GOVERNMENT'S (IN)ABILITY TO PRECOMMIT, AND STRATEGIC TRADE POLICY: THE "THIRD MARKET" VERSUS THE "HOME MARKET" SETUP

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WORKING PAPER SERIES (ISSN 1211-3298)
Electronic Version

319

Working Paper Series 319
(ISSN 1211-3298)

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CERGE-EI
Prague, March 2007

ISBN 978-80-7343-116-7 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-105-0 (Národohospodářský ústav AV ČR, v. v. i.)

Government's (In)ability to Precommit, and Strategic Trade Policy: The "Third Market" *versus* the "Home Market" Setup

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Abstract

We shift the usual perspective of strategic trade policy – the "third market setup" – to the "home market" framework in order to reconsider the consequences of government (in)ability to precommit to its policy and compare these findings with those analogous from the "third market setup". In addition, we also analyze how robust the sign is of particular policy instruments (R&D subsidies) within the home market setup, as opposed to the third market setup, when there is a shift from "second–best" to the "first–best" policy. For that purpose, we apply a standard dynamic Cournot duopoly where the firm's strategic variable is investment in cost reduction whereas policy instruments are import tariffs and R&D subsidies.

Abstrakt

Posouváme obvyklé vnímání strategické obchodní politiky od "modelu třetího trhu" k "domácímu trhu" ve snaze zvážit důsledky (ne)schopnosti vlády zavázat se ke své politice a porovnat tato zjištění s těmi analogickými z "modelu třetího trhu". Rovněž analyzujeme, jak robustní je znaménko jednotlivých nástrojů politik (dotace na R&D – výzkum a rozvoj) v modelu domácího trhu jako protějšku modelu třetího trhu, kdy dochází k přesunu od "druhé nejlepší" k "první nejlepší" politice. Za tím účelem aplikujeme standardní dynamický Cournotův duopol, kde jsou strategickou proměnnou firmy investice do redukce nákladů, zatímco politické nástroje jsou dovozní tarify a dotace na výzkumu a rozvoj (R&D).

JEL: F13; L11; L13; O31

Keywords: government commitment, optimal tariffs and R&D subsides, first–best versus second–best strategic policy.

I am very grateful to 2 anonymous referees and Robert Staiger, co-editor of JIE as well as to Elie Appelbaum, Alan Deardorff, Avner Shaked, and Anu Kovarikova Arro for invaluable comments on this paper. The extraordinary research assistance of Jan Mysilve…ek, Michael Kúnin, Eugen Kováč, and Boryana Madzharova was most appreciated.

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** CERGE-EI is a joint workplace of the Center for Economic Research and Graduate Education, Charles University, and the Economics Institute of the ASCR, v. v. i.

1. Introduction

"An intriguing but under–appreciated aspect of strategic trade policy is the crucial importance of timing in decision," noted J.Brander (1995) in his famous survey on strategic trade policy. Related to the subject of timing, but conceptually different, is the issue of a government's ability to commit to its action. More precisely, this (in)ability determines the timing in decisions. The government is usually assumed to set credibly its policy instrument before the firm sets its respective variables. However, the practical application of the trade policy might go the other way around; the policy makers may either lack the ability to precommit, or they set the concrete policy instruments after the relevant action of the firm took place.

Notably, the "importance of timing" and government's ability to commit to its action have been studied mostly in the "third market setup" in which domestic and foreign firms compete in some third market thus ignoring consumer surplus and (possible) tariff revenue. To paraphrase Brander, it is intriguing that the "home market" framework is under–appreciated (or better to say, not appreciated at all!) in this kind of analysis.

Using a "third market" setup, Carmichael (1987) was one of the first authors who turned attention to the issue of government commitment and the consequent timing in a decision pointing to the example of the Export–Import bank of the United States that sets credit export subsides only after firms set their prices. A firm that anticipates a subsidy has an incentive to inflate a price since the size of the subsidy is usually positively related to the price. In these circumstances, trade policy loses its strategic dimension, and it is a rather responsive device in that governments try to offset an excessive increase in the domestic price[1]. Thus, there is a pure transfer of

[1]In fact, in Carmichael (1987), domestic firms have an incentive to inflate prices to infinity, and so equilibrium prices are obtained as a "corner solution" determined by the price cap set by the policy

rents from the government to the domestic firm without any strategic impact and so without any change in effective export prices and domestic social welfare. Consequently, the government will lose nothing if it can precommit to free trade.

Carmichael's (1987) analysis sparked a discussion and research about the modus and timing of trade policy. One of the crucial features of this discussion is the distinction between the very announcement of a policy program and its actual implementation. Thus, government's decision about the design of a policy program may precede the selection of the actual level of such selected policy, splitting a single stage of the game into two stages. Moreover, different timings of the policy choice (and different policies themselves) usually result in various degrees of policy flexibility pointing to a trade off between flexibility and commitment (see for instance, Cooper and Riezman; 1989, Arvan, 1991; and Shivakumar, 1993). Thus, for instance, Hwang and Schulman (1993) allow a government to explicitly commit to "non–intervention" (that is, to free trade, in our terminology) and investigate when the commitment to free trade yields larger social welfare.

It is important to recall that the above issue of strategic intervention *versus* commitment to free trade is an example of rules versus discretion in the sense described first by Kydland and Prescott, 1977. Since trade policy is, by its nature, of second (or even third–best) character, it is plagued with the time consistency problem and so the above dilemma of rules versus discretion is likely to be relevant here (see, for instance, Staiger and Tabellini, 1987 and 1989; and Stagier, 1995 for a survey of the literature that deals with rules *versus* discretion issues in the context of trade policy).

Inquiry into the impact of timing in subsequent strategic trade policy literature is conducted in a somewhat richer and (for the purpose of our upcoming analysis) more

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makers. However, this problem disappears if, as assumed by Gruenspecht (1988), the opportunity important context, yet still within the third market framework. In this setup, domestic firms undertake some kind of strategic investment prior to market competition (see for instance, Goldberg, 1995; Karp and Perloff, 1995; Neary and O'Sullivan, 1997; Grossman and Maggi, 1998; Neary and Leahy, 2000; and Ionaşcu and Žigić, 2005). The reason why the strategic investment of the firm can precede the government's action is the fact that the policy makers may lack credibility with the firms whose behavior they try to influence (see Neary and Leahy, 2000) or there may be an already noted time lag between the announcement of a trade policy program and the implementation of trade policy instrument at the concrete level. Both these reasons give a strategic motive to the domestic firm to influence (or manipulate) the government's policy response.

In these circumstances, precommitment to free trade looks even more attractive than in Carmichael's (1987) simple setting in which trade policy and free trade are equivalent in terms of social welfare. The point is now that domestic firms are inclined to overinvest in a strategic variable (e.g. in R&D capital) that may be socially costly and inefficient. In turn, it can lead to lower social welfare compared to the corresponding social welfare under free trade (see for instance, Karp and Perloff, 1995; Neary and O'Sullivan; 1997, Grossman and Maggi, 1998; Neary and Leahy 2000; and Ionaşcu and Žigić, 2005). This socially undesirable overinvestment occurs, among other things, when the cost of capital is not excessively large since high costs of capital neutralize the incentives for overinvesting.[2]

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cost of raising a unit of government revenue is bigger than one. See also Neary (1991) and (1994).

[2] Surveying the empirical evidence on international comparison of the costs of capital, Karp and Perloff, 1995 informed us that the U.S. has substantially higher costs of capital than other developed countries (double that of Japan, 89 percent more than in Germany, and 29 percent more than in the United Kingdom in 1988). Yet "... according to some empirical studies, even in the United States, real capital costs are low enough so that strategic U.S. subsides may cause excessive U.S investment" (Karp and Perloff, 1995).

It is worth stressing once again that all of the above conclusions are obtained in the "third market setup". Thus, the aim of this paper is to shift the focus from the "third market setup"[3] to the "home market". One reason for this is to test robustness of the above "third market setup" propositions, and the other is the policy relevance of the home market framework.

To illustrate as clear as possible the analogous effects of trade policy on the home market, we stick to the very simple dynamic Cournot duopoly. Like in most of the above–cited papers, the strategic variable is investment in cost reduction[4] (see, for instance, Karp and Perloff, 1995; or Grossman and Maggi, 1998). We start by analyzing three–stage games in which either the firm or the government moves first depending on whether the government can commit or not to its action before the firm chooses its strategic variable. Since the action takes place on the domestic market, the natural trade policy instrument to consider is an import tariff.

In addition to the above issue of government's (in)ability to commit, we also study how robust the sign is of particular policy instruments (R&D subsidies) within the home market setup (as opposed to the third market setup) when there is a shift from the "second–best" to the "first–best" policy. In a series of papers, Leahy and Neary (1996, 1997, and 1999) and Neary and Leahy (2000) stress the distinction between the "first–best" and "second–best" policy. The "first–best" versus "second–best" policy issue arises in the context of dynamic games where domestic firms have more than a one choice variable (e.g. level of R&D and level of output). In this setup, the first–best policy in principle includes more than one policy instrument in order to

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[3]As Helpman and Krugman (1989) point out the "third market approach is useful for isolating strategic interactions but is aterrible guide to policy ..."

[4]Investing in market-expanding investment or product innovation where the investments shift the demand function is effectively identical with cost-reducing investment (see, for instance, Leahy and Neary, 2001).

induce socially desirable levels of all choice variables. However, in many circumstances the government may be constrained to a smaller number of instruments or even only one instrument (say, an R&D subsidy). Such constrained policies are usually termed “second–best” (or even “third–best”). One of the interesting results of this literature is that, in the case of a Cournot competition and a third market setup, the R&D subsidy, which is generally positive in the “second–best” policy setup, turns out to be negative (an R&D tax) when the “first–best” policy is implemented.

The home market setup yields several strikingly different results in comparison to the third market setup that has routinely been considered in the literature. These are indicated in Table 1 and can be summarized as follows: a) There is likely overinvestment in the strategic variable from a social point of view; b) The social welfare in free trade can be higher than the social welfare under a strategic trade policy; c) The policy in which the government can commit to act upon prior to the strategic action of the domestic firm always generates higher welfare than its non–committed counterpart; and d) The “second–best” policy instrument changes sign when the “first–best” policy is employed.

In contrast, with the home market setup of this paper: a) There is underinvestment rather than overinvestment in strategic variables (i.e. R&D investment) from a social point of view ; b) Free trade is never superior to strategic trade policy; c) A government that is able to commit to its policy generates larger social welfare, but this finding is not robust and generally ceases to hold once we extend our basic model by allowing for a “small” amount of R&D spillovers; and d) Finally, the R&D subsidy is always positive in both the “first–best” and the “second–best” policy.

Table 1		
	Third market	**Home market**
a) Investment in a strategic variable from a social point of view	Likely overinvestment	Underinvestment
b) Free Trade	Can be superior to strategic trade policy	Never superior to strategic trade policy
c) Social welfare	Always lower when the government cannot commit to its policy instrument	Higher when the government cannot commit to its policy instrument, provided that there are at least a "small," critical amount of R&D spillovers"
d) Robustness of the investment subsides when moving from the first– to the second–best policy	Non–robust (change of the sign of the policy instrument)	Robust (no change of the sign of the policy instrument)

2. The basic model

2.1. ASSUMPTIONS

The key difference of our approach is that the stage of action is now domestic or "home" market. In order to focus exclusively on the home market, the easiest but the strongest assumption that we adopt here is that domestic firms produce the goods in question exclusively for the home market. Invoking the standard assumption of the "segmented market hypothesis" whereby foreign and domestic firms consider their respective home and foreign markets as separated, might be problematic here since the incentive to invest in R&D is likely to be affected by the existence of the foreign market for domestic goods. Moreover, Ben-Zvi and Helpman noted that market segmentation may not occur in equilibrium even under the standard assumptions of constant unit costs and no strategic investment[5] (and, especially in a

[5] I am grateful to both referees for pointing this out.

plausible case when the quantity produced is determined after the market price is set; see Ben-Zvi and Helpman, 1988).

Much like in the above described third market setup, we rely on the already standard and simple dynamic setup in which the domestic firm invests in a strategic variable prior to the market competition stage in which the domestic and foreign firms set their respective output levels simultaneously. As for the home government, we assume that for the time being it is constrained to only one policy instrument—an import tariff, denoted as "t".

We consider three government regimes: (1) the "commitment regime" in which the government is capable of committing to both a tariff program and an actual optimal tariff prior to the domestic firm's choice of its strategic variable (so the associated variables carry the subscript "c"); (2) the "non–commitment" regime in which the government announces a tariff program or even the level of the tariff in the first stage but (say, due to the lag in the announcement and implementation of the policy, or due to lack of credibility) imposes the actual tariff only after it observes the domestic firm's choice of its strategic variable (the associated variables have the attached subscript "nc"). The third regime, free trade, is a situation in which the government is assumed to be able to commit to non–intervention, that is, no tariff program. In our setup this is equivalent to setting the tariff to zero.[6] Note that free trade and both "non–commitment" and "commitment" regimes can be considered as "second–best" policies since there is only one policy instrument and two choice variables (strategic variable and quantities).[7]

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[6] In a more complex setup, setting an instrument to zero may not be equivalent to committing to free trade due to the different strategic implications of these two situations (see for instance, Gruenspecht,1988 or Arvan, 1991)

[7] For the whole spectrum of possibilities of commitment patterns between the firms and the government in a dynamic games setting under "third market" assumption, see Leahy and Neary, 1996.

As for the technical details of the basic model, much like in the related "third market" literature (see for instance, Grossman and Maggi; 1998, Neary and Leahy; 2000 and Ionaşcu and Žigić, 2005), we make use of the "linear–quadratic" example. More specifically, we assume the inverse demand function in the domestic market to be linear (with units chosen such that the slope is one). That is, $P = A - Q$ where $Q = q_d + q_f$. The parameter A captures the size of the market, whereas q_d and q_f denote the choice variables, that is, the corresponding quantities produced by the domestic and the foreign firms.

The strategic variable, that we label "y", can assume various interpretations, like upfront investment in capital or knowledge as in Grossman and Maggi (1998), or a variable related to R&D investment ("R&D cost function" as in Žigić, 2004 or Ionaşcu and Žigić, 2005). The point is that in each of these interpretations, these investments are assumed to reduce the marginal costs of the domestic firm by y. We assume that the "R&D cost function" has a quadratic form, $h(y) = y^2 / g$, where g is a parameter capturing the efficiency of marginal cost reduction (the parameter g is directly related to the parameter k used in Grossman and Maggi,(1998) or Karp and Perloff (1995) who interpreted it as the cost of capital or investment, with $g = 1/k$). We stick to the specific functional form of $h(y)$ to state our results as sharply as possible. However, it is important to note that all our results hold for a general R&D function, $h(y)$, under some plausible restrictions on it.[8]

The domestic firm is assumed to have initial constant unit variable costs of production α, with $A > \alpha$, where parameter α can be thought of as pre–innovative constant unit costs describing an old technology initially accessible to both the domestic and the foreign firms. We assume that " is always big enough so that $y \le \alpha$ holds in equilibrium. Consequently the post–innovative unit[9] cost of the domestic firm is now expressed as $C = \alpha - y$ and the corresponding unit costs of the foreign firm are $c = \alpha$.

Social welfare (W) is defined as the sum of consumer surplus (S), the domestic firm's profit (Π_d), and the revenue from tariffs (R). The consumer surplus is defined as

$$S(q) = \int_0^q P(z)dz - qP(q)$$

that, in the case of a linear demand, reduces to $S_d = (½)(q_f + q_d)^2$, the tariff revenue is given as $R = tq_f$ and, finally, the domestic and foreign firms' profits are respectively given as[10]:

$$\Pi_d = (A - Q)q_d - Cq_d - h(y) \text{ and } \Pi_f = (A - Q)q_f - cq_f - tq_f \ .$$

As for the other model assumptions and restrictions, they are primarily concerned with the issue of the existence and viability of a duopoly and the well–defined maximization problems that in turn require constraints on the R&D cost function, $h(y)$. For a duopoly to be a viable market structure in both commitment and non–commitment regimes, it is necessary that a strategy leading to the elimination of the foreign competitor— "strategic predation"— would be too expensive and is never

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[8]More specifically, it is sufficient to assume that *h'*(0) = h(0) = 0 and that the h(y) is sufficiently convex, that is, the marginal cost of the unit cost reduction, h'(y), has to be "steep enough" so that the resulting equilibrium market structure is always a duopoly (see Žigić, 2003).

[9]In the rest of the article, we use the term "unit costs" instead of the more correct "unit variable costs".

[10]Subscript "d" will be omitted further on since we will concentrate only on the domestic variable.

optimal for either the domestic firm or the domestic government. Thus, the marginal cost of the unit cost reduction, $h'(y) > 0$, has to be "steep enough" so that its intersection with the accompanied marginal benefit occurs at a level of y^* such that $0 < y^* < y^p \leq \alpha$ where y^* is the optimal unit cost reduction in a duopoly and y^p is the level of unit cost reduction that leads to the zero output of the foreign firm in equilibrium. More specifically, it means that the size of the parameter, g, should not be "too large" implying an upper bound on g such that for all values of g below this upper bound all problems under considerations would be well defined (that is, the duopoly is both feasible and socially an optimal market structure and all second–order conditions in our analysis are automatically satisfied).[11] The interval of g (or concisely, the "feasibility region") that satisfies the above restrictions, is defined as[12]:

(i) g 0(0, g_{cr}) with g_{cr} = 0.677

We assume further on that g takes values from this interval.

2.2. The "non–commitment" regime

Given our current framework in which the government relies on trade policy, it could be argued that the assumption of the "non–committed" government is a natural one and the one that is easier to justify than its "committed" counterpart. As noted by Kydland and Prescott, 1977, the necessary condition for a government to lack commitment ability is that it finds itself in a second– or even third–best situation. This is a typical situation with trade policy indeed since reliance on trade policy in general implies that the government for some reason does not have other, less distortionary

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[11]Following an alternative interpretation (e.g. Grossman and Maggi, 1998 or Karp and Perloff, 1995) the upper bound on g is equivalent to the lower bound on the cost of capital, k. The reason is that low costs of capital may lead to high investment in R&D that in turn results in drastic innovation and the exit of the foreign firm.

instruments at its disposal (see Staiger, 1995). In such circumstances the government has an incentive to surprise firms by unexpected policies. For instance, in our setup the policy makers are tempted to announce a "high" tariff to enhance the domestic firm's incentive to invest in socially insufficient R&D investment (or unit cost reduction), and then if the domestic firm believed this announcement and did the corresponding R&D investment, it becomes optimal for the government to renege *ex post* on its promise and set a lower, less distortionary tariff. Finally, the fact that the government in our setup relies on strategic trade policy whose successful application requires a high degree of flexibility and discretion, reinforces the case of the "non–committed" government.[13]

The above setup implies strategic interaction between the domestic government, the domestic firm, and the foreign firm, and it can be depicted by means of a sequential, three–stage game. So when, for instance, the domestic firm does not consider the government's policy announcement to be credible, the first stage of the game is the one in which the domestic firm strategically chooses its innovation effort and consequent unit cost reduction. In the second stage, the non–committed government sets the tariff on imports after it observes the firm's choice of y. Finally, in the last stage, the firms select quantities, and consequently, profits and welfare are realized.

As is already clear, the action is on the domestic market, in which the duopoly is assumed to be a viable market form both before and after the tariff is set. In order to ascertain the subgame perfect equilibrium, we proceed by solving the game

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[12] It turns out that the strongest restriction on *g* is imposed by the requirement of the existence of a duopoly in the commitment regime, that is, by the conditions that $q_f\ (y^*(t),t^*) > 0$.

[13] Ultimately, the (in)ability of the government to commit to its policy depends on the strength of the country's institutional and political setup.

backwards. In the last (third) stage, the firms choose the equilibrium quantities. The domestic firm maximizes

$$\underset{q_d}{Max}[\Pi_d] = (A - Q)q_d - C(y)q_d - h(y) \quad \text{(1.a)}$$

given q_f and $Q = q_d + q_f$. The first–order condition for an interior maximum is $\partial\Pi_d / \partial q_d = 0$ and yields $A - 2q_d - q_f - C = 0$.

The maximization problem for the foreign firm yields:

$$\underset{q_{ff}}{Max}[\Pi_f] = (A - Q)q_f - cq_f - tq_f \quad \text{(1.b)}$$

given q_d and t. The first–order condition is: $A - 2q_f - q_d - c - t = 0$. Solving the reaction functions yields the Cournot outputs as a function of y and t:

$$q_d(y,t) = \frac{(A + c - 2C(y) + t)}{3} \quad \text{(2.a)}$$

$$q_f(y,t) = \frac{(A - 2c + C(y) - 2t)}{3} \quad \text{(2.b)}$$

Substituting (2.a) and (2.b) into (1.a) yields the domestic firm's profit function expressed in terms of y, R&D investment costs, $h(y)$, and the tariff:

$$\Pi_d^*(y,t) = \frac{(A + c - 2C(y) + t)^2}{9} - h(y). \quad \text{(3)}$$

In the second stage of the game, the domestic government selects the optimal tariff given the unit cost reduction of the domestic firm. Its objective function is given by the expression

$$W(t) = \Pi(t) + S(t) + R(t) \quad \text{(4)}$$

where consumer surplus, $S(t)$ and tariff revenue $R(t)$ are respectively given by

$$S(t)=\frac{1}{2}(q_d^*+q_f^*)^2=\frac{2(A-\alpha-t+y)^2}{9} \quad (5)$$

and

$$R(t)=tq_f^*=\frac{t(A-\alpha-2t-y)}{3}. \quad (6)$$

Note that domestic profit monotonically increases in tariff (the higher the tariff the larger the effective unit cost difference and, consequently, the higher the domestic firm's profit) while consumer surplus monotonically declines in the tariff. Finally, the function $R(t)$ initially increases in t as t goes above zero, reaches its maximum at $t=\frac{1}{4}(A-\alpha-y)$, but eventually falls to zero as t reaches the prohibitive tariff, t_p, a tariff that causes the exit of the foreign firm. Thus, the function $W(t)$ is strictly concave in t with $d^2W(t)/dt^2=-1<0$ while the whole tariff domain on which a duopoly is defined is given by the interval $t\in[0,\ t_p]$.

The assumption (i) ensures an interior maximum such that $t_{nc}^*<t_p$ and the optimal tariff, t_{nc}^* is obtained by solving $\partial W/\partial t=0$, yielding:

$$t_{nc}^*=\frac{A-\alpha}{3}. \quad (7)$$

There are several interesting observations to be made about the above optimal tariff t_{nc}^*. First, note that the expression for t_{nc}^* is a pure profit–shifting tariff[14] (see Bhattacharjea, 1995), and it is quite general since it is independent of the functional form of the R&D cost function. Second, it does not depend either on the domestic unit cost [α in (7) represents foreign firm unit costs], or on the domestic strategic

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[14] More precisely, it is equivalent to the standard strategic tariff that leads to improvement in terms of trade and to production efficiency gains (see Helpman and Krugman, 1989).

variable, y. The latter is rather important for us because it indicates that the manipulation of the government by the domestic firm (in the form of overinvesting in y) is not possible here. Finally, given the fact that in a "non–commitment" regime, the government lacks the ability to precommit to the tariff before the firm chooses y, the tariff t_{nc}^* then is time consistent.[15]

In the first stage of the game, the domestic firm selects the optimal level of marginal costs reduction, y, taking into account its subsequent impact on its foreign rival's behavior. By substituting t_{nc}^* into (3) and recalling that $h(y) = y^2 / g$, we obtain

$$\Pi_d^{\circ}(y, t_{nc}^*(y)) = \Pi_d^{\circ}(y) = \frac{4(2(A-\alpha)+3y)^2}{81} - \frac{y^2}{g} \quad . \tag{8}$$

Maximizing (8) with respect to y gives the first–order condition[16] and the optimal y_{nc}^*:

$$\frac{24(2(A-\alpha)+3y_{nc}^*)}{81} = h'(y_{nc}^*) \tag{9}$$

that given the functional form of $h(y)$ results in

$$y_{nc}^* = \frac{8(A-\alpha)g}{3(9-4g)} \tag{10}$$

Finally, by substituting (10) into (5), (6), and (8) and summing these three items, we obtain the optimal social welfare in the "non–commitment" regime:

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[15] A sufficient and standard procedure that we apply to solve for a time consistent tariff is the concept of subgame perfect equilibrium (see Fesrthman,1989).

[16] The second order condition requires g <6.75, and (i) is sufficient for this second order condition to hold.

$$W_{nc}^{*}=\frac{(A-\alpha)^2(567-8(43-6g)g)}{18(9-4g)^2} \quad . \tag{11}$$

2.3. The "commitment" regime, free trade, and social planner

Let us now assume that the government somehow possesses the ability to commit to its policy prior of any strategic move (investment) by the domestic firm. Similarly to the above case, this can be again captured by the appropriate three–stage game. In the case of the commitment regime, the only formal difference with the non–commitment regime is that the first two stages are reversed. Thus, the government now credibly commits to the tariff level in the first stage of the game; in the second stage, the domestic firm strategically chooses its innovation effort and the consequent unit cost reduction. Finally in the last stage, the firms choose their equilibrium quantities. In the case of free trade, the government is assumed to be able to commit to non–intervention, and in our setup this is equivalent to precommitment to zero tariff (see footnote 6). The "social planner" setup refers here to the situation in which the government, besides a tariff, also sets R&D investment, y.

We now briefly characterize the optimal tariff, unit costs reduction and social welfare in the commitment regime, free trade, and the constrained social planner and then make the relevant comparisons across the regimes.

a) The "commitment" regime

Maximization of (3) with respect to y, gives the first–order condition that determines the optimal y (but now as a function of the tariff):

$$\frac{4}{9}(A-\alpha+t+2y)=h'(y_c^*)\,. \tag{12}$$

Label it as $y_c^*(t)$ and the explicit value of unit cost reduction is now:

$$y_c^*(t) = \frac{2(A-\alpha+t_c^*)g}{9-4g} \qquad (13)$$

Straightforward substitution of $y_c^*(t)$ into the social welfare function yields the government objective function, $W_c^*(y_c(t_c),t_c)$ to be maximized in the first stage. Setting $dW_c^*/dt = 0$ yields:

$$t_c^* = \frac{(A-\alpha)(27-2g(10-2g))}{81-2g(32-6g)} \quad . \qquad (14)$$

Again, the restriction (i) makes sure that the tariff, t_c^*, lies between zero and the corresponding predatory tariff, t_p.

Finally, social welfare in the commitment regime is given by (15):

$$W_c^* = \frac{(A-\alpha)^2(7-2g)(9-2g)}{2(81-4(16-3g)g)} . \qquad (15)$$

b) Free Trade

As for the free trade regime, it is equivalent to precommitting to the zero tariffs, so obtaining the respective comparable equilibrium values (that we label with subscript “ft’‘) is straightforward:

$$y_{ft}^* = \frac{2(A-\alpha)g}{9-4g} \qquad (16)$$

and

$$W_{ft}^* = \frac{(A-\alpha)^2(27-2(8-g)g)}{18(9-4g)^2} \quad . \qquad (17)$$

c) Social planner

If the government can select both tariffs and R&D, it would maximize $W_s^*(y_s, t)$ with respect to both y and t, and that in turn yields:

$$y_s^* = \frac{2(A-\alpha)g}{3(2-g)} \quad (18)$$

and

$$t_s^* = \frac{A-\alpha}{3} \quad . \quad (19)$$

Finally, the social welfare is given by

$$W_s^* = \frac{(A-\alpha)^2(14-3g)}{18(2-g)} \quad . \quad (20)$$

Note that t_s^* is identical to the non–commitment tariff that should not come as a surprise since the tariff now has only a profit–shifting function because R&D is chosen directly by the government.

2.4. Comparison across the regimes

We start with a comparison of unit cost reductions. The direct comparison reveals that the social planner undertakes the largest unit costs reduction, followed by commitment, non–commitment, and free trade regimes, respectively.

Lemma 1

Unit costs reduction and consequent R&D investment in any of the regimes are below the corresponding social planner's choice. The optimal unit costs reduction and consequent R&D investment are the biggest in the commitment regime and the lowest in the regime of free trade, that is $y_s^* > y_c^* > y_{nc}^* > y_{ft}^*$. [Lemma 1 holds for general $h(y)$; see Appendix 1]

Note that the government could have achieved the level of socially optimal unit cost reduction, y_s^*, if it had at its disposal an instrument that directly targets the socially insufficient unit cost reduction like, for instance, an R&D subsidy[17]. A tariff, on the other hand, is not capable of achieving that goal due to its high distortionary effect. Unlike the R&D subsidy, a tariff has an adverse effect on the market price and consequently, on the consumer surplus, and the government takes this into account when selecting the optimal tariff. Since a tariff ensures a larger market share for the domestic firm compared to free trade, and thus enhances the firm's incentive to invest in R&D, the respective value in free trade, y_{ft}, assumes the lowest value.

As for tariffs in the two "tariff" regimes, they are generally different due to the somewhat different functions that they perform. Namely, a distinctive characteristic of the tariff in the commitment regime is its "technological function". The committed government that sets the tariff, t_c^*, takes into account the tariff's impact on the subsequent choice of a domestic firm's R&D (note that $dy_c / dt > 0$). Thus, t_c^*, besides its profit shifting role, also has the function of stimulating R&D investment and more so the larger the efficiency of the R&D investment, since t_c^* increases in g. In the absence of a R&D subsidy, the tariff t_c^* assumes part of the R&D subsidy's role and acts not only as a trade policy but also as an industrial or technological policy instrument. This additional role of the tariffs in the commitment regime indicates that their optimal values may exceed the optimal values of their counterparts in the non–commitment regime given that in the non–commitment regime R&D investment is

[17]For the related analysis of R&D subsidy see, for instance, Spencer and Brander, 1983; Bagwell and Staiger, 1994; Maggi, 1996; Leahy and Neary, 1997, 2001; Hinloopen, 1997; and Žigić, 2003.

already in place when the tariff t_{nc}^{*} is set. So t_{nc}^{*} has no direct impact on the firm's choice of R&D.

LEMMA 2

The optimal tariff in the commitment regime always exceeds the optimal tariff in the non–commitment regime and, consequently, the first–best tariff.

Proof: A straightforward comparison between (7) and (14) reveals that $t_{nc}^{*} < t_{c}^{*}$ for all permissible values of $g > 0$. [Note that $t_{c}^{*}(g = 0) = t_{nc}^{*} = t_{s}^{*}$ and that $dt_{c}^{*} / dg > 0$. Lemma 1 holds also for general R&D cost function, $h(y)$; see Appendix 1].

As already made clear, the underlying intuition is that the "committed" government enjoys the credibility of the domestic firm. This, in turn, implies that the tariff has a direct beneficial effect on the firm's R&D, and the government exploits this fact in order to boost socially insufficient R&D at the expense of the increased distortion caused by the tariff larger than the first–best.

Lemma 2 gives also a clue for a comparison between y_{c} and y_{nc}. The larger unit cost reduction in the commitment regime is a consequence of the higher tariff that the domestic firm enjoys that in turn stimulates higher R&D investment.

Finally the social welfare comparison reveals that much like in the case of R&D investment, we have $W_{s}^{*} > W_{c}^{*} > W_{nc}^{*} > W_{ft}^{*}$. Again this ranking holds for the general R&D cost function, $h(y)$; see Appendix 2.

Proposition 1

In the home market setup, free trade never generates larger social welfare than the "non–commitment" regime. Moreover, there is underinvestment rather than overinvestment in the strategic variable. However, the commitment regime still yields the highest social welfare.

A closer look, however, reveals that the relative difference between W_c^* and W_{nc}^* is rather small. As the simple simulations across the feasible range of $g \in (0, g_{cr})$ show, the ratio of W_{nc}^* / W_c^* always exceeds 99% while both “tariff” regimes generate significantly higher social welfare than in free trade (16-20%).

3. Extending the basic model: R&D spillovers

3.1. WHY R&D SPILLOVERS?

Although social welfare in the commitment regime is still the largest among the three regimes, the striking issue is that the result is not robust if we slightly enrich our basic model. Given our setup in which the domestic firm exhibits innovative activity before the market competition takes place, we argue that a natural extension of the basic models is to allow for R&D spillovers from the domestic to the foreign firm. The rationale for introducing R&D spillovers stems from the fact that innovations, in general, are subject to R&D spillovers. In particular, our extended setup fits well into an already standard North–South trade setup in which the domestic Northern firms innovate, and the Southern firms imitate or in jargon, benefit from R&D spillovers through trade[18]. (Our analysis and the forthcoming conclusions would be identical if, instead, we consider market–expanding investments that, for instance, occur due to product innovation, and we also allow for demand spillovers; see footnote 19).

Moreover, from the point of view of the comparison to the third market models, one possibly unsatisfactory feature of our basic setup is the absence of the manipulation effect. Once there is a lack of government precommitment, the domestic firm typically manipulates the size of the policy instruments in the third

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[18]The importance of R&D spillovers, imitations and its economic implications in both North-South trade and in general seems to be well and broadly documented in both theoretical and empirical literature (see, for instance, Chin and Grossman, 1990; Griliches,1992; Deardorff, 1992; Žigić, 1998

market setup through overinvesting in the strategic variable (see for instance, Grossman and Maggi, 1998; Karp and Perloff, 1995; or Ionaşcu and Žigić, 2005). As seen from expression (7), the optimal tariff in our basic setup does not depend on the strategic variable, y. However, the introduction of R&D spillovers, as we will see soon, brings back this broken link and the investment in R&D and, consequently unit cost reduction, do affect the optimal tariff in the non–commitment regime.

Technically, allowing for R&D spillovers leads to the change in the profit of the foreign firm which is now expressed as $\Pi_f = (A - Q)q_f - (c - \beta y)q_f - tq_f$ where $\beta \in [0,1]$ stands for the R&D spillovers parameter[19]. In other words, the foreign firm is now assumed to capture a part of the domestic firm's R&D output. However, to be as close as possible to the basic model, we will constrain ourselves to the case of "small" spillovers (consequently, we evaluate and compare the relevant derivatives at β = 0).[20]

3.2. TARIFFS AND R&D COMPARISON ACROSS THE REGIMES

a) Tariffs

In what follows we briefly replicate our comparison across the regimes in this extended setup. First, we note that now the optimal tariff (see expression 21) does

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and 2000; Coe and Helpman, 1995; Lai and Qui, 2003; Qui and Lai, 2004; Grossman and Lai, 2004; among many others).

[19]The respective profit functions in the case of market-expanding investment and demand spillovers would be $\mathbf{A}_d = (A + x - Q)q_d - c\, q_d - x^2/g$ and $\mathbf{A}_f = (A + \gamma x - Q)q_f - c\, q_f - t\, q_f$ where the demand spillovers parameter, $\gamma \in [0,1]$ and x stands for the market-expanding investment.

[20] Note that the introduction of spillovers calls for the modification of the feasibility region defined by (i). The upper border, $g_{cr}(\beta)$, is now an increasing function in β since increasing spillovers softens competition for the given *g* and enables the foreign firm to survive in the market for values of $g(\beta) > g_{cr}(0) = 0.677$ (see Žigić, 2003). However, since we constrain ourselves to the region around zero spillovers, we do not have to bother with this.

depend on y that, in turn, enables the domestic firm to manipulate its own government

$$t^*_{nc}(y) = \frac{A - \alpha + \beta y_{nc}}{3} \ . \tag{21}$$

In terms of the parameters of the model, the corresponding levels of optimal tariffs in the two "tariff" regimes are given now by:

$$t^*_{nc}(\beta) = \frac{(A-\alpha)(27 - 4g(1-\beta)(3-\beta))}{81 - 4g(3-\beta)^2} \tag{22}$$

and

$$t^*_{c}(\beta) = \frac{(A-\alpha)(27 - g(10 - g(2-\beta)(1-\beta)^2 - 11\beta)(2-\beta))}{81 - g(32 - g(3-2\beta)(2-\beta) - 10\beta)(2-\beta)} \ . \tag{23}$$

Proof: The straightforward comparison between (22) and (23) reveals again that $t^*_{nc}(\beta) < t^*_{c}(\beta)$ for all permissible values of g > 0 and β. This extends the validity of Lemma 1 to the case of spillovers. [The relation $t^*_{nc}(\beta) < t^*_{c}(\beta)$ holds for a more general R&D cost function; proof available from author upon request].

Clearly, for β = 0, both tariffs collapse to their corresponding values in the basic model. In addition, (at least initially) both tariffs increase in spillovers assuming a new, R&D spillover counteracting role. That is, both $dt^*_{nc}/d\beta$ and $dt^*_{c}/d\beta$ are positive around β = 0. However, the key distinction lies in the different sensitivity of the two tariffs to spillovers.

LEMMA 3

The optimal tariff in the commitment regime increases more than its non–commitment counterpart with the appearance of small spillovers, that is, $dt^*_{c}/d\beta > dt^*_{nc}/d\beta$ at β = 0.

Proof: See Appendix 3 (The relation holds for more general R&D cost function; proof available from author upon request).

As a consequence of Lemma 3, there is an increasing gap between the two tariffs when spillovers appear. To understand this, note first that both $t^*_{nc}(\beta)$ and $t^*_c(\beta)$ have a profit shifting function that calls for an increase in the optimal tariff since spillovers make, *ceteris paribus*, the foreign firm's output and profit larger. However, $t^*_c(\beta)$ performs in addition a distinct technological function. Since the increased spillovers lead to a disincentive for the domestic firm to invest in R&D, the caring committed government adjusts the tariff upwards to restore (at least partly) the firm's incentive for R&D investment (recall that $dy^*_c / dt > 0$ with or without spillovers). This mechanism is absent in the non–commitment regime leading to a lower sensitivity of $t^*_{nc}(\beta)$ to spillovers.

b) R&D

Besides causing an increasing gap between the two tariffs, the appearance of spillovers has a conspicuous effect on R&D investment of the domestic firm. Much like the case of the tariffs, the clue for this result lies in the different sensitivity of y^*_{nc} and y^*_c with respect to the change in spillovers where now

$$y^*_{nc} = \frac{8(A-\alpha)(3-\beta)g}{81-4g(3-\beta)^2} \qquad (24)$$

and

$$y^*_c = \frac{(A-\alpha+t^*_c)(2-\beta)g}{9-g(2-\beta)^2} \quad . \qquad (25)$$

LEMMA 4

The optimal unit cost reduction in the commitment regime is more sensitive to spillovers than its non–commitment counterpart with the appearance of small spillovers, that is, $|dy_c^* / d\beta|$ > $|dy_{nc}^* / d\beta|$ *at* β *= 0* (note that $dy_c^* / d\beta$ = $dy_c / dt \; dt_c^* / d\beta + \partial y_c / \partial \beta$).

Proof: See Appendix 4. [The validity of Lemma 3 extends to a more general function, $h(y)$; proof available from author upon request].

To understand the intuition behind the lesser sensitivity of unit cost reduction on spillovers in the non–commitment regime, we briefly review the characteristics of the firm's strategic behavior in the context under consideration. First, it is well known that in dynamic Cournot duopoly models, where the domestic firm exhibits "limited leadership", the domestic firm (incumbent) "overinvests" in its strategic variable in order to gain advantage over its competitor[21]. The higher the spillovers, the more the foreign firm appropriates the innovative output of the domestic firm and consequently the higher are the disincentives to invest in R&D. In other words, since this strategic investment effect (present in both regimes) is aimed directly at the competitor, it is very sensitive to spillovers. On the other hand, in the non–commitment regime, there is an additional, "manipulating" motive that the domestic firm faces on top of the standard strategic investment motive described above. Namely, the domestic firm has an incentive to manipulate the government decision on the tariff because in the non–commitment regime, a higher unit cost reduction induces a higher tariff that in turn benefits the domestic firm's profit. This additional motive for overinvestment is not present in the commitment regime, and it is targeted towards the domestic government and not directly towards the foreign firm. Thus the "manipulating"

[21]The notion of over-investment is defined here with respect to the non-strategic benchmark, in which the domestic firm selects its R&D investment by ignoring its impact on the subsequent stage

investment is therefore less vulnerable to spillovers. Consequently, the overall R&D investments in the non–commitment regime (that can conceptually be broken up into two parts: strategic and manipulating R&D investment) are less sensitive to spillovers than the corresponding R&D (and unit cost reduction) in the commitment regime leading to $y_{nc}^* > y_c^*$ when spillovers exceed a certain "small" threshold.

3. 3. SOCIAL WELFARE AND SMALL SPILLOVERS IN THE TWO REGIMES

We start with an analysis of the marginal effects of "small" spillovers[22] on social welfare. Although we use a specific functional form of the R&D cost function, we proceed by ignoring this fact for a while by first trying to see what can be inferred assuming a more general form of $h(y)$.

From the previous section, we know that $t_{nc}^*(\beta) < t_c^*(\beta)$, $W_{nc}^* < W_c^*$ at β = 0 and $y_{nc}^* < y_c^*$ at β = 0. Also $dt_i^* / d\beta > 0, dy_i^* / d\beta < 0$ with $dt_c^* / d\beta >$ $dt_{nc}^* / d\beta$, and $| dy_c^* / d\beta | >$ $| dy_{nc}^* / d\beta |$ at β = 0. Since all these results hold for a more general R&D cost function, we now try to make some general inference on the effect of small spillovers on social welfare in the two regimes under consideration.

Differentiating W^* with respect to β yields:

$$\frac{dW_i^*(\beta = 0)}{d\beta} = \frac{\partial W_i^*}{\partial y}\frac{dy_i}{d\beta} + \frac{\partial W_i^*}{\partial t}\frac{dt_i^*}{d\beta} + \frac{\partial W_i^*}{\partial \beta} \tag{26}$$

where subscript "i" stands for either "nc" or "c". By taking partial derivatives of respective components of W (that is, S, R, and Π; expressions 5, 6 and 7) with

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variable of the competitor. This concept should not be confused with the notion of overivestemnt (or underinvestment) from the social point of view!

[22] That is, around β =0. However, it is easy to show that none of the qualitative results and none of the signs of the marginal changes of S, R, and **A** would change if we allow β to be in the interval [0,1/2] (at least).

respect to y, t and β evaluating them at β = 0 and, at the optimal y_i * and t_i *, and substituting in (26), we obtain (27):

$$\frac{dW_i^*(\beta=0)}{d\beta}=\frac{(2(A-\alpha)+y_i^*-4t_i^*)}{9}\frac{dy_i}{d\beta}+\frac{(A-\alpha-3t_i^*)}{3}\frac{dt_i}{d\beta}+\frac{(t_i^*-y_i^*)y_i^*}{3} \quad . \tag{27}$$

Note that the first part of the first term of (27) is positive[23] reminding us again that R&D is below the socially optimal level in both regimes and implying that the combined marginal effect of R&D on the tariff revenue and the consumer surplus is positive (that is, $\partial W_i^* / \partial y > 0$). This, in turn, implies that the first term in (26) is clearly negative (recall that there is no marginal profit effect in the first term due to the implicit function theorem). As for the respective magnitudes of the first term in (27), in the two regimes, it is likely that the adverse effect is larger in the commitment regime due to higher sensitivity of R&D to spillovers in this regime.

The first part of the second term in (26), $\partial W_i^* / \partial t$, represents the net effect of (due to spillovers) the increased tariff on consumer surplus, the tariff revenue and domestic firm's profit. The first two effects of $\partial W_i^* / \partial t$ (that is, $\partial S_i^* / \partial t$ and $\partial R_i^* / \partial t$) are clearly negative. As for consumer surplus, the tariffs cause an increase in the equilibrium price and thus have a distortional effect on consumer welfare. As for tariff revenue, the optimal tariffs in both regimes are larger than the corresponding tariffs that maximize R_i^* implying that $\partial R_i^* / \partial t < 0$. Finally, the last effect, $\partial \Pi / \partial t$, is clearly positive on the domain $t \in [\ t_i^*, t_m]$ since an increase in the tariff increases the unit costs of the foreign firm and enables the domestic firm to capture a larger market share and realize larger a profit (t_m stands for the tariff level that enables the domestic firm to achieve the unconstrained monopoly position). Clearly, in the non–commitment regime, the whole second term, $\partial W_{nc}^{*} / \partial t$, vanishes since the non–commitment tariff coincides with the first–best tariff that exactly balances the negative marginal effect of tariff on consumer surplus and tariff revenue with the marginal positive effect of the tariff on profit. Consequently, any higher tariff implies that the marginal effect of the tariff on social welfare is negative and so the second term in (26) is unambiguously negative in the commitment regime, due to the fact that, $\partial W_{c}^{*} / \partial t < 0$.

Finally, the third term in (26) is positive since the two direct positive effects of spillovers on the consumer surplus and tariff revenue more than offset the corresponding negative effect of spillovers on profit, but this effect is slightly larger in the commitment regime.[24]

Taking all of the above considerations into account, we conjecture that allowing for a small dose of spillovers causes more adverse (or less favorable) welfare effects in the commitment regime than in its non–commitment counterpart. In other words, the larger adverse effects of spillovers on R&D and the larger optimal tariff in the commitment regime translate to a larger adverse or, analogously, smaller positive impact on social welfare (depending whether $dW_{c}^{*} / d\beta$ is positive or negative) than in the analogous non–commitment setup. That is, we expect that $dW_{c}^{*} / d\beta < dW_{nc}^{*} / d\beta$ holds at $\beta = 0$. Moreover, if the initial difference between W_{c}^{*} and W_{nc}^{*} is "small" enough, the reversal in the rank of these two social welfares may occur at the level of spillovers already "close" to zero. The relation between $dW_{c}^{*} / d\beta$ and $dW_{nc}^{*} / d\beta$ in our

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[23] Substituting the upper bound of the tariff, $t_p = 1/2(A - \alpha - y)$ into the first part of the first term in (27) yields $y_i/3 > 0$.

[24] Note that $\partial S_i^*/\partial\beta > 0$ since an increase in spillovers increases total output in equilibrium. Furthermore, $\partial R_i^*/\partial\beta > 0$ since, other things being equal, an increase in spillovers increases foreign firm output in equilibrium and consequently tariff revenue. Finally, $\partial \Pi/\partial\beta < 0$ since, other things being equal, increase in β enables a foreign firm to decrease its units cost and capture a larger market share in equilibrium at the expense of the domestic firm.

specific setup confirms the above intuition.[25] Moreover, as we noted before, the ratio between W_c^* and W_{nc}^* is in our basic setup close to one, indicating that the above mentioned reversal in the rank between W_c^* and W_{nc}^* occurs at a low level of spillovers. We summarize the above discussion in Proposition 2.

Proposition 2

Social welfare in the non–commitment regime exceeds the social welfare in the commitment regime within the home market setup as soon as spillovers exceed a threshold level of $\beta^w(g)$ whereby its maximum value is given by $\beta^w(g_{cr})$ = 0.037 for $h(y) = y^2 / g$.

See Appendix 5 for the proof.

As for the underlying intuition of the proposition 2, recall that (a) the non–commitment tariff coincides with the first–best tariff, at $\beta = 0$, and b) that a higher tariff than the first–best one in the commitment regime has its rationale in the fact that it leads to an increase in socially insufficient R&D. In terms of social welfare, that increase in R&D more than compensates for the increased distortion caused by a tariff higher than the first–best one. However, R&D spillovers cause disincentive for investing in R&D that in turn leads to a faster rise in the commitment tariff creating further divergence between the commitment and non–commitment tariff (see subsection 3.2. a). This leads to a larger distortion compared to the initial situation without spillovers. At the same time, the higher sensitivity of R&D to spillovers in the commitment regime leads to the comparably faster decrease in R&D implying that the gap between R&D levels in the two regimes shrinks as spillovers appear (see subsection 3.2. b). Consequently, the increased social costs due to the rising tariff

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[25] As it can be easily shown, the above conclusion is valid for any arbitrary value of β when h(y)

distortion and decreased social gain from the technological role of tariff caused by spillovers, imply that there is a critical level of spillovers beyond which social welfare in the non–commitment regime starts to dominate its commitment counterpart.

To the extent that the difference between direct effects of spillovers on welfare in the two regimes, $\partial W_c^* / \partial\beta - \partial W_{nc}^* / \partial\beta$, is negligible[26] at $\beta = 0$, the sufficient condition for the social welfare in the non–commitment regime to dominate its commitment analog is that $y_{nc}^* \geq y_c^*$ since $t_{nc}^*(\beta) < t_c^*(\beta)$. By continuity, of course, the critical point of β at which $W_{nc}^* = W_c^*$ is already at the point where $y_{nc}^* < y_c^*$.

Also note that Proposition 2 is in stark contrast with the third market models outcome. Just a small dose of spillovers would be sufficient to reverse the key result of the third market model in which the value of commitment was unquestionable.[27]

4. The "first–best" *versus* "second–best " policy

Another topic that we now focus on is the "first–best" *versus* the "second–best" policy within the home market setup and its implication on the robustness of the sign of policy instrument when passing from the first– to the second–best policy (or vice versa). Namely, it is well established that in the third market framework (in the benchmark case of Cournot competition) the R&D subsidy is generally positive in the "second–best" policy setup, but then turns out to be negative (R&D tax) when the "first–best" policy is implemented.

To illustrate this issue within the home market framework, we again extend a little bit our basic model but now by allowing the domestic government to have an

= y^2/g.

[26] More precisely, this difference has to be small enough relative to the corresponding between- the- regimes differences for the first and the second terms in (26). As can be easily shown, this is the case when $h(y) = y^2/g$.

additional policy instrument at its disposal. As in the above third market literature, an R&D subsidy is an obvious choice in the considered setup. The relevant framework is now a four–stage game whereby the government sets an R&D subsidy in the first stage, domestic firms select R&D in the third stage, then again the government sets a tariff in the second stage and finally, the foreign and domestic firm compete in quantities on the home market in the last stage. This timing reflects the stylized fact that it is easier for government to commit to an R&D subsidy than to an output subsidy or tariff (see Carmichael, 1987; and Leahy and Neary, 2001).

Before we proceed, it should be made clear at the outset that the term "first–best" is not completely appropriate in this setup (a more correct name would be "constrained first–best policy"). The "true" first–best policy would involve three policy instruments: an import tariff, an output subsidy, and an R&D subsidy or tax. However, the optimal output subsidy would in our setup induce the domestic firm to produce at the point where marginal costs equal price, which in turn would imply that the domestic firm serves the whole domestic market. That is, the optimal market structure would be a domestic monopoly. Moreover, the optimal tariff would be zero. Since the duopoly interaction between the domestic and foreign firms and the strategic tariff are at the core of our analysis, the issue of an optimal output subsidy naturally has to be disregarded. More generally, the output subsidy is considered to be an unrealistic (Dixit, 1988) and due to its heavy informational content often an infeasible and impractical instrument (Bhattacharjea, 1995).

Despite the above cautions, we nonetheless stick to the term "first–best" policy to distinguish it from the one–instrument, "second–best" policy (which, by the above logic would be the "third–best policy") and also to be in line with Neary and Leahy's

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[27] Moreover, Griliches (1992) finds in his summary of the empirical work on spillovers that typical values of β range between 0.2 and 0.4, and this is far above the highest possible value of

(2000) terminology who (although in their setup fully correctly) called the combination of two instruments like output and R&D subsidies the "first–best" policy.

Since the rest of the game is already solved in the first part of the paper (see section 2.2.), we turn immediately to the first stage and the government's choice of the optimal subsidy. The objective function of the government that implements the "first–best" policy is now given by expression (28):

$$W_{fb}^{*}[y^{*}(s), t^{*}(y^{*}(s), s), s] = \Pi^{*}(\cdot) + S^{*}(\cdot) + R^{*}(\cdot) - sh(y^{*}) \quad (28)$$

where "fb" stands for the "first–best" and "s" denotes the subsidy. The domestic firm's profit now has an additional term stemming from its subsidy income, $sh(y)$. The social marginal cost of raising a unit of subsidy is assumed to be one, and so the cost of subsidy payment for the government is $sh(y)$.

Differentiating (28) with respect to the subsidy and equating it to zero while using the domestic firm's first–order condition, (envelope theorem) and noting that $\partial \Pi^{*} / \partial s = h(y^{*})$ yields (implicitly) the optimal "first–best" subsidy:

$$s^{*} = \frac{1}{h'(y^{*})}\left(\frac{\partial S^{*}}{\partial y} + \frac{\partial R^{*}}{\partial y} + \left(\frac{\partial S^{*}}{\partial t} + \frac{\partial R^{*}}{\partial t}\right)\frac{\partial t}{\partial y}\right). \quad (29)$$

Note that in our "first–best" setup the optimal tariff is the same as the tariff that a social planner sets (that is, $t_{s}^{*} = (A - \alpha)/3$) implying that $\partial t / \partial y = 0$. Thus, expression (29) further simplifies to:

$$s^{*} = \frac{1}{h'(y^{*})}\left(\frac{\partial S^{*}}{\partial y} + \frac{\partial R^{*}}{\partial y}\right) = \frac{1}{h'(y^{*})}\frac{\partial W^{*}}{\partial y} \quad . \quad (30)$$

A positive optimal subsidy requires that $\partial W^{*} / \partial y > 0$, and this is clearly the case in our setup. Moreover, note that the optimal first–best subsidy is

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$\beta_w(g_{cr})$.

proportional to the size of the externality, $\partial W^* / \partial y$, where the factor of proportionality is captured by the value of marginal R&D efficiency, $1/h'(y^*)$.

Substituting the relevant values obtained by the differentiation of expressions (5) and (6) into (30) gives

$$s^* = \frac{2(A-\alpha)+3y_s^*}{27h'(y_s^*)} > 0 . \tag{31}$$

Finally, using our specific functional form $h(y) = y^2 / g$, we obtain

$$s^* = \frac{(2(A-\alpha)+3y_s^*)g}{54y_s^*} \tag{32}$$

where the domestic firm selects now the socially efficient level of R&D, y_s^* [note that y_s^* is the same as (18)]. The optimal "first–best" R&D subsidy stimulates investments in R&D, removing the distortion between the privately and socially desirable R&D investment levels and ensuring the unit cost reduction to be at the socially optimal level, y_s^* .

We will now turn to an "R&D subsidy only" or the "second–best" policy. Our look at this policy will be very brief since this issue is discussed at length elsewhere (see for instance, Spencer and Brander, 1983; Bagwell and Staiger, 1994; Maggi, 1996; Leahy and Neary, 1997, 2001; and Hinloopen, 1997). In the absence of a tariff, expression (29) characterizing the optimal subsidy reduces to:

$$s_{sb}{}^* = \frac{1}{h'(y^*{}_{sb})} \frac{\partial S^*}{\partial y} = \frac{2(A-\alpha)+y^*{}_{sb}}{9h'(y^*{}_{sb})} > 0 \tag{33}$$

By visual inspection of (31) and (33), it is clear that $s_{sb}^* > s^*$.[28] This is in line with the findings emphasizing the robustness of the second–best R&D subsidy that has to boost inefficient R&D investment and act as a surrogate for the unavailable tariff (see for instance, Brander,1995; Bagwell and Staiger,1994; and Leahy and Neary, 1997; Hinloopen,1997; and Neary and Leahy, 2000) . We summarize the above observations in Proposition 3.

Proposition 3

Both the "first–best" and the "second–best" R&D subsidies are always positive with $s_{sb}^* > s^*$*.*

The difference from the standard results in Cournot competition where the "first–best" subsidy is negative (i.e., a R&D tax is optimal) stems primarily from the different specification of the welfare function. If we neglect the consumer surplus and tariff revenue, then it is clear from (30) that the optimal subsidy will be zero. [29] The reason for this is that in such a situation both the firm and the government have the same ability to commit, so the firm can achieve the most advantageous strategic position on its own (see also Neary and Leahy, 2000).

[28] Allowing for spillovers would have no impact on the sign of the optimal R&D subsidy in either the "first–" or "second–best" setup nor on their relative size (see Žigić, 2003). However, the optimal subsides would be the function of the level of spillovers in both "first–" or "second–best" setup, so the role of the optimal subsidy in the "first–best" setup would be somewhat blurred due to R&D spillovers. Because of its primary role of correcting for socially insufficient R&D, the 'first-best" subsidy would also affect the optimal tariffs and thus, at least indirectly, assume a profit shifting role (see Žigić, 2003).

[29] However, this is no longer the case if the foreign firm also invests in R&D.

5. Conclusion

The aim of this paper was to change the usual perspective of the strategic trade approach from the “third market setup” to the “home market” framework in order to reconsider several propositions stemming from the “third market setup”. In the first part of the paper, we analyze the value of policy precommitment in the “home market” framework. We show that the trade policy of the “committed” government generates lower social welfare than its “non–committed” counterpart once we slightly and realistically extend our basic model by allowing for only a “small” dose of R&D or demand spillovers. In addition, unlike in the third market models, there is underinvestment rather than overinvestment in strategic variables (i.e. R&D investments) from the social point of view, irrespectively whether the government can make a commitment or not. Finally, commitment to free trade is never optimal. However, it is important to note at this point that the message here was not to discredit the virtue of commitment in general, but rather to stress that there are circumstances in which the significance of government commitment is not crucial. This seems to be the case when policy makers do not deal only with strategic considerations and government’s expenditures but also with issues like consumer benefits and government revenue.

In the second part of the paper, we show that, unlike in the third market models, the R&D subsidy in the home market setup is always positive in both the “first–best” and the “second–best” policy setup, and this finding is robust to whether or not we allow for any degree of spillovers. The reason for this is the socially inefficient level of private R&D due to the appropriability problem that a subsidy aims to correct and due to the scale economies that larger R&D investment brings about.

Our framework may allow us to address some further interesting issues and comparisons between the "third market setup" and the "home market" framework. Thus, analogous to that of tariff comparison, the comparison of "committed" to "non–commitment" R&D subsidies may be of some interest. Moreover, permitting for a "large", full–fledged R&D or demand spillovers would, for instance, lead to interplay and a more complex relation between the R&D subsidies and tariffs while the domestic firm's strategy would turn from "top dog" to "lean and hungry look" after a certain spillover threshold is surpassed (see Žigić, 2003). Also, allowing for "large" spillovers seems to be sufficient to eliminate the "overinvestment" result even in the third market set up.

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Appendix 1: Proof that $y_s^* > y_c^* > y_{nc}^* > y_{ft}^*$ for a general R&D cost function, $h(y)$

To prove that the ranking from Lemma 1 holds for a general R&D cost function $h(y)$, we postulate the following assumptions concerning $h(y)$:

(iA) $h'(y) > 0$ for $y > 0$ and $h'(0) = h(0) = 0$

(iiA) $$h''(y^*) > \frac{4}{9}(4+\sqrt{7}) = 2.954$$

While the assumption (iA) is a rather standard one, the requirement (iiA) guarantees that a duopoly is a viable market structure in both the commitment ("C") and non–commitment ("NC") regimes. It ensures that a strategy leading to the elimination of the foreign competitor— "strategic predation"— would be too expensive and is never optimal for either the domestic firms or for the domestic government. Moreover, condition (iiA) is more restrictive than any other second–order conditions in the optimization problems under considerations. So when (iiA) holds, all second–order conditions in our analysis are automatically satisfied. Finally, note that $g < g_{cr} = 0.677$ is a special case of (iiA) for $h(y) = y^2 / g$.

We first show that there is underinvestment in R&D from a social point of view in the both C and NC regime. The marginal social welfare is given by the expression (1A):

$$\frac{\partial W_i}{\partial y} = \frac{1}{9}(2A - 4t + y_i - 2\alpha) \ . \qquad (1A)$$

To obtain $\frac{\partial W_{nc}}{\partial y}$, we evaluate (1A) at $t = t_{nc}^* = (A-\alpha)/3$ and $y = y_{nc}^*$ that yields:

$$\frac{\partial W_{nc}}{\partial y} = \frac{1}{27}(2A + 3y_{nc}^* - 2\alpha) > 0 \ .$$

In the case of $\frac{\partial W_c}{\partial y}$, we find its lower border by evaluating it at $y = y_c^*$ and at the prohibitive tariff, $t_p > t_c^*$ where

$$t_p = \frac{1}{2}(A - y_c^* - \alpha).$$

This yields $\frac{\partial W_c^{lb}}{\partial y} = \frac{y_c^*}{3} > 0$ implying that $\frac{\partial W_c}{\partial y} > 0$ at y_c^*. Thus, given that $\frac{\partial^2 W_c}{\partial y^2} < 0$, it follows that $y_s^* > y_i^*$ (where y_s^* is determined by the equation $\frac{\partial W}{\partial y} = 0$, and where *i* stands for either NC or C regime).

Now, we show that $y_c^* > y_{nc}^*$. The corresponding first–order conditions are

$$h'(y_c) = \frac{4}{9}(A - \alpha + t_c + 2y_c) \tag{2A}$$

and

$$h'(y_{nc}) = \frac{8}{27}(2(A - \alpha) + 3y_{nc}) \tag{3A}$$

If $y_c^* = y_{nc}^*$, then the corresponding tariff rate would be exactly t_{nc}^*

$$t_{nc}^* = \frac{A - \alpha}{3} \ . \tag{4A}$$

If the tariff t_c^* is greater than t_{nc}^*, then the right hand side of the first–order condition (2A) is increased, which means that also $h'(y_c)$ is increased. This would imply that $y_c^* > y_{nc}^*$, since the other first–order condition remains unaltered. So, the proof that $y_c^* > y_{nc}^*$ is equivalent to the proof that $t_c^* > t_{nc}^*$. The tariff rate t_c^* can be obtained from equation

$\frac{dW(y_c^*(t_c),t_c)}{dt_c} = 0$ which gives

$$t_c^* = \frac{(A-\alpha)(27h''(y_c^*)-16)+4y_c^*}{81h''(y_c^*)-56} \qquad \text{(5A)}$$

Thus the difference between t_c^* and t_{nc}^* is given by

$$t_c^* - t_{nc}^* = \frac{(A-\alpha)(27h''(y_c^*)-16)+4y_c^*}{81h''(y_c^*)-56} - \frac{(A-\alpha)}{3} = \frac{4}{3}\frac{(2A+3y_c^*-2\alpha)}{(81h''(y_c^*)-56)} \qquad \text{(6A)}$$

Since both the numerator and the denominator (by iiA) are positive, $t_c^* > t_{nc}^*$ and thus $y_c^* > y_{nc}^*$.

Finally, to complete the ranking, it is enough to show that $y_{nc}^* > y_{ft}^*$. Again, we start by comparing the first–order conditions in NC and FT respectively:

$$\frac{8y}{9} + \frac{16(A-\alpha)}{27} = h'(y)$$

and

$$\frac{8y}{9} + \frac{4(A-\alpha)}{9} = h'(y)$$

Note that the left hand sides of the two first–order conditions have the same slopes but the intercept in the NC regime is larger than the one in FT, and given the properties of $h(y)$, the intersection of $h'(y)$ and the corresponding left hand side in NC regime occurs at a larger y, than in the FT setup (See Fig 1A). Consequently, $y_{nc}^* > y_{ft}^*$.

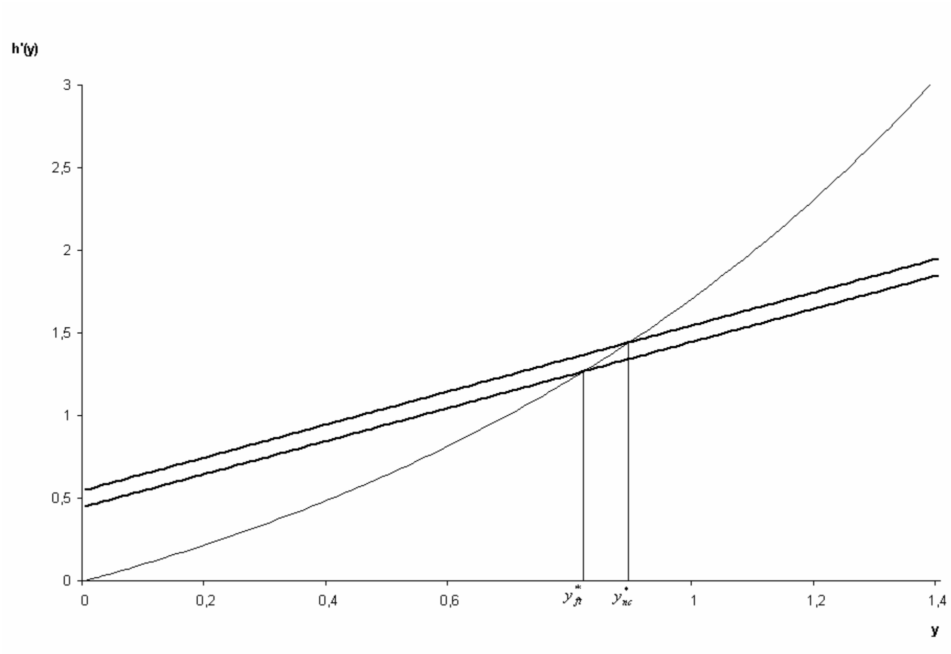

Fig. 1A

Appendix 2: Proof that $W_s^* > W_{c*} > W_{nc}^* > W_{ft}^*$ for general $h(y)$

Social welfare is defined as the sum of the domestic firm's profit, consumer surplus, and tariff revenue, that is, $W = \Pi + S + R$. We start first with the comparison of social welfare in the two regimes. Let $W(t, y)$ be the welfare function and $\Pi(t, y)$ be the innovating firm's profit function for given t and y. Let $y_c(t)$ be the R&D choice as a function of tariff in the commitment regime, when the firm maximizes $\Pi(t, y)$ with respect to y taking t as given. Then it holds that $y_c^* = y_c(t_c^*)$, $W_c^* = W(t_c^*, y_c^*)$, and $W_{nc}^* = W(t_{nc}^*, y_{nc}^*)$, (as usual, the asterisks denote the optimal values). In addition, the optimality of t_c^* in the commitment regime means that for all t,

$$W_c^* = W(t_c^*, y_c^*) \geq W(t, y_c(t)) \quad . \tag{A1}$$

The key fact for the proof is that the non–commitment tariff, $t_{nc}^{*} \equiv (A-\alpha)/3$ does not depend on y_{nc} since the welfare function is additively separable in t and y, i.e., $\partial^2 W/\partial t\partial y = 0$. Recall that in the non–commitment regime the firm chooses y_{nc} taking into account that the government's subsequent choice of t_{nc} in general depends on y_{nc}. However, given the above separability, the domestic firm de facto takes the choice of $t_{nc}^{*} \equiv (A-\alpha)/3$ as given, which implies that[30] $y_{nc}^{*} = y_c(t_{nc}^{*})$. Substitution of t_{nc}^{*} for t into (A1) completes the proof.

As for W_s^{*}, it clearly dominates both W_c^{*} and W_{nc}^{*}, since W_s^{*} is maximized in both t and in y. To complete the ranking among considered social welfares, it suffices to show that $W_{nc}^{*} > W_{ft}^{*}$. Recalling that $y_{nc}^{*} > y_{ft}^{*}$ (see Appendix 1) and that both $\frac{\partial W_{ft}}{\partial y}$ and $\frac{\partial W_{nc}}{\partial y}$ are positive at y_{nc}^{*} and y_{ft}^{*} respectively, we can evaluate both expressions at $y = y_{ft}^{*}$, to find out that $W_{nc}(y_{ft}) - W_{ft}^{*}(y_{ft}) = \frac{1}{18}(A-\alpha)^2 > 0$ implying that $W_{nc}^{*} > W_{ft}^{*}$.

Appendix 3: Proof that $\frac{\mathrm{d}t_c^{*}}{\mathrm{d}\beta} > \frac{\mathrm{d}t_{nc}^{*}}{\mathrm{d}\beta}$ for $h(y) = \frac{y^2}{g}$

Differentiating t_c^{*} with respect to β and evaluating at $\beta = 0$ we obtain

$$\frac{\mathrm{d}t_c^{*}}{\mathrm{d}\beta} = \frac{(\mathrm{A}-\alpha)\,4\,\mathrm{g}\,(297-8\,\mathrm{g}\,(45-(17-2\,\mathrm{g})\,\mathrm{g}))}{(81-4(16-3\mathrm{g})\,\mathrm{g})^2}.$$

Repeating the above procedure for t_{nc}^{*} yields:

[30] Note that in the absence of the above separability, this does not hold in general (for instance, when R&D spillovers are positives, $\beta > 0$, separability breaks away).

$$\frac{\mathrm{dt}^*_{\mathrm{nc}}}{\mathrm{d}\beta} = \frac{(\mathrm{A} - \alpha)\, 8\, \mathrm{g}}{9(9 - 4\, \mathrm{g})}$$

Define $D \equiv \frac{\mathrm{dt}^*_{\mathrm{c}}}{\mathrm{d}\beta} - \frac{\mathrm{dt}^*_{\mathrm{nc}}}{\mathrm{d}\beta}$. It is now straightforward to check that $D > 0$ for $g \in (0, \mathrm{g}_{\mathrm{cr}})$ (see Fig. 2A).

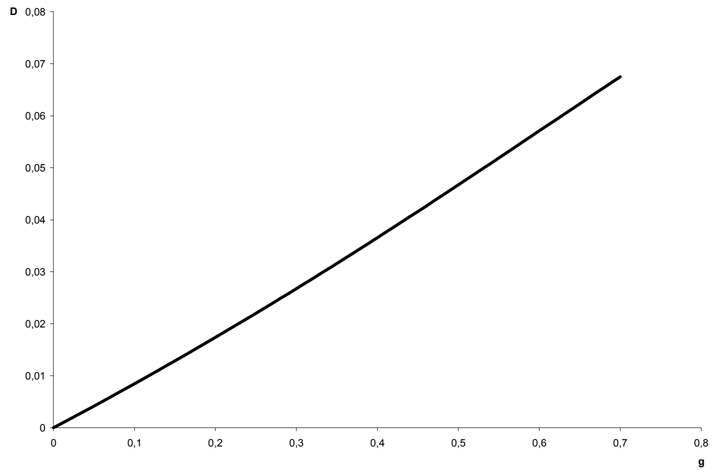

Fig. 2A

Appendix 4: Proof that $\left|\frac{\mathrm{dy}^*_{\mathrm{c}}}{\mathrm{d}\beta}\right| > \left|\frac{\mathrm{dy}^*_{\mathrm{nc}}}{\mathrm{d}\beta}\right|$ for $h(y) = \frac{y^2}{g}$

Differentiating y^*_c with respect to β and evaluating it at $\beta = 0$, we obtain

$$\frac{\mathrm{dy}^*_{\mathrm{c}}}{\mathrm{d}\beta} = -\frac{(\mathrm{A} - \alpha)\, 4\, \mathrm{g}\, (243 - \mathrm{g}\, (123 - 4\, \mathrm{g}(1 + \mathrm{g})))}{(81 - 4(16 - 3\mathrm{g})\, \mathrm{g})^2}.$$

Repeating the above procedure for y^*_{nc} yields:

$$\frac{\mathrm{dy}^*_{\mathrm{nc}}}{\mathrm{d}\beta} = -\frac{(\mathrm{A} - \alpha)\, 8\, \mathrm{g}\, (9 + 4\, \mathrm{g})}{9(9 - 4\, \mathrm{g})^2}$$

Define $B \equiv \left|\frac{\mathrm{dy}^*_{\mathrm{c}}}{\mathrm{d}\beta}\right| - \left|\frac{\mathrm{dy}^*_{\mathrm{nc}}}{\mathrm{d}\beta}\right|$. It is now straightforward to check that $B > 0$ for $g \in (0, \mathrm{g}_{\mathrm{cr}})$

(see Fig. 3A below).

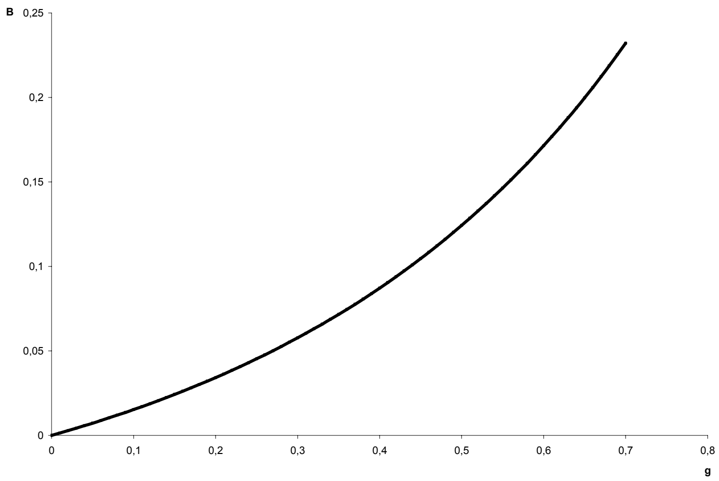

Fig 3A

Appendix 5: Comparison of social welfare in the two regimes when $h(y) = \frac{y^2}{g}$

To find critical values of β and g beyond which $W^*_{nc} > W^*_c$, we could solve the equation $W^*_{nc} - W^*_c = 0$, (expressed in terms of parameters of the model), for, say, the critical value of $g_w(\beta)$ and then find the region of g and β for which $W^*_{nc} > W^*_c$ taking into account the viability region of duopoly (see Žigić, 2003). The critical value of $\beta^w(g)$ is obtained by inverting $g_w(\beta)$. However, this approach, although feasible, gives an extremely messy solution (see Žigić, 2003). Since W^*_{nc} surpasses W^*_c at a rather small level of spillovers, a more elegant approach would be to find an approximation of $\beta^w(g)$ by linearizing W^*_{nc} and W^*_c at $\beta = 0$. Let us label this approximation as $\beta^{wa}(g)$ that is found by solving

$$W^*_{nc}(\beta = 0) + \beta \frac{dW^*_{nc}}{d\beta}\Big|_{\beta=0} = W^*_c(\beta = 0) + \beta \frac{dW^*_c}{d\beta}\Big|_{\beta=0} \ .$$

Thus, $\beta^{wa}(g)$ is given by:

$$\beta^{wa}(g) = \frac{3(9-4g)g(81-4(16-3g)g)}{59049-2g(57591-2g(23283-g(9497-24(79-6g)g)))} \; .$$

The function, $\beta^{wa}(g)$, is depicted in Figure 4A. For all values of β, such that $\beta > \beta^{wa}(g)$, $W^{*}_{nc} > W^{*}_{c}$ and this region is represented by the area above the curve $\beta^{wa}(g)$. The critical value of spillovers is increasing in g. So the biggest value of $\beta^{wa}(g)$ is obtained at the upper border of $g = g_{cr}$ = 0.677. $\beta^{wa}(g_{cr})$= 0.04 while the exact value is even lower since $\beta^{w}(g_{cr})$= 0.037. Thus, $\beta^{wa}(g)$ can be viewed as an upper border of $\beta^{w}(g)$.

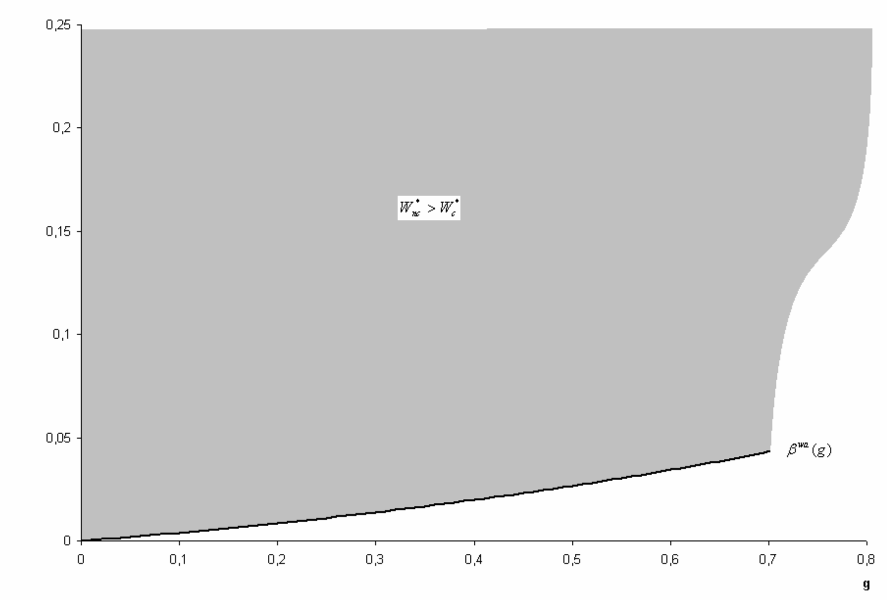

Fig 4A

Individual researchers, as well as the on-line and printed versions of the CERGE-EI Working Papers (including their dissemination) were supported from the following institutional grants:

- Economic Aspects of EU and EMU Entry [Ekonomické aspekty vstupu do Evropské unie a Evropské měnové unie], No. AVOZ70850503, (2005-2010);
- Economic Impact of European Integration on the Czech Republic [Ekonomické dopady evropské integrace na ČR], No. MSM0021620846, (2005-2011);

Specific research support and/or other grants the researchers/publications benefited from are acknowledged at the beginning of the Paper.

Published by
Charles University in Prague, Center for Economic Research and Graduate Education (CERGE)
and
Economics Institute ASCR, v. v. i. (EI)
CERGE-EI, Politických vězňů 7, 111 21 Prague 1, tel.: +420 224 005 153, Czech Republic.
Printed by CERGE-EI, Prague
Subscription: CERGE-EI homepage: http://www.cerge-ei.cz

Editors: Directors of CERGE and EI
Managing editors: Deputy Directors for Research of CERGE and EI

ISSN 1211-3298
ISBN 978-80-7343-116-7 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-105-0 (Národohospodářský ústav AV ČR, v. v. i.)

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