t]dt + [Á(I^{¤})(¼_{2Is})'_R]d\widetilde{R} = 0$$

$$\frac{d\widetilde{R}}{dt} = \frac{Á(I^{¤})[(¼_{2Is})'_t - (¼_{2If})'_t]}{-Á(I^{¤})(¼_{2Is})'_R}$$

Á06 1tTD[(lr3 7.954.24 0 TD[(I)

The denominator of $\frac{d\widetilde{R}}{dt}$ is positive and the sign of $\frac{d\widetilde{R}}{dt}$ is the same as $[(¼_{2Is})'_t - (¼_{2If})'_t]$. Suppose $\Phi = [(¼_{2Is})'_t - (¼_{2If})'_t]$. Use the formul7.971TD[s4.i0TD[(lr3Œ)]TJ/F510.91Tf6.50TD[(()]TJ/F910.91Tf4.240TD[(

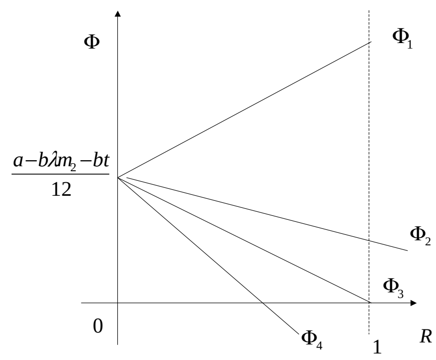


Figure A1: Φ when $t < \frac{a - 2b\lambda m_2 + bm_2}{2b}$

(Φ_1 for $t > \frac{7a - 23b\lambda m_2 + 16bm_2}{23b}$; Φ_2 for $\frac{4a - 20b\lambda m_2 + 16m_2 b}{20b} < t < \frac{7a - 23b\lambda m_2 + 16bm_2}{23b}$; Φ_3 for $t = \frac{4a - 20b\lambda m_2 + 16m_2 b}{20b}$; Φ_4 for $t < \frac{4a - 20b\lambda m_2 + 16m_2 b}{20b}$)

$\widetilde{R}$ decreases in tariff.

Case 3

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

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

$$\Phi = \frac{1}{2}\left(\frac{d\pi_{2ld}}{dt} + \frac{d\pi_{2e}}{dt} - \frac{d\pi_{2md}}{}\right.$$

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

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

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

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

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

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

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
$\pi_{2ms} = \pi_{2md} - E + [\pi_{2mf} - (\pi_{2md} - E)]R + (1 - \mu_2)[\pi_2 - (\pi_2\ \pi_{mf}$	

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	$\pi_{1l} = 0$	$\pi_l = \mu_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf}] > 0$	$\pi_l = \mu_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - \pi_{2lf}$
	$\frac{d\pi_{1l}}{dR} = 0$	$\frac{d\pi_{1l}}{dR} > 0$	$\frac{d\pi_{1l}}{dR} = 0$
First period payoff for the MNE	$\pi_{1m} = 0$;	$\pi_{1m} = (1 - \mu_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - [\phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}]$	$\pi_{1m} = (1 - \mu_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - \pi_{2mf}$
	$\frac{d\pi_{1m}}{dR} = 0$	$\frac{d\pi_{1m}}{dR} < 0$	$\frac{d\pi_{1m}}{dR} = 0$
Two-period payoff for the local firm	$\Pi_l = \phi(I^*)\pi_{2ls} + (1 - \phi(I^*))\pi_{2lf} - I^*$	$\Pi_l = \mu_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})] - I^*$	$\Pi_l = \mu_1[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$
	$\frac{d\Pi_l}{dR} < 0$	$\frac{d\Pi_l}{dR} > 0$	$\frac{d\Pi_l}{dR} = 0$
Two-period payoff for the MNE	$\Pi_m = \pi_1 + \phi(I^*)\pi_{2ms} + (1 - \phi(I^*))\pi_{2mf}$	$\Pi_m = \pi_{1e} + \pi_{2e} + (1 - \mu_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$	$\Pi_m = \pi_{1e} + \pi_{2e} + (1 - \mu_1)[\pi_1 + \pi_2 - (\pi_{1e} + \pi_{2e})]$
	$\frac{d\Pi_m}{dR} > 0$	$\frac{d\Pi_m}{dR} = 0$	$\frac{d\Pi_m}{dR} = 0$

Figure 1: Game Tree

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

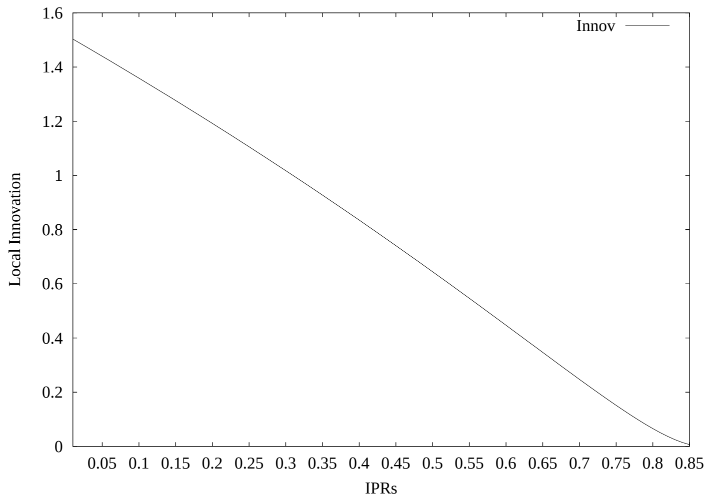


Figure 3: First Period Payoff in the Joint Venture, $R \in ([0; 1]$

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

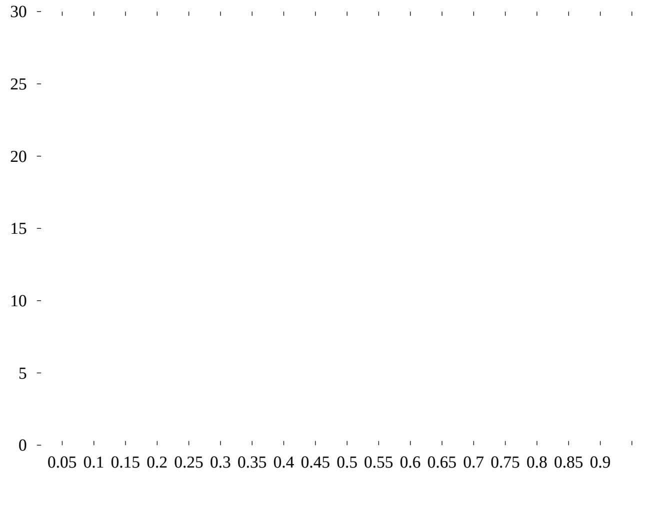


Figure 5: $\widetilde{R}$ and $\overline{R}$ with Different μ_1

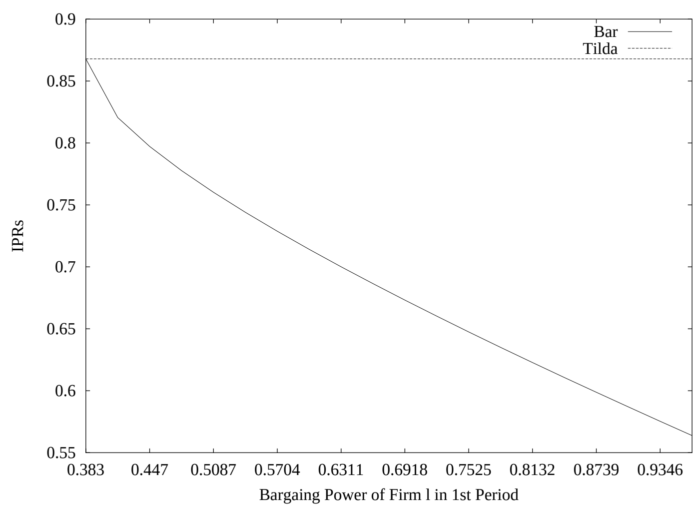
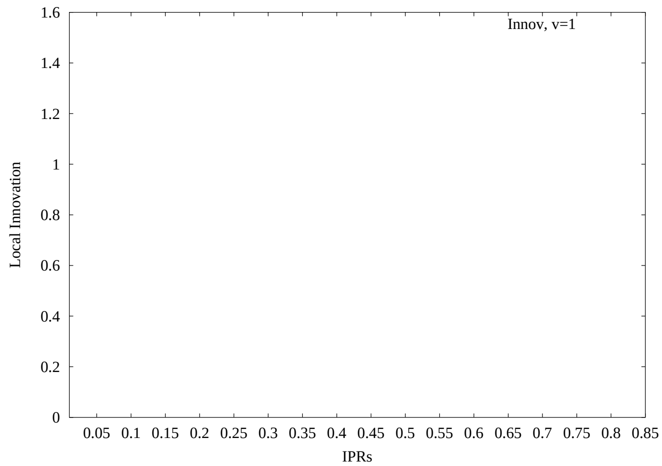


Figure 6: $\widetilde{R}$ and

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 $\widetilde{R}$

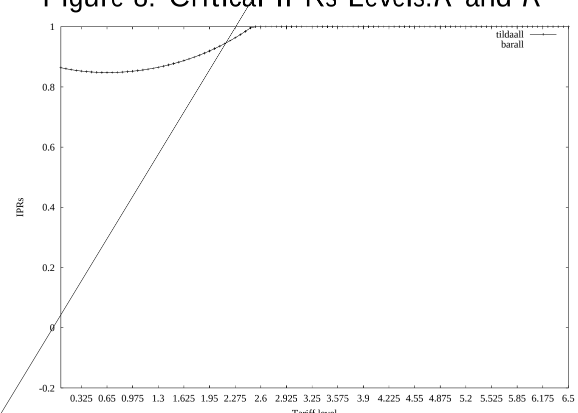


Figure 9: E￿ects of Tari￿ on I^*

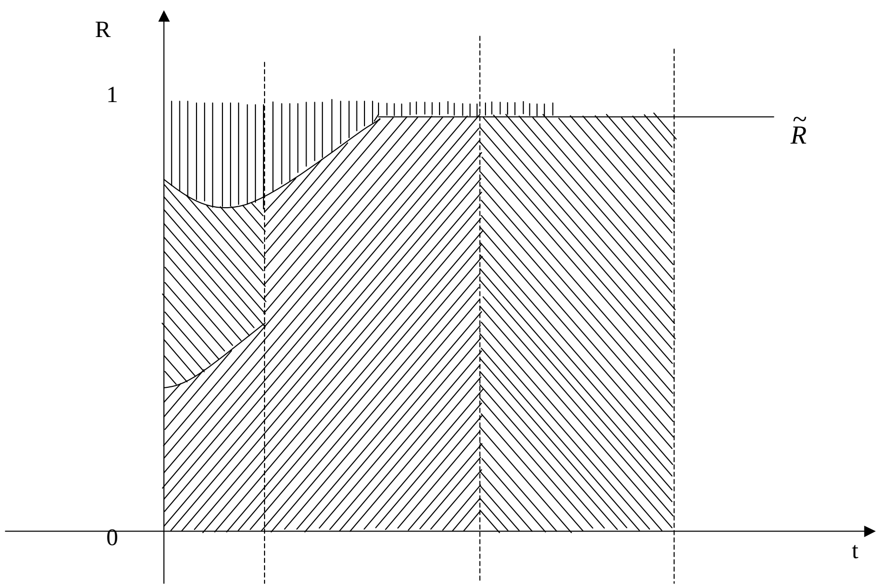
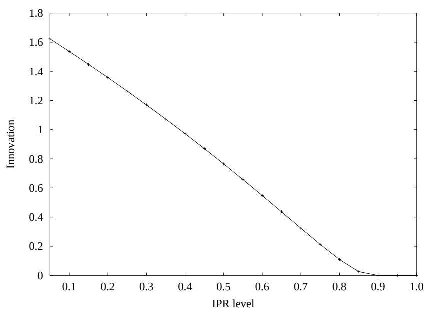
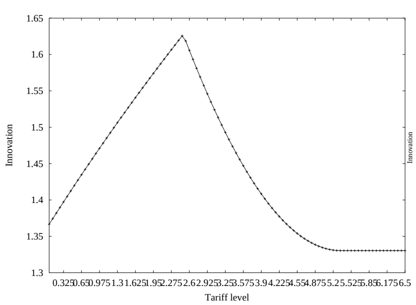


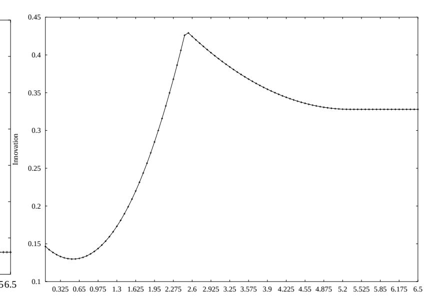
Figure 10: Optimal Local innovation, $t \in (0; 6:5]$ and $R \in ([0; 1]$

(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

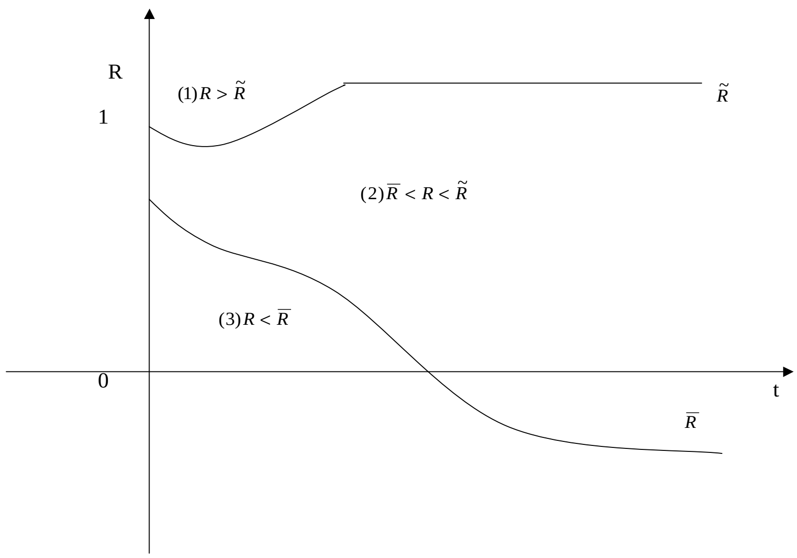
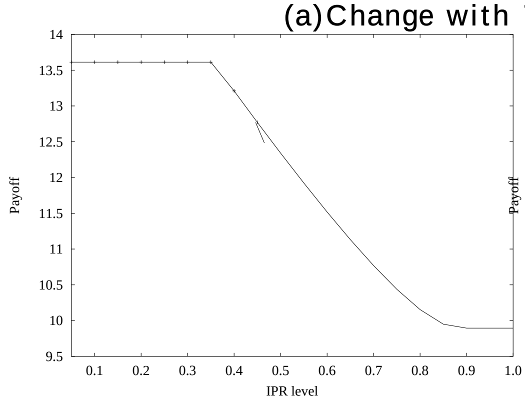
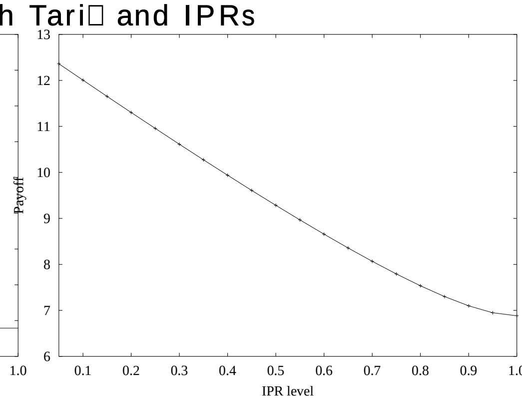


Figure 13: First Period Payoff of the MNE

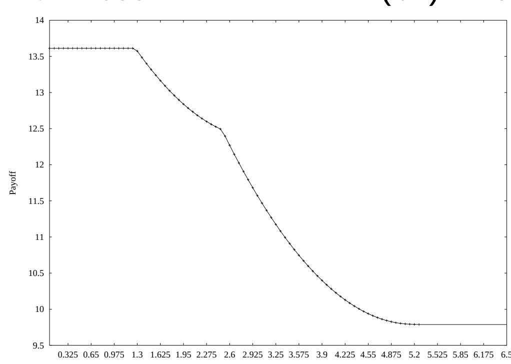
(a) Change with Tariff and IPRs



(b1) When $t = 1.635$



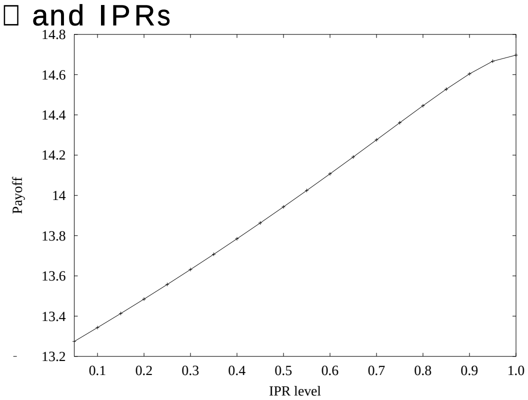
(b2) When $t = 4.55$



(c) When $R = 4$

Figure 14: Two Period Payoff of the Local Firm

(a) Change with Tariff and IPRs



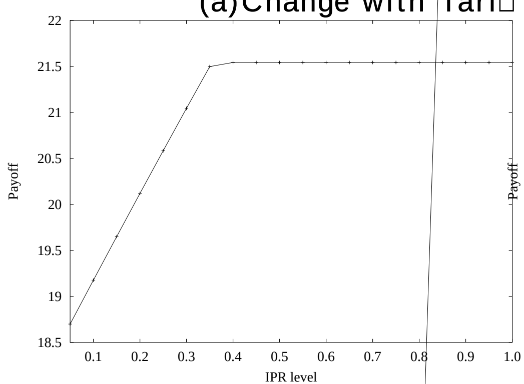
(b1) When $t = 1.635$

(b2) When $t = 4.55$

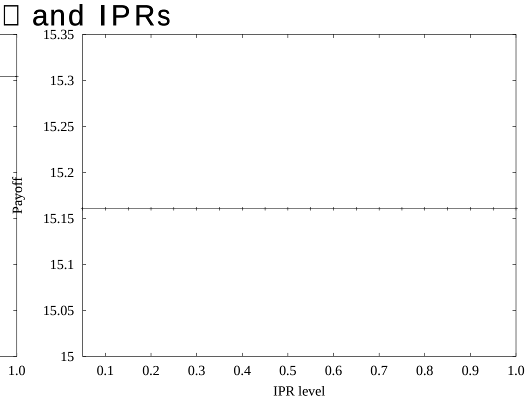
(c) When $R = 0.4$

Figure 15: Two Period Payoff of the MNE

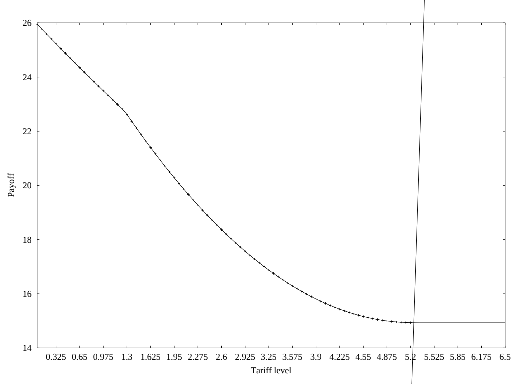
(a) Change with Tariff and IPRs



(b1) When $t = 1.635$



(b2) When $t = 4.55$



(c) When $R = 0.4$