

THE ANTI-EXPORT IMPLICATIONS OF TRADE LIBERALIZATION: THE CASE OF EXPORT-MARKET UNCERTAINTY

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Abstract:

This paper intends to show that once the assumption of the classical model of trade are relaxed, import protection will not necessarily imply a relative anti-export bias. In particular, assuming uncertainty in export markets, and with an incomplete insurance market, the reduction in the level of protection to a specific sector could reduce the incentive and/or the capability of firms to undertake risky export ventures.

Policy conclusions cannot easily be derived from this paper. We show with a partial equilibrium approach, that import protection may help exports. Nevertheless, the general equilibrium effects of protection, which are not taken into account in this analysis, will support the opposite conclusion.

The use of tariff protection to correct for imperfections in the capital market or for the existence of non-convexities in the production process in general will not be the first-best policy. Export subsidies or some kind of export insurance can be more effective in promoting exports than tariff protection.

1. Introduction

One of the main criticisms of the strategy of import substitution followed by many Latin american countries since the early 1940s, is that it generates a trade regime that discriminates against exports (Balassa and Associates, 1971; Bhagwati, 1978; Krueger, 1978; and Corbo, 1986).

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It has been argued that the promotion of import-substitution industrialization by mean of import protection generates a bias against exports, and that this bias is one of the main causes of the recurrent foreign-exchange crises that have affected the countries that have pursued this kind of policy. Consequently, developing countries should pursue trade liberalization policies as a mechanism to foster exports and thereby overcome foreign-exchange crises.

This paper intends to show that under certain conditions, import protection could have a positive impact on exports. In particular, the paper shows that under the assumption of uncertainty in export markets, incomplete insurance market and considering only partial equilibrium effects, a reduction in the level of protection for a specific sector could reduce the incentive and/or the capability of firms to undertake risky export ventures.

What is the traditional wisdom regarding the anti-export implications of import protection? Usually, the anti-export effects of protection have been classified into two categories (Balassa and Associates, 1971): general equilibrium effects and sector specific effects.

The export disincentive which is general equilibrium in nature is the following. Protecting the import-substituting sectors causes a shift in the internal terms of trade against export activities. Raising the level of protection for the manufacturing sector reduces overall demand for import, thus generating an appreciation of the exchange rate. Also, prices in import-substituting industries will be increased, making the manufacturing inputs required by the export activities more expensive. Both factors tend to reduce the profitability of export activities. In conclusion, general equilibrium considerations lead to the conclusion that import protection implies unambiguously an anti-export bias.

The sector-specific effects refer to the selling incentives for firms in the domestic or export market. The traditional argument is very simple: import protection raises prices in the domestic market, so the margin of profit of producing for the domestic market increases relative to exports. This change in relative profitability will have an adverse effect on the volume of exports.

We want to focus attention on the analysis of that anti-export implications of import protection at the sector-specific level. The conclusion that import protection induces a relative anti-export bias relies on the assumption that the only relevant signals to individual producers are the net relative prices of different goods. Almost no role in determining the pattern of incentives is given to the quantities being produced. If we depart from the basic, deterministic, perfect-competition, constant-return-to-scale model of the firm, the quantities produced and overall profits will have a role in determining the relative incentives to export or to sell in the domestic market. This role for quantities and profits alters drastically the above conclusions regarding the relative anti-export-bias implications of protection. This is one of the main messages of the strategic trade literature. In particular, Krugman (1984) shows that under the assumption of economies of scale and an oligopolistic market structure, raising the tariff for imports increases the size of the domestic market and thus reduces the marginal cost of production to domestic firms. The fall in marginal cost enhances the competitive position of domestic producers in export markets, with a positive effect on the volume of exports. The same argument is extended to the case where the economies of scale are of the dynamic type (learning by doing). Furthermore, Dixit (1985) shows that a tariff in the case of oligopolistic industries could be welfare increasing when there are positive profits and/or economies of scale.

This paper provides additional partial-equilibrium arguments that allow us to conclude that import protection may increase exports. First, if the capital market does not provide

enough opportunities to reduce the cost of risk of particular projects (imperfect insurance markets), and assuming that entrepreneurs have a decreasing absolute degree of risk aversion, then increasing domestic firms' level of protection raises profits and thus reduces entrepreneurs' degree of risk aversion. A reduction in entrepreneurs' degree of risk aversion increases their willingness to undertake risky export ventures.

Tariff protection generates a wealth effect that makes the entrepreneur more willing to undertake risky export projects, but in order to determine the overall change in the incentives to export it is necessary to consider a substitution effects that tends to inhibit the incentive to export. If export and domestic activities are competing for the use of resources available in limited amounts to the entrepreneur (given capacity, limited funds for investment), there will be a substitution effect that acts in the opposite direction from the aforementioned wealth effect. Whether the wealth effect or the substitution effect dominates depends on the particular parameters of the problem.

The basic assumption that allows us to conclude that the wealth effect will act as an incentive to export is that export activities are riskier than selling to domestic markets. This assumption is quite reasonable if we take into account that, *ex ante*, the characteristics of foreign demand for domestic products are less well known to domestic producers *vis-a-vis* the domestic demand. Even if the characteristics of foreign demand are known with certainty, the possibility of modifications in the commercial policies of the countries importing the domestic exports tend to impose a significant degree of risk in export activities. Unfortunately, the capital markets of most developing countries are so poorly developed that they provide very few opportunities to reduce the cost of risk of export ventures by portfolio diversification.

The interaction between domestic profits and export incentives arises because of the assumption that entrepreneurs are risk averse. Under this condition any policy that affects domestic profitability will modify the incentive to export. In particular, a subsidy to domestic production will tend to promote exports. From a welfare point of view neither the tariff nor the production subsidy are the first-best policies. The optimal policy is the establishment of an export insurance that reduces the cost of risk associated with export activity.

Besides the aforementioned wealth and substitution effect, trade liberalization may have a significant effect on the marginal financing costs of firms: if individual firms face an upward-sloping supply of funds, a tariff reduction may also have the effect of increasing the marginal cost of financing. Retained earnings will be reduced and the firm will have to rely more heavily on more expensive financing from the capital market. A higher cost of financing in the margin will reduce the incentive to invest in project oriented toward both the domestic and foreign markets. The net effect of a trade liberalization on export-capacity decisions will depend on the relative magnitude of the wealth and cost-of-financing effects and the substitution effect. The former two effects will be an incentive to export, while the latter discourages export activity.

In section two of this paper we develop a model where a risk-averse entrepreneur invest in domestic and foreign capacity, facing an infinitely elastic supply of funds. The profit function will be additively separable between domestic and export profits, such that there is no interaction in the production processes for the domestic and foreign markets. A trade liberalization unambiguously reduces export-oriented investment if the entrepreneur has a decreasing absolute degree of risk aversion.

In section three we modify the financing assumption by considering that the entrepreneur allocates given initial wealth to three alternative investments: domestic capacity, export capacity, and safe bonds. When the optimal decision of the entrepreneur

implies that a positive amount of wealth is allocated to the acquisition of safe bonds, the effect of a reduction in tariff is the same as the model with infinite elastic supply: there is an unambiguous fall in the incentive to export. While, if the initial wealth is split only between domestic and export investments the effect of tariff reduction is ambiguous; the net effect depends on the relative magnitude of the wealth and substitution effects.

In section four we analyze the effect on the volume of export of a trade liberalization in the short run, when the capital stock is fixed. If the marginal cost of production is declining, the effect of trade liberalization in the short run is to worsen the level of exports. If the marginal cost of production is increasing, the result of reducing the level of protection is ambiguous: there is an interaction effect that reduces the marginal cost of production and wealth effect that diminishes the incentive to invest in risky projects.

In section five we develop a model where investment in domestic capacity is financed out of retained earnings and firms' external financing. If the cost of borrowing increases with the size of the loans, a trade liberalization will raise the marginal cost of financing. This policy will also release financial resources from the domestic operation to be used on export-oriented investment. The net effect on export investment is ambiguous, depending on the relative magnitude of the aforementioned wealth effect and the cost of capital effect on the one side and the substitution effect on the other side.

Policy conclusions cannot easily be derived from this paper. We show that import protection may help exports, but this possibility depends on not having very strong competition for scarce resources between domestic production and exports. Also, the general equilibrium effect of protection is not taken into account in this analysis. Nevertheless, this paper suggests that the proposition that trade liberalization will unambiguously foster exports should be taken with caution.

2. The export capacity decision with an infinitely elastic supply of funds.

The situation that this model tries to represent is the following. There is an entrepreneur who can borrow any amount of capital at an exogenously given interest rate. The entrepreneur can use this capital to build capacity to produce for the domestic market or for the foreign market. In the domestic market the firm will face a downward-sloping demand curve whose characteristics are known with certainty. The good produced for the domestic market is an imperfect substitute for an imported good whose supply to the domestic market is infinitely elastic. The domestic price of the imported good is only affected by a tariff t . To save notation the capital-output ratio is set equal to one.

In the export market the demand the firm will face is not known with certainty. For concreteness we assume that foreign demand is infinitely elastic and that there is uncertainty regarding the price domestic producers will obtain in the foreign market. The probability of default on the loan is zero.

There are two periods: in the first period the firm has to invest in domestic and foreign capacity, in the second the uncertainty is resolved and entrepreneur receives the profits or losses of both operations. The entrepreneur is risk averse, so the utility function is concave in its argument, i.e., $U'' < 0$. The objective of the entrepreneur is:

$\text{Max } F(x, x^*) = EU(y)$, where $y = \Pi(t, x) + \Pi^*(x^*) - [(1+r)(x + x^*)]$ $\Pi(t, x)$ defines operating profits in the domestic market (revenue minus variable cost). We assume that the profit function is well behaved, namely $d\Pi(t, x)/dt > 0$ and $d^2(t, x)/dxdt > 0$; raising the tariff increases both total and marginal profits in the domestic market. $\Pi(t, x)$ is assumed to be a concave function of the level of capacity for the domestic market x .

$\Pi^* (x^*) = (P^* - c^*) x^*$ represents the profits in the foreign market; the FOB price P^* is distributed between $\underline{P^*}$ and $\bar{P^*}$ according to the density function $dG(P^*)$; x^* defines the level of capacity for the foreign market.

The first – order conditions for this problem are:

$$F1 : EU'(y) [d\Pi(x, t)/dx - (1 + r)] = 0 \quad (1)$$

$$F2 : EU'(y) [P^* - c^* - (1 + r)] = 0 \quad (2)$$

Where F_i represent the partial derivative with regard to the i th argument.

Equation (1) establishes that the optimal level of capacity for the domestic market is reached when marginal operational profits are equal to per unit cost of financing. The optimal x is independent of the random price P^* .

The second identity defines the optimal level of exports. Notice that the level of sales in the domestic market enters into the determination of the amount exported. This simultaneity is due to the fact that the volume of exports depends on the entrepreneur's degree of risk aversion, which is affected by the profits in the domestic market. In order for identity (2) to be satisfied for a finite value of x^* , it is necessary that $P^* - c^* - (1 + r)$ be less than zero for low values of P^* ; otherwise the entrepreneur will have an incentive to export an infinite amount of the good, since the demand for the good and the supply of credit are infinitely elastic.

The second-order conditions for this problem are $F11 < 0$ and $F22 < 0$ and $(F11)(F22) - (F12)^2 > 0$; the corresponding expressions are shown in full in Appendix 1. In order to determine the effect on exports of a tariff increase, let us implicitly differentiate the identity (2) with regard to the tariff:

$$dx^*/dt = \frac{-F11 K1 \frac{\partial \Pi}{\partial t} + K_1^2 [\frac{\partial \Pi}{\partial X} - (1 + r)] \frac{\partial \Pi}{\partial t}}{F11 F22 - (F12)^2} \quad (3)$$

where ∂ is the partial derivative operator and

$$K1 = EU''(y) [P^* - c - (1 + r)].$$

If the second-order conditions for a maximum are met, $F11 F22 - (F12)^2 > 0$ and $F11 < 0$ then a sufficient conditions for dx^*/dt to be positive if that $K1$ be positive. In appendix 2 we prove that $K1$ is positive provided that the utility function depicts a decreasing absolute degree of risk aversion¹.

The assumption that the utility function depicts a decreasing absolute degree of risk aversion is equivalent to assuming that an investor is willing to invest more money in risky asset the greater his wealth. This is considered to be a very plausible representation of the behavior of economic agents faced with uncertainty.

The conclusion of the previous comparative static exercise is the following: when the factor that limits the level of exports is exclusively the perceived risk involved in export activities, tariff protection of domestic production is a second-best mechanism that will unambiguously induce domestic producer to undertake risky export projects. Nevertheless

the optimal policy from a welfare point of view is to establish some insurance mechanism that reduces the fluctuations of export revenues in term of domestic currency.

3. The export capacity decision with given initial wealth

In this section we introduce a resource that is in fixed supply, so that the effect of raising protection on the incentive to export will be ambiguous.

In this model the investor has a given initial wealth W , he has the alternative of investing his wealth in a safe domestic bond that gives a return r , and he can invest in domestic or export capacity (as in the previous case). The objective of the entrepreneur is to maximize $F = EU(y)$ where $y = (W - x - x^*)(1 + r) + \Pi(x, t) + \Pi^*(x^*)$. $W - x - x^*$ represents the amount invested in the safe asset; it can be positive or zero. It is easy to show that, if the investor invests a positive amount of his wealth in safe assets, the first-order conditions are identical to those in the previous model. In other words, having a certain proportion of a given initial wealth invested in a safe bond that yields the same interest rate as the cost of external financing is equivalent to having an infinitely elastic supply of funds. If the first-order conditions are the same, the comparative static exercise will give the same result as in the previous section, namely: tariff protection unambiguously promotes exports.

The case in which it is optimal not to invest a positive amount of wealth in the safe asset gives different conclusions than the previous model. This alternative is equivalent to having a given wealth that has to be allocated to two competing uses: domestic and foreign capacity. Then we can reformulate the problema as the maximization of $F = EU[\Pi(W - x^*, t) + \Pi^*(x^*)]$.

The first-order condition for this problem is

$$F_1 = EU'(y) [d\Pi^*(x^*)/dx^* - \partial\Pi(x, t)/\partial x] = 0$$

Marginal profits in the domestic market weighted by the expected marginal utility of income must be equal to marginal profits in the export market weighted by the same coefficient. In order to have a maximum the second-order condition has to be met, i.e.:

$$F_{11} = EU'' [d\Pi^*(x^*)/dx^* - \partial\Pi(x, t)/\partial x] + EU' [d\Pi^*(x^*)/dx^* + \partial\Pi(x, t)/\partial x] < 0$$

Differentiating implicitly the first-order condition with regard to t , we get:

$$\frac{dx^*/dt} = \frac{-K_2 (\partial\Pi(x, t)/dt + EU'(y) \partial^2\Pi(x, t)/\partial x \partial t)}{EU'(y) (\partial\Pi/\partial x + \partial\Pi^*/\partial x) + EU''(y) (\partial\Pi/\partial x - \partial\Pi^*/\partial x^*)}$$

where $K_2 = EU''(y) [d\Pi(x^*/dx^* - \partial\Pi(x, t)/\partial x)]$ is equivalent to K_1 in the previous model. With a similar procedure to the one followed in Appendix 2 it is possible to show that $K_2 > 0$. In this case the sign of dx^*/dt is ambiguous; the denominator is less than zero by the second-order condition. Thus, the first term in the numerator is negative, which tends to make dx^*/dt positive, but the second term in the numerator is positive, which tends to make dx^*/dt negative. The former is a wealth effect that arises because raising the tariff increases the wealth of the entrepreneur and, by the assumption of decreasing absolute degree of risk aversion, higher wealth increases the incentive to

export. The second term is a substitution effect: since we have assumed that $\partial \Pi^2(x, t)/\partial x dt > 0$, the increment in tariff makes domestic market production more attractive and provides an incentive to reallocate scarce resources away from export activities to the domestic operation. This substitution effect captures the traditional argument about the relative anti-export-bias implication of tariff protection. But, as we have shown, this is not the only factor that has to be taken into account to address the overall effect on the incentive to export at the sector-specific level.

The impact on the incentive to invest in export capacity depends on the relative size of the income versus the substitution effect. If the latter is greater than the former, a trade liberalization will diminish the incentive to invest in export capacity.

4. The export incentive in the short run

In the first model, operating profits were additively separable into domestic and export profits; this assumption tries to represent a situation where the capacity of production is specific to the market of destination. In the model of this section, we assume, instead that the same plant produces for both the domestic and foreign markets, so that operating profits are jointly determined. This generates an additional interaction between domestic and export production, such that any change in either form of production affects the jointly determined marginal cost. In particular, we address the effect of tariff protection on the incentive to export in the short run: when the firm has a given capital stock, the total short-run cost curve can be either convex or concave (decreasing or increasing returns).

$R(x, t)$ and $R^*(x^*)$ define the total revenue in the domestic and foreign markets, respectively. The total cost function is $C(x + x^*)$, $C' > 0$. The objective of the entrepreneur is:

$$\text{Max } F(x, x^*) = EU[R(x, t) + R^*(x^*) - C(x + x^*)]$$

Two standard assumptions are that $\partial R(x, t)/\partial t > 0$. and

Total and marginal revenue in the domestic market rise when the tariff rate increases. The first-order conditions are:

$$F1 = EU'[\partial R(x, t)/\partial x - C] = 0 \quad (4)$$

$$F2 = EU'[\partial R^*(x^*)/\partial x^* - C'] = 0 \quad (5)$$

where C' denotes the common marginal cost. The second-order conditions are $F11 < 0$, $F22 < 0$, and $F11 F22 - (F12)^2 > 0$; the expressions for $F11$, $F22$ and $F12$ are derived in Appendix 3.

Differentiating implicitly conditions (4) and (5), we solve simultaneously for dx/dt and dx^*/dt . The expression for dx^*/dt is:

$$dx^*/dt = \frac{-F11(K3) \partial R(x, t)/\partial t - EU'(y) C'' \partial^2 R(x, t)/\partial x \partial t}{F11 F22 - (F12)^2}$$

where $K3 = EU''(y) [dR^*(x^*)/dx^* - C']$ is homologous to term $K2$ in the previous model, so it is also positive. The denominator is positive by the second-order condition. If $C'' < 0$, the numerator is positive, hence $dx^*/dt > 0$ and tariff protection unambiguously promotes exports.

When $C'' < 0$ there are economies of scale in production, so raising tariffs generates a direct positive effect on the scale of production and consequently reduces the jointly determined marginal cost of production. The effect of tariff protection on exports is unambiguously positive in this case: This scale effect is similar to the one that led Krugman (1984) to conclude that import protection can act as export promotion.

In the case that $C'' > 0$ there are returns to scale in production, so the interaction effect reduces the incentive to export, but the income effect promotes exports; the overall effect on export incentives will be positive only if the income effect outweighs the interaction effect.

A situation observed in many industries in LDCs in the existence of excess capacity, with marginal cost being approximately constant for a wide range of production. In these cases there is no competition between production for foreign and domestic markets, for if entrepreneurs maximize expected utility, import protection will act as an incentive to export by reducing their degree of risk aversion. In this circumstance a trade liberalization, in addition to its effect on behavior toward risk, will reduce firms' capability to finance the fixed costs associated with chronic excess capacity.

5. The optimal capacity decision with endogenous cost of capital.

This section tries to model the following situation: a firm that has a domestic operation that yields profits can invest in export capacity and/or domestic capacity. The firm can use the profits of the ongoing domestic operation to finance its investment, and it also has access to a capital market, where it faces an upward-sloping supply of funds.

If L defines the firm's demand for credit, then $L = x + x^* - \Pi_0(t)$, where $\Pi_0(t)$ represents the profits of an ongoing domestic operation. We assume that financing with retained earnings is the cheapest source of funds for the firms and that at the optimal level of investment the marginal source of financing is external credit, such that the opportunity cost of own funds does not affect the optimal investment decision. The interest rate schedule is defined as $r(L)$, where $r' > 0$; and $r'' > 0$ i.e., the supply of credit is upward-sloping and the cost of capital raises more than proportionate with L . There are two periods: in the first, the firm makes profits in an import-substituting operation and invests in foreign capacity x^* and in domestic capacity x ; in the second, the firm produces with the new capacity for the export and domestic markets. The objective of the firm is:

$$\text{Max } EU(y), y = \Pi(x, t) + \Pi^*(x^*) - (1 + r(L))L$$

Redefining $S(L) = (1 + r(L))$, the problem becomes $\text{Max } EU[\Pi(x, t) + \Pi^*(x^*) - S(L)]$. Defining V as the objective function, the first-order conditions are:

$$V_1 = EU'(y) [\partial \Pi / \partial x - S'(L)] = 0 \quad (6)$$

$$V_2 = EU'(y) [\partial \Pi / \partial x^* - S'(L)] = 0 \quad (7)$$

The second-order conditions for a maximum are $V_{11} < 0$, $V_{22} < 0$ and $V_{11} V_{22} - (V_{12})^2 > 0$. The expressions for the second-order conditions are similar to the ones derived in Appendix 3. Differentiating conditions (6) and (7) implicitly with regard to the tariff rate and after a good deal of algebraic manipulation we get an expression for dx^*/dt and dx^*/dt . The expression for dx^*/dt is:

$$\frac{dx^*}{dt} = \frac{V_{11} [EU'(y) S'' d\Pi_0/dt + K_4 (\partial\Pi/\partial t + S' d\Pi_0/dt)] - [EU'(y) S'' (\partial^2 \Pi/\partial x \partial t + \partial^2 \Pi/\partial x \partial t) + S'' d\Pi_0/dt]}{V_{11} V_{22} - V_{12}^2}$$

where $K_4 = EU'(y) [\partial\Pi^*/\partial x^* - S']$ is positive when the utility function depicts a decreasing absolute degree of risk aversion. The denominator is unambiguously positive if the second-order conditions are met. The first term in the numerator is positive. The term $EU'(y) S'' d\Pi_0/dt$ represents the effect of the tariff in the marginal cost of financing. A rise in the tariff rate reduces the costs of capital and thereby tends to increase export oriented investment. The term $K_4 (\partial\Pi/\partial t + S' d\Pi_0/dt)$ represents the effect of the tariff on the entrepreneur's degree of risk aversion; this also tends to enhance investment in export capacity. The second term in the numerator represents the substitution effect, which tends to reduce investment in export activities. Raising the tariff rates increases marginal profits in the domestic market, which is an incentive to higher investment and thereby raises the marginal cost of financing: this effect is captured by the term $EU'(y) \partial^2 \Pi/\partial x \partial t$. Also, there is a second-order effect on the cost of capital of increasing the tariff rate in the first period. This is because raising the first period's profits induces higher overall investment and thus raises the marginal cost of capital. The effect of tariff protection on the incentive to invest in export capacity is the net result of the three effects we have identified. Whether the financial and wealth effects will dominate over the substitution effect enough for tariff protection to promote export-oriented investment is an empirical issue that depends on the characteristic of the industry at hand, and also on the characteristic of the capital market faced by the firm.

7. Conclusions

The traditional view among trade economists is that import protection generates a trade regime that discriminates against exports. There is not much discussion about the general equilibrium effects of import protection: it is fairly clear that it will cause the exchange rate to appreciate in the long run and will make the inputs from those protected sectors that are used by the exporting sectors more expensive. What is less obvious is the anti-export implication of tariff protection at the sector-specific level.

In a partial-equilibrium framework we have shown that tariff protection may have diverse effects on export incentives.

The existence of scarce resources, such as a given amount of wealth that can be devoted to investment, or a certain installed capacity that has to be split in production between the domestic and foreign markets, or any other resource with inelastic supply, generates competition between domestic markets and the export market in terms of the allocation of these scarce resources.

On the other hand, the existence of uncertainty in export activities and entrepreneurs whose degree of risk aversion decreases with wealth implies that tariff protection generates an income effect that makes firms more willing to undertake risky export projects. Additionally, if there are imperfections in the capital market that generate an upward-sloping supply of funds to the firms, a trade liberalization will have a significant impact on the cost of capital, since the amount of retained earning of firms in the tradable sectors will be reduced, which will induce firms to rely more heavily on more expensive external financing.

Finally, the existence of economies of scale, fixed cost or learning by doing are additional factor that tend to strengthen the export-promoting effect of tariff protection.

The use of tariff protection to correct for imperfections in the capital market or for the existence of non-convexities in the production process in general will not be the first-best policy. Export subsidies or some kind of export insurance can be more effective in promoting exports than tariff protection. Nevertheless, the use of export subsidies to promote exports is more likely to spur retaliatory measures from the importing country than the use of import protection as an export-promoting policy.

Appendix 1

The second order conditions for the problem $\text{Max } F = EU(y)$ where $y = \Pi(x, t) + \Pi(x^*) - (1+r)(x + x^*)$ are:

$$F_{11} = EU''(y) [\partial \Pi / \partial x - (1+r)^2] + EU''(y) (4) \frac{\partial^2 \Pi}{\partial x^2} < 0$$

$$F_{22} = EU''(y) [P^* - c^* - (1+r)]^2 < 0$$

and $(F_{11})(F_{22}) - (F_{12})^2 > 0$ where

$$F_{12} = EU''(y) [\partial \Pi / \partial x - (1+r)] [P^* - c^* - (1+r)]$$

Appendix 2

A similar proposition has been proved by many authors following different approaches (Arrow (1971)), Katz *et al.* (1982) Srinivasan (1972).

We want to prove that $K1 = EU''(y) [P^* - c^* - (1+r)] > 0$

PROOF.

$K1 = EU''(y) [P^* - c^* - (1+r)] = -Er(y) [P^* - c^* - (1+r)] U'(y)$ where $r(y)$ is the coefficient of absolute degree of risk aversion.

$K1 = -[(Er(y)) (E[P^* - c^* - (1+r)] U'(y)) + \text{cov}(r(y), U'(y))]$ substituting in the first order conditions we get.

$K1 = \text{cov}(-r(y), [P^* - c^* - (1+r)] U'(y))$ which is unambiguously positive if the utility function depict decreasing absolute degree of risk aversion, thus $K1 > 0$.

Appendix 3

The second-order conditions of the problem $\text{Max } F = EU(y)$ where $y = R(x, a) + R^*(x^*) - c(x + x^*)$ are:

$$F_{11} = EU'(y) [\partial R/\partial x - c'] + EU''(y) [\partial R/\partial x - c'] < 0.$$

$$F_{22} = EU''(y) [dR^*/dx^* - c'] < 0 \quad (F_{11})(F_{22}) - (F_{12})^2 > 0 \text{ where}$$

$$F_{12} = EU''(y) [dR^*/dx^* - c'] - c'' EU''(y)$$

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