Strategic Investment and the Gains from Trade

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Abstract: This paper examines how trade liberalisation affects innovation, profits and welfare when firms are engaging in strategic R&D investment. We show that there are multiple equilibria including an autarky equilibrium for a range of high but non-prohibitive trade costs. At lower trade costs, only the trading equilibrium survives. Welfare is U-shaped in the trade costs, so a small fall in trade costs can be welfare reducing. However we find a threshold level of the effectiveness of investment above which trade is always welfare superior to autarky.

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Key words: Reciprocal Markets, Strategic R&D Investment, Trade Costs, Trade Liberalisation, Effectiveness of R&D.

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1. Introduction

In this paper we examine how trade liberalisation affects welfare when firms are engaging in R&D investment. Trade liberalisation can be expected to intensify the competition that firms face. Does more competition encourage innovation? On the one hand, there is the Schumpeterian tradition (Schumpeter (1934, 1942)) emphasizing that monopoly rents give incentives for innovation. On the other hand, there is the view that competition puts pressure on firms to innovate so as not to fall behind. There have been many theoretical papers on the topic, both from a general equilibrium growth theory and from a partial equilibrium IO perspective. Despite the voluminous literature, there does not appear to be a theoretical consensus in the "competition and innovation" debate.[1] However, when it comes to trade liberalisation, there is a greater consensus among authors on the benefits for innovation of trade liberalisation. Many empirical studies suggest that the typical firm improves its productivity performance in response to lower trade costs.[2]

In this paper, international oligopolists choose process R&D. The firms set their R&D in a strategic environment and use it to improve their own profitability in two ways. They do so directly, through a reduction in production costs, and indirectly (strategically) through the effect on their rivals' output. We derive the comparative-static effects of trade liberalisation on outputs, exports, R&D levels, profits and welfare. We show how strategic investment has important implications for the welfare effects of trade liberalisation.

[1] Some highlights in this debate include: Arrow (1962), who concluded that a firm in a competitive industry has a greater incentive to innovate than a monopoly; Dasgupta and Stiglitz (1980), who showed that competition can lead to redundant R&D investment; Aghion et al. (2005), who found an inverted U-shaped relationship between increased competition and innovation; Gilbert (2006), who provides a useful survey of recent state of the competition and innovation debate.

[2] See, for instance, Krishna and Mitra (1998), Pavcnik (2002), Amiti and Konings (2007) and Fernandes (2007)). Trefler (2004), by contrast, finds a reduction in domestic tariffs has no significant impact on firm level productivity. Ederington and McCalman (2007) looking at the Colombian experience with trade liberalisation. They found it tended to raise the productivity of the typical firm in industries with low barriers to entry, small technology gaps, large markets and also large initial levels of protection.

We build on the reciprocal markets (RM) model of trade liberalisation first developed by Brander (1981) and Brander and Krugman (1983). They used the RM model to consider multilateral trade liberalisation between two identical countries, with firms competing in a Cournot manner. They demonstrated that intra-industry trade can occur in equilibrium –even when goods are identical– and that welfare is U-shaped in transport costs. There is no investment in their model.

Unlike in the original RM model, our model allows for firms to make a prior investment in R&D that works to reduce marginal production costs. Hence, when competing, firms choose their investment strategically. In modelling R&D investment, we follow the standard approach in models of strategic investment, pioneered by d'Aspremont and Jacquemin (1988), but, unlike the latter, we do so in an open-economy set-up.

The work most resembling ours is probably that of Van Long, Raff and Stähler (2008). They combine the RM trade liberalisation model with a model of R&D setting firms that is an extension of the Melitz (2003) heterogeneous firms model. But, unlike in our model and that of d'Aspremont and Jacquemin (1988), firms do not choose R&D to manipulate rivals in their model. This turns out to matter significantly for the question whether it is possible that trade, no matter how limited, always yields higher welfare than autarky. Our model allows us to find conditions under which any trade is better than no trade. The reason for this lies in the fact that, in our model, firms choose investment before outputs with the intention to strategically manipulate their rivals' behaviour. We show that, although strategic behaviour is mutually harmful to firms, it benefits innovation and consumers and is welfare improving in an overall sense.

Clearly, if trade costs are sufficiently high, then –just as in the reciprocal markets model without investment– no trade can occur and the firms are monopolists in their own markets. However, unlike in the original RM model, multilateral trade liberalisation will not necessarily result in a unique equilibrium. We find that, in the case of symmetric multilateral trade liberalisation, as trade costs are lowered enough, we pass through a region of trade costs in which there are two stable equilibria. In one of these, there is intra-industry trade and at the other, there is no trade. Further liberalisation leads to a disappearance of the no trade equilibrium. We find that such symmetric multilateral trade liberalisation increases R&D-spending and firm productivity for all trade costs at which trade actually occurs and always benefits consumers. However, it lowers profits at high trade costs but increases them at low trade costs. Nevertheless, firms are always worse off in trading equilibria than under autarky. The U-shaped effect of trade liberalisation on social welfare, found in the standard RM model, persists. However, unlike in the RM model, it is not necessarily true that limited trade liberalisation lowers welfare below the autarky welfare level. In fact, we show that, if R&D is sufficiently effective in lowering costs, trade *always* yields higher welfare than autarky.

In section 2, we develop a RM model with R&D investment. We first discuss firms' optimal output decisions and then derive firms' best response functions in R&D. In section 3, we discuss the effects of multilateral trade liberalisation on R&D, consumer surplus, profits and overall welfare. Section 4 concludes.

2. The model

Consider two countries, "Home" and "Foreign". There are two firms labelled 1 and 2. Firm 1 produces and invests in Home, and is fully owned by Home residents while firm 2 produces and invests in Foreign and is Foreign owned. Firms are identical in all other respects. The Home and the Foreign market are segmented.[3] If firms want to sell in their rival's domestic market, they export and face the same per unit trade cost, t. Note that t is not a tariff. Instead, one can interpret the trade cost as a non-tariff barrier or a transport cost.[4] Demand in Home and Foreign is given by:

$$p = a - Q \tag{1a}$$

and

$$p^* = a - Q^*, \tag{1b}$$

[3] This is a key assumption in RM type models and implies no resale between markets so that, in principal, market prices could differ.

[4] This has implications for the welfare functions. Like in the original RM model, there will not be any tariff revenues to be returned to consumers. Including tariff revenues would actually strengthen the gains from trade liberalisation.

respectively, with $Q = q_1 + q_2$ and $Q^* = q_1^* + q_2^*$; q_i refers to output by firm i ($i = 1, 2$) intended for sale in Home and q_i^* refers to output intended for Foreign. Note that variables referring to the Foreign market are starred.

Each firm undertakes R&D, the costs of which are represented by k_i. Marginal production costs are denoted by c_i. Hence, firm 1's and firm 2's profits are given by:

$$\pi_1 = pq_1 + p^* q_1^* - c_1(q_1 + q_1^*) - tq_1^* - k_1 \tag{2a}$$

and

$$\pi_2 = pq_2 + p^* q_2^* - c_2(q_2 + q_2^*) - tq_2 - k_2 \tag{2b}$$,

respectively.

A firm's R&D affects its marginal production costs. Let $c_i = \bar{c} - x_i$, where x_i represents the reduction in marginal production cost generated by the R&D firm *i* has undertaken. Henceforth, we will refer to x_i as the level of innovation by firm *i*. We define $k_i \equiv x_i^2 / 2\eta$, where η is the effectiveness of R&D. Note that investment reduces marginal production cost at a diminishing rate. This is both for reasons of plausibility and to ensure an interior solution.

Firms play a two-stage game, in which they simultaneously choose R&D in the first stage and subsequently choose outputs for each market in the second stage. Hence, output levels will depend on R&D levels.

2.1. Output

When both firms are active in both markets, each firm maximises its profits in each market given rival output. At this stage, R&D levels are given. Firm 1 and firm 2's respective outputs for the "Home" country are:

$$q_1 = (1/3)(A + t + 2x_1 - x_2) \tag{3a}$$

and

$$q_2 = (1/3)(A - 2t + 2x_2 - x_1) \tag{3b}$$,

while they produce:

$$q_1^* = (1/3)(A - 2t + 2x_1 - x_2) \quad (4a)$$

and

$$q_2^* = (1/3)(A + t + 2x_2 - x_1) \quad (4b)$$

for the "Foreign" country, respectively. We have defined $A \equiv a - \bar{c}$ for convenience.

For a given $t > 0$ and for $x_1 = x_2$, it is clear from expressions (3a)-(4b) that each firm has a larger market share in its domestic market than in the export market. Furthermore, exports are decreasing in t. It is obvious that, at sufficiently high trade cost, trade ceases ($q_2 = q_1^* = 0$) and firms are in autarky. Each firm is then a monopolist in its domestic market, with outputs given by:

$$q_1 = (1/2)(A + x_1) \quad (5a)$$

$$q_2^* = (1/2)(A + x_2) \quad (5b)$$

2.2. Innovation reaction functions

In this subsection, we derive the innovation reaction functions. Since innovation, x_i, is monotonically increasing in R&D, k_i, one can think of the firms as directly choosing their level of innovation (or marginal production cost reduction), x_i. This simplifies the algebraic derivations somewhat. Given that we assume firms to be symmetric, firm 2's reaction function is the mirror image of firm 1's. So, without loss of generality, we will adopt the perspective of firm one.

As a preliminary, note that expressions (3a)-(4b) indicate that, given sufficiently low x_i and sufficiently high x_j ($j \neq i$) and high enough t, it is possible that even when output for the domestic market q_i is positive, the firm is not able to export. Firms only export when the non-negativity constraints on exports, $q_2 \geq 0$ and $q_1^* \geq 0$ are not violated. When the non-negativity constraint on q_2 is just binding, it implies:

$$A - 2t + 2x_2 - x_1 = 0 \tag{6a}$$

When the non-negativity constraint on q_1^* is just binding, we have:

$$A - 2t + 2x_1 - x_2 = 0 \tag{6b}$$

Figure 1 depicts these non-negativity constraints in (x_1, x_2)-space for $t > A/2$. Below the locus $q_2 = 0$, the non-negativity constraint on q_2 is binding. Also, above the locus $q_1^* = 0$, the non-negativity constraint on q_1^* is binding. The two non-negativity constraints on exports divide the (x_1, x_2)-space up in four areas. In area 1, autarky prevails, since $q_1^* = q_2 = 0$. In area 4, neither non-negativity constraint is binding, implying that two-way trade will prevail. In areas 2 and 3, we have one-way trade (only firm 2 exports in area 2 ($q_1^* = 0$), whereas only firm 1 exports in area 3 ($q_2 = 0$)).

Bearing this in mind, let us first consider firm 1's best-response x_1-level when there is two-way trade, that is, when both firms export to each other's domestic market. We denote this best-response function by $R_1^{ee}(x_2)$. Firm 1 then maximises profits given x_2, implying:

$$\frac{d\pi_1}{dx_1} = \frac{\partial \pi_1}{\partial x_1} + \frac{\partial \pi_1}{\partial q_2}\frac{dq_2}{dx_1} + \frac{\partial \pi_1}{\partial q_2^*}\frac{dq_2^*}{dx_1} = 0 \tag{7}$$

with $\partial \pi_1 / \partial x_1 = q_1 + q_1^* - x_1 / \eta$, $\partial \pi_1 / \partial q_2 = -q_1$, $\partial \pi_1 / \partial q_2^* = -q_1^*$ and $dq_2 / dx_1 = dq_2^* / dx_1 = -1/3$ from expressions (3a)-(4b); note that $\partial \pi_1 / \partial q_1 = \partial \pi_1 / \partial q_1^* = 0$ from the final stage. Firm *i*'s best response function is then given by:

$$R_1^{ee}(x_2) = \frac{(4/9)(2A - t) - (8/9)x_2}{1 - (16/9)\eta}\eta \tag{8}$$

We now turn to the best-response function of firm 1 when there is only one-way trade. We first derive the optimal x_1-level when firm 1 does not export ($q_1^* = 0$) and faces competition in its domestic market from firm 2 (q_1 and q_2 are given by expressions (3a) and (3b), respectively, while q_2^* is given by (5b)) and denote this best-response function by $R_1^{0e}(x_2)$. The first-order condition for x_1 is then:

$$\frac{d\pi_1}{dx_1} = \frac{\partial \pi_1}{\partial x_1} + \frac{\partial \pi_1}{\partial q_2}\frac{dq_2}{dx_1} = 0 \tag{9}$$

with $\partial\pi_1 / \partial x_1 = q_1 - x_1 / \eta$, $\partial\pi_1 / \partial q_2 = -q_1$, and $dq_2 / dx_1 = -1/3$. Hence, firm 1's best response function is given by:

$$R_1^{0e}(x_2) = \frac{(4/9)[(A+t) - x_2]}{1-(8/9)\eta}\eta \tag{10}$$

Now we derive the optimal x_1-level when firm 1 exports to and competes in Foreign with firm 2, but does not face any competition from firm 2 in its domestic market ($q_2 = 0$, q_1^* and q_2^* are given by expressions (4a) and (4b), respectively, while q_1 is given by (5a)); denote this best-response function by $R_1^{e0}(x_2)$. The first-order condition for x_1 is then:

$$\frac{d\pi_1}{dx_1} = \frac{\partial \pi_1}{\partial x_1} + \frac{\partial \pi_1}{\partial q_2^*}\frac{dq_2^*}{dx_1} = 0 \tag{11}$$

with $\partial\pi_1 / \partial x_1 = q_1 + q_1^* - x_1 / \eta$, $\partial\pi_1 / \partial q_2^* = -q_1^*$, and $dq_2^* / dx_1 = -1/3$. Now, the best response for firm 1 is:

$$R_1^{e0}(x_2) = \frac{(17/18)A - (8/9)t - (4/9)x_2}{1-(25/18)\eta}\eta \tag{12}$$

Next, we derive the optimal x_1-level in autarky. In autarky, a firm does not choose its R&D strategically as it cannot influence its rival's output through its R&D. In contrast to the regimes with trade, there are no strategic terms and profit maximisation now simply implies:

$$\frac{d\pi_1}{dx_1} = \frac{\partial \pi_1}{\partial x_1} = 0 \tag{13}$$

with $\partial\pi_1 / \partial x_1 = q_1 - x_1 / \eta$. So, the marginal production cost reduction chosen by firm 1 in autarky (denoted by x_1^{00}) is given by:

$$x_1^{00} = \frac{\eta}{2-\eta}A \tag{14}$$

Using Figure 2, we now discuss the best response for firm 1 at all possible x_2-values for given *t*. Expression (8), $R_1^{ee}(x_2)$, is firm 1's best-response function only when there is two-way trade. That is, it is relevant –and therefore depicted– in area 4 only. More specifically, it only applies for $\bar{x}_2 < x_2 < \bar{\bar{x}}_2$. At $x_2 = \bar{\bar{x}}_2$, firm 1 ceases to export to Foreign (i.e., $q_1^* = 0$ for $R_1^{ee}(\bar{\bar{x}}_2)$); at this point $R_1^{ee}(\bar{\bar{x}}_2)$ coincides with the $q_1^* = 0$-locus. Hence, for $x_2 > \bar{\bar{x}}_2$, firm 1's best response to x_2 is $R_1^{0e}(x_2)$ (given by expression (10) and relevant for area 2 in Figure 1). The lower boundary for the two-way trade best response function $R_1^{ee}(x_2)$ occurs at $x_2 = \bar{x}_2$; at that point, firm 2 ceases to export to Home (i.e., $q_2 = 0$ for $R_1^{ee}(\bar{x}_2)$).

Let us now turn to area 1 of Figure 1. In area 1, neither firm is exporting ($q_1^* = q_2 = 0$), and hence each firm chooses its R&D as a monopolist firm in autarky; in other words, firm 1's optimal x_1-level is given by x_1^{00} (expression (14)). Firm 1 will choose the autarky x_1-level as its best response to x_2, for $\underline{\underline{x}}_2 < x_2 < \underline{x}_2$. When x_2 falls just below $\underline{\underline{x}}_2$, firm 1 starts exporting to Foreign, but firm 2 remains active only in its own domestic market (i.e., $q_1^* = 0$ for $R_1^{e0}(\underline{\underline{x}}_2)$); at $\underline{\underline{x}}_2$, $R_1^{e0}(\underline{\underline{x}}_2)$ coincides with the $q_1^* = 0$-locus. Hence, for $x_2 < \underline{\underline{x}}_2$, firm 1's best response to x_2 is $R_1^{e0}(x_2)$ (given by expression (12)). So, $R_1^{e0}(x_2)$ is relevant in area 3 in Figure 2. In Figure 2, at $x_2 = \underline{x}_2$, the upper boundary for firm 1 choosing the autarky x_1-level as its best response to x_2, firm 2's exports to Home are just equal to zero (i.e., $q_2 = 0$).

The range of x_2-values for which we have not yet determined firm 1's best response is $\underline{x}_2 < x_2 < \bar{x}_2$. Define $\tilde{x}_2$ as the x_2-value at which the two non-negativity constraints ($q_1^* = 0$ and $q_2 = 0$) intersect. First, consider x_2-values in the sub-range $\underline{x}_2 < x_2 \leq \tilde{x}_2$. At x_2 slightly above $\underline{x}_2$, firm 1's best response can no longer be the autarky x_1-level (given by expression (14)) since then firms would end up in area 2 in which firm 2's exports are positive. If firm 1 faces competition by firm 2 in Home but is not exporting, its best response is given by $R_1^{0e}(x_2)$ (expression (10)). However, the x_1-level implied by $R_1^{0e}(x_2)$ would be so large that it would violate the non-negativity constraint on firm 2's exports. Hence, firm 1's best response is constrained by $q_2 = 0$ and it has to choose x_1 so that this constraint is not violated (see expression (6a)). The same reasoning holds for all x_2-values in the sub-range $\underline{x}_2 < x_2 \leq \tilde{x}_2$, hence firm 1's (constrained) best response for this sub-range is given by $q_2 = 0$. Next, consider x_2-values in the sub-range $\tilde{x}_2 < x_2 \leq \bar{x}_2$. At x_2 slightly below $\bar{x}_2$, firm 1's best response can no longer be given by the $R_1^{ee}(x_2)$ best response function since it would violate the non-negativity constraint on firm 2's exports. Hence, firm 1's best response is constrained by $q_2 = 0$ and it has to choose x_1 so that this constraint is not violated (see expression (6a)). The same reasoning holds for all x_2-values in the sub-range $\tilde{x}_2 < x_2 \leq \bar{x}_2$, hence firm 1's (constrained) best response is here too given by $q_2 = 0$ and is denoted by $R_1(x_2)\big|_{q_2=0}$.

Table 1 summarises the best response function for firm 1. Note that firm 2's best response function is derived in an analogous way and is completely symmetric.

3. Multilateral trade liberalisation

As we will show in this section the firm's best response function derived in section 2.2 is only valid for a certain range of trade costs. In subsection 3.1, we derive the equilibria of the game for all possible trade cost levels. This allows us to discuss how the equilibrium outcomes change as countries gradually and multilaterally liberalise trade, starting from autarky. Trade liberalisation here implies that countries multilaterally reduce the non-tariff barriers that exist between them. Subsequently, in subsection 3.2, we discuss the impact of this multilateral trade liberalisation on innovation, profits, prices, consumer surplus and, ultimately, on overall welfare. In subsection 3.3, we highlight the significance of strategic investment for our results.

3.1. Equilibria

We distinguish between three ranges of trade cost, in each of which the possible equilibrium outcomes are qualitatively different. In order to define these ranges, it proves useful to define some critical t-values. Define $\hat{t}$ as the critical t-threshold at and above which trade cannot occur in equilibrium. This is the prohibitive trade cost. There is another level of trade cost, $\tilde{t}$, which is defined as the critical t-threshold below which autarky cannot occur in equilibrium. We will show that, unlike in the initial RM model, these two thresholds do not coincide. Instead in this model with strategic investment we have $0 < \tilde{t} < \hat{t}$.

The innovation reaction functions in section 2 were derived for trade costs in the region $\tilde{t} < t < \hat{t}$, that is, for the range of trade costs at which neither trade nor autarky are ruled out. Hence, it proves convenient to discuss the equilibrium outcomes for this case first. Figure 3a depicts both firms' innovation reaction functions (firm 2's reaction function, $R_2(x_1)$, is depicted by the bold dashed kinked line) for $\tilde{t} < t < \hat{t}$. In this case, the reaction functions intersect three times, hence there are three equilibria. The equilibrium at point O is stable and implies autarky; the autarky innovation level for each firm is given by expression (14). The equilibrium at point E is also stable and involves two-way trade; the two-way trade equilibrium level of innovation for each firm is:

$$x_i^{ee} = \frac{(4/9)\eta(2A-t)}{1-(8/9)\eta} \tag{15}$$

The equilibrium in the middle, at point U, is unstable; at U, each firm produces for its domestic market only and chooses its R&D to keep its rival's exports equal to zero. The implied x_i-level is denoted by $x_i\big|_{q_j=0}$ and is equal to:

$$x_i\big|_{q_j=0} = 2t - A \tag{16}$$

with $t > A/2$ in this region.

Suppose that trade costs decrease. As t falls, the non-negativity constraint on firm 1's exports ($q_1^* = 0$) shifts to the left, while the non-negativity constraint on firm 2's exports ($q_2 = 0$) shifts down. As a result, area 1 in Figure 1 contracts, whereas area 4 expands.

We now examine what happens when t falls below $\tilde{t}$. The autarky equilibrium has vanished in this case and, with it, has the unstable equilibrium. Figure 3b shows an example of what the innovation reaction functions will look like when trade costs fall below $\tilde{t}$. They only intersect once (point E); only the two-way trade equilibrium remains.

In the case in which $t \geq \hat{t}$, area 1 in Figure 1 has expanded at the expense of area 4. In fact, the two-way trade equilibrium has disappeared now (and, again, so has the unstable equilibrium) and only the autarky equilibrium survives. This case is depicted in Figure 3c; the reaction functions intersect only once (point O); now the unique equilibrium is autarky.

Let us now consider a process of gradual multilateral trade liberalisation, in which countries start with trade costs above $\hat{t}$ and eventually end up with free trade. As they first liberalise trade and as t falls below $\hat{t}$ but remains above $\tilde{t}$, countries will *either* remain in autarky, *or* start to engage in two-way trade. Only when trade liberalisation is sufficiently drastic, i.e., implying a fall in trade costs such that t falls below $\tilde{t}$, will two-way trade be guaranteed. In short, the path of trade liberalisation is not unique. While a limited degree of trade liberalisation may be sufficient to generate trade between the countries involved, it does not guarantee it. Instead, the integrating countries may be "trapped" in autarky until a more radical degree of trade liberalisation is attained.

The precise path of trade liberalisation that is followed will have implications for countries' welfare levels. These will be discussed in the next subsection.

3.2. Innovation, prices, profits and welfare

We will now look at the effect of multilateral trade liberalisation on innovation, profits, consumer surplus and welfare. As we have seen above, given our assumption that the countries are symmetric and the multilateral trade liberalisation takes a symmetric form, the equilibria themselves are always symmetric. We can therefore focus on the effects of trade liberalisation on the home country as the effects on the foreign country are identical.

The level of innovation is captured by the cost reduction, x_i. Figure 4 depicts innovation as a function of trade costs. As is clear from expression (15), the cost reduction is linear in the trade cost when the firm is trading, with lower *t* leading to more innovation. Since the cost reduction, x_i^{ee}, is monotonically increasing in the level of R&D spending, k_i^{ee}, this too increases when trade costs fall. Furthermore, there is a discrete upward jump in the degree of innovation (cost-reduction) when we move from the autarky to the trading equilibrium. This is due to the fact that R&D is chosen more aggressively when firms face foreign rivals than when they are not trading.

Firms' profits are U-shaped in the trade cost and are higher in autarky than under completely free trade. In the neighbourhood of free trade the trade cost works like a tax reducing the firms' profits. However, when trade costs are nearly prohibitive, they, although reducing profits on export sales, serve to protect the now relatively much more important own market profits from import competition. Hence, in this region profits increase in trade costs. As can be seen in Figure 5, which represents how trade costs affect firm profits, there is a discrete fall in profits when firms start to trade even when the level of trade is infinitesimally small. This is due to the more aggressive way in which R&D is chosen when firms face competition. Compared to monopolist firms under autarky, trading firms set higher total outputs given the level of R&D and they choose their investment more aggressively. From the point of view of the firms, trade is a prisoner's dilemma outcome.

To see how trade affects consumers, consider how it affects consumer surplus. Consumer surplus in the Home country is given by: $CS = Q^2 / 2$. Figure 6 depicts how trade costs affect consumer surplus. Consumption of the imperfectly competitive good increases for two reasons as trade is liberalised. Firstly, total output increases at given R&D levels due to the fall in the level of the trade costs. Secondly, the increase in R&D resulting from trade liberalisation leads to a further increase in output. The net result is that trade liberalisation reduces the price of imperfectly competitive good and raises consumer surplus. Note that the price is always lower and the consumers are better off under trade, no matter how restricted it is, than they are under autarky.

In our model, welfare is the sum of consumer surplus and profit. For the home country, this is given by:

$$W = CS + \pi_1 \qquad (17)$$

Welfare is higher under free trade than autarky but it inherits the property of being U-shaped from the profit function. As a result, small reductions in trade costs from a high level can lead to a fall in welfare. If η, the effectiveness of R&D is low, welfare under restricted trade can fall below the level under autarky. This is illustrated in Figure 7a. However, there exists a level of η high enough such that trade –no matter how limited– yields higher welfare than autarky. This case is depicted in Figure 7b.

3.3. The role of strategic investment

In our model the firms commit to their R&D level in stage one and then choose outputs in the second stage. Hence, the R&D is chosen strategically to affect rival outputs. To see how important this feature of the model is for the welfare benefits of trade liberalisation, consider a hypothetical alternative in which R&D and outputs are chosen simultaneously. We will refer to this as the non-strategic benchmark. In that case the firms cannot use their investments to manipulate rivals strategically. Also, in that case the trade cost thresholds, $\tilde{t}$ and $\hat{t}$ coincide. This means that there is no region with multiple equilibria. Above $\hat{t} = \tilde{t}$, autarky is the unique equilibrium, whereas below $\hat{t} = \tilde{t}$ the trading equilibrium is unique.

In the non-strategic benchmark case, there is no discrete upward jump in the level of innovation when firms move from the autarky to the trade equilibrium (as there is in Figure 4). The reason for this lies in the fact that trading firms do not behave differently when choosing innovation levels than when they are monopolists in autarky. Whether trading or producing in autarky, innovation only affects firm profits directly, i.e., through the investing firm's costs. Hence, firms choose innovation levels that minimises costs. In this case, a small reduction in trade costs from the prohibitive level *always* results in welfare falling below the autarky level, irrespective of the effectiveness of R&D (η). This hypothetical benchmark is represented in Figure 8. In our model of strategic investment, firms also choose their innovation levels to minimise costs under autarky. However, when they compete with their rival in the trading equilibrium, innovation also affects firm profits indirectly, i.e., firms will choose their investment trying to manipulate rival output. It is precisely the fact that firms choose R&D strategically and hence above the level that minimises costs that allows the *possibility* that the trading equilibrium *guarantees* higher welfare than autarky. Strategic investment in the trading equilibrium, combined with a sufficiently high degree of R&D effectiveness, will in fact ensure that trade is welfare superior to autarky throughout the whole process of trade liberalisation.

4. Conclusion

In this paper we have developed a reciprocal markets model with strategic R&D to examine how trade liberalisation affects innovation, profits and welfare. We found that there exists a range of trade costs at which there are two stable equilibria. At one of these equilibria, firms do not export, while there is intra-industry trade at the other. When trade is liberalised further, only the equilibrium with trade continues to exist.

Compared to the autarky equilibrium, the trading equilibrium involves higher R&D spending and innovation. Both profits and welfare are U-shaped in the trade cost. Thus, a small reduction in trade cost can raise profits at low trade costs, even though it causes profits to fall at high trade costs. Similarly, there is a range of trade costs over which a fall in trade costs can lower welfare. Importantly, however, if the effectiveness of investment is sufficiently high, trade yields higher welfare than autarky at *any* level of non-prohibitive trade costs.

Clearly, our model can be extended or modified along a number of lines to address related questions in the trade-IO literature. Although we have focused on symmetric multilateral liberalisation, it is straightforward to use our framework to examine asymmetric and unilateral liberalisations. Another natural extension would be to allow for R&D-spillovers and for international R&D joint ventures. In addition, there is a number of other extensions in which we could allow for more firms and more goods. For instance, it is possible to merge our framework with one in which there is an endogenous number of firms and one with multi-product firms.

Figure 1: Non-negativity constraints in (x_1,x_2)-space

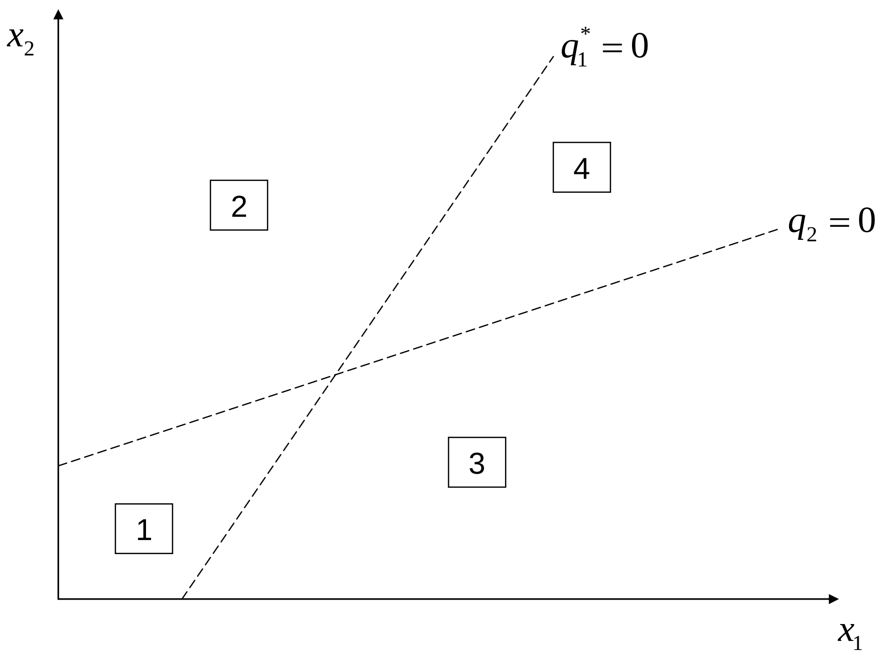

Figure 2: Firm 1's reaction function in (x_1,x_2)-space

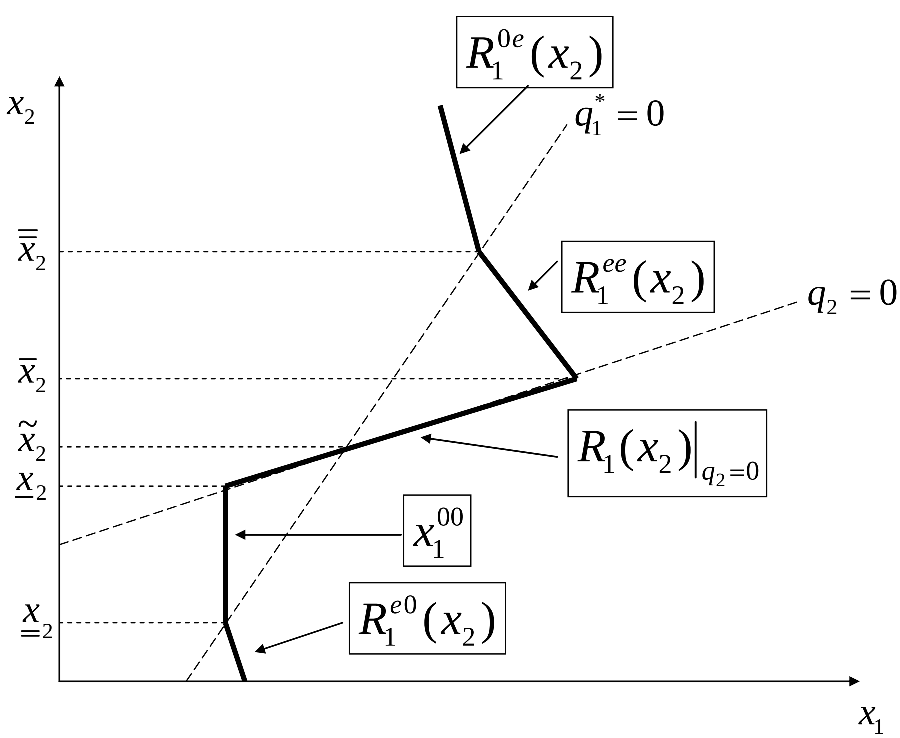

Figure 3a: Equilibria for trade costs $\tilde{t} < t < \hat{t}$

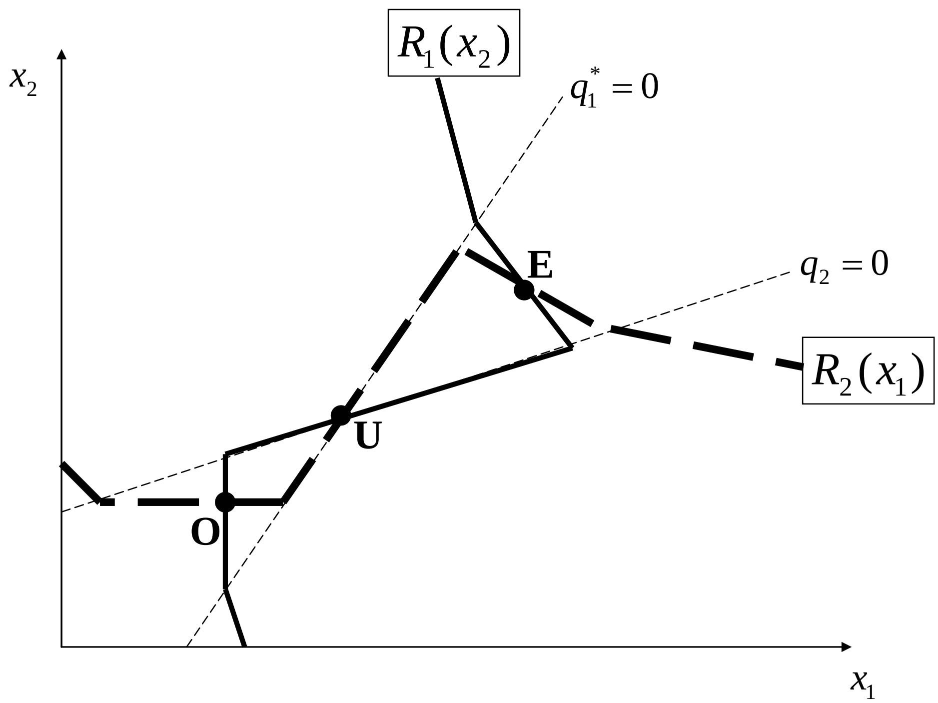

Figure 3b: Equilibria for trade costs $t \leq \tilde{t}$

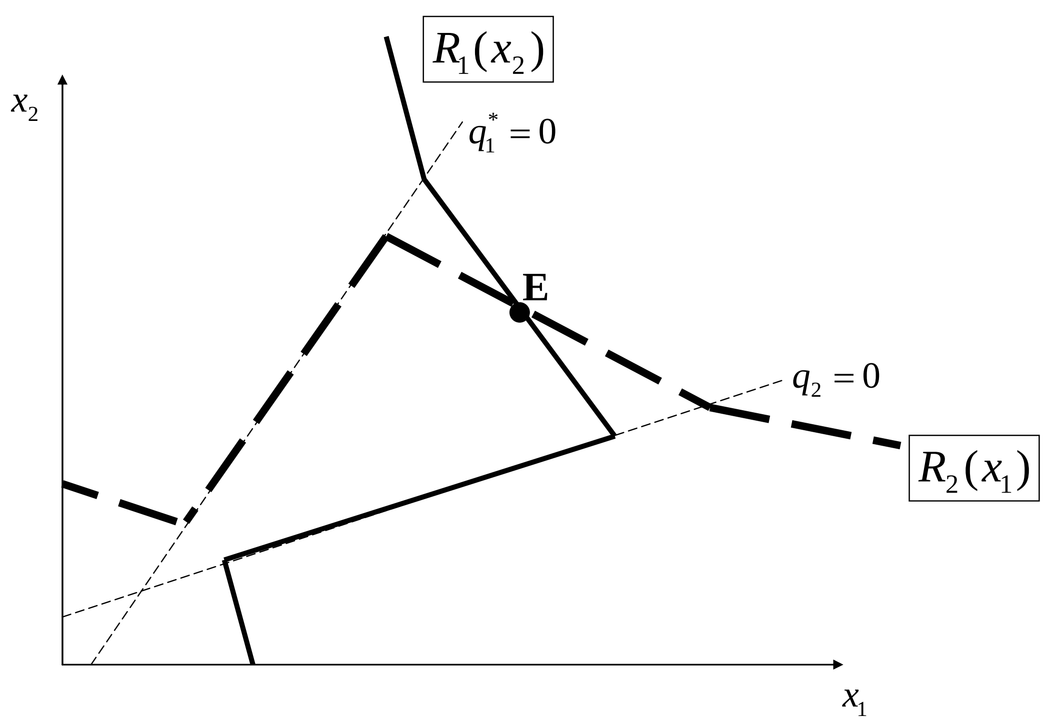

Figure 3c: Equilibria for trade costs $t \geq \hat{t}$

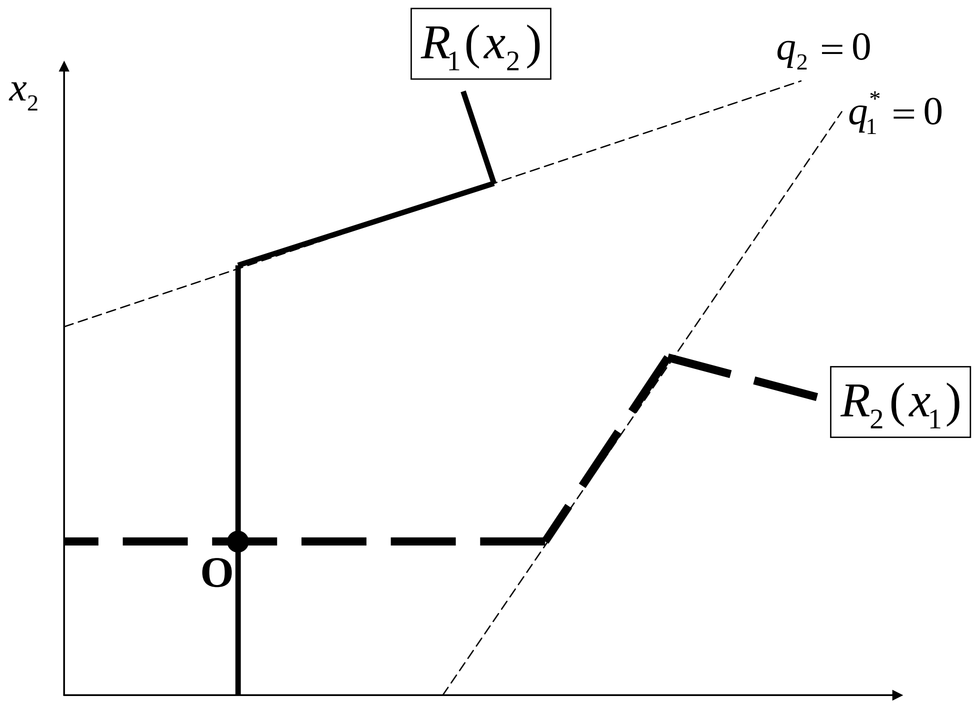

Figure 4: Innovation and trade liberalisation

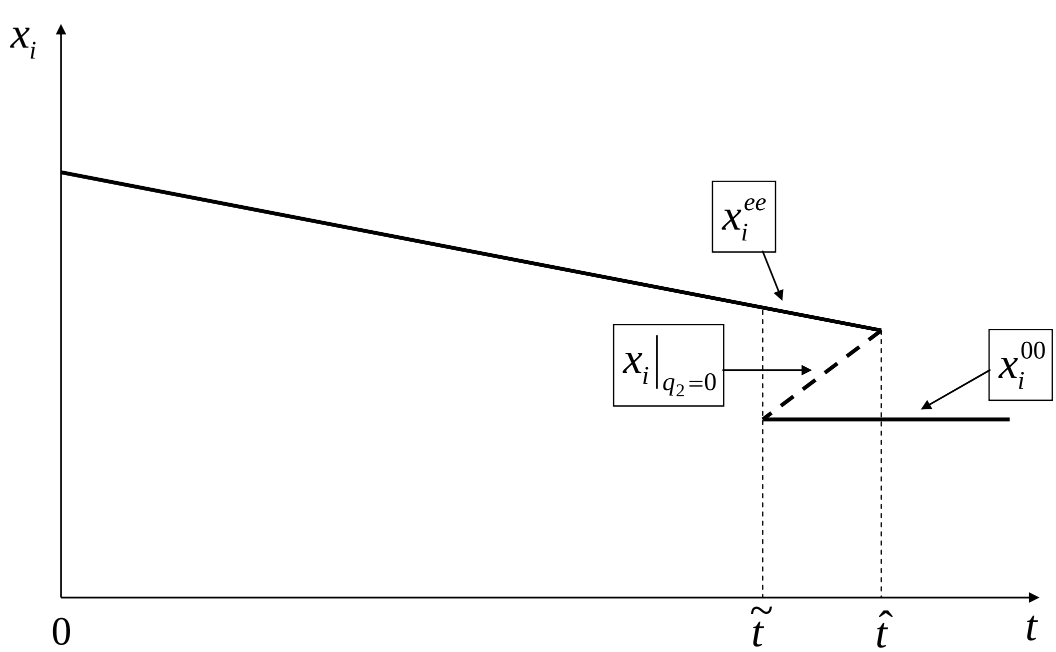

Figure 5: Profits and trade liberalisation

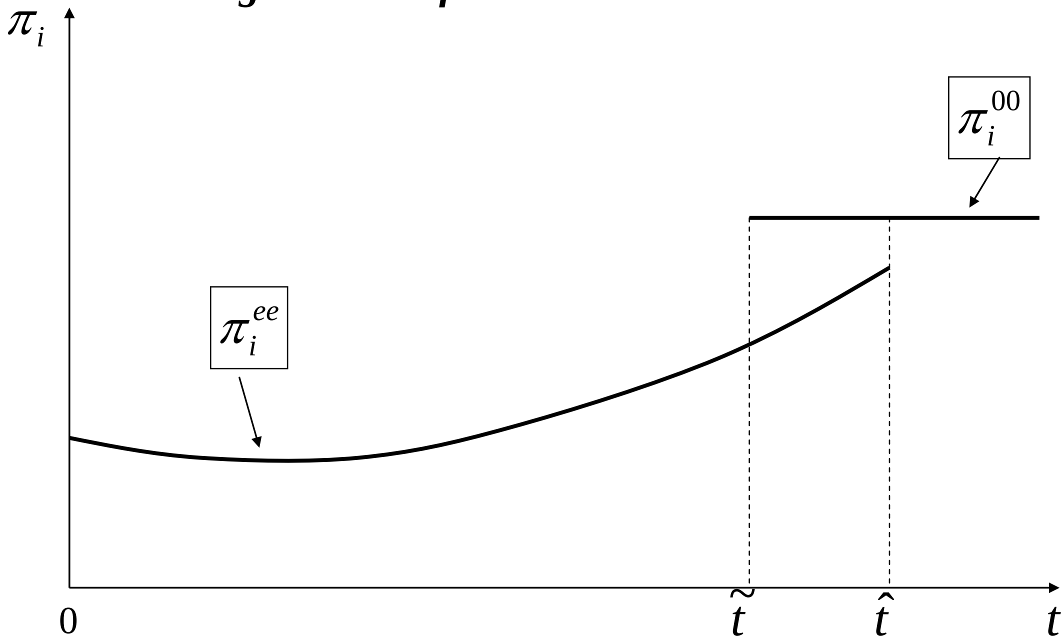

Figure 6: Consumer surplus and trade liberalisation

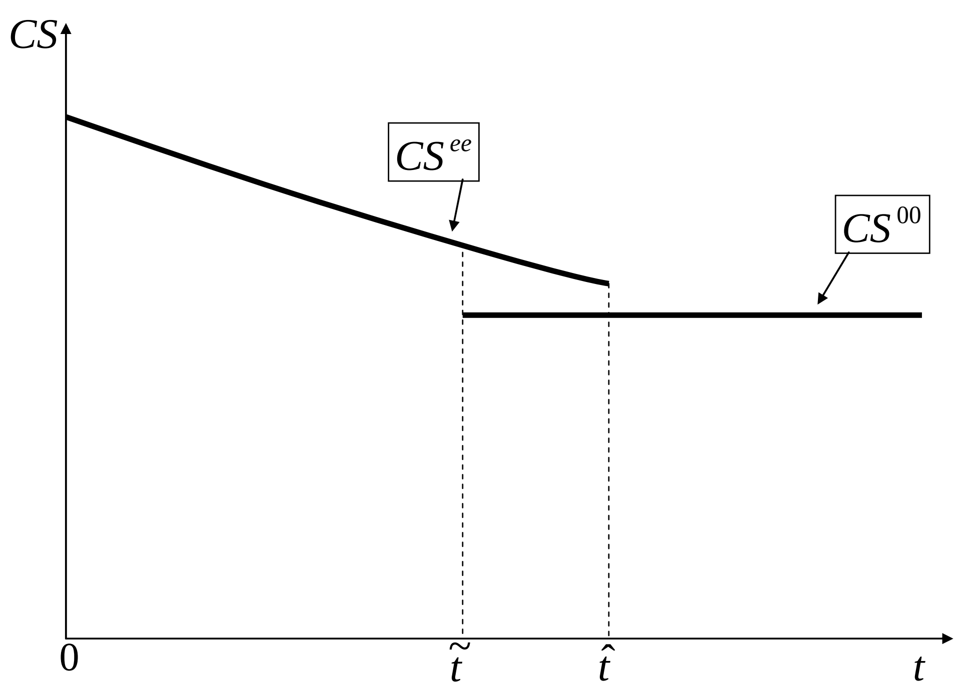

Figure 7a: Welfare when the effectiveness of R&D (η) is low

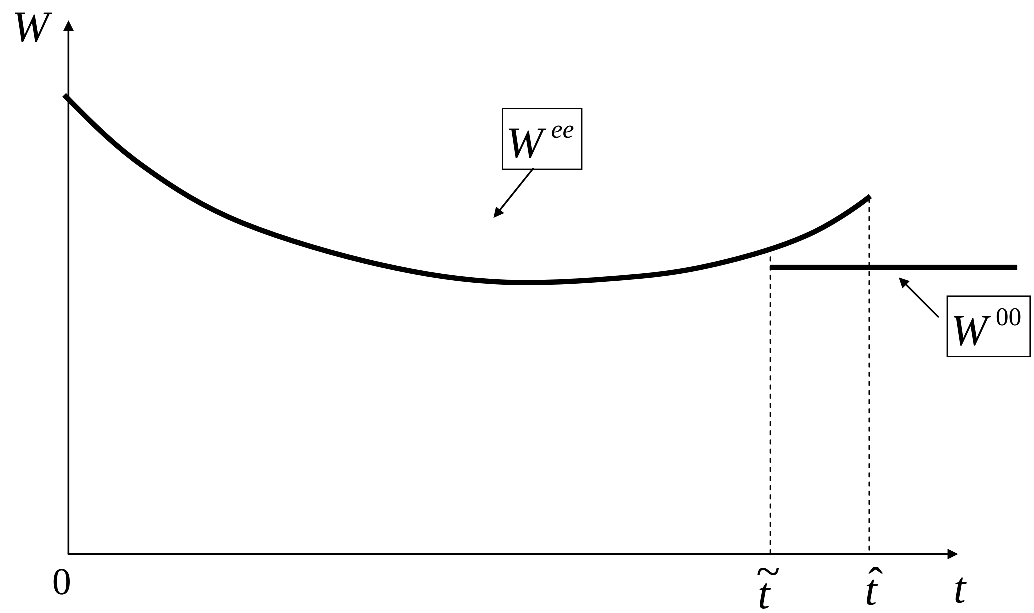

Figure 7b: Welfare when the effectiveness of R&D (η) is high

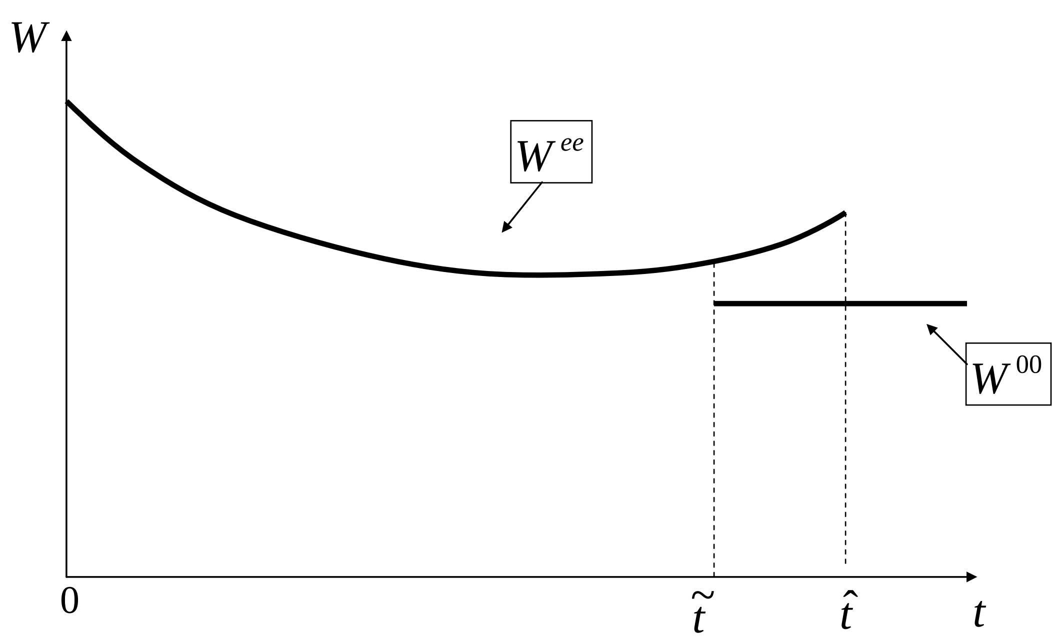

Figure 8: Welfare in the non-strategic benchmark

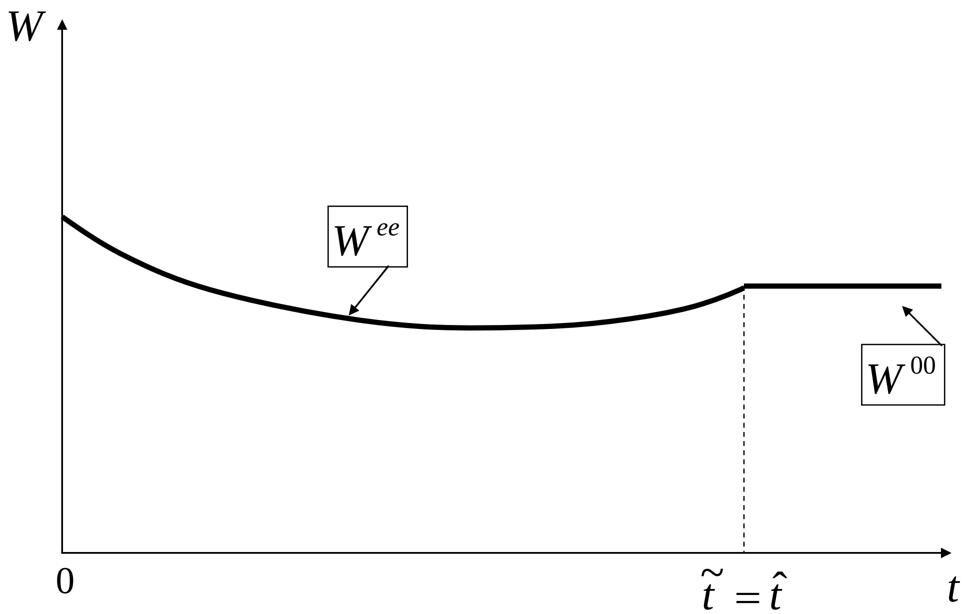

Table 1: Firm 1's best R&D response function

x_2-range	Firm 1's best response
$x_2 > \bar{\bar{x}}_2$	$R_1^{0e}(x_2)$
$\bar{x}_2 \le x_2 \le \bar{\bar{x}}_2$	$R_1^{ee}(x_2)$
$\underline{x}_2 < x_2 < \bar{x}_2$	$R_1(x_2)\big\vert_{q_2=0}$
$\underline{\underline{x}}_2 \le x_2 \le \underline{x}_2$	x_1^{00}
$x_2 < \underline{\underline{x}}_2$	$R_1^{e0}(x_2)$

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