RIVALRY IN UNCERTAIN EXPORT MARKETS: COMMITMENT VERSUS FLEXIBILITY

by

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February 2001

Abstract:
This paper examines optimal trade policy in a two-period oligopoly model, with a home and a foreign firm choosing capital and output. Demand uncertainty, resolved in period two, gives rise to a trade-off between strategic commitment and flexibility in the firms' investment decisions. When the government can commit to an export subsidy, it may choose to over- or under-subsidise to deter private-sector capital commitment. When the government chooses its trade policy flexibly, the relative value of commitment to the unsubsidised foreign firm is greater than to the subsidised home firm. Finally, a flexible subsidy regime is compared to free trade.

Key words: Demand Uncertainty; Strategic Commitment; Flexibility; Trade Policy.

JEL Codes: D80, F12, F13

Acknowledgements: We are grateful for helpful comments by participants of the European Research in International Trade Workshop in Rotterdam (ERWIT-CEPR, June 1999) and of the Econometric Society European Meeting in Santiago de Compostela (ESEM, September 1999), and thank seminar participants at University College Cork. Gerda Dewit acknowledges that the research work reported in this paper was financially assisted and supported through a Research Fellowship awarded by the ASEAN-EC Management Centre.

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1. Introduction

The vast majority of investment decisions share three characteristics. Firstly, they are carried out under uncertainty about future economic conditions. Secondly, the investment, once it has taken place, is at least partly irreversible. Thirdly, the actual timing of the investment is crucial. These three features of investment shape policy both in a micro- and a macroeconomic setting.

The industrial organisation literature on the strategic aspects of investment (surveyed by Tirole (1988) and Shapiro (1989)) stresses the importance of investment irreversibility to firms. They commit early to capital, capacity or R&D with the aim of influencing the future course of the game. In these models, it is typically assumed that firms do not face uncertainty about future demand when choosing their investment level. However, with uncertainty, it is clear that strategically motivated investment commitment by rival firms implies the loss of the flexibility required for adjusting to unexpected demand changes. The importance of investment flexibility has been stressed by Dixit and Pindyck (1994) for a wide range of economic applications. In contrast to the literature on strategic commitment, their option approach to investment emphasises the value of delaying investment until (at least part of) the uncertainty has been resolved.

This paper examines the trade-off between investment flexibility and strategic commitment from the point of view both of firms and policy makers. In the case of firms, they face a choice between investing early or retaining flexibility to cope with demand fluctuations. Retention of flexibility, however, may imply the surrender of a first mover advantage. Especially in newly emerging markets such as the South-East Asian economies and the reformed economies of Central and Eastern Europe, different trading blocs tend to fight for leadership in key industries. While early investment fuelling an aggressive exporting approach towards these markets may allow the leading exporter to capture high rents, it also carries the risk of being overambitious. This is particularly true for many newly developing regions where the macroeconomic climate is typically unstable.

The question of *when* to invest naturally gives rise to endogenous timing in the investment game. Since the 1980s there has been considerable interest in the issue of endogenous timing in the choice

of strategic variables in oligopolistic markets[1]. From the perspective of policy makers, it is important to consider how optimal policies under a government with commitment power differ to those chosen by a government with policy flexibility.

To study these issues, we use a dynamic oligopoly model in which a home and a foreign firm invest in capital and export to a third market and the home government chooses its trade policy[2]. We examine the case where the home government is able to use an export subsidy to influence the game played by firms[3,4]. We examine how policy commitment or flexibility affects the firms' strategic investment decisions for an export market where demand uncertainty prevails. In our model there are two periods, during the first of which players face uncertainty about future demand in the export market. In period two, when actual outputs are chosen, uncertainty disappears[5].

We show that governments can, and may wish to, alter the relative advantages of investment flexibility to the home firm and its foreign rival. If the government cannot credibly commit to its policy in advance and hence sets its policy flexibly, it intervenes after uncertainty has disappeared. In that case, the value to firms of committing early to their capital investment is higher than when the government itself commits to policy in advance.

The game is more complicated if the government commits to its trade policy before the firms choose their capital levels and the timing of their investments. Government commitment implies a loss of policy flexibility in the sense that the policy action chosen cannot be adjusted to take account of

[1] See for instance Gal-Or (1985), Dowrick (1986), Boyer and Moreaux (1987), Hamilton and Slutsky (1990) and Spencer and Brander (1992).

[2] The key early papers on trade policy towards exporting oligopolists without capital investment include Brander and Spencer (1985) and Eaton and Grossman (1986). Spencer and Brander (1983) examine a model similar to these that includes an investment stage. Brander (1995) provides a comprehensive survey of this literature.

[3] Although the use of export subsidies is prohibited by the WTO Subsidy-Code, most countries surreptitiously use forms of export subsidisation. The public provision of cheap loans to finance export activities (e.g., export credits) is one example through which significant subsidies were channelled indirectly to exporters in the late eighties and nineties (Stephens, 1999), especially to firms targeting newly emerging markets.

[4] Expanding the number of policy instruments increases the model's complexity without yielding additional insights. The model we discuss here is similar in structure to Grossman and Maggi (1998) in which firms choose capital and output and the government chooses an export subsidy. Goldberg (1995) and Karp and Perloff (1995) adopt a similar approach. In Neary and O' Sullivan (1999) the firms choose R&D and output while the government choose an export subsidy. Like these papers we do not discuss the first-best policy which entails a mix of investment and export subsidies. For a comprehensive discussion of first-best versus second-best cases without uncertainty and endogenous timing, see Neary and Leahy (2000).

[5] This temporal structure is similar to that in Cooper and Riezman (1989) and Arvan (1991).

actual demand in period two. However, the options of the government are now wider in the sense that it may choose a policy of *Commitment Deterrence* with respect to its own firm or the foreign rival. This involves intervention to strategically manipulate instead of accommodate the timing of home or foreign investment. The government can force the foreign firm to remain flexible or persuade the home firm to avoid commitment.

In section two we describe the basic model in which a home and a foreign firm choose the timing and level of their investment and export to a third market characterised by demand uncertainty. Section three briefly presents the investment timing pattern that would emerge under free trade. In section four we examine the case in which the government chooses its export subsidy flexibly after uncertainty has been resolved. Our discussion turns to the case of credible government commitment in section five, where we derive the optimal policy under different levels of uncertainty and discuss the possibility of strategic commitment deterrence. Section six examines optimal policy when the government has the option to commit to a free trade stance. The final section concludes and suggests future research directions.

2. The model

Consider a home and a foreign firm which are competing *à la* Cournot in a third market, facing demand uncertainty. The stochastic demand component is denoted by u, defined over the closed interval $[\underline{u}, \bar{u}]$ and characterised by a zero mean ($Eu = 0$) and variance of s^2. Demand is given by

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

where p is the price prevailing in the export market, $Q = x + y$ is total output, and x and y denote output of the home and foreign firm, respectively. Firms also invest in capital, represented by k and k^*. Henceforth, starred variables refer to the foreign firm. We assume the firms' total cost functions (TC , TC^*) are

$$TC = (c_0 - k)x + \frac{k^2}{2h} \tag{2a}$$

$$TC^* = (c_0^* - k^*)y + \frac{k^{*2}}{2h} \tag{2b}$$

where c_0 and c_0^* are constants. The total capital cost is captured by $\frac{k^2}{2h}$ where h is a constant (and assumed to be identical for both firms)[6].

There are two periods, during the first of which players face uncertainty about future demand in the export market. At the start of period two, in which the actual output is chosen, uncertainty disappears. Firms have the option to commit strategically to investment in period one. However, since this choice implies foregoing capital flexibility in the second period, commitment is less appealing for high levels of uncertainty. If investment is delayed to period two, capital is chosen simultaneously with output and optimally for the demand then prevailing.

Under free trade, the firms play a three-stage game. In stage one, they decide *whether* to invest in period one or two and are then committed to this decision. In stage two, firms that are committed to invest in period one choose their actual capital level. This investment decision is irreversible. In stage three, firms choose output simultaneously and firms that have not yet chosen their capital do so[7].

Governments can alter the relative advantages of investment flexibility. We examine the case where export subsidies set by the home government influence the timing of the investment chosen by the home firm and its foreign rival. Depending on whether the government can commit to the subsidy or not, the subsidy is set before demand uncertainty is resolved (i.e., in period one) or after demand is known (i.e., in period two). As we will discuss in sections three and four, this will crucially determine the investment decisions of both firms.

Profits for the home and foreign firm are given by:

$$\pi = (p + s_t)x - TC \qquad t = 1,2 \qquad (3a)$$

[6] Grossman and Maggi (1998) use the same cost specification. It is also commonly used in the process R&D-literature (see d'Aspremont and Jacquemin (1988)).

[7] In the terminology of Hamilton and Slutsky (1990) the game we examine here is one with *"observable delay"*. In a model without policy, Dewit and Leahy (1999) also consider an alternative game structure in which the firms cannot simply commit to a timing of investment. Instead, a firm can only choose its capital early by selecting the *level* of first-period capital investment to which it is then committed. Hamilton and Slutsky refer to this type of extended game as one with *"action commitment"*. They examine and compare extended games of observable delay and action commitment in simple output and price games without prior capital investment or uncertainty.

$$p^* = py - TC^* \tag{3b}$$

s_t is the export subsidy set in period t.

For simplicity, players are assumed to be risk neutral. Risk aversion raises the range of uncertainty at which flexibility is preferred to commitment and complicates the analysis significantly, but without changing the qualitative nature of our results.

Firms always choose outputs simultaneously in the last stage of the game. Maximising second-period profits yields expressions (4a) and (4b) for optimal outputs:

$$x = \left[2A - A^* + 2s_t + 2k_t - k_t^* + u\right]/3 \qquad \text{with } A \equiv a - c_0 \text{ and } A^* \equiv a - c_0^* \tag{4a}$$

$$y = \left[2A^* - A - s_t + 2k_t^* - k_t + u\right]/3 \tag{4b}$$

These expressions clearly show that firms affect their output flexibility by the decision either to delay investment until period two or to commit to capital in period one. Capital commitment eliminates the possibility of aligning capital to the actual level of demand observed in period two. This capital rigidity indirectly narrows the firm's scope for output adjustments. Since expected profits increase in output flexibility (formally measured by the variance of the stochastic demand component), firms will only commit to capital if this choice generates strategic gains which are sufficiently large to compensate for the losses suffered by foregoing flexibility[8]. Thus, our model captures the stylised fact that, ceteris paribus, investors prefer investment projects that allow flexibility to those which require investing in capital which is irrevocably fixed.

The following sections examine the respective investment timing patterns that prevail under free trade, when the home government sets its subsidy flexibly and when the home government, alternatively, commits to its subsidy. Since the analysis involves many unwieldy algebraic expressions, graphical simulations are extensively used to ease the exposition. This approach allows us to minimise the number of equations we give in the text, but does not reduce the generality of our

[8] Profits are convex in u, implying that expected profits increase in the variance of u. Due to the indirect effect of capital on output, the effect of the variance on expected profits is larger under investment flexibility than with commitment. This generates the trade-off between flexibility and commitment in our model. Arvan (1991) and Spencer and Brander (1992) use a similar approach. Explicitly modelling agents as risk averse would simply reinforce the incentive of investors to remain flexible.

analysis in any way. We consider both situations in which firms have symmetric and asymmetric production costs. For completeness, our analysis exhausts *all* the qualitatively different cases.

3. Investment timing under free trade

It proves useful to first sketch the results under the free trade benchmark. In this case, stage one can be represented in normal form (see figure 1). In figure 1, *C* represents commitment and *D* stands for delay. The outcome of this game depends on the level of uncertainty and the marginal production and capital cost. Given the marginal production costs for both firms, we calculate the values of $\overline{s}^2$ (with $\overline{s}^2 \equiv s^2 / A^2$) and h for which each firm is indifferent between capital commitment and investment delay. Indifference in this context means that investing in period one and two yields the same level of expected profits given the timing choice of the competitor. Hence there is a total of four indifference loci in $\overline{s}^2, h$-space; each firm has two, one of which is derived given rival commitment whereas the other is calculated given rival delay.

[Figure 1 about here]

The position of these four indifference loci in $(\overline{s}^2, h)$-space depends on the cost asymmetry between firms at the start of the game. With free trade, considering the entire range of possible cost asymmetries yields only three qualitatively different outcomes. More specifically, depending on whether the relative cost difference between the rival firms is "large", "small" or zero, different investment timing patterns emerge. Defining a as $a \equiv A^* / A$, the term "large" relative cost difference refers to a value of a for which the indifference loci of the low-cost firm both lie above those of its higher-cost rival. "Small" relative cost differences refer to values of a for which this is no longer true and as a result firms' indifference loci may intersect.

We first discuss the outcome of the investment timing game under free trade for the case where the *home* firm has a "large" relative cost advantage, illustrated in Figure 2 (for $a = 0.8$). Here, only two loci are relevant for demarcating the separate commitment/delay regimes, which are graphically represented by regions I-III. Commitment is chosen by the home firm in area I. Given home commitment, the foreign firm chooses to commit as well. Hence, commitment by both firms is the

unique equilibrium. In region II, the foreign firm delays, while commitment continues to be chosen by the home firm. In this region the firm with the relative cost advantage emerges as the natural leader since it values commitment more highly than its rival. A firm that chooses its capital before its rivals' output in a strategic manner credibly commits itself to a higher future output. But the advantage of a higher output is greater the wider is the gap between the expected price and the marginal cost. The low-cost firm has a larger price-cost margin and hence values strategic commitment more highly. In area III, the uncertainty is so high that both firms prefer to stay flexible and delay investment.

[Table 1 about here]

Capital investment for given outputs under free trade are represented in table 1. It is clear from this table that the functional forms are symmetrical (compare *C*,*D** and *D*,*C**). However, the actual levels of capital are not identical as they depend, through the outputs, on the marginal production costs.

[Figure 2 about here]

If, instead of the home firm, the *foreign* competitor has a similar large cost advantage, the $(\overline{s}^2, h)$-space is demarcated in exactly the same way as in figure 2. The only difference is that the foreign firm now commits in area II, whereas the home firm chooses to delay at intermediate levels of uncertainty.

When firms have the same costs, the outcome of the investment timing game looks somewhat different (see figure B.1 in Appendix B). Here too, both firms will delay at high levels of uncertainty and commit when uncertainty is low. But, it is no longer true that, at intermediate levels of uncertainty, an investment leader emerges. Instead there are two equilibria in area II, one of which involves delay by both competitors while the other is characterised by investment commitment by both. Note that commitment implies that firms strategically overinvest, which is not the case with investment delay. Hence, investment delay by both firms is the Pareto-dominant equilibrium in area II.

In addition to these two generic cases, there is the case where there is only a "small" cost asymmetry between firms. Clearly, the outcome of the investment game for this case takes a hybrid form (as illustrated in figure B.2 of Appendix B for $\alpha = 0.97$). It combines features of the symmetric case and the "large" cost asymmetry case. When the marginal cost of capital is high (i.e., at low θ), investment leadership by the low-cost firm is the equilibrium at intermediate levels of uncertainty (see region IIa), while commitment and delay by both firms are the equilibria in region IIb[9].

4. Investment timing and government flexibility

We now allow the home government to choose an optimal strategic export subsidy. In the next section we examine the case in which the government *commits* to this subsidy at the beginning of the game. However, here we assume the government sets its subsidy *flexibly* in period two (hence $s_t = s_2(u)$). So, the government sets its export subsidy *after* uncertainty has disappeared. It maximises second-period welfare, which is equal to profit of the home firm net of the subsidy cost:

$$\max_{s_2} \; W = \pi - s_2 x \qquad (5)$$

While the optimal subsidy is set flexibly after uncertainty is resolved, it is also influenced by the investment choices firms make in period one. Figure 3 shows the move orders implied by the four possible combinations of investment timing, chosen by firms in stage one of the game. The subsidy and capital levels as functions of outputs for each of those four scenarios are reported in table 2.

[Figure 3 about here]

Table 2 shows that, unlike in the free trade case (see table 1), the equilibrium capital functions are no longer symmetric if firms commit. This is due to the fact that the subsidy is affected by first-period capital decisions. This affects the firms' first order conditions for first-period capital in an asymmetric manner.

[9] In other words, when capital investment is expensive, the low-cost firm will, even as a leader, invest relatively little. Hence, the damage to the high-cost firm in terms of induced future output reductions will not be very large. For that reason, the latter prefers to stay flexible. However, as θ rises and investment becomes cheaper, a firm that does not invest in period one while its rival does, exposes itself to substantial future market share losses. In region IIb, the high-cost firm chooses therefore to commit, in spite of the relatively high level of uncertainty, so as to protect its future share of the market.

[Table 2 about here]

For all possible relative cost differences (i.e., values of α) that guarantee interior solutions, an outcome similar to the one represented in figure 4 prevails. Figure 4 depicts the relevant indifference loci (for $a = 1$), dividing the $\bar{s}^2, h$- diagram into three areas. When the government moves in period two, both firms value commitment relative to delay much more highly than in the free trade case or when the government commits to its policy in period one. This can be seen clearly by comparing the vertical intercepts of the firms' indifference loci in figure 4 on the one hand and figures 2, 5a and 6a on the other hand. Here, commitment by a firm has the additional advantage of allowing it to influence the level of the government's period-two subsidy. The subsidy increases in the relative cost advantage of the home firm as shown in de Meza (1986) and Neary (1994). Hence, both firms strategically overinvest to alter the subsidy to their own advantage.

In figure 4, both firms commit to capital $(s_2; C, C^*)$ in area I. In area III where uncertainty is relatively high, both firms choose to keep capital flexible $(s_2; D, D^*)$. For intermediate levels of uncertainty (area II), the foreign firm commits whereas the home firm remains flexible $(s_2; D, C^*)$. This last result contrasts sharply with the choices made, at intermediate levels of uncertainty, by the respective firms under the previously discussed free trade case. While the home firm was assumed to have a relative cost advantage in the free trade benchmark, here the firms' production cost structures are symmetric but the subsidy gives the home firm a comparable net cost advantage over the foreign rival. Yet, firms' investment timing choices are now reversed. Now, the foreign firm values flexibility much less than the home firm. It has an additional reason for wanting to move before the home government. By doing so, it limits its vulnerability to the home government's subsidy policy. The optimal export subsidy depends on the slope of the foreign reaction function. Compared to foreign delay, foreign investment commitment makes the foreign reaction function less steep. A comparison of subsidy formulas in table 2 (rows 1 and 3 versus rows 2 and 4) shows that the subsidy as a fraction of home output (s_2 / x) is larger for foreign firm delay than for foreign commitment.

[Figure 4 about here]

Note that the intermediate area in figure 2 will widen if the foreign firm has a relative production cost advantage (i.e., $a > 1$). Having a relatively large cost advantage increases the attractiveness of commitment to the foreign firm. Hence, the foreign rival will decide to move before the home government at levels of uncertainty which are higher than under cost symmetry. Conversely, if the home firm has a larger production cost advantage over its rival (i.e., $a < 1$), area II will become more narrow[10].

5. Investment timing and government commitment

We now consider the case in which the government always sets the export subsidy at the beginning of the game, without being able to change it in period two when the uncertainty has been resolved (hence, now $s_t = s_1$). Government commitment to its trade policy implies a loss of flexibility in the sense that the subsidy chosen can not be adjusted in line with *actual* demand in period two[11]. It also implies that the government always moves first, that is, before the investment timing decisions are made by firms. Hence, the firms' investment timing and investment levels will depend on the value of the subsidy chosen.

The capital variables for each of the four possible investment timing combinations are of the same form as those under free trade (see table 1). Now, however, output levels are functions of s_1, as indicated by expressions (4a) and (4b). Unlike in the game with subsidy flexibility but as in the free trade case, the capital levels per unit of (expected) output are symmetric even if firms commit to investment. This is due to the fact that here the investment timing stage of the game comes *after* the government has set the subsidy.

In the first stage, the government sets the subsidy, maximising *expected* welfare:

$$\max_{s_1} EW = E\pi - s_1 Ex \qquad \text{with } E\pi = E\left\{x^2 - \frac{k^2}{2\beta}\right\} \tag{6}$$

[10] Note that, even if the home firm has a relative cost advantage, the restrictions on α that guarantee an interior solution for the foreign rival's output will prevent $(s_2; C, D^*)$ from replacing $(s_2; D, C^*)$ as an equilibrium in region II.

[11] This also means that, compared to the previous scenario of government non-commitment, capital flexibility is now relatively more attractive to the foreign firm.

The solution to this maximisation problem depends on h, a and the level of uncertainty[12].

The fact that the government always moves first complicates the nature of the game significantly. Most importantly, it widens the government's options. In particular, it implies that, if the government wants to prevent strategic investment by firms, it can, as we will discuss below, deter capital commitment by choosing the appropriate subsidy. We refer to this strategy as *Commitment Deterrence*. The reason for using commitment deterrence against the foreign firm differs from the motivation behind deterring home commitment. By keeping the foreign firm flexible, the government guarantees that the rival will not have a first-mover advantage over the domestic firm, whereas home firm flexibility guarantees adjustment to unexpected demand shocks, while at the same time avoiding the domestic social costs associated with overinvestment. Since commitment deterrence implies deviating from the subsidies that would be optimal *given* firms' capital commitment or flexibility choices (as reported in table A.1 of Appendix A), it entails a cost for the government. The government's optimal policy will involve commitment deterrence if these costs are outweighed by the welfare gains from firm flexibility.

Lower subsidy levels increase the relative attractiveness of flexibility to the home firm by reducing the firm's relative cost advantage. Likewise, a higher export subsidy to the home firm raises the relative value of flexibility to the foreign firm. Hence, deterring home capital commitment requires lowering the export subsidy, while deterring foreign commitment involves increasing the export subsidy relative to the *Commitment Accommodation* level (i.e., s_1 *given* the commitment/delay decisions of firms). Which, if either, type of commitment deterrence is used depends crucially on the level of uncertainty prevailing and the relative cost difference between competing firms. It is natural to start with the case in which firms are initially symmetric ($a = 1$). Subsequently, we examine the effect of cost asymmetries on firms' investment timing under government commitment.

5.1. Government commitment with initial cost symmetry

[12] As an intermediate step in obtaining this solution, it proves useful to calculate the optimal subsidies for *given*

By initial cost symmetry we mean the case in which α=1. The outcome of the game under government commitment for this case is presented in figures 5a and 5b. While figure 5a shows the outcome of the game in $\bar{s}^2, \eta$-space, figure 5b illustrates how the subsidy under government commitment (where s_1 is normalised as $\bar{s}_1 \equiv s_1 / A$) changes with $\bar{s}^2$, keeping η constant. For other values of α that entail a substantial cost advantage for the home firm, a qualitatively similar outcome prevails.

In area I in figure 5a, both firms commit since uncertainty is very low and the firms thus find it optimal to invest strategically. The firms' relative valuation of commitment to flexibility is high here, implying that commitment deterrence is very costly in this region[13]. So, the government accommodates the firms' strategic investment decisions by setting the optimal subsidy *given* firms' commitment (s_1^{cc*}). The first subsidy switch point is determined by the level of uncertainty at which the cost of commitment deterrence is sufficiently low. Foreign firm flexibility can only be enforced by raising the subsidy to a level above s_1^{cc*}, whereas deviating in the opposite direction is required to ensure home firm flexibility. The government chooses to tailor its subsidy to the least costly type of commitment deterrence. With symmetric initial costs *and* subsidisation by the home government (thus giving the home firm a net cost advantage), enforcing foreign firm flexibility is the cheaper option because commitment has lower value for the foreign rival than it has for the home firm. Hence, moving from area I to area II in figure 5a implies that the government will switch from commitment accommodation ($s_1^{cc*}; C, C^*$) to *foreign* commitment deterrence while allowing the home firm to commit (($s_1^{ct*}; C, D^*$), where s_1^{ct*} refers to the lowest possible subsidy that deters foreign commitment, given home commitment).

[Figure 5a about here]

[Figure 5b about here]

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capital commitment/flexibility combinations. The values of these 'accommodating' optimal subsidies are reported in table A.1 of appendix A.

[13] Foreign commitment deterrence in this region requires a huge subsidy while home commitment deterrence implies taxing the domestic firm. The welfare costs involved in either alternative form of commitment deterrence outweigh the small welfare gains from firm flexibility.

More precisely, this switch point is indicated by the locus on which the government is indifferent between these two policies because they yield the same expected welfare: $EW\left(s_1^{cc*};C,C^*\right)=EW\left(s_1^{ct*};C,D^*\right)$. Figure 5b shows that, at that point, the subsidy jumps discretely to a higher level (s_1^{ct*}) implying that the deviation from the commitment accommodating subsidy (s_1^{cc*}) has to be quite large to ensure that the foreign firm prefers to stay flexible. At higher levels of uncertainty, a smaller deviation is sufficient to attain that objective, thus, s_1^{ct*} decreases as uncertainty rises. Note that the subsidy s_1^{ct*} is not the *optimal* subsidy *given* firms' investment timing. Instead, it ensures a particular timing decision (i.e. *C,D**) which yields the highest attainable expected welfare.

As the level of uncertainty rises, the commitment deterring subsidy s_1^{ct*} falls and approaches s_1^{cd*}. When uncertainty is so high that s_1^{ct*} is equal to s_1^{cd*}, the policy of commitment deterrence becomes obsolete. This second switch point occurs when $s_1^{ct*}=s_1^{cd*}$ in figure 5b and is indicated by locus $E\boldsymbol{p}^*\left(s_1^{cd*};C,C^*\right)=E\boldsymbol{p}^*\left(s_1^{cd*};C,D^*\right)$ in figure 5a. Hence, in area III the foreign firm remains flexible and the government subsidy accommodates home firm commitment and foreign firm flexibility. At this level of uncertainty, deterring the home firm from commitment still proves too costly.

Home commitment deterrence becomes sufficiently attractive to the government when the maximum subsidy that enforces home firm flexibility given foreign delay (s_1^{td*}) is sufficiently high. This is indicated in figure 5a by the locus $EW\left(s_1^{cd*};C,D^*\right)=EW\left(s_1^{td*};D,D^*\right)$. Hence, home commitment considerations shape the subsidy policy prevailing in area IV. In figure 5b, the switch point from s_1^{cd*} to s_1^{td*} is characterised by a discrete drop in the subsidy level, which is the minimum subsidy deviation necessary to enforce flexibility of the home firm. For higher levels of uncertainty, this policy involves a subsidy closer to the unconstrained subsidy with firm flexibility (s_1^{dd*}), which is reflected in the upwards sloping s_1^{td*} - segment in figure 5b.

Here too commitment deterrence only prevails until uncertainty is so high that such a policy becomes unnecessary ($s_1^{td*}=s_1^{dd*}$, implying $E\boldsymbol{p}\left(s_1^{dd*};C,D*\right)=E\boldsymbol{p}\left(s_1^{dd*};D,D^*\right)$). From this point on, the

home firm optimally prefers to remain flexible (area V) given s_1^{dd*}. As a result, the government simply accommodates firms' choices, setting the optimal subsidy given capital flexibility by both firms.

5.2. Government commitment and cost asymmetry

Now, we consider asymmetric cost cases ($\alpha \neq 1$). If the home firm has an initial cost advantage over its rival ($\alpha < 1$), the outcome of the game is qualitatively the same as with initial cost symmetry[14]. So, we focus on situations in which the foreign firm's costs are initially lower than the home firm's ($\alpha > 1$). More specifically, this subsection covers the cases in which the foreign rival's cost advantage over the home firm is "large". Like in section three, a "substantial" or "large" initial cost advantage refers to values of α for which the indifference loci of the lower-cost firm all lie above those of its rival for all relevant values of η. The outcome of the game is now illustrated in figures 6a and 6b (for $\alpha = 1.4$)[15]. As in the previous case, five areas are demarcated in the $\bar{s}^2, \eta$-diagram, now given by figure 6a. For extremely low and high levels of uncertainty, the government accommodates the investment timing choices of both firms, involving double commitment in area I and double flexibility in area V. The respective subsidies that accommodate firms' investment timing choices are denoted in the diagram by s_1^{cc*} (in area I) and s_1^{dd*} (in area V) (their values are reported in table A.1 of appendix A).

[Figure 6a about here]

[Figure 6b about here]

The outcome of the game differs from the outcome under cost symmetry for less extreme levels of uncertainty. Due to the cost asymmetry, commitment is now relatively more valuable to the *foreign* firm than to its home competitor. As a result, deterring commitment by the home firm will be relatively cheaper, implying that the ranking of the commitment deterrence policy prevailing under

[14] With initial symmetric costs, the home firm effectively has a cost advantage over the foreign firm since it benefits from the export subsidy. Hence, giving the home firm an additional initial cost advantage will yield the same qualitative results.

[15] This value is chosen deliberately because it gives the foreign firm a relative net cost advantage over the home firm, similar to the relative cost advantage inclusive of subsidy of the home firm in section 5.1.

symmetry is reversed. Here, home firm flexibility is enforced for relatively low uncertainty (using subsidy s_1^{tc*} in area II), while commitment by the foreign firm is deterred at high levels of uncertainty (using subsidy s_1^{dt*} in area IV)[16]. In area III, the government prefers to accommodate foreign commitment and home flexibility. To do this, it chooses the subsidy $\overline{s}_1^{cd*}$ (again, see appendix A). Figure 6b shows the actual subsidy levels for varying levels of uncertainty and is, to a large extent, the mirror image of figure 5b.

The third possible outcome of the game under home government commitment prevails when the foreign firm's relative cost advantage is "small". We illustrate the outcome for this case in which $A + s_1$ is near to A^* in figure C.1 of Appendix C (with $\alpha = 1.2$). The main difference with the two generic cases discussed above (no foreign cost advantage and large foreign cost advantage, respectively) lies in the fact that, even at intermediate levels of uncertainty, investment leadership is less likely simply because firms' cost are less dissimilar. Also, the range of uncertainty over which the government engages in commitment deterrence shrinks.

6. Commitment to free trade versus policy intervention

The respective outcomes of the games under a policy active government on the one hand and under free trade on the other hand were discussed in the previous sections. Here, we examine whether it is possible for the home government to attain higher welfare by committing to free trade instead of being policy active. We first compare a policy of commitment to free trade to the case in which a government credibly sets an optimal subsidy in period one. Then, commitment to free trade is compared to policy flexibility.

The first comparison is trivial. From section four, we know that the *optimal* subsidy under government commitment is always positive ($s_1 > 0$). Since free trade can be interpreted as policy commitment to a zero-subsidy ($s_1 = 0$), it immediately follows that a government with commitment power never prefers free trade to an export subsidy.

[16] $\overline{s}_1^{tc*}$ is the maximum subsidy that deters home commitment given foreign commitment, while $\overline{s}_1^{dt*}$ is the minimum subsidy that guarantees foreign flexibility given home delay.

However, in an environment where the government sets its subsidy flexibly ($s_2 = s_2(u)$), the choice between free trade and policy intervention is no longer trivial. Setting the subsidy in period two has the advantage that the government can choose its policy in line with actually observed demand, but has the drawback that firms can influence the subsidy by investing strategically in period one. By committing to free trade, the government can avoid policy manipulation by firms, but at the expense of giving up supporting its domestic firm once demand is known. Our analysis indicates that this trade-off only results in the government preferring free trade to a flexible export subsidy if uncertainty is relatively low (i.e., for low $\overline{s}^2$) and if the marginal cost of capital is relatively low (i.e., for high h).

This is illustrated in figures 7a and 7b. In figure 7a, the home firm has an initial production cost advantage relative to the foreign rival ($a = 0.8$), while, conversely, the foreign firm has a similar initial cost advantage in figure 7b ($a = 1.25$)[17]. In both diagrams, the $\overline{s}^2, h$-space is divided into two main regions (I and II). These are separated by a steep upwards sloping locus (represented by a bold demarcation line), starting at a positive value of h and hitting a 'ceiling' at a certain value of $\overline{s}^2$. The government chooses free trade over flexible subsidisation in region II, while the converse holds in region I. The dashed lines delineate various subzones within each region, characterised by different investment timing decisions by firms.

[Figure 7a about here]

In figure 7a, the home government always prefers subsidy flexibility to commitment to free trade at high levels of uncertainty (i.e., in regions Ia and Ib). The intuition for this is straightforward in region Ia, where the high level of uncertainty induces both firms to delay investment. Under those investment timing choices, the flexible subsidy allows the government to exploit unexpected demand shocks in favour of its home firm, without itself being manipulated by either firm. However, in region Ib, the government faces a trade-off. On the one hand, the flexible subsidy policy induces the foreign firm to invest strategically in period one. This affects home welfare negatively and does not

[17] The symmetric production cost case ($a = 1$) is shown in figure D.1 of appendix D.

occur under free trade. On the other hand, uncertainty is still sufficiently high in region Ib for the advantages of policy flexibility to outweigh those under free trade.

In the area *below* region Ib, the marginal cost of capital becomes the crucial factor in the home government's choice between free trade and policy flexibility. Here, because uncertainty is lower, the relative flexibility advantage from a subsidy in period two is smaller, especially when the marginal cost of capital investment is low (i.e., h is high). By committing to free trade, the home government shelters itself from strategic manipulation by both the rival and the domestic firm. Moreover, this non-active policy stance even *deters* investment commitment by firms, provided that the uncertainty is not too low. So, the theme of commitment deterrence re-emerges, albeit in a different form.

In region IIa of figure 7a, both firms are deterred from capital commitment compared to the investment timing scenario under subsidy flexibility. In region IIb, free trade still achieves foreign commitment deterrence, but investment commitment by the home firm cannot be prevented due to the latter firm's initial relative cost advantage. In region IIc, uncertainty is sufficiently low for both firms to commit to investment, even under the free trade regime. The locus along which the government is indifferent between policy flexibility and free trade exhibits a discontinuous jump to the right when the switch from region IIb to IIc occurs. When free trade no longer entails foreign commitment deterrence (see region IIc), its relative welfare gains vis-à-vis policy flexibility become weaker at given h than in region IIb. Hence, at very low values of uncertainty, government indifference between the two alternative policy stances now occurs at higher values of h.

Figure 7b depicts the government's choice between free trade and subsidy flexibility when the foreign firm has an initial production cost advantage (see figure 7b with $a = 1.25$). The government's indifference locus between the two policy stances, depicted in figure 7b, is very similar in shape to the one represented in figure 7a. This indicates that our conclusions about the overall conditions under which the government prefers free trade to policy flexibility are robust. The main difference is that the locus in figure 7b does not show any indentations at very low levels of

uncertainty because under this cost asymmetry free trade never leads to foreign commitment deterrence[18].

[Figure 7b about here]

In our discussion we have endogenised the government's choice between policy action and non-action. Alternatively, we could endogenise the government's choice between committing to a subsidy in period one and choosing a flexible subsidy in period two. Although this is interesting from a theoretical perspective, one could argue that, in reality, a government is constrained in the timing of its policy by the institutional environment in which it operates. Usually, an economy's institutional framework favours *either* policy flexibility *or* policy commitment. So, changing the policy timing as a function of the level of uncertainty prevailing may not be feasible for governments in practice. Yet, for completeness we conclude our analysis with a brief comparison between welfare under commitment to the optimal subsidy (s_1) and under policy flexibility ($s_2(u)$). This welfare comparison yields clear-cut results, which may be more useful for policy conclusions in a "positive" than in a "normative" sense. The shape of the locus on which the government is indifferent between the alternative policy options is similar to the one depicted in figures 7a and 7b. In both cases, it is mainly upwards sloping. However, it now starts at the origin. Home welfare under commitment to the optimal subsidy is higher than welfare under commitment to free trade. Therefore, the region where commitment to free trade is preferred to a flexible subsidy (see area II in figures 7a and 7b) is a subset of the region in which commitment to a period-one subsidy is preferred to subsidy flexibility in period two.

7. Conclusion

In this paper we have taken the first steps in examining optimal trade policy when the timing of firms' investment decisions is endogenous and demand is uncertain. In our set-up, firms face a trade-off between remaining flexible in order to adjust their capital appropriately in the face of uncertain demand, or moving earlier in order to strategically manipulate their rival's future output.

[18] At higher levels of uncertainty than those shown in figure 7b, there is another subzone of the subsidy flexibility regime, characterised by the equilibrium ($s_2; D, D^*$). For a complete representation of the game under subsidy flexibility, we refer to figure 4.

We have shown that endogenous timing of investment creates a new motive for government intervention. The government may adjust its policy to affect the investment timing decision of the firms. This possibility arises because the relative value of commitment to flexibility for a firm depends on its marginal costs relative to that of its rival. It was shown that, *ceteris paribus,* firms with lower marginal costs gain more from commitment than firms with relatively high costs. When the government sets its subsidy at the beginning of the game before firms decide when and how much to invest, it may find it optimal to over- or under-subsidise to deter private-sector capital commitment. If it chooses to deter foreign commitment this necessitates a larger export subsidy which reduces the relative advantage of commitment to the foreign firm. By contrast, to deter home commitment and thus guarantee flexible investment by the home firm, while preventing socially wasteful over-investment, the government needs to under-subsidise.

In the case in which the government sets it subsidy in period two, the relative value of commitment to the foreign firm rises sharply, so much so that even when it has an initial cost disadvantage (which is compounded by the subsidy received by the domestic firm), it will remain committed at higher levels of uncertainty than its domestic rival.

We also examined a policy of commitment to free trade. Clearly, such a policy is never better than commitment to the optimal first-period subsidy. However, if the relevant choice is between a second-period subsidy and free trade, then commitment to non-intervention can be superior. The government can gain from committing to free trade as this greatly reduces the incentives of firms to commit. This is more likely to be a welfare increasing policy the lower is the marginal capital cost and the lower is the level of uncertainty.

So, we have found two ways in which the government may engineer investment delay. One way involves manipulating the firms' marginal costs, while the other entails choosing to refrain from intervention altogether. This leads us to conjecture that there will be a wide range of policy environments where commitment deterrence in some form would be optimal, implying that the incentive to pursue a policy of commitment deterrence may be quite general.

Before concluding we wish to discuss briefly some possible extensions of the analysis. In this paper we have focussed on demand uncertainty. Firms may also be uncertain about their own and rival's future costs. In that case it would be natural to assume that they know less about their rival's costs than their own. This would raise the issue of asymmetric information which we have assumed away here. Allowing for asymmetric information in the analysis would lead to other interesting lines of research. Even with demand uncertainty there may be cases in which one firm knows more than the other. We could for instance consider a case in which one firm (with local knowledge) has better information about the market demand. These issues are left as topics for future research.

Appendix A

The subsidies under government commitment for different investment choices are presented in Table A.1.

[Table A.1 about here]

Appendix B

[Figure B.1 about here]

[Figure B.2 about here]

Appendix C

[Figure C.1 about here]

In area IVa of figure C.1, $(s_1^{dd*}; DD*)$ is the unique equilibrium, while it is the Pareto-dominant equilibrium (among other possible equilibria) in area IVb.

Appendix D

[Figure D.1 about here]

In region IIb and in the shaded area of the diagram, there are multiple equilibria under the free trade regime: both *(C,C*)* and *(D,D*)* are equilibria of the timing subgame. In area IIb, the government will prefer free trade to policy flexibility irrespective of which of the two investment timing equilibria were to emerge. However, the government's choice in the shaded area depends on the investment timing that it anticipates under free trade. If the government anticipates that under free trade both firms will delay investment, it will opt for free trade, but if it anticipates that firms would instead decide to commit to investment in period one, the home government reaches a higher welfare level by choosing to set a flexible subsidy.

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Table 1: Capital investment under free trade

Investment Timing	k	k^*
C,C*	$k_1 = \frac{4}{3} hEx^{cc*}$	$k_1^* = \frac{4}{3} hEy^{cc*}$
C,D*	$k_1 = \frac{2(2-h)}{3-2h} hEx^{cd*}$	$k_2^* = hy^{cd*}$
D,C*	$k_2 = hx^{dc*}$	$k_1^* = \frac{2(2-h)}{3-2h} hEy^{dc*}$
D,D*	$k_2 = hx^{dd*}$	$k_2^* = hy^{dd*}$

Table 2: Equilibrium subsidy and capital under government flexibility

Investment Timing	s_2	k	$k*$
C,C*	$\frac{x^{cc*}}{2}$	$k_1 = 2hEx^{cc*}$	$k_1^* = \frac{3}{2} hEy^{cc*}$
C,D*	$\frac{x^{cd*}}{2-h}$	$k_1 = \frac{2-h}{1-h} hEx^{cd*}$	$k_2^* = hy^{cd*}$
D,C*	$\frac{x^{dc*}}{2}$	$k_2 = hx^{dc*}$	$k_1^* = \frac{3-h}{2(1-h)} hEy^{dc*}$
D,D*	$\frac{x^{dd*}}{2-h}$	$k_2 = hx^{dd*}$	$k_2^* = hy^{dd*}$

Table A.1: Subsidies under government commitment for given investment choices by firms

s_1^{cc*}	$\frac{1-(4/9)\theta(2-(4/3)\theta)}{2-(4/3)\theta} Ex^{cc*}$
s_1^{dc*}	$\frac{3-2\theta}{2\left[3-4\theta+\theta^2\right]} Ex^{dc*}$
s_1^{cd*}	$\frac{(3-2\theta)^2-2\theta(2-\theta)^2}{(3-2\theta)^2(2-\theta)} Ex^{cd*}$
s_1^{dd*}	$\frac{Ex^{dd*}}{2-\theta}$

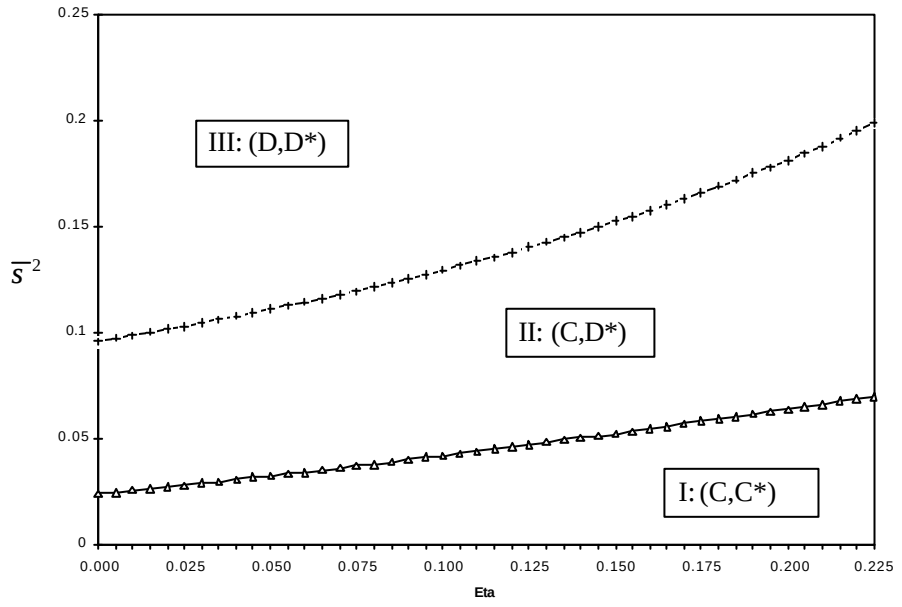
Note: $s_1^{dc*} > s_1^{dd*} > s_1^{cc*} > s_1^{cd*}$ if $A^* = A$

$s_1^{dd*} > s_1^{dc*} > s_1^{cc*} > s_1^{cd*}$ if $A^* = 1.4A$

Figure 1: The investment timing game under free trade in normal form

		Foreign Firm	
		C^*	D^*
Home Firm	C	$E\pi^*\left(k_1(C,C^*),k_1^*(C,C^*)\right)$ $E\pi\left(k_1(C,C^*),k_1^*(C,C^*)\right)$	$E\pi^*\left(k_1(C,D^*),k_2^*(C,D^*)\right)$ $E\pi\left(k_1(C,D^*),k_2^*(C,D^*)\right)$
	D	$E\pi^*\left(k_2(D,C^*),k_1^*(D,C^*)\right)$ $E\pi\left(k_2(D,C^*),k_1^*(D,C^*)\right)$	$E\pi^*\left(k_2(D,D^*),k_2^*(D,D^*)\right)$ $E\pi\left(k_2(D,D^*),k_2^*(D,D^*)\right)$

Figure 2: Firms' investment timing under free trade (A*=0.8A)



$-\Delta-: E\pi^*(C,C^*) = E\pi^*(C,D^*) \quad -+-: E\pi(C,D^*) = E\pi(D,D^*)$

Figure 3: The sequence of the game under government flexibility

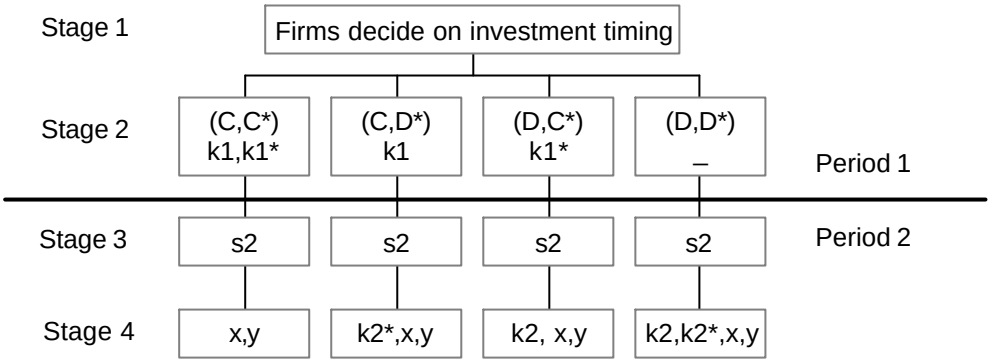
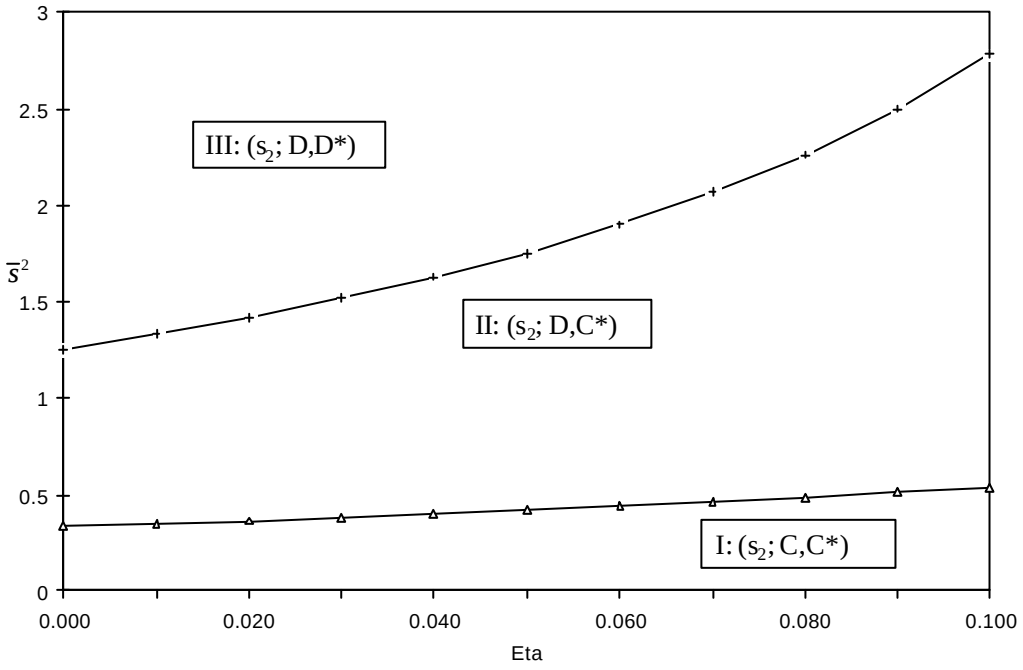


Figure 4: Firms' investment timing under policy flexibility of the home government (A*=A)



$$-+-: E\boldsymbol{p}^*(s_2; D, C^*) = E\boldsymbol{p}^*(s_2; D, D^*) \qquad -\Delta-: E\boldsymbol{p}(s_2; C, C^*) = E\boldsymbol{p}(s_2; D, C^*)$$

Figure 5a: Firms' investment timing for commitment by the home government (A*=A)

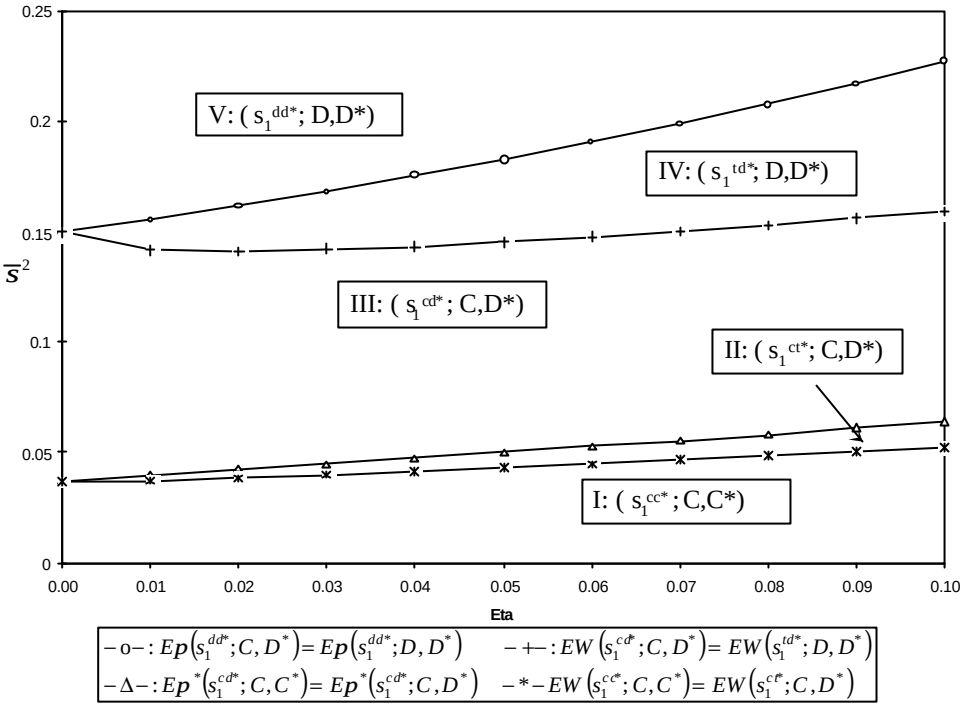


Figure 5b: Subsidy under commitment by home government as a function of uncertainty (A*=A; eta=0.1)

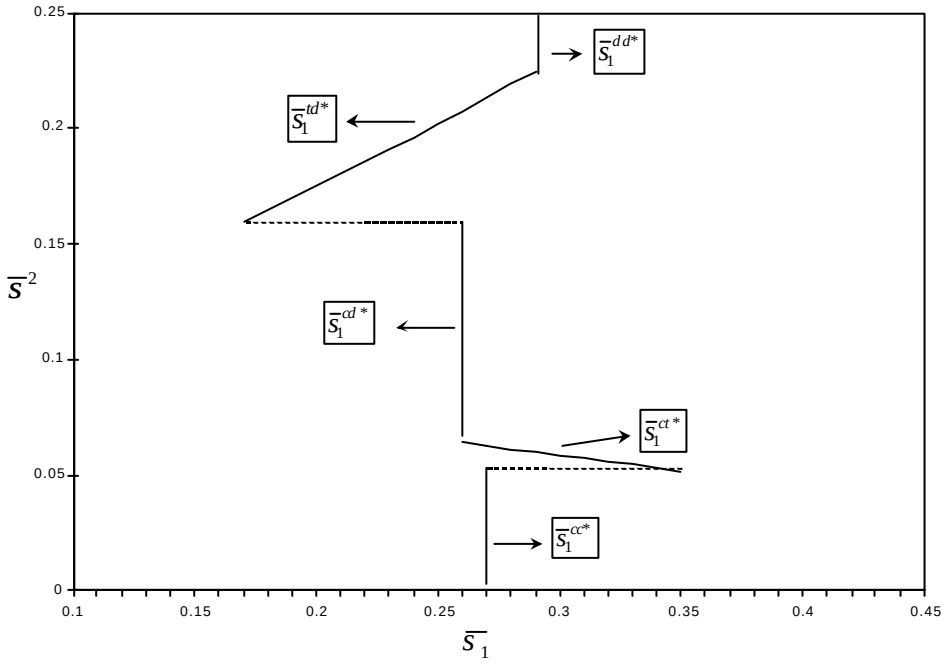
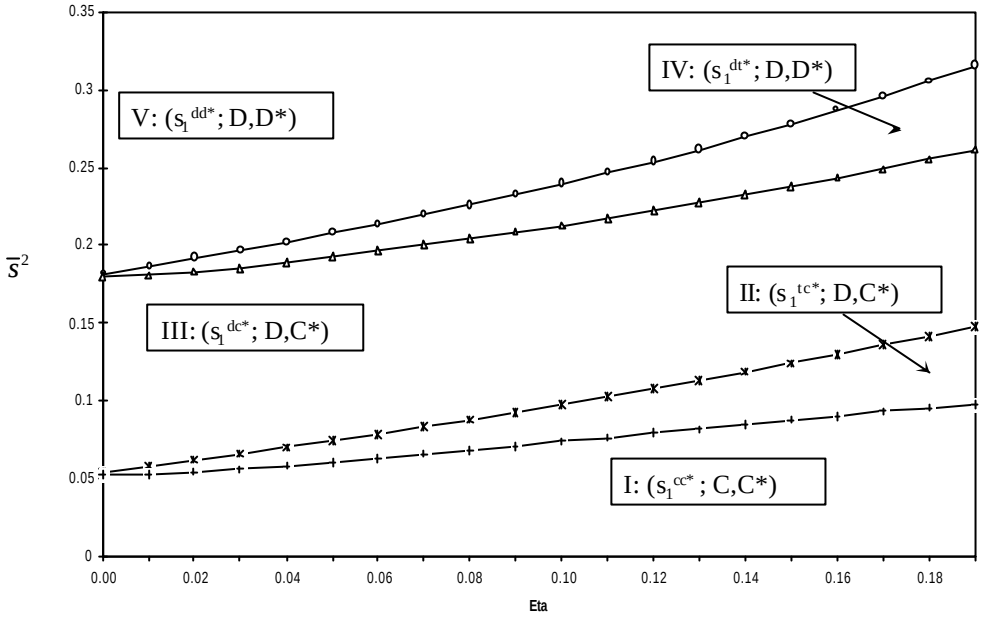


Figure 6a: Firms' investment timing for commitment by home government (A*=1.4A)



$-o-: Ep^*(s_1^{dd*}; D, C*) = Ep^*(s_1^{dd*}; D, D*)$ $\quad -\Delta-: EW(s_1^{dc*}; D, C*) = EW(s_1^{dt*}; D, D*)$

$-*-: Ep(s_1^{dc*}; C, C*) = Ep(s_1^{dc*}; D, C*)$ $\quad -+-: EW(s_1^{cc*}; C, C*) = EW(s_1^{tc*}; D, C*)$

Figure 6b: Subsidy under commitment by the home government (A*=1.4A; eta=0.1)

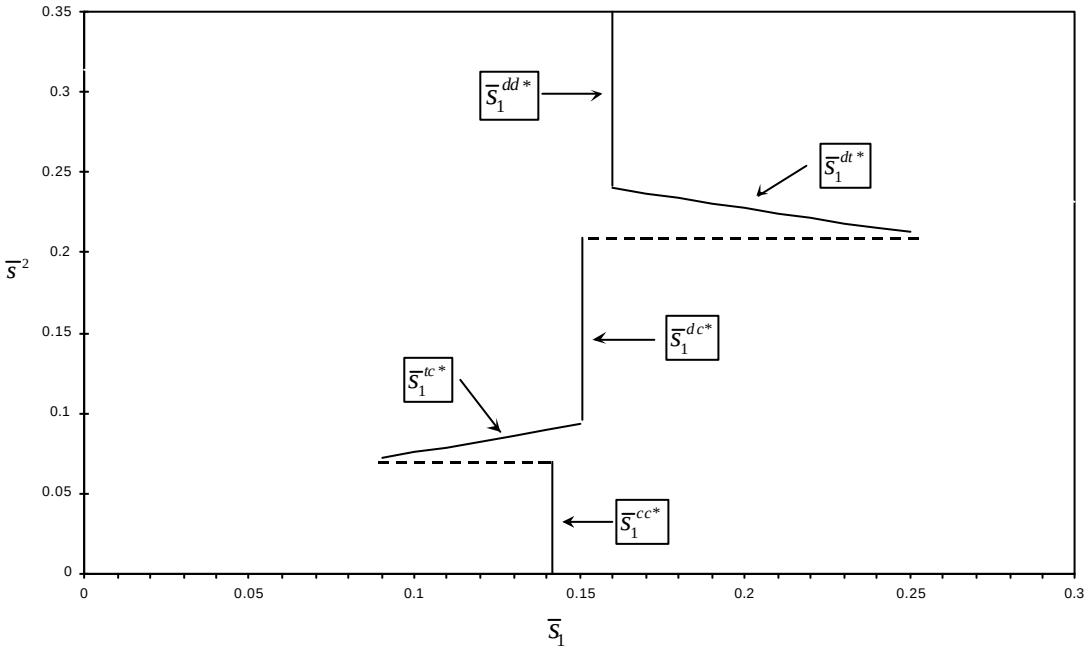
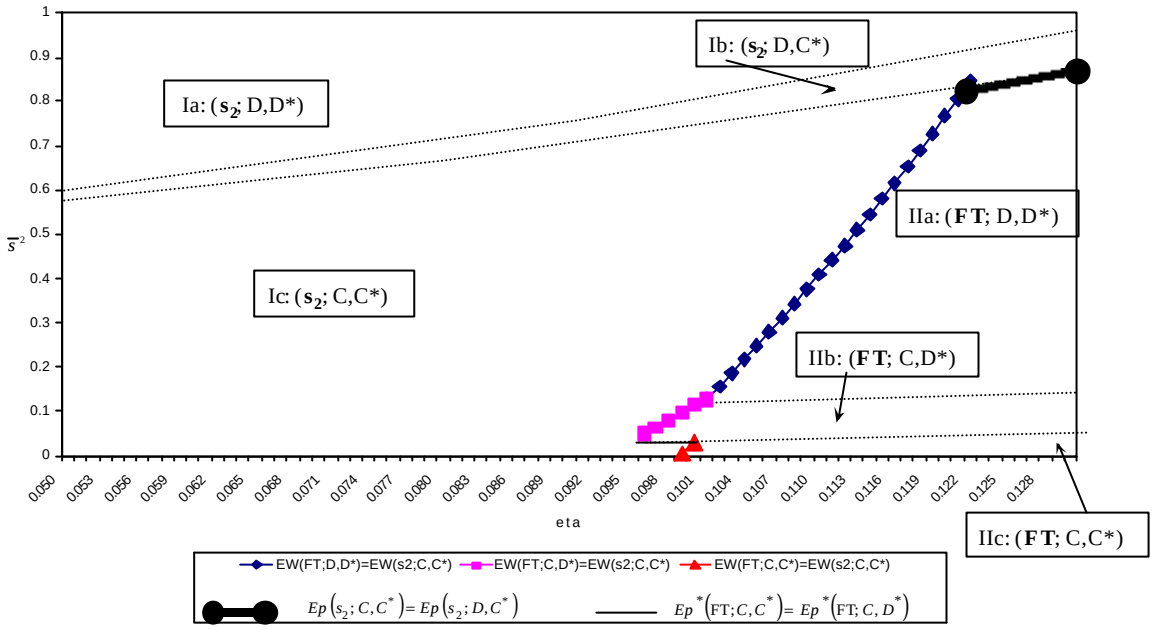
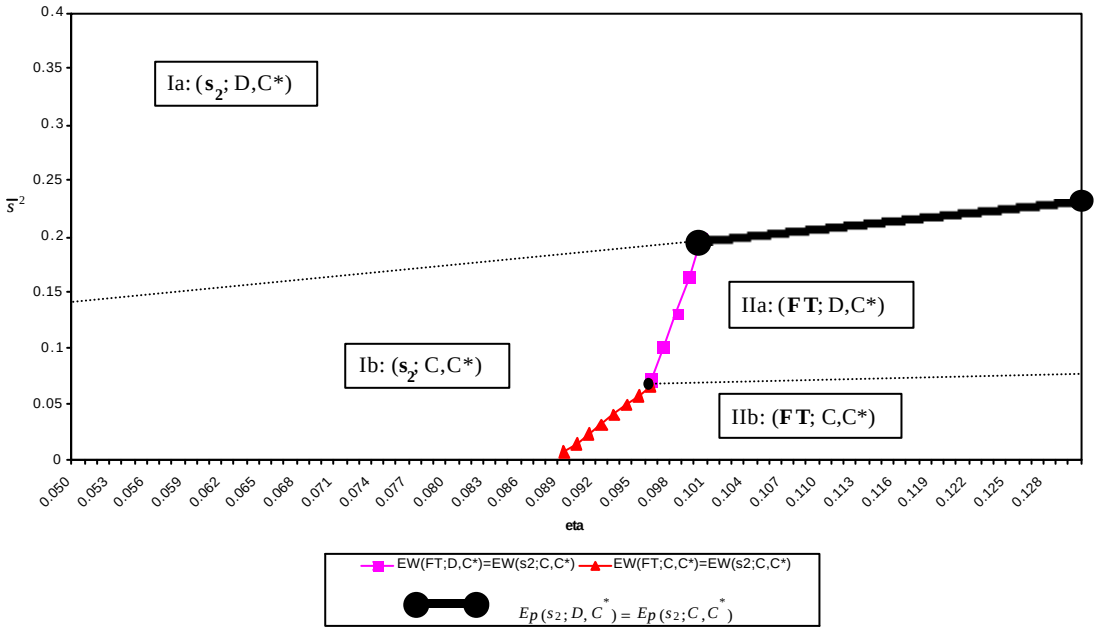


Figure 7a: Commitment to free trade (FT) versus a flexible subsidy (A*=0.8A)[a]



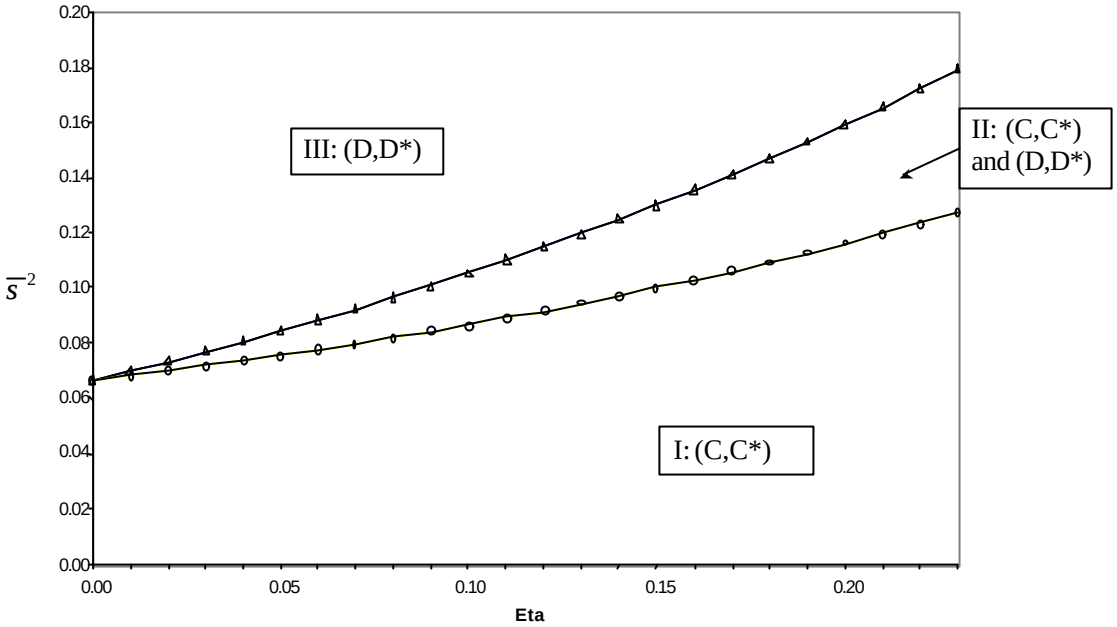
[a] Note that, to enhance the clarity of the graph, the horizontal axis does not start at the origin.

Figure 7b: Commitment to free trade (FT) versus a flexible subsidy (A*=1.25A)[a]



[a] Note that, to enhance the clarity of the graph, the horizontal axis does not start at the origin.

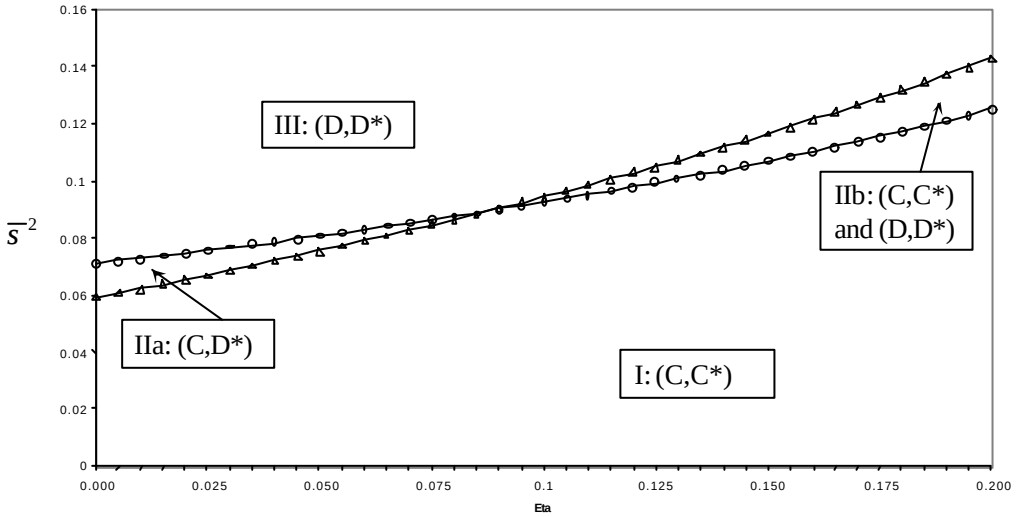
Figure B.1: Firms' investment timing under free trade (A*=A)



$-\Delta-: E\Pi(C,C^*) = E\Pi(D,C^*)$ and $E\Pi^*(C,C^*) = E\Pi^*(C,D^*)$

$-O-: E\Pi(C,D^*) = E\Pi(D,D^*)$ and $E\Pi^*(D,C^*) = E\Pi^*(D,D^*)$

Figure B.2: Firms' investment timing under free trade for a "small" cost asymmetry (A*=0.97A)



$-\Delta-: Ep^*(C,C^*) = Ep^*(C,D^*)$

$-O-: Ep(C,D^*) = Ep(D,D^*)$

Figure C.1: Firms' investment timing for commitment by the home government (A*=1.2A)

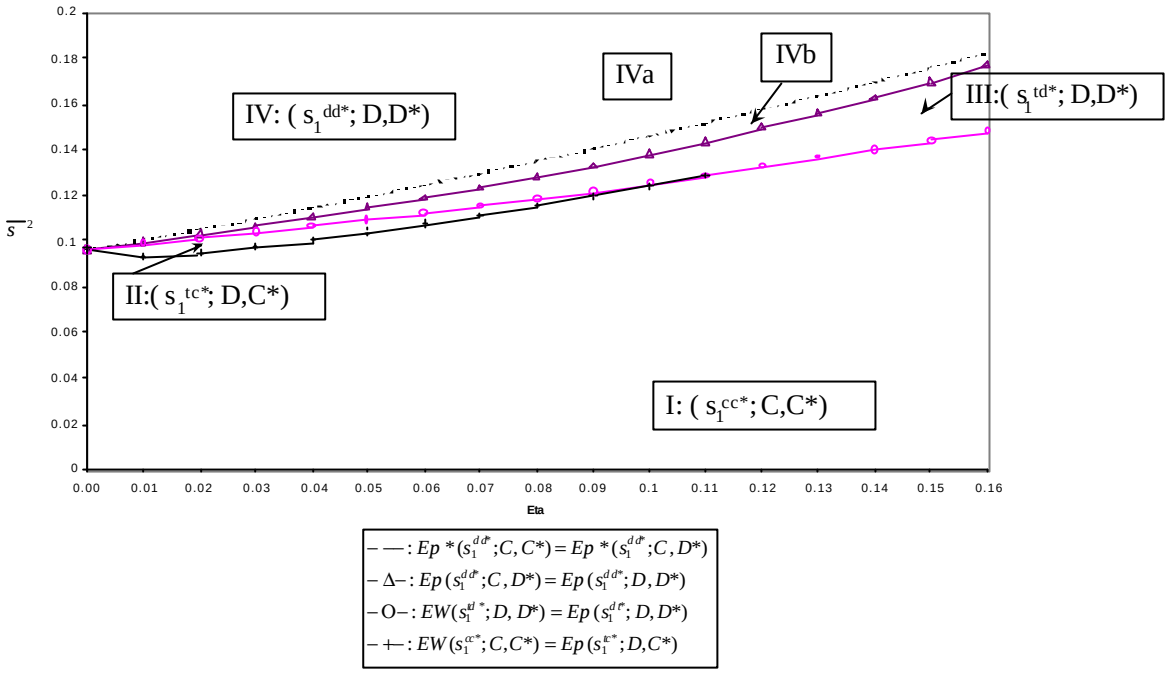
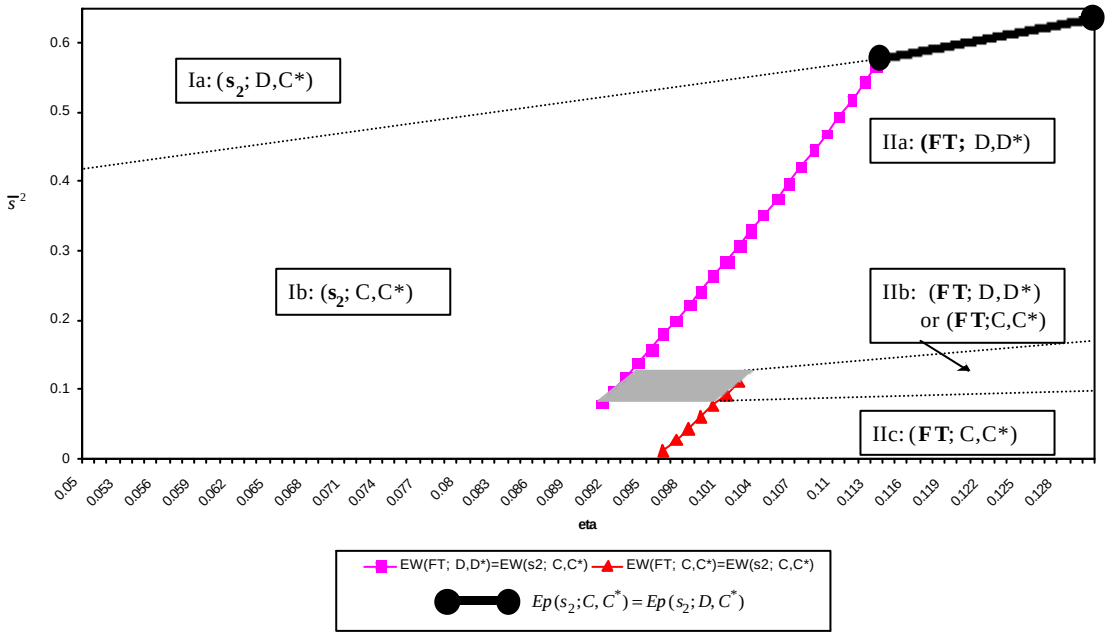


Figure D.1: Commitment to free trade (FT) versus a flexible subsidy (A*=A)[a]



[a] Note that, to enhance the clarity of the graph , the horizontal axis does not start at the origin.