The Hold-up Problem in the Presence of Free Trade Agreement Negotiations

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Statement of Originality

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the aware of any other higher degree of a university or other institute of higher learning, except where acknowledgement is made in the text. Any contribution made to the research by others is explicitly acknowledged in this thesis and abides with the University of Sydney's policy on academic honesty.

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4th June 2010

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Abstract

This paper examines how the underinvestment that results from the hold-up problem is affected when there is some probability of reaching a free trade agreement (FTA). This paper examines the canonical *domestic* hold-up problem in an international context. It considers an input supplier undertaking one-sided cost-reducing relationship-specific investment to produce an input for a final-good producer. Once the FTA is reached, both the final-good producer and input supplier face foreign competition. This study finds that it is possible for the presence of FTA negotiations to either aggravate or alleviate the *domestic* hold-up problem. The total effect of the presence of FTA negotiations on ex-ante investment incentives can be decomposed into an "output competitive effect" and an "input substitution effect". Both effects can be further decomposed into a "strategic effect" and a "cost effect". The fundamental driving forces behind the "strategic effect" and "cost effect" are the characteristics of the cost function for the non-standardised input, the characteristics of the final-good's demand function, and the relative efficiency of the two final-good producers in the two countries. In addition, the probability of reaching the FTA serves as an "intensifier" of the aggravation or alleviation. The modification cost of the foreign input serves as a "protector" for the domestic non-standardised input against competition from the cheaper foreign substitutes.

Contents

1. Introduction

The trend of trade liberalization has significantly boosted world trade in the past five decades. According to conventional trade theory, this trade boom has been led by falling trade barriers. However, the increasing rate of trade volume has been higher than the decreasing rate of trade barriers. Therefore, conventional trade theory is not able to explain this rise (Feenstra, 1998). A new trade phenomenon in the last few decades is the significant rise in foreign outsourcing and foreign direct investment (FDI). Since both usually involve trade in intermediate inputs, both might be additional driving forces behind the trade boom (Feenstra, 1998). Since inputs production is explained by theories of the firm, but not by conventional trade theories, researchers began to explore this new trade phenomenon by combining these two literatures. This combination of theories is hoped to shed light on the causes of recent world trade boom(Ornelas and Turner, 2008).

This paper is motivated by this new literature. The goal of this paper is to demonstrate that in the presence of free trade agreement (FTA) negotiations, how the probability of opening up to free trade affects the *ex-ante* investment incentives in a standard *domestic* hold-up situation[1]. The objective is unlike most papers in this literature, which focus on the optimal choices of organizational forms under free trade. Here, choice of organizational forms does play an important role, but it is not the main focus of this paper.

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[1] As opposed to *international* hold-up problem where the final-good producer and the specialized input supplier are located in different countries.

A real-world phenomenon motivates this paper in particular. FTA has been popular since 1990s as the total number signed worldwide has dramatically increased from around 30 to approximately 400 (World Trade Organization, 2010). However, FTA negotiations normally take a long time and FTAs may not be reached eventually. For example, Australia-China FTA Negotiations started in 2005 but are still ongoing. The time-consuming nature is not only because of the bargaining complexity, but also because of unforeseen changes in political and economic relationships between countries. Hence, FTA negotiations create *uncertainty* for an investor who is about to undertake relation-specific investments (RSI) in a *domestic* hold-up situation. To my knowledge, no existing literature investigates the *domestic* hold-up problem (*domestic* HUP) under this uncertainty arising from FTA negotiations.

As an illustrative example, consider a final-good producer and a fully-specialised input supplier in Australia. There is an Australian-China FTA negotiations going on when the supplier chooses RSI. Once the FTA is reached, the Australian final-good producer engages in quantity competition with its Chinese counterpart. Furthermore, the Australian input supplier faces fierce competition from the cheaper Chinese inputs priced competitively. Is it still rational for the Australian input supplier to undertake RSI? If so, how different the investment level would be relative to that in the absence of FTA negotiations? This article is aimed at giving some answers to these questions.

The setting is as follows. There are two countries, Home and Foreign. Home has a monopoly final-good producer using one standardised input and one non-standardized input to produce one final good. The non-standardized input is supplied by a monopoly supplier through a cost-reducing RSI.[2] RSI is observed by both firms but not enforceable by the court. Thus RSI is non-contractible *ex-ante*, when its nature is not revealed yet. The terms-of-trade is determined through Nash-bargaining *ex-post*. Foreign is identical in every respect except two aspects. Firstly, prices for the homogeneous standardised inputs in the two countries may not be equal. Secondly, both of the foreign producer's inputs are standardized one with no RSI required. This foreign standardized input and the domestic non-standardized input are partial substitutes since both final-good producers need to incur specific modification costs to the input supplied aboard for them to become perfect substitutes.

The bilateral FTA is reached with a probability that is common knowledge among all parties in both countries. If the FTA is reached, the final-good industry structure shifts from two monopolies in the two countries to Cournot duopoly in an integrated market. In addition, since the input market also open, both producers can access to cheaper foreign inputs. For simplicity, the foreign input is assumed to be sufficiently cheap so that the foreign final-good producer never buys the domestic non-standardized input under free trade. i.e., only the domestic final-good producer, not the domestic supplier, is possible to have positive outside option under FTA negotiations.

This paper firstly shows the existence of the *domestic* HUP under autarky. Secondly, it investigates how partial FTA negotiations (free trade only in the final-good market) affect investments under autarky. This effect is denoted as the

[2] A domestic bilateral monopoly is assumed so that outside options are normalized to zero for both domestic firms under autarky. This simplification allows clear focus on how FTA negotiations affect their outside options.

“output competitive effect”. Thirdly, it explores the additional change in investments under FTA negotiations (free trade in both the final-good and input markets) relative to partial FTA negotiations. This effect is denoted as the “input substitution effect”. The total effect of FTA negotiations on investments is a combination of the two effects. The main finding of this study is that it is possible for the presence of FTA negotiations to either aggravate or alleviate the *domestic* HUP. Both effects can be further decomposed into a “strategic effect” and a “cost effect”. The “strategic effect” arises from the change in the impact of additional investment on the final-good total revenue through the investment’s direct effect on the final-good’s Cournot equilibrium price. The “cost effect” comes from the change in the impact of additional investment on the final-good total cost through changes in final-good output. There are three fundamental driving forces behind the “strategic effect” and “cost effect”: (1) the characteristics of the cost function for the non-standardised input; (2) the characteristics of the final-good’s demand function; (3) the relative efficiency of the two final-good producers in the two countries. In addition, the probability of reaching the FTA serves as an “intensifier” of the aggravation or alleviation. While the modification cost of the foreign input serves as a “protector” against competition from the cheaper foreign substitute. As expected, low modification cost *alone* may not result in low investment, as the investment also depends on other parameters. For example, if the probability of reaching the FTA is considerably low and the domestic final-good producer is more efficient than its foreign counterpart, then the investment may actually increase.

This paper is the first one to address the impact of FTA negotiations (expected free trade) on the *domestic* HUP. It contributes to the hold-up literature as it indentifies the presence of FTA negotiations as a new channel through which the HUP can be alleviated. It also contributes to the international trade literature by further identifying the implications of free trade on productive efficiencies, and thus welfare.

2. Literature Review

2.1. Field overview

Since this research studies the *domestic* HUP in the international context, two areas of research are relevant: theories of the firm and international trade theories.

There are four major firm boundary theories: Transaction-cost economics (TCE), property-rights theory, incentive systems, and delegation of authority (Spencer, 2005). HUP is firstly studied by transaction-cost economics informally, and later modelled by property-rights theory formally. As mentioned in Introduction, conventional trade theories are no longer sufficient to explain the rapid growth in intermediate goods trade; researchers began to combine trade theories with the theories of the firm, in particular, TCE and PRT (Spencer, 2005). This chapter firstly reviews TCE and PRT. Secondly, it reviews the new literature. Lastly, it evaluates the most relevant articles to this study, and indentifies the gap to be explored in this research.

2.2. Two relevant branches of the theories of the firm

2.2.1. Transaction-cost economics

TCE is set out by Coase (1937). Prior to Coase (1937), researchers only focused on the market mechanism and paid little attention to transactions within firm boundaries. Coase (1937) holds that firms exist because it is more efficient to undertake some transactions within firms rather than in the market if the internal transaction costs are lower than external transaction costs. Internal transaction costs mainly arise from management and coordination costs associated with higher bureaucracy. External transaction costs come from searching and matching suitable transacting parties as well as negotiating, writing and enforcing contracts. Nonetheless, a firm cannot do all the transactions inside because of the rising internal transaction costs. Furthermore, undertaking some transactions in the market is more efficient than within firms. Therefore, firms choose organization forms to minimize total transaction costs.

Modern TCE is mainly developed by Williamson (1971, 1975, 1979) and Klein et al. (1978) and others. TCE focuses on relationship-specific investments (RSI) in specific asset which has higher value within the relationship than its value from the next best alternative use outside the relationship. This gap between first-best and second-best payoffs gives rise to positive quasi-rent as firstly noted by Klein et al. (1978). The nature of the asset is not revealed until the investment is sunk. Since in a world of uncertainty, it is almost impossible for a contract to specify all possible contingencies, and it is extremely costly to write a complex contract, contracts are normally incomplete. The quasi-rent created by RSI for the investing parties are subject to potential appropriation of the non-investing party through ex-post renegotiation. The fear of not getting full marginal benefit from investment leads the investing party to underinvests, which is well-known as the hold-up problem (HUP). The larger the quasi-rent is, the higher a party's incentive to behave opportunistically and hold up the other (Klein et al., 1978). Williamson (1975) firstly adds this ex-post opportunistic behavior in the form of renegotiation as a new type of transaction costs to those identified in Coase (1937). TCE proposes that vertical integration can alleviate the HUP. However, the "make-or-buy" decision depends on the assessment between the costs of integration and the costs of underinvestment.

2.2.2. Modern property-rights theory

Seminal papers in modern property-rights theory (PRT) were by Grossman and Hart (1986) and Hart andMoore (1990). PRT has the same antecedent as TCE, namely Coase (1937). It also concerns the inefficiency arising from the underinvestment when specific assets create quasi-rents and contracts are incomplete (Whinston, 2003). PRT predicts that ownership of assets gives a firm the residual rights of control over assets. This improves its bargaining position ex-post. Ownership should be allocated to the party who is most important in generating the joint surplus. In this way, the relatively important firm has increased incentives to undertake RSI, however, at the expense of reduced incentives for the other firm. If firms are equally important, then they should be separate. Thus, boundaries of firms are determined to minimise the deadweight loss due to the HUP (Grossman and Hart, 1986, Hart and Moore, 1990).

2.2.3. Transaction-cost economics vs. Modern property-rights theory

PRT is distinct from TCE in several ways. Firstly, TCE is relatively informal but PRT provides formal modeling. Secondly, TCE emphasizes *ex-post* opportunistic behavior, while PRT emphasizes *ex-ante* investment incentives, which can be altered by allocating rights of control over the asset ex-ante. Thirdly, while TCE holds that vertical integration minimises the HUP, it does not explain why the distortion in investment incentives is corrected within firms. By contrast, PRT proposes that the HUP exists under any governance structure, including vertical integration. So it is a matter of choosing an optimal governance structure which has the least severe HUP. Unlike TCE's prediction, vertical integration may aggravate the HUP, for example, when both parties are important in generating joint surplus (Grossman and Hart, 1986, Hart and Moore, 1990, Whinston, 2003). Fourthly, TCE has been widely supported by rich empirical works. In contrast, too little empirical testing is done for PRT mainly due to the fragility of its predictions (Lafontaine and Slade, 2007, Whinston, 2003).

The recent literature in the theories of the firm begins incorporating *ex-post* inefficiency (Matouschek, 2004, Kvaløy, 2007, Hart and Moore, 2008, Hart, 2009).

For example, Hart and Moore (2008) argues that contracts are still not perfectly contractible *ex-post* because the short-changed party may shade on "consummate performance" that is not contactable ex-post. This new research direction is beyond the scope of this paper, which still solely focuses on *ex-ante* inefficiency.

2.3. Combination of theories of firms and trade theory

There are two main branches of the new trade literature which combine international trade theory with TCE and PRT respectively. In the literature that combine trade theory with TCE (e.g. McLaren (2000) , Grossman and Helpman (2002, 2005)), vertical integration alleviates the HUP at a fixed cost. These papers all hold that organization forms are also affected by the market thickness. Thicker market reduces searching-and-matching costs and makes international outsourcing more attractive than FDI (international vertical integration).

Antràs (2003, 2005a, 2005b) , and Antràs and Helpman (2004) embed PRT into general equilibrium monopolistic competitive models of trade. Antràs (2003) finds that FDI is more likely for capital-intensive input production that involving greater RSI; foreign outsourcing is more likely for labour-intensive input production. In Antràs and Helpman (2004), organization forms and production destinations are driven by the productivity of final-good producers.

This study takes TCE approach[3], rather than PRT approach since it takes into account future extension of this model to the *international* HUP. PRT has weakness in

[3] This paper assumes that vertical integration *eliminates* HUP with fixed cost, just for technical simplicity.

application to the *international* HUP, as it assumes residual rights of control can be fully enforced by the Court ex-post (Demsetz, 1998). However, contract enforcement is more lenient across national boarder (Ornelas and Turner, 2007). Furthermore, these two branches both concentrate on firms' "make-or-buy" or "Home-or-Foreign" decisions. But this study focuses on the *domestic* HUP.

2.4. The gap to explore

The following discusses four most relevant articles to this work.

Ornelas and Turner (2009) explores the effects of the input-tariff on the HUP, organization choice and welfare. One of its main findings is most relevant to this work. It indentifies the welfare-enhancing effect of the input-tariff through attenuation of the *domestic* HUP, in a similar but distinct setting relative to this study. In their paper, Home is a small economy. Under free trade, the domestic final-good producer takes the world competitive price for the final good as given. One unit of final good needs one unit of input. The producer undertakes "dual sourcing" and buys both a standardized input from foreign competitive market and a non-standardized input (involving RSI) from *Home or Foreign*. The standardized and non-standardized inputs are perfect substitutes. If it buys the non-standardized input domestically, the *domestic* HUP exists; if it buys it from Foreign, the *international* HUP exists. It identifies that an exogenously given input-tariff can alleviate the *domestic* HUP because a higher input-tariff may worsen the domestic final-good producer's outside option of buying the foreign standardized input. Thus the domestic specialized supplier's bargaining position can be improved and investment incentives can rise. In contrast, if it buys the non-standardized input from Foreign, the input-tariff does not alleviate the *international* HUP as the same input-tariff is imposed on both the foreign standardized and non-standardized inputs. So the input-tariff does nothing in favor of the foreign specialized supplier.

The similarities between their findings and this study lie in the focus on the impact of exogenously given trade policy on the HUP. In addition, their finding of the alleviation of the *domestic* HUP due to trade policy is also one of the key results in this work, which studies the *domestic* HUP.

Nonetheless, similar results are driven by different forces due to different settings. In this study, the integrated final-good market is Cournot-duopoly, rather than perfect competition. Thus, unlike their paper where the final-good price under free trade is given exogenously and unaffected by investment, investment has an extra "strategic effect" on final-good price under free trade in this study. In addition, they only focus on the effect of trade policy on the input market rather than the final-good market. While in this work, the FTA affects both input and final-good markets. Therefore, the "cost-effect" driven by the relative efficiency of domestic and foreign final-good producers does not exist in their paper. In fact, the input-tariff resembles the modification cost of the foreign input in this work since both affect the outside option of the domestic final-good producer.

Unlike Ornelas and Turner (2009) and this paper, in Antràs and Staiger (2010), trade policy is endogenously chosen. They assume that all final-good producers are in Home, and all specialized suppliers are in Foreign. They demonstrate the existence of optimal FTA which completely solves the *international* HUP. The optimal FTA should provide free trade in final-goods market and appropriate trade subsidies to encourage input trade volume. Then the foreign input supplier’s ex-post bargaining positions and investment incentives improve.

To my knowledge, Antràs and Staiger (2010) is the only article that also models the relationship between the HUP and the FTA. However, this work assumes that FTA’s design is exogenous, i.e., completely opening up the final-good and input markets. Then it examines how a potential FTA affects the *domestic* HUP. In contrast, Antràs and Staiger (2010) endogenize the design of FTA, and studies how the *international* HUP affects the optimal FTA design.

Wes (2000) is interested in the *domestic* HUP when the economy shifts from autarky to partial free trade only in the final-good market, which has the same focus as the “partial FTA negotiations model” from this work. It also adopts a partial equilibrium approach and considers two identical countries, each with a bilateral monopoly of a final-good producer and a specialised input supplier who undertakes one-sided cost-reducing RSI. It assumes that the domestic and foreign final-good producers engage in *Bertrand* competition under partial free trade. It concludes that partial free trade in final good has a “knock-on” effect on the input market and alleviates the *domestic* HUP. The driving force is similar to the positive “cost effect” in this study. Bertrand output is higher under partial free trade than monopoly output under autarky. The investment is more valuable as it reduces costs across larger final-good output. Nonetheless, they have no “strategic effect” identified in this study. This is because final-good price under *Bertrand* competition (unlike Cournot duopoly in this work) is not affected by investment. Furthermore, Wes (2000) only explicitly compares the privately-optimal investment under partial free trade relative to the socially-optimal investment under autarky[4], rather than to the privately-optimal investment under autarky as in this work.

The general setting in this study mostly resembles that in Spencer and Qiu (2001). Spencer and Qiu (2001) is distinct from all papers mentioned above as it applies theories to explain a real-world trade phenomenon. When Japan and US shift from partial free trade (only in automobile) to free trade (also opens up auto-parts market), A representative Japanese car maker (domestic final-good producer) starts having two input procurement options: switching to buy the standardised input from US competitive market or remain buying non-standardised input from Keiretsu (domestic specialised input supplier). The setting is broader than that in this study as the car maker has a continuum of inputs, each produced by a specialised Keiretsu supplier undertaking cost-reducing RSI. There exists a *domestic* HUP between the car maker and each Keiretsu supplier. The fundamental difference of this paper from their paper is that while this paper concentrates on the *domestic* HUP, they only concentrate on the range and volume of Japanese import of US auto-parts, in explaining the US perception of trade barrier.

[4] Neither the *domestic* HUP nor the allocative inefficiencies of monopoly exists.

In sum, the originality of this paper is that it is the first one to address the impact of FTA negotiations (expected free trade) on the *domestic* HUP. It incorporates the probability of opening up free trade, which is not done by any paper above. It contributes to the hold-up literature as it indentifies a new channel of alleviating the HUP, i.e. the presence of FTA negotiations. It also contributes to the international trade literature by further indentifying the implications of free trade on productive efficiencies, and thus welfare, although welfare discussion is beyond the scope of this paper.

3. Closed-economy model

There are two countries, Home and Foreign. Initially, there is no free trade between these two countries.

3.1. Home country

The home country has a final-good producer producing good 1. It needs two inputs, one is standardised, called input S, with price P_S. The other is non-standardized, called input N, with price P_N. The final-good producer has a Leontief production function

$$Q_1 = f(Q_S, Q_N) = \min(Q_S, Q_N)$$

Q_1 is the final-good output and Q_S, Q_N are the quantities of the input S and N respectively. The production function indicates that to produce one unit of good 1, at least one unit of input S and one unit of input N are required. To minimize production cost, one unit of each input is used to produce one unit of good 1. Therefore, $Q_1 = Q_N = Q_s$. The demand function for the final good is $Q_1 = Q_1(P_1)$, so the quantity demanded only depends on the price for good 1, and is independent of other variables, such as consumers' income and taste (Spencer and Qiu, 2001, Wes, 2000).

The producer buys input S from a domestic competitive market, so $P_S = C_S$, where C_S is the constant marginal cost of producing input S. However, it buys input N from a domestic supplier who undertakes a cost-reducing RSI to produce the non-standardized input N. RSI is the investment in specific asset which is valued higher within a trading relationship than outside the relationship. The quasi-rent[5] of the investor created by the specific asset is the primal value of the asset within the trading relationship (first-best option) over its salvage value outside the relationship (second-best option) to the investor, after the RSI is sunk (Klein et al., 1978). In this closed-economy model, it is assumed that there are no outside options for both firms, so the salvage value of the input supplier's asset equals zero. Consequently, the quasi-rent of the input supplier equals to the asset's primal value within the trading relationship[6].

The domestic input supplier holds a monopoly in the non-standardized input N as it owns the specific technology required to produce it. Input N is produced with a

[5] Quasi-rent in this paper refers to the quasi-rent of the *individual firm* who invests in the specific asset (Klein et al., 1978, Besanko, 2010). In some articles, quasi-rent refers to the ex-post joint surplus (Koss and Eaton, 1997, Antràs and Helpman, 2004) . Another example is that Spencer and Qiu (2001) uses "rent" which refers to "relational quasi-rent". See its footnote 6 on page 872.

[6] See further discussion below in footnote 17.

marginal cost $C_N(k)$ plus a fixed cost $k \in (0, K]$, which are the units of the RSI. K is the highest investment level given the resources constraint of the input supplier. This specific investment is assumed to be one-shot, that is, the two firms only trade once. k is observed by both firms, but it is not enforceable by the court. So k is not contractible *ex-ante*, when its nature is not revealed yet. The marginal cost of input N is assumed to be

$$C_N(k) = c - c_N(k),$$

where c is the initial marginal cost with no RSI undertaken. k reduces $C_N(k)$ from the initial marginal cost c at a decreasing rate by the amount $c_N(k)$:

(1) $$\frac{dc_N(k)}{dk} > 0, \frac{d^2 c_N(k)}{dk^2} < 0$$

Therefore,

(2) $$\frac{dC_N(k)}{dk} < 0, \frac{d^2 C_N(k)}{dk^2} > 0.$$

Thus, $C_N(k)$ is a twice differentiable, strictly convex and decreasing function of k.

3.1.1. Non-vertically integrated solution

This model involves two stages: stage 1 and stage 2. In stage 1, supplier of input N strategically chooses the RSI level, k, taking into account the effect of k on P_N and Q_1 in stage 2. k is sunk immediately after it is made. k is non-contractible and no contract is signed in this stage. In stage 2, given k committed, P_N and Q_1 are determined simultaneously.[7] The two firms engage in Nash cooperative bargaining

[7] There are three alternative orders of moves. [1] Two stage game: in Stage 1, k and Q_1 are simultaneously determined; in Stage 2, P_N is determined. [1] is suitable if design changes to the input for compatibility

(Nash, 1953) over P_N to maximize the surplus from agreement which is expressed as a function of Q_1. The final-good producer chooses Q_1 to maximize its payoff, which is expressed as a function of P_N. P_N and Q_1 are derived by solving these two equations simultaneously.

As usual, the problem is solved backwards.

3.1.1.1. Stage 2: bargaining over input price and output decision

After k is sunk, $C_N(k)$ is committed. The two firms engage in Nash cooperative bargaining over P_N, which is expressed as a function of Q_1. α and $1-\alpha$ are the bargaining powers of the final-good producer and the input supplier respectively. It is assumed that $\alpha \in (0,1)$. $\alpha < 1$ is the condition for the input supplier to invest, otherwise, its profit is negative as it cannot recover the investment cost (Spencer and Qiu, 2001). Assuming $\alpha > 0$ is because once the specific k is committed, the input supplier is vulnerable to no trade threat (Williamson, 1975), which gives the final-good producer positive bargaining power. This paper further assumes that neither firm has any outside option. In addition, this ex-post Nash bargaining is efficient as there is no informational asymmetry, i.e., all the relevant variables are

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improvement with other inputs. Then, it is critical to know the exact production requirement when making relationship-specific investment (Spencer and Qiu, 2001) But in this case, it is not necessary to know the exact production requirement when making relationship-specific investment, so the original order of moves is more natural. [2] Three stage games: in stage 1, k is determined; in stage 2, P_N is determined; in stage 3, Q_1 is determined. [3] Three stage games: in stage 1, k is determined; in stage 2, Q_1 is determined; in stage 3, P_N is determined. [2] and [3] give the same result as the order of moves in the main text. This is because both P_N and Q_1 are chosen at the levels that maximise the surplus from agreement. See (3) and (7).

common knowledge for both firms(Wes, 2000). P_N satisfies

(3) $$\begin{aligned} P_N &= \arg\max_{P_N} \left\{\left[P_1(Q_1) - P_S - P_N\right]Q_1 - 0\right\}^{\alpha} \left\{\left[P_N - C_N(k)\right]Q_1 - 0\right\}^{1-\alpha} \\ &= \left[P_1(Q_1) - P_S - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1 \end{aligned},$$

where $\left[P_1(Q_1) - P_S - P_N\right]Q_1$ and $\left[P_N - C_N(k)\right]Q_1$ are the respective *ex-post* payoffs from bargaining for the final-good producer and the input supplier.

It is assumed that $\left[P_1(Q_1) - P_S - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1$ is concave in P_N and twice differentiable.

First-order condition (FOC) for (3):

$$-\alpha\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1 - (1-\alpha)\left[P_1(Q_1) - P_S - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{-\alpha} Q_1 = 0$$

Second-order condition (SOC) for (3):

$$-\alpha(1-\alpha)Q_1[P_1(Q_1) - P_S - P_N]^{\alpha-2}[P_N - C_N(k)]^{-\alpha-1}[P_1(Q_1) - P_S - C_N(k)] \le 0$$

The above FOC and SOC guarantee that the FOC solves for a unique maximizer

(4) $$P_N(Q_1, k) = C_N(k) + (1-\alpha)\left[P_1(Q_1) - P_S - C_N(k)\right]$$[8].

Denote Π_1 as the final-good producer's ex-ante and ex-post payoff. [9] Simultaneously, given k, the final-good producer chooses Q_1 to solve for

(5) $$\max_{Q_1} \Pi_1 = [P_1(Q_1) - P_S - P_N]Q_1$$

subject to (4) $P_N(k) = C_N(k) + (1-\alpha)[P_1(Q_1) - P_S - C_N(k)]$.

Substituting the constraint (4) into (5) yields

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[8] See A.1 in Appendix for derivation.

[9] *Ex ante* payoff is equivalent to rent or economics profit, which is the excess payoff to a factor of production over the minimum amount of payoff needed to remain it in its current use (Bird and Tarascio, 1992). So they are used interchangeably thereafter.
Ex post payoff does not include the ex ante investment cost as the *ex ante* payoff does. So *ex post* payoff equals *ex ante* payoff plus the ex ante investment cost. Since the final-good producer does not invest ex ante, its ex ante and ex post payoff are equal.

(6) $$\max_{Q_1} \Pi_1 = \alpha[P_1(Q_1) - P_S - C_N(k)]Q_1$$

It is assumed that Π_1 is strictly concave in Q_1 and twice differentiable.

FOC for (6):

(7) $$\frac{d\Pi_1}{dQ_1} = \alpha\left[P_1'(Q_1)Q_1 + P_1(Q_1) - P_S - C_N(k)\right] = 0$$

SOC for (6):

(8) $$\frac{d^2\Pi_1}{dQ_1{}^2} = \frac{d\left[P_1'(Q_1)Q_1 + P_1(Q_1) - P_S - C_N\right]}{dQ_1} = P_1''(Q_1)Q_1 + 2P_1'(Q_1) < 0$$

The above FOC and SOC guarantee that the FOC solves for a unique maximiser, i.e. the optimal output $Q_1(k)$.

Adopting implicit function theorem on (7) yields[10]:

$$Q_1'(k) \equiv \frac{C_N'(k)}{P_1''(Q_1(k))Q_1(k) + 2P_1'(Q_1(k))}.$$

According to (2) and (8),

(9) $$Q_1'(k) > 0,$$

which indicates that the optimal output $Q_1(k)$ increases in k. The intuition is that when k rises, the marginal cost of the final-good producer falls. Since the final-good producer holds a monopoly, it always chooses the optimal output that equates its marginal revenue to marginal cost to maximise its profit. As marginal cost falls, marginal revenue must fall. Since marginal revenue decreases in output, the optimal

---

[10] Firstly, express Q_1 in (7) in terms of k and rewrite (7) as

$P_1'\left(Q_1(k)\right)Q_1(k) + P_1\left(Q_1(k)\right) - P_S + C_N(k) \equiv 0$. Secondly, differentiate the above equation with respect to k:

$P_1''\left(Q1(k)\right)Q_1'(k)Q_1(k) + P_1'\left(Q1(k)\right)Q_1'(k) + P_1'\left(Q1(k)\right)Q_1'(k) - C_N'(k) \equiv 0$.

output level rises consequently.

Substituting the optimal output $Q_1(k)$ into (4) gives

(10) $$P_N(k) = C_N(k) + (1-\alpha)\left[P_1\left(Q_1(k)\right) - P_S - C_N(k)\right].$$

Given $Q_1(k)$ and $P_N(k)$, the respective optimal *ex-post* payoffs[11] for the final-good producer and the input supplier are $\left[P_1\left(Q_1(k)\right) - P_s - P_N(k)\right]Q_1(k)$ and $\left[P_N(k) - C_N(k)\right]Q_1(k)$. These two ex-post payoffs sum up to the optimal *total value* achievable by the asset for the two firms if and only if the agreement is reached:

$$\left[P_1\left(Q_1(k)\right) - P_s - C_N(k)\right]Q_1(k)$$

Define $R(k)$ as the optimal *surplus*[12] from agreement between the two firms under autarky. It equals the total value of the asset subtracted by each firm's outside options under autarky:

(11) $$\begin{aligned} R(k) &= R\left(Q_1(k), C_N(k)\right) = \left[P_1\left(Q_1(k)\right) - P_s - C_N(k)\right]Q_1(k) - 0 - 0 \\ &= \left[P_1\left(Q_1(k)\right) - P_s - C_N(k)\right]Q_1(k) \end{aligned}$$

This surplus gets divided between the two firms in the proportion of $\alpha : 1-\alpha$ by $P_N(k)$, which is bargained over. They agree to trade in stage 2 if and only if the surplus is nonnegative. This is because firstly we assume that the two firms are both risk neutral (Grossman and Hart, 1986); secondly, under Nash bargaining, each firm gets a payoff which equals to its outside option plus the bargaining share of the surplus. If the surplus is negative, each firm simply chooses its outside option (Nash, 1953).

[11] For simplicity, the word "optimal" may be omitted thereafter when referring to an "optimal" value, once it is clearly defined as an "optimal" value.
[12] The surplus from agreement is assumed not to diminish during Nash bargaining (Koss and Eaton, 1997).

Proposition 1. *(i)The surplus between the domestic final-good producer and the input supplier under autarky is increasing in k:* $R'(k) > 0$. *(ii)The marginal benefit from investment for the domestic input supplier is increasing in the domestic final-good producer's output:* $\frac{\partial(1-\alpha)R'(k)}{\partial Q(k)} > 0$.

Proof. Rearranging (7) gives $P_1\left(Q_1(k)\right) - P_S - C_N(k) = -P_1'\left(Q_1(k)\right)Q_1(k)$.

Using the above equation, totally differentiate $R(k)$ with respect to k,

$$
\begin{aligned}
R'(k) &= \left[P_1'\left(Q_1(k)\right)Q_1'(k) - C_N'(k)\right]Q_1(k) + \left[P_1\left(Q_1(k)\right) - P_S - C_N(k)\right]Q_1'(k) \\
&= \left[P_1'\left(Q_1(k)\right)Q_1'(k) - C_N'(k)\right]Q_1(k) - P_1'\left(Q_1(k)\right)Q_1(k)Q_1'(k) \qquad (12) \\
&= -C_N'(k)Q_1(k) > 0
\end{aligned}
$$

Partially differentiate $(1-\alpha)R'(k)$ with respect to $Q_1(k)$,

$$\frac{\partial\left((1-\alpha)R'(k)\right)}{\partial Q_1(k)} = -(1-\alpha)C_N'(k) > 0$$

Q.E.D.

The value of additional unit of k comes from its ability of reducing the marginal cost of input N by $-C_N'(k) = c_N'(k) > 0$ across all the optimal output $Q_1(k)$. Ceteris Paribus, the surplus between the two domestic firms increases. When output rises, additional unit of k is more valuable since it can reduce cost across larger output.

- **Example for Proposition 1(i)**

The demand function for good 1 in Home: $Q_1 = a - bP_1$

The marginal cost function of the non-standardised input N: $C_N(k) = c - \sqrt{k}$

The surplus between the two domestic firms under autarky is calculated to be

$$R(k)=\frac{(a+b(-c+\sqrt{k})-bP_S)^2}{4b}.$$

The derivative of the surplus with respect to k is calculated to be

$$R'(k)=\frac{a+b(-c+\sqrt{k})-bP_S}{4\sqrt{k}}$$

Parameters of relevant variables:

$a=100$

$b=1$

$c=50$

$P_S=10$

Using these parameters, if $k>0$, the derivative of the surplus with respect to k is calculated to be positive, $R'(k)=\frac{40+\sqrt{k}}{4\sqrt{k}}>0$.

3.1.1.2. Stage 1: Relationship-specific investment

Denote π_N as the input supplier's *ex-ante* payoff under autarky. By further solving backwards, in stage 1, the input supplier strategically chooses the optimal investment that solves for

(13) $$\max_k \pi_N=\left[P_N(k)-C_N(k)\right]Q_1(k)-k=(1-\alpha)R(k)-k$$ [13]

It is assumed that π_N is increasing and strictly concave in k, twice differentiable and

13

$$\begin{aligned}&\left[P_N(k)-C_N(k)\right]Q_1(k)-k\\&=\left\{C_N(k)+(1-\alpha)\left[P_1\left(Q_1(k)\right)-P_S-C_N(k)\right]-C_N(k)\right\}Q_1(k)-k\\&=(1-\alpha)\left[P_1\left(Q_1(k)\right)-P_S-C_N(k)\right]Q_1(k)-k\\&=(1-\alpha)R(k)-k\end{aligned}$$

has a unique interior maximiser $k^A \in (0, K]$ (Che and Hausch, 1999). The subscript A denotes autarky.

FOC for (13):

(14) $$\frac{d\pi_N}{dk} = (1-\alpha)R'(k) - 1 = 0$$

Denote MB^A as the marginal benefit from investment for the input supplier under autarky. Denote MC as the marginal cost from investment, which equals to one

(15) $$MB^A(k) = (1-\alpha)R'(k), \\ MC = 1$$

SOC for (13):

(16) $$\frac{d^2\pi_N}{dk^2} = (1-\alpha)R''(k) < 0$$

Since $(1-\alpha) > 0$, (16) is equivalent to assuming that

(17) $$R''(k) < 0$$

The above FOC and SOC guarantee that the FOC solves for a unique interior maximiser k^A, which satisfies (14),

(18) $$(1-\alpha)R'(k^A) = 1,$$

The input supplier chooses k^A at which $MB^A(k^A) = MC = 1$ to maximise profit.

The necessary and sufficient condition for the input supplier to choose $k^A > 0$ is $\pi_N(k^A) = (1-\alpha)R(k^A) - k^A \geq 0$. Positive profit implies that the surplus is sufficiently large, such that $1-\alpha$ of it is still large enough to recoup the investment cost k^A. Rearrangement yields that the surplus must be positive if $k^A > 0$:

(19) $$R(k^A) \geq \frac{k^A}{1-\alpha} > 0.$$

3.1.1.3. Summary

In stage 2, given $k^A > 0$ committed in stage 1, $Q_1(k^A)$ and $P_N(k^A)$ are determined. From (19), $R(k^A) > 0$, so agreement is always reached between the two firms. The final-good producer orders input N, and the input supplier starts producing $Q_1(k^A)$ units of input N, and charges price $P_N(k^A)$. The final-good producer's ex-ante payoff is

$$(20) \quad \Pi_1 = \begin{cases} \alpha R(k^A) & \text{if } R(k^A) \geq 0 \\ 0 & \text{if } R(k^A) < 0 \end{cases}$$

If the investment generates non-negative surplus, the final-good producer can obtain a non-negative payoff, which is α fraction of the surplus, otherwise, it gets zero.

The input supplier's ex-ante payoff is

(21)

$$\pi_N = \begin{cases} (1-\alpha)R(k^A) - k^A & \text{if } R(k^A) \geq 0 \\ -k^A & \text{if } R(k^A) < 0 \end{cases}$$

If the investment generates non-negative surplus, the input supplier obtains a non-negative ex-ante payoff, which is $1-\alpha$ fraction of the surplus. Otherwise, since the asset has zero salvage value, all the investment cost cannot be recovered.

3.1.2. Vertically integrated solution as a benchmark

This model assumes that if the two firms vertically integrate, the hold-up problem[14] is completely eliminated, but at a fixed integration cost C^I (Hart and Tirole, 1990, McLaren, 2000, Ornelas and Turner, 2008) .[15] The vertically integrated solution requires both output and the investment are at the efficient levels that maximise the profit of the vertically integrated firm:

$$\max_{k,Q_1} \Pi^I = \left[P_1(Q_1) - P_S - C_N(k)\right]Q_1 - k - C^I \tag{22}$$

It is assumed that Π^I is increasing, jointly strictly concave and twice differentiable in Q_1 and k.

FOCs for (22):

$$\frac{\partial \Pi^I}{\partial Q_1} = P_1'(Q_1)Q_1 + P_1(Q_1) - P_S - C_N(k) = 0 \tag{23}$$

$$\frac{\partial \Pi^I}{\partial k} = -C_N'(k)Q_1 - 1 = 0 \tag{24}$$

SOCs for (22):

$$\frac{\partial^2 \Pi^I}{\partial {Q_1}^2} = P_1''(Q_1)Q_1 + 2P_1'(Q_1) < 0$$

$$\frac{\partial^2 \Pi^I}{\partial k^2} = -C_N''(k)Q_1 < 0$$

$$\frac{\partial^2 \Pi^I}{\partial {Q_1}^2}\frac{\partial^2 \Pi^I}{\partial k^2} - \left(\frac{\partial^2 \Pi^I}{\partial k Q_1}\right)^2 > 0$$

---

[14] See Section 3.1.3 for detailed discussion.

[15] C^I may due to lower managerial incentive(Crémer, 1995, Williamson, 1971) or fewer opportunities to diversify risk(Hanson, 1995) etc. The assumption of complete elimination of hold-up here is just for technical simplicity. Vertical integration cannot eliminate but may attenuate hold-up problem (Grossman and Hart, 1986, Hart and Moore, 1990).

The above conditions guarantee that the FOCs are sufficient for solving for a pair of maximiser $\left(Q_1^I, k^I\right)$.

There are two steps to derive $\left(Q_1^I, k^I\right)$.

Step1. Solve (23) and (24) together to get the optimal investment under vertical integration k^I which satisfies:

(25) $$-C_N'(k^I)Q_1(k^I) = 1$$

Since from (12), $R'(k) = -C_N'(k)Q_1(k)$, (25) is equivalent to

(26) $$R'(k^I) = 1$$

Step2. Substitute k^I into (23) or (24) to get the optimal output under vertical integration $Q_1(k^I)$.

Substitute k^I into (22) yields the *optimal* profit of the integrated firm

(27) $$\Pi^I(k^I) = \left[P_1\left(Q_1(k^I)\right) - P_S - C_N(k^I)\right]Q_1(k^I) - k - C^I = R(k^I) - k - C^I$$

The profit of the integrated firm is the total value created by k^I subtracted by the investment and fixed integration costs. The second equality is due to two reasons. Firstly, (23) or (24) give the same output function expressed in k as (6). So the total values created by an investment under vertical and non-vertical integration are equal (reducing cost across the same output). Secondly, the total value under non-vertical integration also equals the surplus under autarky since neither firm has outside option.

3.1.3. Non-vertically integrated solution vs. vertically integrated solution

Comparing (18) and (26), when $\alpha = 0$, they are the same.[16] When the final-good producer has no bargaining power, the input supplier can receive all the marginal benefit from its investment, it chooses the efficient level k^I, so there is no HUP.

Proposition 2. *(i) Under autarky, if the final-good producer's bargaining power* $\alpha \in (0,1)$, π_N *and* Π^I *are increasing, twice differentiable, strictly concave in* k, *and have* k^A *and* k^I *as unique interior maximisers respectively, then* $k^A < k^I$. *(ii) Ceteris Paribus, the magnitude of this underinvestment increases in* α.

Proof.

(i) Since $\alpha \in (0,1)$, from (18) and (26), we have

(28) $$R'(k^A) = \frac{1}{1-\alpha} > 1 = R'(k^I)$$

From (17) on page 25, $R''(k) < 0$,

$k^A < k^I$.

(ii) Since $R'(k^A) - R'(k^I) = \frac{\alpha}{1-\alpha} > 0$,

$$\frac{\partial\left[R'(k^A) - R'(k^I)\right]}{\partial\alpha} > 0,$$

$$\frac{\partial\left|k^A - k^I\right|}{\partial\alpha} > 0.$$

[16] Although $\alpha = 0$ is ruled by assumption, it is worth mentioning this case here.

Ceteris Paribus, the magnitude of this underinvestment increases in α.

Q.E.D.

- **Example for Proposition 2**

This example uses the same demand and cost functions and parameters as in the previous example and additional parameters: the domestic final-good producer's bargaining power

$\alpha = 0.5$,

The fixed cost of vertical integration

$C^I = 300$ [17]

the investment under non-vertical integration is calculated to be $k^A = 32.65$ and the investment under vertical integration is calculated as $k^I = 177.78$. Thus, there is underinvestment under non-vertical integration relative to vertical integration under autarky,

$$k^A - k^I = -145.13 < 0.$$

Then, Figure 1 is plotted to show we how α affects the difference in investments in Figure 1. The horizontal axis measures α, and the vertical axis measures k. k^I is independent of α since there is no ex-post bargaining under vertical integration. k^A is decreasing in α. As α rises, the domestic input supplier receives smaller share of the benefit from investment, so it invests less. For $\alpha \in (0,1)$, $k^A < k^I$. As α rises, the magnitude of the underinvestment rises.

[17] C^I is chosen to be large, since this model assumes that the vertical integration does not occur under autarky as integration costs outweigh integration benefits.

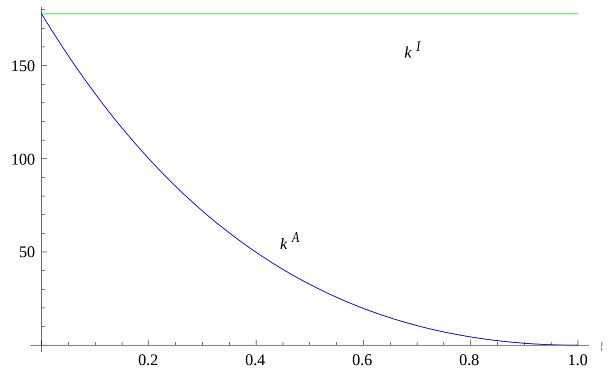

Figure 1

This underinvestment under non-vertical integration is known as the hold-up problem. The existence of positive quasi-rent of the investing party creates hold-up potentials. In this model, since the asset has zero salvage value, the quasi-rent of the input supplier is the asset's primal value to the supplier within the relationship: $\left[P_N(k) - C_N(k)\right]Q_1$.[18] As long as $P_N(k) > C_N(k)$, the final-good producer may attempt to lower the input price $P_N(k)$ and appropriate this quasi-rent (Klein et al., 1978). Its ability to appropriate depends on its bargaining power α. Under non-vertical integration, foreseeing this potential hold-up, the input supplier strategically chooses k^A by taking into account its inability in getting the full MB^A since α fraction of it is appropriated by the final-good producer. *Lower* marginal

[18] In this model, the input supplier's quasi-rent equals to its *ex post* payoff. To show this equality, suppose that the supplier has a positive second-best outside option $\lambda(k)$. The surplus is $R\left(k, \lambda(k)\right) = \left[P_1\left(Q_1(k)\right) - P_s - C_N(k)\right]Q_1(k) - \lambda(k) - 0 = \left[P_1\left(Q_1(k)\right) - P_s - C_N(k)\right]Q_1(k) - \lambda(k)$ The supplier's quasi-rent is the extra payoff from its first-best option over its second-best option: $(1-\alpha)R\left(k, \lambda(k)\right) - \lambda(k)$; its *ex post* payoff from bargaining is $\lambda(k) + (1-\alpha)\left[R\left(k, \lambda(k)\right) - \lambda(k)\right]$. Since $\lambda(k) = 0$ in this model, its quasi-rent and *ex post* payoff are equal.

It is also notable that, *Ceteris Paribus*, both its quasi-rent and *ex post* payoff are decreasing in α since $\frac{\partial\left[(1-\alpha)R\left(k, \lambda(k)\right) - \lambda(k)\right]}{\partial\alpha} = -\alpha R\left(k, \lambda(k)\right) < 0$ and $\frac{\partial\left\{\lambda(k) + (1-\alpha)\left[R\left(k, \lambda(k)\right) - \lambda(k)\right]\right\}}{\partial\alpha} = -\alpha\left[R\left(k, \lambda(k)\right) - \lambda(k)\right] < 0$. Higher α enables the final-good producer appropriates more quasi-rent, so the supplier gets less *ex post* payoff.

benefit from investment distorts the input supplier's investment incentive and generates the hold-up problem (Klein et al., 1978, Williamson, 1979). Ceteris Paribas, the magnitude of this further underinvestment $k^I - k^A$ increases in α (Besanko, 2010). If α rises, the domestic input supplier gets even lower MB^A, so it further underinvests.

3.2. Foreign country

The similar structure exists in Foreign. Foreign also has a final-good producer also producing homogeneous output, good 1. Production of good 1 requires two inputs. One is the homogenous standardised input S which is also used in home country, with price P_S^*. Foreign is identical in every respect to Home except two aspects. One is that the prices for input S in the two countries, P_S^* and P_S, may not equal. The other is that another input needed by the foreign final-good producer is a standardized one with no RSI required, called input S^*, with price $P_{S^*}^*$. It has a Leontief production function

$$Q_1^* = f\left(Q_S,\ Q_{S^*}\right) = \min\left(Q_S,\ Q_{S^*}\right)$$ [19]

Q_1^* is the foreign output of good 1; Q_S and Q_{S^*} are the quantities of input S and S^* respectively. To produce one unit of good 1, at least one unit of input S and one unit of input S^* are required. To minimize production cost, one unit of each input is used to produce one unit of good 1. Foreign has the same market size and demand

[19] Good 1 produced in Home and Foreign are assumed to be homogeneous for convenience, as in Spencer and Qiu (2001). It is possible for a final good to be homogeneous even though they are produced with different inputs. For example, if the input is human capital, then it is possible for different human capital to make homogenous product.

function as that of Home. Denote foreign demand function as $Q_1^* = Q_1^*(P_1^*)$. The foreign final-good producer buys both input S and input S^* from foreign competitive markets, so $P_S^* = C_S^*$, $P_{S^*}^* = C_{S^*}^*$, where C_S^* and $C_{S^*}^*$ are the constant foreign marginal cost of producing input S and S^* respectively. It chooses Q_1^* to maximise its payoff Π_1^*

(29) $$\max_{Q_1^*} \Pi_1^* = \left[P_1^*(Q_1^*) - P_S^* - P_{S^*}^* \right] Q_1^*$$

FOC for (29):

(30) $$P_1^{*}{}'(Q_1^*)Q_1^* + P_1^*(Q_1^*) - P_S^* - P_{S^*}^* = 0$$

The optimal output Q_1^* satisfies (30). Substitute Q_1^* into (29) yields the optimal payoff for the foreign final-good producer

(31) $$\Pi_1^* = \left[P_1^*(Q_1^*) - P_S^* - P_{S^*}^* \right] Q_1^*.$$

To summarize Chapter 3, under autarky, the domestic final-good producer buys both standardized and non-standardized inputs domestically. It produces good 1 and holds a monopoly domestically. (20) and (21) give the payoffs of the domestic final-good producer and domestic input supplier of N respectively. The foreign final-good producer buys both standardized inputs from the foreign competitive markets. It produces good 1 and holds a monopoly in Foreign, getting a payoff given by (31).

4. Partial free trade agreement negotiations model

This model involves three stages: stage 1, stage 2 and stage 3.

In stage 1, the domestic input supplier strategically chooses k units of RSI.

In stage 2, a bilateral partial FTA is reached with a probability $\theta \in (0,1]$.[20] This partial FTA aims at only opening up the final-good market to free trade. θ is exogenously determined and it is common knowledge among all parties in both countries, such as firms and governments.

In stage 3, if FTA is not reached, the remaining game between the two domestic firms is the same as stage 2 under autarky in Section 3.1.1.1 on page 19.

If the partial FTA is reached, trade opens for good 1, but the input market is still closed. Transportation cost is assumed to be zero. There are no further renegotiations or reneging by any government. The two final-good producers sell the homogenous good 1 in an integrated market and compete in quantities, so the standard Cournot model applies (Tirole, 1988). The total market demand for good 1 is the horizontal summation of the two countries' demands

$$Q_1(P_1^{PT}) + Q_1^*(P_1^{PT}).$$

The subscript PT denotes partial free trade; P_1^{PT} is the price for good 1 under partial free trade; $Q_1(P_1^{PT})$ and $Q_1^*(P_1^{PT})$ are the Cournot equilibrium outputs of the domestic and foreign final-good producers respectively at P_1^{PT}.

[20] $\theta = 0$ is ruled out since there is no need for the two countries to negotiate a FTA if there is no possibility of reaching it.

In stage3, P_N^{PT}, Q_1 and Q_1^* are determined simultaneously by solving a system of three equations simultaneously. Here, P_N^{PT} is the price for input N under partial free trade.

Again, the model is solved backwards.

4.1. Stage 3: Bargaining over input price and output decisions

As mentioned, if the partial FTA is not reached in stage 2, the game remains the same as stage 2 under autarky.

If the partial FTA is reached in stage 2, the domestic final-good producer and the domestic input supplier engage in Nash bargaining over P_N, taking Q_1 and Q_1^* as given.

After k is sunk, $C_N(k)$ is committed. The two domestic firms engage in Nash bargaining over P_N^{PT} which satisfies:

(32) $$P_N^{PT} = \arg\max_{P_N} \left\{\left[P_1^{PT}(Q_1 + Q_1^*) - P_S^{PT} - P_N\right]Q_1 - 0\right\}^{\alpha} \left\{\left[P_N^{PT} - C_N(k)\right]Q_1 - 0\right\}^{1-\alpha},$$

where $\left[P_1^{PT}(Q_1 + Q_1^*) - P_S - P_N^{PT}\right]Q_1$ and $\left[P_N^{PT} - C_N(k)\right]Q_1$ are the respective *ex-post* payoff from bargaining under partial free trade for the domestic final-good producer and the domestic input supplier. Both domestic firms still have zero outside options, as the input market is still closed.

FOC for (32) yields

(33) $P_N^{PT} = P_N^{PT}(k, Q_1, Q_1^*) = C_N(k) + (1-\alpha)\left[P_1^{PT}(Q_1 + Q_1^*) - P_S - C_N(k)\right]$.[21]

The domestic final-good producer chooses Q_1 to solve for

(34) $$\max_{Q_1} \Pi_1^{PT} = \left[P_1^{PT}(Q_1 + Q_1^*) - P_S - P_N^{PT}\right] Q_1$$

subject to (33) $P_N^{PT} = C_N(k) + (1-\alpha)\left[P_1^{PT}(Q_1 + Q_1^*) - P_S - C_N(k)\right]$.

Substitute (33) into (34) :

(35) $$\max_{Q_1} \Pi_1^{PT} = \alpha\left[P_1^{PT}(Q_1 + Q_1^*) - P_S - C_N(k)\right] Q_1$$

The foreign final-good producer chooses Q_1^* to solves for

(36) $$\max_{Q_1^*} \Pi_1^{*PT} = \left[P_1^{PT}(Q_1 + Q_1^*) - P_S^* - P_{S^*}^*\right] Q_1^*$$

The Cournot FOCs for (35) and (36):

(37) $$\begin{aligned} \frac{\partial \Pi_1^{PT}}{\partial Q_1} &= \frac{\partial P_1^{PT}(Q_1 + Q_1^*)}{\partial Q_1} Q_1 + P_1^{PT}(Q_1 + Q_1^*) - P_S - C_N(k) = 0, \\ \frac{\partial \Pi_1^{*PT}}{\partial Q_1^*} &= \frac{\partial P_1^{PT}(Q_1 + Q_1^*)}{\partial Q_1^*} Q_1^* + P_1^{PT}(Q_1 + Q_1^*) - P_S^* - P_{S^*}^* = 0 \end{aligned}$$ [22]

The above conditions guarantee that the FOCs solve for a unique Cournot-Nash equilibrium outputs $\left(Q_1^{PT}(k, P_S, P_S^*, P_{S^*}^*), Q_1^{*PT}(k, P_S, P_S^*, P_{S^*}^*)\right)$.

Define $R^{PT}(k)$ as the optimal surplus from agreement under partial free trade between the two firms. It equals to the total value of the asset subtracted by each firm's outside options under partial free trade:

(38) $$\begin{aligned} R^{PT}(k) &= \left[P_1^{PT}\left(Q_1^{PT}(\cdot) + Q_1^{*PT}(\cdot)\right)\right] Q_1^{PT}(\cdot) - 0 - 0 \\ &= \left[P_1^{PT}(\cdot) - P_S - C_N(k)\right] Q_1^{PT}(\cdot) \end{aligned}$$

[21] The derivation is analogous to that of (4), as shown in A.1 in Appendix.

[22] Note that the domestic final-good producer chooses the output that maximises both its own payoff and the joint surplus under partial free trade, because its payoff is proportional to the latter. Thus, when competing with its foreign counterpart, it is as if its own marginal cost is $P_S + C_N(k)$.

Proposition 3. *The surplus $R(k)^{PT}$ under partial free trade is increasing in k.*

Proof. See A.2 in Appendix.

From (80) in the proof,

(39) $$R'(k)^{PT} = P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k)Q_1^{PT}(k) + (-C_N{}'(k))Q_1^{PT}(k) > 0$$

Under partial free trade, additional unit of investment not only reduces the cost of input N across the domestic final-good producer's equilibrium output, but also increases the equilibrium price through decreasing the foreign final-good producer's equilibrium output. The two effects both increase the surplus under partial free trade.

In sum, the *ex-ante* payoffs of domestic and foreign final-good producers as well as the domestic input supplier under partial free trade are

$$\Pi_1^{PT} = \alpha\left\{\left[P_1^{PT}(\cdot) - P_S - C_N(k)\right]Q_1^{PT}(k)\right\} = \alpha R^{PT}(k)$$

$$\Pi_1^{*PT} = \left[P_1^{PT}(\cdot) - P_S^* - P_{S^*}^*\right]Q_1^{*PT}(k)$$

$$\pi_N^{PT} = \left[P_N^{PT}(k) - C_N(k)\right]Q_1^{PT}(k) = (1-\alpha)R^{PT}(k) - k.$$

4.2. Stage 2: Partial FTA reached or not reached

The partial FTA is reached with probability $\theta \in (0,1]$. No decision making is required for any firms.

4.3. Stage 1: Relationship-specific investment

The domestic input supplier chooses investment under partial FTA negotiations to maximise its *expected* profit

(40) $$\max_{k} E\pi_{N}^{PT}(k) = \theta\pi_{N}^{PT}(k) + (1-\theta)\pi_{N}(k)$$

The subscript E denotes the expected value; θ is the probability of reaching the partial FTA; $\pi_{N}^{PT}(k)$ is the domestic input supplier's partial-trade profit if the partial FTA is reached given an investment k; $\pi_{N}(k)$ is its autarky profit, given the same investment.

For $\theta \in (0,1]$, it solves for

(41) $$\begin{aligned}&\max_{k} E\pi_{N}^{PT}(k) = \theta\pi_{N}^{PT}(k) + (1-\theta)\pi_{N}(k)\\ &= \theta\left[(1-\alpha)R^{PT}(k) - k\right] + (1-\theta)\left[(1-\alpha)R(k) - k\right]\\ &= (1-\alpha)R(k) + \theta(1-\alpha)\left[R^{PT}(k) - R(k)\right] - k\end{aligned}$$

FOC for (41):

(42) $$\frac{dE\pi_{N}^{PT}}{dk} = (1-\alpha)R'(k) + \theta(1-\alpha)\left[R^{PT}{}'(k) - R'(k)\right] - 1 = 0.$$

Denote EMB^{PT} as the *expected* marginal benefit from investment under the partial FTA negotiations

(43) $$\begin{aligned}&EMB^{PT}(k) = \theta(1-\alpha)R^{PT}{}'(k) + (1-\theta)(1-\alpha)R'(k)\\ &= (1-\alpha)R'(k) + \theta(1-\alpha)\left[R^{PT}{}'(k) - R'(k)\right]\end{aligned}.$$

SOC for (41):

(44) $$\frac{d^2E\pi_{N}^{PT}}{dk^2} = R''(k) + \theta\left[R^{PT}{}''(k) - R''(k)\right] < 0$$

From (17), $R''(k) < 0$, for (44) to hold for any $\theta \in (0,1]$, we need $R^{PT}{}''(k) < 0$.

Thus, (44) is equivalent in assuming

(45) $$R^{PT}''(k) < 0 .$$

The above conditions ensure that the FOC solves for a unique maximiser, which is assumed to be interior: $k^{PT} \in [0, K]$. k^{PT} satisfies (42):

(46) $$EMB^{PT}(k^{PT}) = 1 \ ,$$

At k^{PT}, $E\pi_N^{PT}$ is maximised.

Substitute k^{PT} into (41) to get the optimal $w\pi_N^{PT}$ which is assumed to be nonnegative:

(47) $$E\pi_N^{PT}(k^{PT}) \geq 0 .$$

4.3.1. Investment under autarky vs. investment under partial FTA negotiations

Proposition 4.

(i) The hold-up problem that results in underinvestment is alleviated under Partial FTA negotiations in two cases: (ii.1) the partial-trade output is above the autarky output $Q_1^{PT}(k^A) \geq Q_1(k^A)$ *; (ii.2) the partial-trade output is less than the autarky output* $Q_1^{PT}(k^A) < Q_1(k^A)$ *and* $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) \geq -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$.

(ii) The hold-up problem that results in underinvestment is aggravated under partial FTA negotiations if the partial-trade output is less than the autarky output $Q_1^{PT}(k^A) < Q_1(k^A)$ *and* $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$.

(iii) Ceteris paribus, the magnitudes of aggravation in (i) and alleviation in (ii) both

increase in the probability of reaching the partial FTA, θ .

Proof. See A.3 in Appendix.

Denote the total effect of opening up the final-good market on the optimal investment under autarky k^A as the "output competitive effect". To examine this "output competitive effect", the key is to analyse the difference in the marginal benefit from investment under partial free trade from that under autarky, given k^A :

(48)
$$\begin{aligned}&(1-\alpha)R^{PT}{}'(k^A)-(1-\alpha)R'(k^A)\\&=(1-\alpha)P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A)+(1-\alpha)\left(-C_N{}'(k^A)\right)\left[Q_1^{PT}(k^A)-Q_1(k^A)\right]\end{aligned}$$
[23]

If $R^{PT}{}'(k^A)\geq R'(k^A)$, k^A is more valuable once the partial FTA is reached. Thus, the domestic input supplier invests more when there is probability of reaching the partial FTA. Analogously, if $R^{PT}{}'(k^A)<R'(k^A)$, it invests less relative to k^A .

The direct effect of opening up the final-good market on the marginal benefit from investment under autarky as given by (48) can be decomposed into two effects: a "strategic effect" and a "cost effect".

The "strategic effect" is represented by the first term

$$(1-\alpha)P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A).$$

Since this term is always positive, the "strategic effect" always puts *upward* pressure on k^A. This is because additional unit of investment at k^A reduces the domestic final-good producer's marginal cost. Thus, it has a direct positive effect on the Cournot equilibrium price through reducing the foreign final-good producer's

[23] (48) is derived from (12) and (80).

partial-trade output. Higher equilibrium price raises revenue across partial-trade output of the domestic final-good producer, so the investment is more valuable.

The "cost effect" is given by the second term

$$(1-\alpha)\left(-C_N'(k^A)\right)\left[Q_1^{PT}(k^A)-Q_1(k^A)\right]$$

This "cost effect" on k^A may be positive or negative depending on the difference between the partial-trade output and the autarky output, given k^A. The ***absolute value*** of the second term,

$$(1-\alpha)\left(-C_N'(k^A)\right)\left|Q_1^{PT}(k^A)-Q_1(k^A)\right|$$

indicates the *strength* of the "cost effect". The "cost effect" on k^A is positive if $Q_1^{PT}(k^A)\geq Q_1(k^A)$ since investment is more valuable by reducing costs across larger partial-trade output. The "cost effect" is negative if $Q_1^{PT}(k^A)<Q_1(k^A)$, since investment is less valuable by reducing costs across smaller partial-trade output.

From (48), the total effect of opening up the final-good market on k^A is a combination of the "strategic effect" and the "cost effect". If $Q_1^{PT}(k^A)\geq Q_1(k^A)$, the two effects work in the same direction, and both put *upward* pressures on k^A. If $Q_1^{PT}(k^A)<Q_1(k^A)$, the two effects work in the opposite directions. Although the "strategic effect" has *upward* pressure, the "cost effect" puts *downward* pressure on k^A. So the total effect depends on which effect dominates. The following three cases discuss these situations.

Case 1.

If $Q_1^{PT}(k^A)\geq Q_1(k^A)$, both the "strategic effect" and "cost effect" put *upward* pressures on k^A, so the investment under partial free trade is higher relative to autarky.

Consequently, if there is *probability* of opening up final-good market, there exists a chance to have higher marginal benefit from investment relative to autarky. Thus, $EMB^{PT}(k^A) > MB^A(k^A)$, the domestic input supplier invests more under partial FTA negotiations relative to autarky, $k^{PT} \geq k^A$.

Case 2.

If $Q_1^{PT}(k^A) < Q_1(k^A)$, and the positive "strategic effect" is stronger than the negative "cost effect", i.e., $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) \geq -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$, then the total effect puts *upward* pressure on k^A. Following the same argument above, the domestic input supplier invests more under partial FTA negotiations relative to autarky, $k^{PT} \geq k^A$.

Case 3.

If $Q_1^{PT}(k^A) < Q_1(k^A)$, and the negative "cost effect" is stronger than positive "strategic effect", i.e., $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$, then the total effect puts *downward* pressure on k^A. The domestic input supplier invests less under partial FTA negotiations relative to autarky, $k^{PT} < k^A$.

The probability of reaching the partial FTA θ serves as an "intensifier" of the difference between $EMB^{PT}(k^A)$ and $MB^A(k^A)$, which is represented by $\theta(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right]$. Thus, as in case 1 and case 2 when $k^{PT} \geq k^A$, if the probability rises, the domestic input supplier has higher chance of getting *higher* marginal benefit from investment, so it invests even higher k^{PT} relative to k^A. Hold-up problem is further alleviated. However, in case 3 when $k^{PT} < k^A$, if the probability rises, the domestic input supplier has higher chance of getting *lower* marginal benefit from investment, so it invests even lower relative to k^A. The hold-up problem is further aggravated.

- **Example for Proposition 4**

This example uses the same functions and parameters as in previous examples, and the following additional parameters:

the price for foreign input S

$P_S = 8$;

the price for foreign input S^*

$P^*_{S^*} = 15$;

and the probability of reaching the partial FTA

$\theta = 0.5$.

The following results are calculated.

The investment under partial FTA negotiations

$$k^{PT} = 15.69$$

There is underinvestment under partial FTA negotiations relative to autarky

$$k^{PT} - k^A = -16.96 < 0$$

The partial-trade output is less than the autarky output

$$Q_1^{PT}(k^A) - Q_1(k^A) = -13.24 < 0$$

The negative "cost effect" outweighs the positive "strategic effect"

$$P_1^{PT}{}'(\cdot)\, Q_1^{*PT}{}'(k^A)\, Q_1^{PT}(k^A) = 0.28 < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right| = 1.44$$

This example has the same conditions as in case 3, as predicted by Proposition 4 (ii), the investment under partial FTA negotiations is less than the investment under autarky

$$k^{PT} < k^{A} \quad .$$

Figure 2 is plotted to show the relationship between the probability of reaching the partial FTA, θ, and the magnitude of the underinvestment $k^{PT} - k^{A}$. The horizontal axis measures θ, and the vertical axis measures k. Figure 2 illustrates that k^{A} is independent of θ. Since under autarky, it is certain to get $MB^{A} = (1-\alpha)R(k^{A})$. Under partial FTA negotiations, as θ rises, it is more likely to get $(1-\alpha)R^{RT}(k^{A})$ which is less than MB^{A}, so $E\,MB^{PT}(k^{A})$ falls and less investment is chosen. Thus, the magnitude of the underinvestment $k^{PT} - k^{A}$ increases, which verifies Proposition 4 (iii).

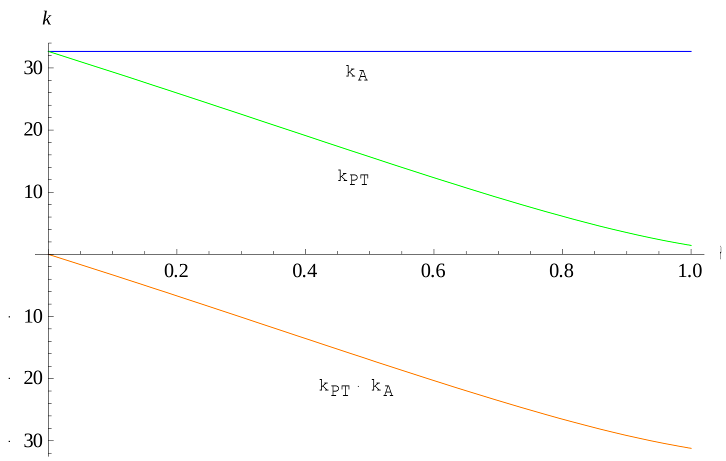

Figure 2

It is notable that the results of Proposition 1 are based on whether the partial-free output $Q_1^{PT}(k^{A})$ exceeds the autarky output $Q_1(k^{A})$ or not, given k^{A}. In fact, there are two well-known driving forces behind this. One is that the total equilibrium outputs are larger that the summation of monopoly outputs, since the markets are more competitive under Cournot competition relative to monopoly (Church and Ware, 1999). Since the two markets are of equal size, even if they are equally efficient, each final-good producer produces higher output under Cournot competition relative to its monopoly output under autarky. The other is that the Cournot equilibrium output of a producer is increasing in its relative efficiency to its counterpart (Church and Ware, 1999). Whether the output under partial free trade is higher than the output under autarky is ambiguous since it depends on both driving forces discussed above.

To sum up Chapter 4, there is less underinvestment under partial FTA negotiations in two scenarios. One is when the domestic final-good producer's equilibrium output is higher than its autarky output, given the optimal investment under autarky unchanged. The other is when the former output is less than the latter, but the strategic effect outweighs the cost effect. There is further underinvestment under partial FTA negotiations when the former output is less than the latter, but the cost effect outweighs the strategic effect.

5. Free trade agreement negotiations model

The setting of this model is similar to that of the partial FTA negotiations model, except that once the partial FTA is reached, not only the final-good market, but the *input market* is also open. This model also involves three stages: stage 1, stage 2 and stage 3.

In stage 1, the domestic input supplier strategically chooses k units of RSI.

In stage 2, a bilateral FTA is reached with a probability $\theta \in (0,1]$, θ is exogenously determined.

In stage 3, if FTA is not reached, the remaining game between the two domestic firms is the same as stage 2 under autarky in Section 3.1.1.1 on page 19.

If the FTA is reached, trade opens in both the final-good market and input market. Thus the integrated world market demand function for good 1 is

$$Q_1(P_1^T) + Q_1^*(P_1^T)$$

where P_1^T is the price for the final-good under free trade, with the subscript T denoting the free trade; $Q_1(P_1^T)$ and $Q_1^*(P_1^T)$ are the Cournot equilibrium outputs of the domestic and foreign countries respectively at P_1^T.

Because input S produced domestically is a perfect substitute for input S produced overseas, and the markets of input S are perfectly competitive in both countries, both the domestic and foreign final-good producers buy input S at the competitive price from the market with lower marginal cost:

(49) $$P_S^T = \min\{P_S, P_S^*\}$$

However, input N and S^* are heterogeneous. The domestic final-good producer needs to incur a per-unit modification cost $\delta \in (0,\infty)$ in terms of quantity of input S^*, to turn input S^* into a perfect substitute for input N. That is, one unit of input N is to be equivalent to $1+\delta$ of input S^*. It has a production function

(50) $$Q_1 = f\left(Q_S,\ Q_N\right) = \min\left(Q_S,\ Q_N\right) = \min\left(Q_S,\ \frac{Q_{S^*}}{1+\delta}\right)$$

Analogously, the foreign final-good producer incurs a per-unit modification cost $\delta^* \in (0,\infty)$ in terms of quantity of input N to make N a perfect substitute for S^*. It has a production function

$$Q_1^* = \min\left(Q_S,\ Q_{S^*}\right) = \min\left(Q_S,\ \frac{Q_N}{1+\delta^*}\right)$$

To focus on the domestic market, the following assumption is made for simplicity.

ASSUMPTION 1. *The lowest marginal cost of input N possible given the investment constraint of the domestic input supplier is still higher than the marginal cost of input* S^* *in Foreign :* $C_N(K) > C^*_{S^*}$.

This assumption simplifies the model by removing the possibility that the foreign final-good producer has the option to buy from the domestic input supplier.

Denote $\min P_N^T$ as the lowest price for input N under FTA negotiations.

Under this assumption, we have $\min P_N^T(1+\delta^*) > \min P_N^T > C_N(K) > C^*_{S^*} = P^*_{S^*}$ because:

i. $\min P_N^T(1+\delta^*) > \min P_N^T$ since $\delta^* > 0$

ii. $\min P_N^T > C_N(K)$ is because: the domestic input supplier's ex-ante profit is $\left[P_N^T(k) - C_N(k)\right]Q_1 - k$, thus positive profit implies that $P_N^T(k) > C_N(k)$. Since $C_N(k) \geq C_N(K), \forall k \in [0, K]$, we get $P_N^T(k) > C_N(k) \geq C_N(K), \forall k \in [0, K]$ which implies that any price for input N (including the minimum price) exceeds the lowest marginal cost of input N. Otherwise, the ex-ante profit is negative since the ex-ante investment cost is not recoverable for certain.

iii. In Foreign, the input S^* is produced competitively, so $C^*_{S^*} = P^*_{S^*}$.

Under this assumption, because the lowest price for "modified" input N is still higher than that for input S^*, the foreign final-good producer never switches to buy input N once the FTA is reached.

In stage3, P_N, Q_1 and Q_1^* are determined simultaneously by solving a system of three equations simultaneously.

Again, the model is solved backwards.

5.1. Stage 3: Bargaining over input price and output decisions

If FTA is reached in stage 2, the two domestic firms bargain over P_N^T, taking Q_1 and Q_1^* as given. The following two sections evaluate the payoffs of the domestic final-good producer associated with its two procurement options.

5.1.1. Outside option

If the domestic final-good producer switches to buy input S^* from the foreign input supplier, it solves for

$$\max_{Q_1} \Pi_1 = \left[P_1^T(Q_1 + Q_1^*) - P_S^T - (1+\delta)P_{S^*}^* \right] Q_1$$

where $P_S^T = \min\left\{C_S^*, C_S\right\}$ is from (49), indicating that the standard input S is bought from the competitive market with lower marginal cost; $(1+\delta)P_{S^*}^*$ is from (50), referring to the domestic final-good producer's marginal cost of the *"modified"* foreign input S^*.

Under Assumption 1, the foreign final-good producer still buys both inputs from the foreign competitive markets. It solves for

$$\max_{Q_1^*} \Pi_1^* = \left[P_1^T(Q_1 + Q_1^*) - P_S^T - P_{S^*}^* \right] Q_1^*$$

The Cournot FOCs:

(51) $$\frac{\partial \Pi_1}{\partial Q_1} = \frac{\partial P_1^T(\cdot)}{\partial Q_1} Q_1 + P_1^T(\cdot) - P_S^T - (1+\delta) P_{S^*}^* = 0$$

(52) $$\frac{\partial \Pi_1^*}{\partial Q_1^*} = \frac{\partial P_1^T(\cdot)}{\partial Q_1^*} Q_1^* + P_1^T(\cdot) - P_S^T - P_{S^*}^* = 0$$

The Cournot SOCs and the stability condition:

(53) $$\frac{\partial^2 \Pi_1}{\partial Q_1^2} = \frac{\partial P_1^{T2}(\cdot)}{\partial Q_1^2} Q_1 + 2\frac{\partial P_1^T(\cdot)}{\partial Q_1} < 0$$

$$\frac{\partial^2 \Pi_1^*}{\partial Q_1^{*2}} = \frac{\partial P_1^{T2}(\cdot)}{\partial Q_1^{*2}} Q_1^* + 2\frac{\partial P_1^T(\cdot)}{\partial Q_1^*} < 0$$

$$\frac{\partial^2 \Pi_1}{\partial Q_1^2} \frac{\partial^2 \Pi_1^*}{\partial Q_1^{*2}} - \frac{\partial^2 \Pi_1}{\partial Q_1 Q_1^*} \frac{\partial^2 \Pi_1^*}{\partial Q_1^* Q_1} > 0$$

The above conditions guarantee that the FOCs solve for a unique Cournot-Nash equilibrium $\left(\bar{Q}_1(\delta, P_S^T, P_{S^*}^*), \bar{Q}_1^*(\delta, P_S^T, P_{S^*}^*) \right)$.

Since $\frac{\partial P_1(\cdot)}{\partial Q_1} = \frac{\partial P_1(\cdot)}{\partial Q_1^*}$, subtracting (51) by (52) yields

$$\frac{\partial P_1^T(\cdot)}{\partial Q_1}(Q_1 - Q_1^*) - \delta P_{S^*}^* = 0$$

Substitute $\left(\bar{Q}_1, \bar{Q}_1^* \right)$ into the above equation and rearrange to obtain

(54) $$\bar{Q}_1 = \bar{Q}_1^* - \frac{\delta P_{S^*}^*}{-\frac{\partial P_1^T(\cdot)}{\partial Q_1}} < \bar{Q}_1^*$$

implying that at the equilibrium, the domestic final-good producer produces less than the foreign good producer since it has higher marginal cost. The magnitude of this difference in outputs increases in the modification cost δ and $P_{S^*}^*$ but decreases in the marginal effect of output on the final-good price.

Given $\left(\bar{Q}_1, \bar{Q}_1^*\right)$, the respective equilibrium payoffs for the two producers are

$$\bar{\Pi}_1(P_s^T, \delta, P_{s^*}^*) = \max\{0, \left[P_1^T\left(\bar{Q}_1(\cdot)+\bar{Q}_1^*(\cdot)\right) - P_s^T - (1+\delta)P_{s^*}^*\right]\bar{Q}_1(\cdot)\}$$

$$\bar{\Pi}_1^*(P_s^T, \delta, P_{s^*}^*) = \max\{0, \left[P_1^T\left(\bar{Q}_1(\cdot)+\bar{Q}_1^*(\cdot)\right) - P_s^T - P_{s^*}^*\right]\bar{Q}_1^*(\cdot)\}$$

Note that if δ and $P_{s^*}^*$ are sufficiently high, the domestic final-good producer's outside option is nonbinding since $\bar{\Pi}_1 = 0$.

It is well known that in a Cournot duopoly model, if one firm's marginal cost goes up, *ceteris paribus*, its equilibrium output and payoff falls, and the other firm's equilibrium output and payoff rises (Church and Ware, 1999) . Since δ is part of the domestic final-good producer's marginal cost, its equilibrium output and payoff are decreasing in δ, but the equilibrium output and payoff of the foreign final-good producer are increasing in δ,i.e.,

(55) $$\frac{\partial \bar{Q}_1(\cdot)}{\partial \delta} < 0, \frac{\partial \bar{Q}_1^*(\cdot)}{\partial \delta} > 0$$

(56) $$\frac{\partial \bar{\Pi}_1(\cdot)}{\partial \delta} < 0, \frac{\partial \bar{\Pi}_1^*(\cdot)}{\partial \delta} > 0$$

To sum up Section 5.1.1, denote Π_1^T, Π_1^{*T} and π_N^T as the respective *ex-ante* payoffs for the domestic and foreign final-good producers as well as the domestic input supplier *under free trade*. If switching occurs, the respective payoffs are

$\Pi_1^T = \bar{\Pi}_1$

$\Pi_1^{*T} = \bar{\Pi}_1^*$

$\pi_N^T = -k, \ k \geq 0$

5.1.2. Inside option

If the domestic final-good producer still deals with the domestic input supplier, the two firms engage in Nash bargaining over P_N that satisfies:

$$(57) \qquad P_N^T = \arg\max_{P_N} \left\{ \left[P_1^T(Q_1 + Q_1^*) - P_S^T - P_N \right] Q_1 - \bar{\Pi}_1 \right\}^{\alpha} \left\{ \left[P_N - C_N(k) \right] Q_1 - 0 \right\}^{1-\alpha}$$

where $\left[P_1^T(Q_1 + Q_1^*) - P_S^T - P_N \right] Q_1$ and $\left[P_N - C_N(k) \right] Q_1$ are the respective *ex-post* payoffs from bargaining under FTA negotiations for the domestic final-good producer and the domestic input supplier. $\bar{\Pi}_1$ is the domestic final-good producer's payoff from its outside option if it switches. The domestic input supplier still has zero outside option, since the foreign final-good producer never switches to it under Assumption 1. FOC for (57) solves for

$$(58) \; P_N^T = P_N^T(k, Q_1, Q_1^*) = C_N(k) + (1-\alpha)\left[P_1^T(\cdot) - P_S^T - C_N(k) - \frac{\bar{\Pi}_1}{Q_1} \right].$$ [24]

The domestic final-good producer chooses Q_1 to solve for

$$(59) \qquad \max_{Q_1} \Pi_1 = \left[P_1^T(\cdot) - P_S^T - P_N^T \right] Q_1$$

subject to (58) $P_N^T = C_N(k) + (1-\alpha)\left[P_1^T(\cdot) - P_S^T - C_N(k) - \frac{\bar{\Pi}_1}{Q_1} \right].$

Substitute (58) into (59) and solve for

$$(60) \qquad \begin{aligned} \max_{Q_1} \Pi_1 &= \bar{\Pi}_1 + \alpha \left\{ \left[P_1^T(\cdot) - P_S^T - C_N(k) \right] Q_1 - \bar{\Pi}_1 \right\} \\ &= \alpha \left[P_1^T(\cdot) - P_S^T - C_N(k) \right] Q_1 + (1-\alpha)\bar{\Pi}_1 \end{aligned}$$

The foreign final-good producer chooses Q_1^* to solves for

$$(61) \qquad \max_{Q_1^*} \Pi_1^* = \left[P_1^T(\cdot) - P_S^T - P_{S^*}^* \right] Q_1^*$$

[24] The derivation is analogous to that of (4), shown in A.1 in Appendix.

The Cournot FOCs for (60) and (61):

(62)
$$\frac{\partial \Pi_1}{\partial Q_1} = \frac{\partial P_1^T(\cdot)}{\partial Q_1} Q_1 + P_1^T(\cdot) - P_S^T - C_N(k) = 0,$$
$$\frac{\partial \Pi_1^*}{\partial Q_1^*} = \frac{\partial P_1^T(\cdot)}{\partial Q_1^*} Q_1^* + P_1^T(\cdot) - P_S^T - P_{S^*}^* = 0$$

The Cournot SOCs and stability conditions are the same as (53).

The above conditions guarantee that the FOCs solve for a unique Cournot-Nash equilibrium outputs $\left(Q_1^T(k, P_S^T, P_{S^*}^*), Q_1^{*T}(k, P_S^T, P_{S^*}^*)\right)$. Note that δ does not affect the equilibrium outputs once the domestic final-good producer chooses not to switch.

Define $R(k)^T$ as the *optimal* surplus from agreement under free trade

(63)
$$R(k)^T = \left[P_1^T(\cdot) - P_S^T - C_N(k)\right] Q_1^T(k) - \bar{\Pi}_1 - 0$$
$$= \left[P_1^T(\cdot) - P_S^T - C_N(k)\right] Q_1^T(k) - \bar{\Pi}_1$$

Proposition 5. *Given that δ and $P_{S^*}^*$, are sufficiently low so that the outside option is binding ($\bar{\Pi}_1 > 0$),*

(i) the surplus under free trade $R(k)^T$ is increasing in k , $P_{S^*}^*$ and δ , but decreasing in P_S^T ;

(ii) the marginal benefit from investment under free trade $(1-\alpha)R'(k)^T$ is independent of δ. Thus, δ does not affect the investment decision under FTA negotiations.

Proof. See A.4 in Appendix.

Intuition for (i)

If δ and $P^*_{S^*}$ are sufficiently low so that the outside option is binding, the surplus under free trade is increasing in investment since the investment reduces cost across all output. The surplus under free trade is also increasing in $P^*_{S^*}$ and δ because the outside option of buying the foreign input S^* decreases when $P^*_{S^*}$ or δ rises.

Intuition for (ii)

Since the final good producer still uses the input N, not the "modified" input S^*, if its outside option is nonbinding, the modification cost of δ does not affect the marginal benefit from investment under free trade. Consequently, it does not affect the investment decisions under FTA negotiations, which depends on a weighted-average of the marginal benefit from investment under free trade and under autarky (*expected* marginal benefit from investment under FTA negotiations).

To sum up Section 5.1.2, if no switching occurs, the respective *ex-ante* payoffs of domestic and foreign final-good producers, and the domestic input supplier under FTA negotiations are

$$\Pi_1^T = \overline{\Pi}_1 + \alpha\left\{\left[P_1^T(\cdot) - P_S^T - C_N(k)\right]Q_1^T(k) - \overline{\Pi}_1\right\} = \overline{\Pi}_1 + \alpha R(k)^T$$

$$\Pi_1^{*T} = \left[P_1^T(\cdot) - P_S^T - P^*_{S^*}\right]Q_1^{*T}(k)$$

$$\pi_N^T = \left[P_N(k) - C_N(k)\right]Q_1^T(k) = (1-\alpha)R(k)^T - k$$

5.1.3. Buying from domestic input supplier vs. buying from foreign input supplier

Proposition 6. *Let* $\hat{k}$ *be the threshold investment that satisfies* $C_N(\hat{k}) = (1+\delta)P^*_{S^*}$. *Once the FTA is reached, (i) the domestic final-good producer remains dealing with the domestic input supplier if and only if* $\hat{k} \le k \le K$. *(ii) the domestic final-good producer switches to the foreign input supplier if and only if* $k < \hat{k}$.

Proof. See A.5 in Appendix.

The surplus under free trade $\mathrm{R(k)}^{\mathrm{T}}$ is monotonically increasing in investment, and $\mathrm{R(k)}^{\mathrm{T}} = 0$ at the threshold $\hat{\mathrm{k}}$. If the domestic input supplier just invests the threshold level $\hat{\mathrm{k}}$, then the domestic final-good producer's inside option and outside option are equal, so the producer is indifferent between remaining and switching. It remains dealing with the domestic input supplier if the supplier invests an above-threshold investment as in (i). This high investment creates a nonnegative surplus under free trade and promotes trading between the two domestic firms. However, it switches to the foreign supplier if the domestic input supplier chooses a below-threshold investment as in (ii). This low investment creates a negative surplus under free trade, which prohibits trading between the two domestic firms.

5.2. Stage 2: FTA reached or not reached

The FTA is reached with probability $\theta \in (0,1]$. No decision making is required for any firms.

5.3. Stage 1: Relationship-specific investment

The domestic input supplier chooses investment level under FTA negotiations to maximise its *probability-expected* profit

$$\max_{k} E\pi_N^T(k) = \theta\pi_N^T(k) + (1-\theta)\pi_N(k), \tag{64}$$

where $\pi_N^T(k)$ is the domestic input supplier's payoff under free trade if FTA is reached, given investment level k; $\pi_N(k)$ is its autarky payoff given the same investment.

Since $\pi_N^T(k)$ depends on whether k is above or below the threshold investment level $\hat{k}$:

$$\pi_N^T(k) = \begin{cases} -k & \text{if } k \le \hat{k} \\ (1-\alpha)R(k)^T - k & \text{if } k > \hat{k}, \end{cases}$$

there are two cases with two possible payoffs for the domestic input supplier to compare: (i) $k \le \hat{k}$ and (ii) $k > \hat{k}$.

5.3.1. Expected profit created by below-threshold investment

Let the optimal investment in this case be k^L. The subscript L denotes “lower than threshold”.

The profit maximisation problem is

(65)
$$\max_k E\pi_N^T(k) = \theta\pi_N^T(k) + (1-\theta)\pi_N(k) = \theta(-k) + (1-\theta)\left[(1-\alpha)R(k) - k\right]$$
$$= (1-\theta)(1-\alpha)R(k) - k$$

FOC for (65):

(66)
$$\frac{dE\pi_N^T(k)}{dk} = (1-\theta)(1-\alpha)R'(k) - 1 = 0$$

Denote $EMB_L^T(k)$ as the *expected* marginal benefit from investment under FTA negotiations given a below-threshold investment

(67)
$$EMB_L^T(k) = (1-\theta)(1-\alpha)R'(k)$$

SOC for (65):

(68)
$$\frac{d^2E\pi_N^T(k)}{dk^2} = R''(k) < 0$$

The above conditions ensure that the FOC solves for a unique maximiser, which is assumed to be interior: $k^L \in [0, K]$. k^L satisfies (66):

(69)
$$EMB_L^T(k^L) = (1-\theta)(1-\alpha)R'(k^L) = 1$$

implying that the expected marginal benefit equals the marginal cost of investment at k^L under FTA negotiations.

Obviously, the solution to (69) is valid if and only if it not only satisfies its definition, $k^L \leq \hat{k}$, but also creates a nonnegative expected profit, $E\pi_N^T(k^L) \geq 0$.

Existence of solution to (69) does not guarantee that the solution satisfies both conditions.

5.3.2. Expected profit created by above-threshold investment

For $\theta \in (0,1]$, the rent maximisation problem is

$$\max_k E\pi_N^T(k) = \theta\pi_N^T(k) + (1-\theta)\pi_N(k)$$

(70) $$= \theta\left[(1-\alpha)R(k)^T - k\right] + (1-\theta)\left[(1-\alpha)R(k) - k\right]$$

$$= (1-\theta)(1-\alpha)R(k) + \theta(1-\alpha)R(k)^T - k$$

FOC for (70):

(71) $$\frac{dE\pi_N^T(k)}{dk} = (1-\theta)(1-\alpha)R'(k) - \theta(1-\alpha)R'(k)^T - 1 = 0$$

Denote $EMB_H^T(k)$ as the *expected* marginal benefit from investment under FTA negotiations given an above-threshold investment

(72) $$\begin{aligned} EMB_H^T(k) &= \theta(1-\alpha)R'(k)^T + (1-\theta)(1-\alpha)R'(k) \\ &= (1-\alpha)R'(k) + \theta(1-\alpha)\left[R'(k)^T - R'(k)\right] \end{aligned}.$$

SOC for (70):

(73) $$\frac{d^2E\pi_N^T(k)}{dk^2} = (1-\theta)R''(k) + \theta R''(k)^T < 0$$

(73) is equivalent in assuming[25]

(74) $$R''(k)^T < 0$$

The above conditions ensure that the FOC solves for a unique maximiser, which is

[25] Analogous to deriving $R^{PT}''(k) < 0$ in (45).

assumed to be interior: $k^H \in [0, K]$. The subscript H denotes "higher than threshold". k^H must satisfy (71):

(75) $$EMB_H^T(k^H) = (1-\theta)(1-\alpha)R'(k^H) - \theta(1-\alpha)R'(k^H)^T = 1,$$

implying that at k^H, the expected marginal benefit from investment equals the marginal cost of investment under FTA negotiations.

Obviously, the solution to (75) is valid if and only if it not only satisfies its definition, $k^H > \hat{k}$, but also creates a nonnegative expected profit $E\pi_N^T(k^H) \geq 0$.[26]

In the following, we show that $k^H > k^L$ by comparing (75) and (69).

Rearrange(69) to get $R'(k^L) = \dfrac{1}{(1-\theta)(1-\alpha)}$.

Rearrange (75) to get $R'(k^H) = \dfrac{1}{(1-\theta)(1-\alpha)} - \dfrac{\theta}{1-\theta}R'(k^H)^T$.

Since $R'(k^H)$ has an extra negative term $-\dfrac{\theta}{1-\theta}R'(k^H)^T$, we have $R'(k^H) < R'(k^L)$.

Since $R''(k) < 0$, we get $k^H > k^L$ as expected.

5.3.3. Below-threshold investment vs. above-threshold investment

Whether the domestic input supplier chooses k^L or k^H depends on which one is larger, $E\pi_N^T(k^L)$ or $E\pi_N^T(k^H)$:

[26] Existence of solution to (69) does not guarantee that the solution satisfies both conditions.

$$E\pi_N^T(k^H) - E\pi_N^T(k^L)$$

$$(76) \qquad = (1-\alpha)\left\{R(k^H) - \theta\left[R(k^H) - R(k^H)^T\right]\right\} - k^H - \left[(1-\theta)(1-\alpha)R(k^L) - k^L\right]$$

$$= (1-\alpha)\left\{\theta R(k^H)^T + (1-\theta)\left[R(k^H) - R(k^L)\right]\right\} - \left(k^H - k^L\right)$$

Firstly consider $E\pi_N^T(k^H) < E\pi_N^T(k^L)$,

From (77), $E\pi_N^T(k^H) < E\pi_N^T(k^L)$ is equivalent to

$$(77) \qquad (1-\alpha)\left\{\theta R(k^H)^T + (1-\theta)\left[R(k^H) - R(k^L)\right]\right\} < k^H - k^L$$

That is, the additional cost exceeds the additional benefit from choosing k^H. Then, the domestic input supplier chooses k^L and gets $E\pi_N^T(k^L)$.

Note that what the domestic input supplier tries to maximise is the *expected* payoff. Therefore, although in stage 1, it knows that if the FTA is reached in stage 2, it will incur the negative rent $\pi_N^T(k^L) = -k^L$ for certain, it still chooses k^L as there is possibility that it can get $\pi_N(k^L) = (1-\alpha)R(k^L) - k^L > 0$ if the FTA is not reached.

Secondly consider $E\pi_N^T(k^H) \geq E\pi_N^T(k^L)$,

From (77), $E\pi_N^T(k^H) \geq E\pi_N^T(k^L)$ is equivalent to

$$(78) \qquad (1-\alpha)\left\{\theta R(k^H)^T + (1-\theta)\left[R(k^H) - R(k^L)\right]\right\} \geq k^H - k^L$$

That is, the additional benefit exceeds the additional cost from choosing k^H. Then, it chooses k^H and gets $E\pi_N^T(k^H)$.

5.4. Investment under FTA negotiations vs. investment under FTA negotiations

Proposition 7. *(i) the investment under FTA negotiations is no more than that* *under partial FTA negotiations in two cases: (i.1)* k^H *is chosen but* $R'(k^{PT})^T < R'(k^{PT})^{PT}$ *; (i.2)* k^L *is chosen ;(ii) the investment under FTA negotiations is higher than that under partial FTA negotiations if* k^H *is chosen and* $R'(k^{PT})^T \geq R'(k^{PT})^{PT}$*. (iii)The magnitude of the difference between the investments under FTA negotiations and under partial FTA negotiations depends on the probability of reaching the FTA,* θ*. (iv) Sufficiently high* δ *is a necessary but not a sufficient condition for* k^H *to be chosen.*

Proof. See A.6 in Appendix.

Intuition for (i)and (ii)

Denote the total effect of opening up the input market on the investment under partial free trade k^{PT} as the "input substitution effect". This is because the only difference between partial free trade and free trade is that if the domestic input S is more expensive than foreign input S; the domestic final-good producer can substitute cheaper foreign inputs for more expensive domestic inputs.

There are two cases to consider since there are two investment options under FTA negotiations, k^{H} or k^{L}.

Case 1. k^{H} is chosen

The key is to examine this "input substitution effect" in this case is to analyse the difference between the marginal benefit from investment under free trade and that under partial free trade, given k^{PT}:

$$(79)\qquad \begin{aligned}&(1-\alpha)R'(k^{PT})^{T}-(1-\alpha)R'(k^{PT})^{PT}\\&=(1-\alpha)\left[P_1^{T}{}'(\cdot)Q_1^{*T}{}'(k^{PT})Q_1^{T}(k^{PT})-P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^{PT})Q_1^{PT}(k^{PT})\right]+\\&(1-\alpha)(-C_N{}'(k^{PT}))\left[Q_1^{T}(k^{PT})-Q_1^{PT}(k^{PT})\right]\end{aligned}$$

This is because if $R'(k^{PT})^{T}\geq R'(k^{PT})^{PT}$, k^{PT} is more valuable under free trade relative to partial free trade. Ceteris paribus, the domestic input supplier invests more under FTA negotiations relative to partial FTA negotiations, $k^{H}\geq k^{PT}$. Analogously, if $R'(k^{PT})^{T}<R'(k^{PT})^{PT}$, it invests less, $k^{H}<k^{PT}$. So the "input substitution effect" is positive if $R'(k^{PT})^{T}\geq R'(k^{PT})^{PT}$ and negative if $R'(k^{PT})^{T}<R'(k^{PT})^{PT}$.

The effect of opening up the input market on the marginal benefit from investment under autarky as given by (79) can also be decomposed into two effects: a "strategic effect" and a "cost effect" of opening up free trade.

The "strategic effect" is represented by the first term

$$(1-\alpha)\left[P_1^{T}{}'(\cdot)Q_1^{*T}{}'(k^{PT})Q_1^{T}(k^{PT})-P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^{PT})Q_1^{PT}(k^{PT})\right].$$

Unlike the "strategic effect" of the "output competitive effect" which is always positive, the sign of this "strategic effect" of the "input substitution effect" is ambiguous. Applying the explanation on page 40, additional investment at k^{PT}[27] has a direct positive effect on the *partial-trade price* through reducing the foreign final-good producer's partial-trade output. Higher *partial-trade price* raises *partial-trade revenue* across *partial-trade output* of the domestic final-good producer. However, under free trade, additional investment at k^{PT} also has a direct positive effect on the *free-trade price* which raises *free-trade revenue* across *free-trade output* of the domestic final-good producer. Since given k^{PT}, the domestic final-good

[27] The explanation on page 40 not only applies to k^{A}, but also applies to any k.

producer's *partial-trade output* $Q_1^{PT}(k^{PT})$ and *free-trade output* $Q_1^{T}(k^{PT})$ may be different, the abilities of additional investment in raising the *partial-trade price* $P_1^{T}'(\cdot)Q_1^{*T}'(k^{PT})$ and *free-trade price* $P_1^{PT}'(\cdot)Q_1^{*PT}'(k^{PT})$ may be different, as it depends on the characteristics of the input N's cost function and the characteristics of the final-good demand function . The above differences in outputs and impact on prices may cause the "strategic effect" of "input substitution effect" on k^{PT} to be positive, negative or zero.

The "cost effect" is given by the second term

$$(1-\alpha)(-C_N'(k^{PT}))\left[Q_1^{T}(k^{PT})-Q_1^{PT}(k^{PT})\right].$$

The analysis of the "cost effect" of opening up free trade is similar to that of opening up partial free trade. The strength of the "cost effect" of opening up free trade is the ***absolute value*** of the second term

$$(1-\alpha)(-C_N'(k^{PT}))\left|Q_1^{T}(k^{PT})-Q_1^{PT}(k^{PT})\right|$$

Firstly, the "cost effect" puts *upward* pressure on k^{PT} if $Q_1^{T}(k^{PT})\geq Q_1^{PT}(k^{PT})$. This is because additional unit of investment is more valuable as it reduces the marginal cost of input N across higher output under partial free trade. Secondly, the "cost effect" puts *downward* pressure on k^{PT} if $Q_1^{T}(k^{PT})<Q_1^{PT}(k^{PT})$.

From (80), the "input substitution effect" on k^{PT} is a summation of the "strategic effect" and "cost effect". The "input substitution effect" is ambiguous as it depends on whether the two effects work in the same direction or not. If not, it depends on which effect dominates.

Case 2. k^{L} is chosen

k^L is lower than k^{PT} for certain. This is because the domestic final-good producer still deals with the domestic input supplier once the partial FTA is reached. Given k^{PT}, the domestic input supplier still gets positive profit $(1-\alpha)R'(k^{PT})^{PT}-k^{PT}$. But once the FTA is reached, given k^L, the domestic final-good producer switches. So the domestic input supplier gets negative profit $-k^L$. Since the probabilities of reaching the partial FTA and FTA are the same, $k^L < k^{PT}$, i.e., this example has a negative "input substitution effect" .

Intuition for (iii)

Te intuition for (iii) is analogous to that for Proposition 4 (iii).

Intuition for (iv)

Consider the extreme case where the modification cost δ is close to zero. Then the domestic final-good producer's outside option is to buy the foreign input S^* at a price close to $P^*_{S^*}$. Under Assumption 1, the lowest price for input N is still higher than the foreign input S^* $\min P_N(k) > P^*_{S^*}$. The domestic final-good producer switches to its outside option once the FTA is reached. So it is optimal to choose k^L, implying that no valid k^H exists. In other words, k^H is chosen implies that δ is sufficiently high.

However, high δ does not implies that k^H is always chosen. Consider the other extreme case where the modification cost is infinity. Then the domestic final-good producer's outside option is nonbinding. Even if the FTA is reached, it still does not switch. A valid k^H may exists. From (77)

$$E\pi^T_N(k^H) - E\pi^T_N(k^L)$$
$$=(1-\alpha)\left\{\theta R(k^H)^T + (1-\theta)\left[R(k^H)-R(k^L)\right]\right\} - \left(k^H - k^L\right),$$

whether the valid k^H is chosen over the valid k^L further depends on its bargaining power $1-\alpha$, the probability of reaching the FTA θ, and the characteristics (e.g. curvature) of the $C_N(k)$ function and the final-good demand functions. For example, when $\alpha \to 1$, even if $\delta \to \infty$, it is still possible for $E\pi_N^T(k^H, \delta) \le E\pi_N^T(k^L)$ and k^L to be chosen.

Overall, the modification cost serves as a "protector" for the domestic input supplier against the competition from cheaper foreign substitute (as if it makes the foreign substitute more expensive). Higher modification cost is a necessary but not a sufficient condition for above-threshold investment to be chosen.

Lemma 1. *If the demand functions in the two countries are linear, (i) the investment under FTA negotiations is no more than that under partial FTA negotiations if* $P_S < P_S^*$ *;(ii) the investment under FTA negotiations is higher than that under partial FTA negotiations if* k^H *is chosen and* $P_S \ge P_S^*$.

Proof. See A.7 in Appendix.

For linear demand functions, the term $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^{PT})$ is constant. So the sign of the "input substitution effect" solely depends on the difference in outputs under free trade and partial free trade, given k^{PT}:

$$\begin{aligned}&(1-\alpha)R'(k^{PT})^T-(1-\alpha)R'(k^{PT})^{PT}\\&=(1-\alpha)P_1^T{}'(\cdot)Q_1^{*T}{}'(k^{PT})(-C_N{}'(k^{PT}))\left[Q_1^T(k^{PT})-Q_1^{PT}(k^{PT})\right]\end{aligned}$$

The difference in outputs only comes from the change in costs. Once the input market opens, if $P_S < P_S^*$, the *foreign* final-good producer now benefits by getting cheaper domestic input S. So the *domestic* final-good producer's output falls under free trade relative to partial free trade. So $k^H < k^{PT}$. Since $k^L < k^{PT}$ also holds for linear demand function, $P_S < P_S^*$ serves as the condition for the underinvestment relative to k^{PT}. Analogously, if $P_S \geq P_S^*$, $k^H \geq k^{PT}$.

- **Example for Proposition 7 and Lemma 1**

This example uses the same functions and parameters as previous examples, and the following additional function and parameter:

the demand function for good 1 in Foreign: $Q_1^* = a - bP_1$

the modification cost of foreign input S^*:

$\delta = 2.5$.

The below-threshold investment under FTA negotiations is $k^L = 7.11$, which is less than the investment under partial FTA negotiations

$$k^L - k^{PT} = -8.57 < 0$$

The above-threshold investment under FTA negotiations is $k^H = 21.00$, which is higher than the investment under partial FTA negotiations

$$k^H - k^{PT} = 5.31 > 0$$

The expected profit from the above-threshold investment is higher than that from the below-threshold investment

$$E\pi_N^T(k^H) - E\pi_N^T(k^L) = 10.85 > 0$$

Thus, k^H is chosen.

As predicted by Proposition 4 (iv), k^H is chosen implies that δ is sufficiently high.

In this example, $\delta = 2.5$ is sufficiently high, as it requires 2.5 units of foreign input S^* as per-unit modification cost.

The marginal benefit from investment under free trade is higher relative to partial free trade $(1-\alpha)R^{T}{}'(k^{PT}) > (1-\alpha)R^{PT}{}'(k^{PT})$ because

$$R^{T}{}'(k^{PT}) = 1.67 > R^{PT}{}'(k^{PT}) = 1.23$$

Since k^H is chosen and $R^{T}{}'(k^{PT}) > R^{PT}{}'(k^{PT})$, so this example has the same conditions as in Proposition 7 (ii), as predicted, the above-threshold investment under FTA negotiations is higher than the investment under partial FTA negotiations

$$k^H > k^{PT}$$

In addition, this example also verifies Lemma 1. Firstly, the final-good demand functions in the two countries are linear. Secondly, the standardized input S produced domestically is more expensive that that produced in Foreign:

$$P_S = 10 > P_S^* = 8$$

So the domestic final-good producer benefits by getting cheaper foreign input S^*. The domestic final-good producer's output rises under free trade relative to partial free trade, given k^{PT}. Thus, the "input substitution effect" is positive, whose sign solely depends on the difference in the above outputs. As predicted by Lemma 1,

$$k^H > k^{PT}.$$

5.5. Summary

In stage 1, the domestic input supplier chooses investment level.

In stage 2, all firms know whether FTA is reached or not.

In stage 3, the final-good producer makes input procurement decision.

There are four cases to consider:

Case 1: k^L **is chosen and FTA is reached**

Since $\alpha R(k^L)^T \le 0, \bar{\Pi}_1 + \alpha R(k^L)^T \le \bar{\Pi}_1$. The domestic final-good producer can access to its binding outside option and switches to the foreign input supplier. The respective rents for the domestic and foreign final-good producers and the domestic input supplier *under free trade* are

$$\Pi_1^T = \bar{\Pi}_1$$

$$\Pi_1^{*T} = \bar{\Pi}_1^*$$

$$\pi_N^T = -k^L$$

Case 2: k^L **is chosen and FTA is not reached**

The two domestic firms remain trading. The respective payoffs are

$$\Pi_1 = \alpha R(k^L)$$

$$\Pi_1^* = \Pi_1^*$$

$$\pi_N = (1-\alpha)R(k^L) - k^L$$

Case 3: k^H **is chosen and FTA is reached**

Since $\alpha R(k^H)^T > 0, \bar{\Pi}_1 + \alpha R(k^H)^T > \bar{\Pi}_1$. Although the domestic final-good producer can access to its outside option, since its outside option is nonbinding, it cannot switch. The respective payoffs are

$$\Pi_1^T = \alpha R(k^H)^T$$

$$\Pi_1^{*T} = \Pi_1^{*T}(k^H)$$

$\pi_N^T = (1-\alpha)R(k^H)^T - k^H$

Case 4: k^H **is chosen and FTA is not reached**

The two domestic firms remain trading. The respective payoffs are

$\Pi_1 = \alpha R(k^H)$

Π_1^*

$\pi_N = (1-\alpha)R(k^H) - k^H$

5.6. Investment under FTA negotiations vs. investment under autarky

Proposition 8. *(i) The total effect of FTA negotiations on the investment under autarky is a combination of the "output competitive effect" and the "input substitution effect". (ii) The magnitude of the difference between the above two investments depends on the probability of reaching the FTA,* θ .

Proof. See A.8 in Appendix.

Since under free trade, there are both free trade in the final-good market and input market, the effect of opening up free trade on the optimal investment under autarky k^A can be decomposed into the "output competitive effect" of opening up final-good market, and the "input substitution effect" of opening up the input market. Thus, when there is probability of reaching a FTA, whether the investment is above or below k^A

is a combination of the two effects. The magnitude of the difference between investment under FTA negotiations and k^A depends on the probability of reaching the FTA, θ.

It is notable that there are more cases in which a further underinvestment under FTA negotiations relative to under autarky is observed. This is because of Assumption 1, which assumes that the production of foreign input S^* is always more efficient that of input N, even with the domestic input N supplier undertake the highest investment.

- **Example for Proposition 8**

Using the same functions and parameters as previous examples, the following figure is plotted, which summarises the derivation of different investments. The horizontal axis measures the relationship-specific investment k. The vertical axis measures the marginal benefit and marginal cost of investment.

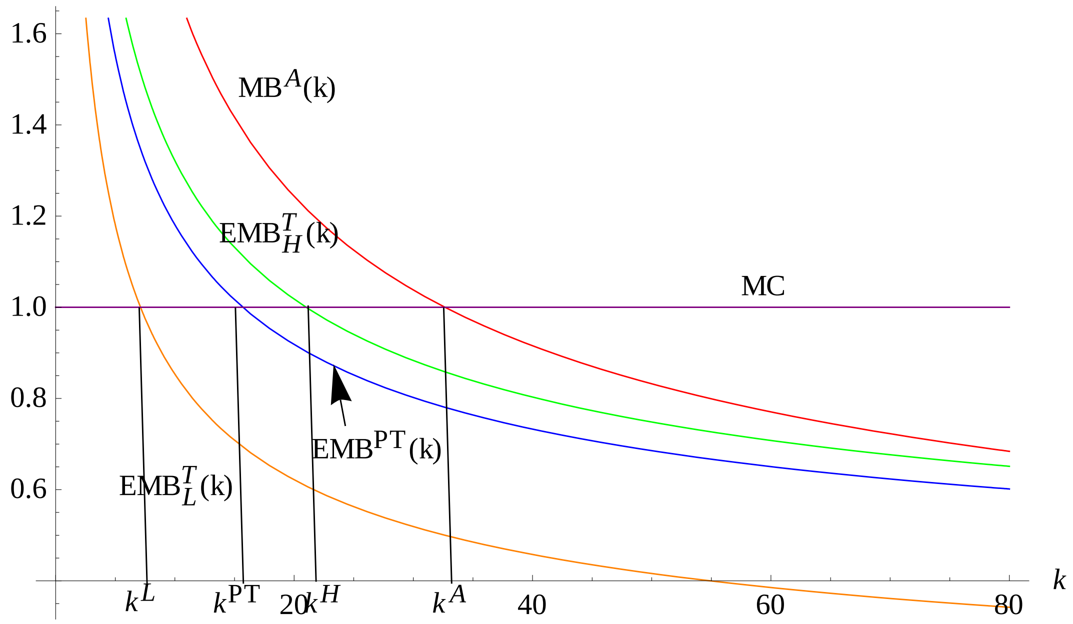

Figure 3

The marginal benefit from investment under autarky is

$$MB^{A} = (1-\alpha)R'(k)$$

The *expected* marginal benefit from investment under partial FTA negotiations is

$$EMB^{PT} = (1-\alpha)R'(k) + \theta\left[R^{PT}{}'(k) - R'(k)\right]$$

The *expected* marginal benefit from investment under FTA negotiations given the above-threshold and below-threshold investment are

$$EMB_{H}^{T} = (1-\alpha)R'(k) + \theta\left[R^{T}{}'(k) - R'(k)\right]$$

$$EMB_{L}^{T} = (1-\theta)(1-\alpha)R'(k)$$

respectively.

k^{A}, k^{PT}, k^{H} and k^{L} are the investment levels given by the intersections of the above four curves with the marginal cost of investment curve $MC = 1$ respectively. Then the domestic input supplier's profit or expected profit is maximised in each case.

In this example, k^{H} is chosen. From Figure 3

$$k^{PT} < k^{H} < k^{A},$$

which implies that the negative "output competitive effect" which causes $k^{PT} < k^{A}$ outweighs the positive "input substitution effect" which causes $k^{PT} < k^{H}$ in this example. Overall, the presence of FTA negotiations aggravates the *domestic* HUP.

6. Results

This paper demonstrates that it is possible for the *domestic* hold-up problem to be either aggravated or alleviated in the presence of FTA negotiations. The magnitude of aggravation or alleviation is intensified by the probability of reaching the FTA. Since the FTA open up both the final-good and the input markets, whether aggravation or alleviation occurs depends on the combination of the “output competitive effect” resulted from free trade in the final-good market, and the “input substitution effect” resulted from free trade in the input market. Both the “output competitive effect” and the “input substitution effect” can be further decomposed into a “strategic effect” and a “cost effect”. The “strategic effect” comes from the change in the impact of additional investment on the final-good total revenue through the investment’s direct effect on the final-good price. The “cost effect” comes from the change in the impact of additional investment on the final-good total cost through the change in final-good output. There are three fundamental driving forces behind the “strategic effect” and the “cost effect”: (1) the characteristics of the cost function for the non-standardised input; (2) the characteristics of final-good’s demand function; (3) the relative efficiency of the two final-good producers in the two countries. The modification cost of the foreign input serves as a “protector” for the domestic input supplier. In this model, higher relationship-specific investment is more likely to be undertaken by the domestic input supplier only if the modification cost is sufficiently high.

7. Conclusion

This study originally presents a formal model which identifies the impact of potential free trade on the underinvestment resulting from the *domestic* HUP. It also explores the driving forces behind the impacts. Consequently, from the theoretical perspective, this model constitutes an attempt for formal demonstration of the productive efficiency gains or losses resulting from potential free trade (Wes, 2000). It serves as one example showing that free trade is a "double-edged sword" and it may or may not increase efficiency.

The immediate policy implication from this study is to provide more accurate welfare assessment, especially for the FTA negotiators and the competition policy makers. Firstly, consider the implication for the FTA negotiators. If the presence of FTA negotiations causes aggravation of the *domestic* HUP, the negotiators need to assess this welfare loss against the possible welfare gains arising from the domestic final-good producer's access of cheaper foreign inputs. Gradual rather than radical trade liberalization in the input market may be one option. Secondly, consider the implication for the competition policy makers. If the presence of FTA negotiations causes severe aggravation of the *domestic* HUP, this may become justification for vertical integration[28] (Williamson, 1975, Klein et al., 1978). The competition policy makers also need to assess welfare changes carefully before allowing the two domestic firms to merge.

In order to focus on the fundamental driving forces behind the impact of FTA negotiations on the *domestic* HUP, this paper involves simplifying approaches and assumptions when constructing models. The main limitations of this paper lie in those simplifications. Firstly, it adopts a partial equilibrium approach and does not take into account the difference between countries in factor endowments and shift in consumer demand for the final-good. Secondly, it only allows the RSI to be undertaken by one firm in one country, and the two countries are of equal size. Future work can extend this

[28] For instance, if the FTA negotiations are expected to be considerably time-consuming, the domestic final-good producer may prefer merging as it takes into account of the cost of waiting for accessing cheaper foreign inputs when calculating its *expected* payoff. The domestic input supplier may also prefer merging if its *expected* payoff under non-vertical integration is less than that under vertical integration, in the presence of FTA negotiations.

model by examining the issue in a more complex setting of *two-sided* RSI[29] in each country and there are multiple countries with different market sizes. Thirdly, it rules out the possibility for the foreign final-good producer to procure inputs from the domestic non-standardised input supplier. If this is allowed, the model is expected to yield more interesting results as the domestic input supplier no longer has zero outside option. The results are likely to depend on the relative sizes of outside options for the two domestic firms. Fourthly, the probability of reaching the FTA is assumed to be common knowledge among all parties. One possible extension is to introduce information asymmetry among firms regarding this probability. Fifthly, current analysis restricts attention to *ex-ante* investment incentives by assuming that the *ex-post* bargaining is always efficient. Following the recent development in theories of the firm[30], future applications can loosen this assumption and explore the organization forms in a more comprehensive way. Last but not least, the results derived in this paper are subject to future empirical tests.

[29] Both the final-good producer and the input supplier undertake RSI.
[30] See page 10.

Appendix

A.1 Derivation of the autarky-price for input N

$$P_N = \arg\max_{P_N} \left\{\left[P_1(Q_1) - P_s - P_N\right]Q_1 - 0\right\}^{\alpha} \left\{\left[P_N - C_N(k)\right]Q_1 - 0\right\}^{1-\alpha}$$

$$= \arg\max_{P_N} \left[P_1(Q_1) - P_s - P_N\right]^{\alpha} \left[P_N - C_N(k)\right]^{1-\alpha} Q_1$$

FOC:

$$\frac{d\left[P_1(Q_1) - P_s - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1}{dP_N} = -\alpha\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1 -$$

$$(1-\alpha)\left[P_1(Q_1) - P_s - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{-\alpha} Q_1 = 0$$

$$\alpha\left[P_N - C_N(k)\right] + (1-\alpha)\left[P_1(Q_1) - P_s - P_N\right] = 0$$

$$\frac{P_1(Q_1) - P_s - P_N}{P_N - C_N(k)} = \frac{\alpha}{1-\alpha}$$

$$P_N = C_N(k) + (1-\alpha)\left[P_1(Q_1) - P_S - C_N(k)\right]$$

SOC:

$$\frac{d\begin{Bmatrix} -\alpha\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1 \\ -(1-\alpha)\left[P_1(Q_1) - P_s - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{-\alpha} Q_1 \end{Bmatrix}}{dP_N}$$

$$= -\alpha Q_1 \begin{Bmatrix} -(\alpha-1)\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-2}\left[P_N - C_N(k)\right]^{1-\alpha} Q_1 \\ +(1-\alpha)\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{-\alpha} \end{Bmatrix}$$

$$-(1-\alpha)Q_1 \begin{Bmatrix} -\alpha\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{-\alpha} \\ -\alpha\left[P_1(Q_1) - P_s - P_N\right]^{\alpha}\left[P_N - C_N(k)\right]^{-\alpha-1} \end{Bmatrix}$$

$$= -\alpha Q_1(1-\alpha)\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-2}\left[P_N - C_N(k)\right]^{-\alpha}\left[P_N - C_N(k) + P_1(Q_1) - P_s - P_N\right]$$

$$+\alpha(1-\alpha)Q_1\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-1}\left[P_N - C_N(k)\right]^{-\alpha-1}\left[P_N - C_N(k) + P_1(Q_1) - P_s - P_N\right]$$

$$= -\alpha(1-\alpha)Q_1\left[P_1(Q_1) - P_s - P_N\right]^{\alpha-2}\left[P_N - C_N(k)\right]^{-\alpha-1}\left[P_1(Q_1) - P_s - C_N(k)\right] < 0$$

Non-positive SOC guarantees that the solution

$P_N = C_N(k) + (1-\alpha)\left[P_1(Q_1) - P_S - C_N(k)\right]$ is a maximiser.

A.2 Proof of Proposition 3

Rearranging (37) yields

$P_1^{PT}(\cdot) - P_S - C_N(k) = -\frac{\partial P_1^{PT}(\cdot)}{\partial Q_1^{PT}}$, substitute this equation into $R^{PT}{}'(k)$ yields

$$
\begin{aligned}
R'(k)^{PT} &= \frac{d\{[P_1^{PT}(\cdot) - P_S - C_N(k)]Q_1^{PT}(k)\}}{dk} \\
&= \{P_1^{PT}{}'(\cdot)[Q_1^{PT}{}'(k) + Q_1^{*PT}{}'(k)] - C_N{}'(k)\}Q_1^{PT}(k) + [P_1^{PT}(\cdot) - P_S - C_N(k)]Q_1^{PT}{}'(k) \\
(80) &= \{P_1^{PT}{}'(\cdot)[Q_1^{PT}{}'(k) + Q_1^{*PT}{}'(k)] - C_N{}'(k)\}Q_1^{PT}(k) - P_1^{PT}{}'(\cdot)Q_1^{PT}(k)Q_1^{PT}{}'(k) \\
&= [P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k) - C_N{}'(k)]Q_1^{PT}(k) \\
&= P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k)Q_1^{PT}(k) - C_N{}'(k)Q_1^{PT}(k) > 0
\end{aligned}
$$

where the last inequality is because $P_1^{PT}{}'(\cdot) < 0$, $Q_1^{*PT}{}'(k) = Q_1^{*PT}{}'(Q_1^{PT})Q_1^{PT}{}'(k) < 0$ and $-C_N{}'(k) > 0$.

Q.E.D.

A.3 Proof of Proposition 4

(i) and (ii)

From (17), $R''(k) < 0$ and (45), $R^{PT}{}''(k) < 0$, the expected marginal benefit from investment under partial FTA negotiations is decreasing in k,

(81) $\quad EMB^{PT}{}''(k) = (1-\alpha)R''(k) + \theta(1-\alpha)\left[R^{PT}{}''(k) - R''(k)\right] < 0$

Therefore, to compare k^{PT} and k^A, we only need to compare the expected marginal benefit from investment under partial FTA negotiations given k^{PT} and k^A:

$EMB^{PT}{}'(k^{PT})$ and $EMB^{PT}{}'(k^A)$.

The marginal benefit from investment under partial free trade given k^A is

$(1-\alpha)R^{PT}{}'(k^A) = (1-\alpha)[P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) - C_N{}'(k^A)Q^{PT}(k^A)]$

Case 1. $Q_1^{PT}(k^A) \geq Q_1(k^A)$

The marginal benefit under partial free trade given k^A is higher relative to autarky:

$$(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right]$$
$$= (1-\alpha)P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) + (1-\alpha)\left(-C_N{}'(k^A)\right)\left[Q_1^{PT}(k^A) - Q_1(k^A)\right] \geq 0$$

So the *expected* marginal benefit from investment under partial FTA negotiations given k^A exceeds the marginal benefit from investment under autarky, which equals to the marginal cost of investment:

$$EMB^{PT}{}'(k^A) = (1-\alpha)R'(k^A) + \theta(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right] \geq MB^A(k^A) = 1$$

From (46), the *expected* marginal benefit from investment under partial FTA negotiations given k^{PT} equals to marginal cost of investment:

$$EMB^{PT}{}'(k^{PT}) = 1$$

Therefore,

(82) $EMB^{PT}{}'(k^A) \geq EMB^{PT}{}'(k^{PT}) = 1$

From (81), $EMB^{PT}{}''(k) < 0$,

we have

$$k^{PT} \geq k^A$$

Case 2. $Q_1^{PT}(k^A) < Q_1(k^A)$ and

$$P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) \geq -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$$

The marginal benefit under partial free trade given k^A is higher relative to autarky:

$$(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right]$$
$$= (1-\alpha)P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) + (1-\alpha)\left(-C_N{}'(k^A)\right)\left[Q_1^{PT}(k^A) - Q_1(k^A)\right] \geq 0$$

Following the same reasoning in case 1,

$$k^{PT} \geq k^A.$$

Case 3. $Q_1^{PT}(k^A) < Q_1(k^A)$ and

$$P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$$

The marginal benefit under partial free trade given k^A is lower relative to autarky:

$$(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right]$$
$$= (1-\alpha)P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) + (1-\alpha)\left(-C_N{}'(k^A)\right)\left[Q_1^{PT}(k^A) - Q_1(k^A)\right] < 0$$

Following the reasoning in case 1, but in the opposite direction, we get

$k^{PT} < k^A$.

(iii) From (71), the difference between k^A and k^{PT} is increasing in the difference between the expected marginal benefits from investment under partial FTA, given k^A and k^{PT}:

(83) $$\frac{d\left|k^{PT} - k^A\right|}{d\left|(1-\alpha)R'(k^A) + \theta(1-\alpha)\left[R'(k^A)^{PT} - R'(k^A)\right] - 1\right|} > 0$$

Partially differentiate the denominator of (83) with respect to the probability of reaching the partial FTA, θ,

(84)

$$\frac{\partial\left|(1-\alpha)R'(k^A) + \theta(1-\alpha)\left[R^{PT}{}'(k^A) - R'(k^A)\right] - 1\right|}{\partial\theta} = (1-\alpha)\left|R^{PT}{}'(k^A) - R'(k^A)\right| > 0$$

From (83) and (84),

$$\frac{\partial\left|k^{PT} - k^A\right|}{\partial\theta} > 0$$

implying that the magnitude of difference in k^{PT} and k^A is increasing in the probability of reaching the partial FTA.

Q.E.D.

A.4 Proof of Proposition 5

(i) Analogous to the proof of Proposition 3 (i),

(85) $R^{T}'(k) = \left[P_1^{T}'(\cdot)Q_1^{*T}'(k) - C_N'(k)\right]Q_1^{T}(k) > 0$

Since the outside option is binding $\bar{\Pi}_1 > 0$, partially differentiate $R^{T}(k)$ with respect to δ,

(86) $\dfrac{\partial R^{T}(k)}{\partial \delta} = \dfrac{\partial R^{T}(k)}{\partial \bar{\Pi}_1}\dfrac{\partial \bar{\Pi}_1}{\partial \delta} = -\dfrac{\partial \bar{\Pi}_1}{\partial \delta} = -(-P_{S^*}^{*}\bar{Q}_1) > 0$

Similarly, partially differentiate $R(k)^{T}$ with respect to $P_{S^*}^{*}$,

(87) $\dfrac{\partial R^{T}(k)}{\partial P_{S^*}^{*}} = \dfrac{\partial R^{T}(k)}{\partial \bar{\Pi}_1}\dfrac{\partial \bar{\Pi}_1}{\partial P_{S^*}^{*}} = -\dfrac{\partial \bar{\Pi}_1}{\partial P_{S^*}^{*}} > 0$

(ii) Since the final good producer still uses the input N, not the “modified” input S^* if its outside option is nonbinding, the modification cost of δ does not affect the marginal benefit from investment under free trade, using (85),

(88) $\dfrac{\partial\left((1-\alpha)R^{T}'(k)\right)}{\partial \delta} = -(1-\alpha)\dfrac{\partial\left[P_1^{T}'(\cdot)Q_1^{*T}'(k) - C_N'(k)\right]Q_1^{T}(k)}{\partial \delta} = 0$

From (69) $EMB_L^{T}(k^{L}) = (1-\alpha)(1-\theta)R'(k^{L}) = 1$

and (75) $EMB_H^{T}(k^{H}) = (1-\alpha)R'(k) + \theta(1-\alpha)\left[R^{T}'(k^{H}) - R'(k)\right] = 1$,

Together with (88),

Neither the level of k^{L} or k^{H} is affected by δ.

Q.E.D.

A.5 Proof of Proposition 6

Note that the only difference between the Cournot FOCs (51) (52) for outside option and the Cournot FOCs (62) for inside option is the marginal cost of the non-standardised input. If there is no such difference, i.e., $C_N(\hat{k}) = (1+\delta)P_{S^*}^{*}$, the

FOCs (51) (52) and the FOCs (62) yield the same Cournot equilibrium outputs: $Q_1(\hat{k}) = \bar{Q}_1$ and $Q_1^*(\hat{k}) = \bar{Q}_1^*$. Thus,

(89)
$$\begin{aligned} R^T(\hat{k}) &= \left[P_1^T(\hat{k}) - P_S^T - C_N(\hat{k}) \right] Q_1(\hat{k}) - \bar{\Pi}_1 \\ &= \left[P_1^T(\hat{k}) - P_S^T - C_N(\hat{k}) \right] Q_1(\hat{k}) - \left[P_1^T(\hat{k}) - P_S^T - (1+\delta)P_{S^*}^* \right] \bar{Q}_1 = 0 \end{aligned}$$

There are two cases:

(i) $K \geq k \geq \hat{k}$

$C_N(k)$ is monotonically decreasing in k. Therefore, as long as k is above $\hat{k}$, $C_N(k) < C_N(\hat{k}) = (1+\delta)P_{S^*}^*$.

Since from (85), $R^T{}'(k) > 0$, we get

$R^T(k) \geq R^T(\hat{k}) = 0$

As $\alpha > 0$, $\bar{\Pi}_1 + \alpha R^T(k) \geq \bar{\Pi}_1$.

The domestic final-good producer remains dealing with the domestic input supplier after trade opens to get higher payoff $\bar{\Pi}_1 + \alpha R^T(k)$. When $\alpha R^T(k) = 0$, we assume that the domestic final-good producer still deal with the domestic input supplier as there is no incentive for it to switch.

(ii) $k < \hat{k}$

As long as k is below $\hat{k}$, $(1+\delta)P_{S^*}^* = C_N(\hat{k}) < C_N(k)$. Since $R^T{}'(k) > 0$, we get $R^T(k) < R^T(\hat{k}) = 0$.

As $\alpha > 0$, $\bar{\Pi}_1 + \alpha R^T(k) < \bar{\Pi}_1$.

The domestic final-good producer switches to foreign supplier of S^* to get higher payoff $\bar{\Pi}_1$.

Q.E.D.

A.6 Proof of Proposition 7

(i) and (ii)

From (17), $R''(k) < 0$ and (74), $R^T''(k) < 0$, the *expected* marginal benefit from investment under FTA negotiations is decreasing in k,

(90) $EMB_H^T''(k) = (1-\alpha)R''(k) + \theta(1-\alpha)\left[R^T''(k) - R''(k)\right] < 0$

Case 1. k^H is chosen

Both the expected marginal benefit from investment under free trade given k^H and that under partial free trade given k^{PT} equal to the marginal cost of investment:

(91) $$EMB_H^T(k^H) = EMB^{PT}(k^{PT}) = 1$$

Case 1.1.

If $R^T'(k^{PT}) \geq R^{PT}'(k^{PT})$,

the expected marginal benefit from investment under free trade is higher relative to partial free trade, given k^{PT}:

(92) $EMB_H^T(k^{PT}) \geq EMB^{PT}(k^{PT}) = 1$.

Following the inequality sign in (90) and (91) yield

$EMB_H^T(k^{PT}) \geq EMB_H^T(k^H)$

Since $EMB_H^T''(k) < 0$,

$k^H \geq k^{PT}$.

Case 1.2.

Analogously, If, $R^T'(k^{PT}) < R^{PT}'(k^{PT})$,

$k^H < k^{PT}$.

Case 2. k^{L} is chosen

Since

$$EMB^{PT}(k^{PT}) = (1-\alpha)(1-\theta)R'(k^{L}) = 1,$$

Rearrangement yields

$$R'(k^{L}) - R'(k^{PT}) = \frac{\theta}{1-\theta} R^{PT}{}'(k^{PT}) > 0$$

since $R''(k) < 0, \dfrac{\theta}{1-\theta} > 0$,

$$k^{L} < k^{PT}.$$

(iii) Analogous to the proof of Proposition 4 (iii).

(iv) From (76)

$$E\pi_{N}^{T}(k^{H},\delta) - E\pi_{N}^{T}(k^{L}) = (1-\alpha)\left\{\theta R^{T}(k^{H},\delta) + (1-\theta)\left[R(k^{H}) - R(k^{L})\right]\right\} - \left(k^{H} - k^{L}\right)$$

from (86), $\dfrac{\partial R(k)^{T}}{\partial\delta} > 0$,

(93) $$\frac{\partial\left[E\pi_{N}^{T}(k^{H},\delta) - E\pi_{N}^{T}(k^{L})\right]}{\partial\delta} = (1-\alpha)\theta\frac{\partial R^{T}(k^{H})}{\partial\delta} > 0.$$

Since from (63)

$$\begin{aligned} R^{T}(k) &= \left[P_{1}^{T}(\cdot) - P_{S}^{T} - C_{N}(k)\right]Q_{1}^{T}(k) - \bar{\Pi}_{1} \\ &= \left[P_{1}^{T}(\cdot) - P_{S}^{T} - C_{N}(k)\right]Q_{1}^{T}(k) - \left[P_{1}^{T}(\cdot) - P_{S}^{T} - (1+\delta)P_{S^{*}}^{*}\right]\bar{Q}_{1}(\cdot) \end{aligned}$$

and from Assumption 1

$$C_{N}(k) \geq C_{N}(K) > P_{S^{*}}^{*},$$

for sufficiently small modification cost $\delta \to 0$,

$$R^{T}(k) \leq 0,$$

i.e., valid k^{H} does not exist, only k^{L} can be chosen.

From (92), k^H is *more likely* to be chosen when δ rises.

Thus, k^H is chosen implies that δ is sufficiently high.

However, from (76), high δ does not implies that k^H is always chosen. Whether k^H or k^L to be chosen further depends on α, θ, and the characteristics (e.g. curvature) of the $C_N(k)$ function and the final-good demand functions. For example, when $\alpha \to 1$, even if $\delta \to \infty$, so $\bar{\Pi}_1 = 0$ and a valid k^H exist, it is still possible for $E\pi_N^T(k^H, \delta) - E\pi_N^T(k^L) \leq 0$ and k^L to be chosen.

Q.E.D.

A.7 Proof of Lemma 1

Case 1

For linear demand functions, $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^{PT})$ is constant.

$$(1-\alpha)R^T{}'(k^{PT}) - (1-\alpha)R^{PT}{}'(k^{PT})$$
$$= (1-\alpha)P_1^T{}'(\cdot)Q_1^{*T}{}'(k^{PT})(-C_N{}'(k^{PT}))\left[Q_1^T(k^{PT}) - Q_1^{PT}(k^{PT})\right]$$

If $P_S \geq P_S^*$, $Q_1^T(k^{PT}) \geq Q_1^{PT}(k^{PT})$, then

$(1-\alpha)R^T{}'(k^{PT}) \geq (1-\alpha)R^{PT}{}'(k^{PT})$.

Following the proof in case 1.1 Proposition 7,

$k^H \geq k^{PT}$.

Analogously, If $P_S > P_S^*$, $Q_1^T(k^{PT}) < Q_1^{PT}(k^{PT})$, then

$(1-\alpha)R^T{}'(k^{PT}) < (1-\alpha)R^{PT}{}'(k^{PT})$.

Following the proof in case 1.2 Proposition 7,

$k^H \geq k^{PT}$.

Case 2

Same as Case 2 in Proposition 7.

Q.E.D.

A.8 Proof of Proposition 8

(i)

Combination of the findings of Proposition 4 and Proposition 7 yields the following cases:

Case 1.1 $Q_1^{PT}(k^A) < Q_1(k^A)$, $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$, k^L is chosen

$k^L < k^{PT} < k^A$

Case1.2 $Q_1^{PT}(k^A) < Q_1(k^A)$, $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$, k^H is chosen but $R^T{}'(k^{PT}) < R^{PT}{}'(k^{PT})$

$k^H < k^{PT} < k^A$

Case1.3 $Q_1^{PT}(k^A) < Q_1(k^A)$, $P_1^{PT}{}'(\cdot)Q_1^{*PT}{}'(k^A)Q_1^{PT}(k^A) < -C_N{}'(k^A)\left|Q_1^{PT}(k^A) - Q_1(k^A)\right|$, k^H is chosen and $R^T{}'(k^{PT}) \geq R^{PT}{}'(k^{PT})$

Case1.3.1 "output competitive effect" outweighs "input substitution effect"

$k^{PT} < k^H < k^A$

Case1.3.2 "input substitution effect" outweighs "output competitive effect"

$k^A < k^{PT} < k^H$

Case 2.1 $Q_1^{PT}(k^A) \geq Q_1(k^A)$, k^L is chosen

$k^L < k^A < k^{PT}$

Case 2.2 $Q_1^{PT}(k^A) \geq Q_1(k^A)$, k^H is chosen but $R^T{}'(k^{PT}) < R^{PT}{}'(k^{PT})$

Case2.2.1 "output competitive effect" outweighs "input substitution effect"

$k^{A} < k^{H} < k^{PT}$

Case2.2.2 "input substitution effect" outweighs "output competitive effect"

$k^{H} < k^{A} < k^{PT}$

Case 2.3 $Q_1^{PT}(k^{A}) \geq Q_1(k^{A})$, k^{H} is chosen and $R^{T}'(k^{PT}) \geq R^{PT}'(k^{PT})$

$k^{A} < k^{PT} < k^{H}$

Case3.1 $Q_1^{PT}(k^{A}) < Q_1(k^{A})$, $P_1^{PT}'(\cdot)Q_1^{*PT}'(k^{A})Q_1^{PT}(k^{A}) \geq -C_N'(k^{A})\left|Q_1^{PT}(k^{A}) - Q_1(k^{A})\right|$,

k^{L} is chosen

$k^{L} < k^{A} < k^{PT}$

Case3.2 $Q_1^{PT}(k^{A}) < Q_1(k^{A})$, $P_1^{PT}'(\cdot)Q_1^{*PT}'(k^{A})Q_1^{PT}(k^{A}) \geq -C_N'(k^{A})\left|Q_1^{PT}(k^{A}) - Q_1(k^{A})\right|$,

k^{H} is chosen but $R^{T}'(k^{PT}) < R^{PT}'(k^{PT})$

Case3.2.1 "output competitive effect" outweighs "input substitution effect"

$k^{A} < k^{H} < k^{PT}$

Case3.2.1 "input substitution effect" outweighs "output competitive effect"

$k^{H} < k^{A} < k^{PT}$

Case 3.3 $Q_1^{PT}(k^{A}) < Q_1(k^{A})$, $P_1^{PT}'(\cdot)Q_1^{*PT}'(k^{A})Q_1^{PT}(k^{A}) \geq -C_N'(k^{A})\left|Q_1^{PT}(k^{A}) - Q_1(k^{A})\right|$,

k^{H} is chosen and $R^{T}'(k^{PT}) \geq R^{PT}'(k^{PT})$

$k^{A} < k^{PT} < k^{H}$

(ii)

Analogous to the proof of Proposition 4(iii).

Q.E.D.

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