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Working Paper

Privatization and investment: Crowding-out effects vs financial diversification

Nota di Lavoro, No. 108.2002

Provided in Cooperation with:

Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Girmens, Guillaume; Guillard, Michel (2002) : Privatization and investment: Crowding-out effects vs financial diversification, Nota di Lavoro, No. 108.2002, Fondazione Eni Enrico Mattei (FEEM), Milano

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Fondazione Eni Enrico Mattei

**Privatization and Investment:
Crowding-Out Effect vs
Financial Diversification**

Guillaume Girmens and Michel Guillard

NOTA DI LAVORO 108.2002

DECEMBER 2002

PRIV – Privatisation, Regulation, Antitrust

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Privatization and Investment: Crowding-Out Effect vs Financial Diversification

Summary

In this paper, we study the effect of share issue privatization (SIP) on private investment and financial market under incomplete risk diversification. Risk neutrality and imperfect intertemporal substitutability make investment decreasing in privatization (crowding-out effect). Vice-versa with risk aversion and perfect intertemporal substitutability (diversification effect). Finally, with risk aversion and imperfect intertemporal substitutability, crowding-out effects are more than compensated by diversification effects if and only if risk aversion is sufficiently high (relatively, i.e. compared to the inverse of the elasticity of intertemporal substitution). We establish these results in the most favorable case for the dominance of the crowding-out effect, when the revenues of privatization are devoted to present public consumption.

Keywords: Crowding-out effect, non-expected preferences, privatization, risk-sharing

JEL: D81, L33

This research is part of the research project "Privatisation and Financial Market Development", funded by the European Commission (contract n. HPSE-CT-1990-00007). It was presented at Athens University of Economics and Business within an intermediate workshop of this research project. We also appreciated comments from participants to the 7th Annual Congress of the research network Theories and Methods in Macroeconomics (Université d'Evry, June 2002), participants to PET 02 - Third International Conference on Public Economics (Université Paris 1, July 2002) and participants to the conference on privatization, corporate governance, and financial market development (Milan, Fondazione Eni Enrico Mattei, July 2002).

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1 Introduction

According to the famous proverb saying that nobody should keep all its eggs in one basket, from the investors' point of view, privatization may be considered as a new "basket". Symmetrically, from the governments' point of view, privatization revenue may be considered as new "eggs". In more economic terms, Maskin [2000] argues that because different assets have different distributions of returns, privatization is a way of allocating risks across members of the economy. Therefore, even if privatization has no direct implications (e.g. for the performance of divested firms), it is not neutral, because of indirect general equilibrium considerations (i.e. taking into account interdependence between markets); more precisely it may have an effect on risk sharing. In this respect, Bosi, Girmens, and Guillard [2001] and Girmens [2001] present a channel through which privatization may affect financial market development. But these papers are based on the single role of financial markets in achieving the need for insurance felt by risk-averse agents, whereas financial markets also facilitate such intertemporal choices as saving and investing.

In this paper, compared to the ones cited above, we replace exogenous fixed-size projects by endogenous investment decisions (with, simultaneously, a consumption-saving decision to make), in order to connect privatization, private investment and financial market development, in a context of incomplete risk diversification. So, taking explicitly into account consumption-saving and investment decisions, we should be able to answer the following questions:

- How does privatization influence financial markets, taking into account both insurance and intertemporal issues?
- Does privatization lead to an increase in private investment?

The answer will depend both on intertemporal substitution and on risk aversion, hence we adopt a utility specification which permits to isolate the roles played by these two distinct aspects of preferences, precisely a Kreps-Porteus formulation of preferences.¹

In the case where risk neutrality is combined with an infinite intertemporal elasticity of substitution, the expected gross interest rate is constant, as well as private investment, which does not depend on the privatization extent. In this case, the only effect of privatization is a substitution between present private good consumption and expected future consumption.

With risk neutrality but imperfect intertemporal elasticity of substitution, if privatization revenues are devoted to present public consumption, privatization leads to an increase in the expected gross interest rate, itself reducing capital accumulation by private firms. This is basically a crowding-out effect: an increase in the supply of public assets on financial markets (in this case, an increase in risky public

¹See the seminal articles by Selden [1978], Selden [1979] and Kreps and Porteus [1978] and among many others applications Epstein [1988] and Kimball and Weil [1992].

assets, through the increase in privatization), leads not surprisingly to an increase in interest rates, thereby reducing private investment.

This is an interesting result, because crowding-out effect is a well-known phenomenon when an increase in public spending occurs through public borrowing: this leads to a decrease in private investment, because of an increase in interest rates. Public and private needs are indeed competing on a financial market whose capacities are limited; an increase in interest rates allows the adjustment; as a result, because interest rates represent the cost of capital for private firms, private investment decreases.

In other words, if crowding-out effects have been extensively studied in the case of public borrowing (an increase in the supply of *riskless* assets), we emphasize it here in the case of share issue privatization (an increase in the supply of *risky* public assets).

However, this result is established in the most favorable case for the appearance of the crowding-out effect, when the revenue of privatization is devoted to present public spending. What happens if privatization revenue is used to reduce public debt in this context (risk neutrality and some intertemporal complementarity)? The answer is straightforward: without risk aversion, if an increase in the supply of risky public assets (i.e. an increase in privatization) compensates a decrease in the supply of public riskless assets (i.e. a decrease in public debt), the crowding-out effect simply disappears!

In contrast, with risk aversion but perfect intertemporal substitutability a pure diversification effect appears, and private investment is increasing in the privatization extent.

When there is at the same time some risk aversion and some complementarity between present and future consumption, both crowding-out and diversification effects, as described above, will play. The question is: which one of these two effects dominates the other one, and under which condition(s)? A first step is to study the Von-Neumann Morgenstern case, in which the risk aversion coefficient is by definition equal to the inverse of the intertemporal elasticity of substitution. We show that for a given privatization extent, and in a neighborhood of this public divestment level, the diversification effect dominates the crowding-out one for sufficiently high values of the risk aversion measure: in this case, private investment is an increasing function of the privatization extent. Equivalently, we show that for a given level of risk aversion, privatization extent must be sufficiently high, to have investment locally increasing with privatization. A surprising result of the Von Neumann-Morgenstern is that the cases characterized by a positive relationship between privatization and investment are associated with a negative relationship between privatization and public receipts and expenses. Moreover, with Von Neumann-Morgenstern preferences, we show also that the level of private investment under total privatization is always less than its level if there is no privatization at all.

Finally, we deal with the more general case, where there is at the same time some risk aversion and some complementarity between present and future consumption, with a risk aversion coefficient possibly different from the inverse of the intertemporal elasticity of substitution. We show that if risk aversion is sufficiently high (relatively, i.e. compared to the inverse of the elasticity of intertemporal substitution),

crowding-out effects are likely to be more than compensated by diversification effects. Vice-versa, the crowding-out effect dominates if risk aversion is relatively low.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 presents and discuss crowding-out and diversification effects, according to the relative levels of risk aversion and intertemporal substitutability. Last section concludes.

2 The model

We consider a two-period model of a closed economy, populated by a representative consumer, interacting with a government and N firms. The representative consumer initially owns the property rights over the n private firms; the government initially owns the property rights over the $N - n$ public firms. Each firm is representative of an industry. Each industry is not characterized by the type of good it produces (there is only one type of private good), but by the realization of a particular state of nature, affecting its production. More precisely, given a production function f and first-period investment k_j , the production of firm j in state of nature s is the following:

$$y_j(s) = e_j(s) f(k_j)$$

where:

$$e_j(s) = \begin{cases} 1 & \text{if } s = j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

An industry j differs from another one by this parameter e . There are S exogenously determined and equally likely states of nature, revealed at the beginning of the second period, and we assume that $S > N$, such that we are in a context of incomplete risk diversification.

Alternatively, we could consider an economy populated by n private agents, both consuming and investing. But the separation between consumption-saving decisions (the representative consumer) and investment decisions (the firms) helps to understand the mechanisms playing in this model.

2.1 The representative consumer

2.1.1 Preferences

We consider a Kreps and Porteus [1978] representation of preferences. Let G^t be the public good consumption of period t , and c^t the private good consumption. The utility of a private agent has the following form:

$$u(c^1) + \beta u(\hat{c}^2) + \bar{z}(G^1, \hat{G}^2) \quad (2)$$

with:

$$\hat{c}^2 = v^{-1}(E[v(c^2(s))])$$

$$\widehat{G}^2 = v^{-1} (E [v (G^2 (s))])$$

\widehat{c}^2 (\widehat{G}^2) is the certainty equivalent of the random second-period private (public) consumption. This representation permits us to disentangle the coefficient of risk aversion which is associated with the curvature of the function v , and the intertemporal elasticity of substitution which is associated with the curvature of the function u . The functions v and u are required to be strictly increasing and concave. In addition, the concavity of the objective function (2) requires that the absolute risk tolerance index, $-v'/v''$, be concave.² In particular, it is concave in the set of utility functions with harmonic absolute risk aversion (HARA), including well-known special cases, such as utility functions with constant relative risk aversion (CRRA), constant absolute risk aversion (CARA) or quadratic utility functions.

The utility of public good \bar{z} is independent on the consumer's will.

We will derive most of the results in this general case, but we will also use functional forms, by defining u and v as follows:

$$\begin{cases} u(x) = \frac{x^{1-1/\delta}}{1-1/\delta}, \delta > 0 \\ v(x) = \frac{x^{1-\rho}}{1-\rho}, \rho > 0 \end{cases} \quad (3)$$

In this case, δ is the (constant) intertemporal elasticity of substitution and ρ is the (constant) relative risk aversion index.

2.1.2 Consumption-saving decision

The program of the representative agent is written as follows:

$$\max_{c^1, b, \{\eta_j\}_{j=1}^N, \{c^2(s)\}_{s=1}^S} u(c^1) + \beta u(\widehat{c}^2)$$

subject to:

$$c^1 + b + \sum_{j=1}^N q_j \eta_j^h \leq w^1 + \sum_{j=1}^n q_j \quad (4)$$

$$c^2(s) \leq w^2 + Rb + \sum_{j=1}^N d_j(s) \eta_j^h, \quad s = 1, \dots, S \quad (5)$$

b denotes a riskless asset, q_j is the price of asset j , η_j^h the demand of the representative household for this asset. w^t is the certain endowment (in private good) of period t . R is the real riskless gross interest rate. $d_j(s)$ is the dividend per share of firm j in state s . In the first period, thanks to its endowment in private good and to its property rights on private firms³, the representative agent consumes and purchases riskless and risky assets, including shares of the initially public firms, as soon as there is some privatization.

First order conditions can be written as:

$$u'(c^1) = \beta \frac{u'(\widehat{c}^2)}{v'(\widehat{c}^2)} E \left[\frac{d_j(s)}{q_j} v'(c^2(s)) \right], \quad j = 1, \dots, N \quad (6)$$

²See for instance Gollier [2001] for details

³We assume here that there is no *ex ante* distribution of free shares of the public firms (no voucher privatization).

$$u'(c^1) = \beta \frac{u'(\hat{c}^2)}{v'(\hat{c}^2)} E[v'(c^2(s))] R \quad (7)$$

Binding budget constraints (4) and (5) complete these first-order conditions.

2.2 Private firms

In the first period, private firm j ($j = 1, \dots, n$) invests thanks to share issue:

$$k_j = (\eta_j - 1) q_j \quad (8)$$

k_j denotes investment, η_j the number of shares (i.e. $\eta_j - 1$ is the number of new shares issued). q_j (the price of one share) is also the initial value of this firm. In the second period, this firm pays a dividend to shareholders. The dividend per share in state s is equal to:

$$d_j(s) = \frac{y_j(s)}{\eta_j} = \frac{e_j(s) f(k_j)}{\eta_j} \quad (9)$$

where $e_j(s)$ is defined by (1), and f is an increasing concave function. We will derive most of the results with this general formulation, but we will also use a functional form, by defining f as follows:

$$f(k) = Ak^\varepsilon, \quad 0 < \varepsilon < 1, \quad A > 0 \quad (10)$$

The objective of a firm is, basically, to maximize the welfare of its shareholders. In our model, firm j decides the level of k_j in order to maximize q_j (the value of this firm), taking into account first-order conditions derived from the shareholder's program. Formally, using equations (6) and (7), the initial value of firm j is given by:

$$q_j = E \left[\frac{v'(c^2(s))}{E[v'(c^2(s))]} \frac{d_j(s)}{R} \right] \quad (11)$$

Therefore, using (8) and (9) in (11), the objective of firm j can be written as:

$$\max_{k_j} q_j = \frac{E[v'(c^2(s)) e_j(s)]}{E[v'(c^2(s))]} \frac{f(k_j)}{R} - k_j \quad (12)$$

The first-order condition is simply given by:

$$E[e_j(s)] f'(k_j) = R \frac{E[v'(c^2(s))] E[e_j(s)]}{E[v'(c^2(s)) e_j(s)]}$$

The left-hand side is the expected marginal product of capital, and the right-hand side is the expected risky gross interest rate for industry j . Using this result in (12) and then in (8), we get that the value q_j of firm j , as well as the total number of shares η_j depend only on the investment level of this firm, as follows:

$$\begin{aligned} q_j &= \frac{f(k_j)}{f'(k_j)} - k_j \\ \eta_j &= \frac{1}{1 - \frac{k_j f'(k_j)}{f(k_j)}} \end{aligned}$$

2.3 Government

At the beginning of the first period, the government has property rights over the $N - n$ initially public firms. If we assume that (i) there is no *ex ante* distribution of free shares of the public firms to private agents (no voucher privatization); (ii) there is no public investment on financial markets (i.e. the government do not use resources to purchase shares of private firms); (iii) an exogenous share π of each initially public firm is proposed on the financial market through a share issue privatization (SIP); then its first-period budget constraint can be written as:

$$G^1 + \sum_{j=n+1}^N k_j \leq w_g^1 + B + \sum_{j=n+1}^N q_j \pi \quad (13)$$

where w_g^1 denotes an endowment in private good and B resources taken from the sale of riskless assets. Private good can be used as input and converted in public good by the government thanks to a specific technology. For simplicity we consider an identity production function which transforms one unit of private good in one unit of public good. We will assume from now on that the level of public investment (k_j , for all $j = n + 1, \dots, N$) is exogenously determined.

According to equation (13), an increase in privatization revenues may be devoted to present public consumption G^1 , or to a reduction in public debt B .

In the second period, the government budget constraint can be written as follows:

$$G^2(s) + RB \leq w_g^2 + \sum_{j=n+1}^N (1 - \pi) d_j(s), \quad s = 1, \dots, S \quad (14)$$

Budget constraints (13) and (14) are binding at equilibrium.

2.4 Equilibrium

2.4.1 Private assets markets

$$\eta_j^h = \eta_j, \quad \text{for all } j = 1, \dots, n$$

Since we have assumed that the government does not purchase shares of private firms, at equilibrium, the representative consumer holds all these shares.

2.4.2 Public assets markets

$$\eta_j^h = \pi, \quad \text{for all } j = n + 1, \dots, N$$

The representative consumer holds all the shares issued at the time of the privatization.

2.4.3 Riskless asset market

$$b = B$$

In what follows, results will be written under the assumption $b = B = 0$ (privatization revenues exclusively devoted to present public consumption). Even in this case, the introduction of a riskless asset was not useless: it allowed us to define the riskless gross interest rate R . This variable will be very useful to interpret some results of the model. Besides, results of the model with $B > 0$ but $G^1 = 0$ are presented in appendix A. In this case, privatization (other things equal, an increase in π in the right-hand side of the government first-period budget constraint) is exclusively used to reduce public debt (other things equal, a decrease in B in the right-hand side of the government first-period budget constraint).

2.4.4 Symmetry

In addition, at the symmetric⁴ equilibrium, we have:

Private firms	Public firms
$q_j = q$ for all $j = 1, \dots, n$	$q_j = q_g$ for all $j = n + 1, \dots, N$
$k_j = k$ for all $j = 1, \dots, n$	$k_j = k_g$ for all $j = n + 1, \dots, N$
$\eta_j = \eta$ for all $j = 1, \dots, n$	

First-order conditions for the representative consumer and for the firms, as well as the government (binding) budget constraints can be rewritten at the symmetric equilibrium, leading to a system including $2S + 7$ equations, for $2S + 7$ unknowns.⁵

$S + 3$ equations taken from the consumer first-order conditions

$$c^1 = w^1 - (nk + (N - n)q_g\pi) \quad (15)$$

$$c^2(s) = w^2 + \begin{cases} f(k) & \text{for all } s = 1, \dots, n \\ \pi f(k_g) & \text{for all } s = n + 1, \dots, N \\ 0 & \text{for all } s = N + 1, \dots, S \end{cases} \quad (16)$$

$$\frac{f(k_g)}{q_g} \frac{1}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + \pi f(k_g))} R \quad (17)$$

$$R = \frac{u'(c^1)}{\beta u'(\tilde{c}^2)} \frac{v'(\tilde{c}^2)}{E[v'(c^2(s))]} \quad (18)$$

⁴Symmetry is not an assumption here, but a first result. We have no reasons in our model to have something else than a symmetric equilibrium.

⁵ $c^1, \eta, \{c^2(s)\}_{s=1}^S, k, q, G^1, \{G^2(s)\}_{s=1}^S, q_g, R.$

3 equations taken from firms first-order conditions

$$\frac{f'(k)}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + f(k))} R \quad (19)$$

$$\eta = \frac{1}{1 - \frac{kf'(k)}{f(k)}} \quad (20)$$

$$q = \frac{f(k)}{f'(k)} - k \quad (21)$$

$S + 1$ equations taken from the government binding constraints

$$G^1 + (N - n)k_g = w_g^1 + (N - n)q_g\pi \quad (22)$$

$$G^2(s) = w_g^2 + \begin{cases} 0 & \text{for all } s = 1, \dots, n \\ (1 - \pi)f(k_g) & \text{for all } s = n + 1, \dots, N \\ 0 & \text{for all } s = N + 1, \dots, S \end{cases} \quad (23)$$

Notice that equations (15) and (22) give the first-period resource constraint of the economy, as follows:

$$c^1 + G^1 + nk + (N - n)k_g = w^1 + w_g^1 \quad (24)$$

3 Crowding-out and diversification effects

3.1 Risk neutrality and infinite intertemporal elasticity of substitution

Risk neutrality combined with an infinite intertemporal elasticity of substitution mean that both $u(c)$ and $v(c)$ are linear in consumption. In this case, from the system (15)-(23), we get, in particular, that:

$$\frac{f'(k)}{S} = R = \frac{1}{\beta}$$

The expected gross interest rate on risky assets is equal to the riskless gross interest rate, and is constant (in the sense that it does not depend on privatization extent π), given by $1/\beta$. Private investment k is also constant, it does not depend on the privatization extent π . The only effect of privatization is a substitution between present private good consumption (c^1 , decreasing) and expected future private good consumption ($E[c^2(s)]$, increasing).

This result is valid if privatization revenues are devoted to a reduction in public debt.⁶

3.2 Risk neutrality and imperfect intertemporal elasticity of substitution: a pure crowding-out effect

In this case, $v(c) = c$. From the system (15)-(23), we get, in particular, that:

$$\frac{f'(k)}{S} = R = \frac{u'(c^1)}{\beta u'(E[c^2(s)])}$$

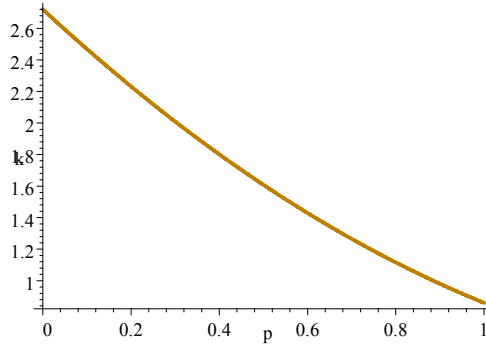
⁶See appendix A.

$$= \frac{u' \left(w^1 - \left(nk + (N - n) \frac{f(k_g)}{f'(k)} \pi \right) \right)}{\beta u' \left(\frac{n}{S} (w^2 + f(k)) + \frac{N-n}{S} (w^2 + \pi f(k_g)) + \frac{S-N}{S} w^2 \right)}$$

It is straightforward to check that, implicitly, private investment k is a decreasing function of the privatization extent π , for all π . With imperfect intertemporal elasticity of substitution, privatization leads to an increase in the gross interest rate R , itself reducing capital accumulation by private firms. This is basically a crowding-out effect: an increase in the supply of public assets on financial markets (in this case, an increase in risky public assets, through the increase in π), leads not surprisingly to an increase in interest rates, thereby reducing private investment.

The magnitude of this crowding-out effect is increasing in the degree of complementarity between present and future consumption.

Intuitively, without risk aversion but with imperfect intertemporal substitution, consumption smoothing across states of nature does not matter, whereas intertemporal smoothing does. And other things equal, at equilibrium, an increase in the privatization extent mechanically increases expected future consumption, and decreases present consumption. If there is some complementarity between present and future consumption, a reduction in private investment k allows some readjustment between present and future consumption.



Crowding-out effect (k as a function of π)

If we remove the assumption $B = 0$, i.e. if we assume that, roughly speaking, privatization receipts are used to reduce public debt, then, in this case without risk aversion, the crowding-out effect completely disappears and privatization has no effect on private investment.⁷

3.3 Risk aversion and infinite intertemporal elasticity of substitution: a pure diversification effect

In this case, $u(c) = c$. From the system (15)-(23), we get, in particular, that:

$$\frac{f'(k)}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + f(k))} R \quad (25)$$

⁷See appendix A.

and the riskless gross interest rate is given by:

$$R = \frac{v'(\hat{c}^2)}{\beta E[v'(c^2(s))]}$$

where:

$$\hat{c}^2 = v^{-1} \left(\frac{n}{S} v(w^2 + f(k)) + \frac{N-n}{S} v(w^2 + \pi f(k_g)) + \frac{S-N}{S} v(w^2) \right)$$

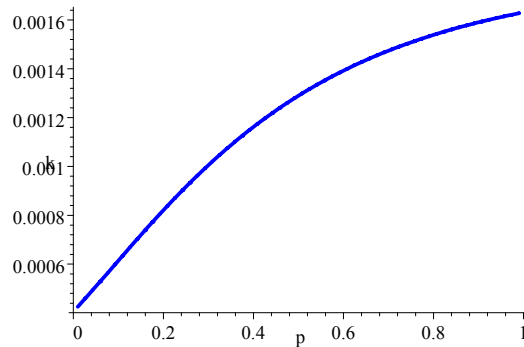
In equation (25), the fraction in the right-hand term can be interpreted as a gross risk premium. As a consequence, the link between privatization and private investment will depend both on the effect on this risk premium, and on the effect of the riskless gross interest rate R . The risk premium is unambiguously decreasing in privatization extent, and if for instance R is constant, this diminution of the risk premium leads to an increase in private investment. This is clearly the case with constant absolute risk aversion (CARA)⁸. In this case, the riskless gross interest rate R is equal to $1/\beta$, for all privatization levels π .

More generally, the effect on the riskless gross interest rate R depends on the utility function v , and we can not argue for the moment that, in the general case, if it is increasing in π , this rise is always dominated by the diminution of the risk premium and therefore that investment is always increasing in π . But, still in the general case, we can derive a sufficient condition, as follows:

$$\text{if } -v''(w^2 + f(k)) > \frac{-n}{S} v''(\hat{c}^2) \text{ then } \frac{dk}{d\pi} > 0$$

This sufficient condition is likely to hold for n/S sufficiently low (i.e., roughly speaking, if the private sector initially represents a small share of the economy).

Moreover, after the CARA unambiguous case, and the above sufficient condition in the general case, we get also the positive relationship between privatization and private investment if we use the functional forms for preferences and production defined by equations (3) and (10). This result will appear as a special case in paragraph 3.5, and can be illustrated by the following representation:



Diversification effect (k as a function of π)

⁸The generic form of these functions is

$$v(z) = -\frac{\exp(-Az)}{A}$$

where A is the (constant) Arrow-Pratt coefficient of absolute risk aversion

Intuitively, with perfect intertemporal substitution but with risk aversion, consumption smoothing across states of nature matters, whereas intertemporal smoothing does not. And other things equal, at equilibrium, an increase in the privatization extent mechanically increases consumption in states of nature $s = n + 1, \dots, N$. If there is some risk aversion, an increase in private investment k allows some readjustment between consumption levels across states of nature.

3.4 Von Neumann-Morgenstern case

We guess now that when there is at the same time some risk aversion and some complementarity between present and future consumption, both crowding-out and diversification effects, as described above, will play. The question is: which one of these two effects dominates the other one, and under which condition(s)? A first step is to study the Von-Neumann Morgenstern case, in which utility is simply given by the sum of present utility $u(c^1)$, plus discounted expected future utility $\beta E[u(c^2(s))]$. To get this formulation of preferences from our initial model, we have simply to set $u(c) = v(c)$. From the system (15)-(23), we get, in particular, that:

$$\frac{f'(k)}{S} = \frac{E[u'(c^2(s))]}{u'(w^2 + f(k))} R = \frac{u'(c^1)}{\beta u'(w^2 + f(k))} \quad (26)$$

$$= \frac{u' \left(w^1 - \left(nk + (N - n) \frac{f(k_g)}{f'(k)} \frac{u'(w^2 + \pi f(k_g))}{u'(w^2 + f(k))} \pi \right) \right)}{\beta u'(w^2 + f(k))} \quad (27)$$

It is straightforward to check that, implicitly, private investment k is function of the privatization extent π . This implicit function is strictly increasing if and only if:

$$-\pi f(k_g) \frac{u''(w^2 + \pi f(k_g))}{u'(w^2 + \pi f(k_g))} > 1$$

or, equivalently:

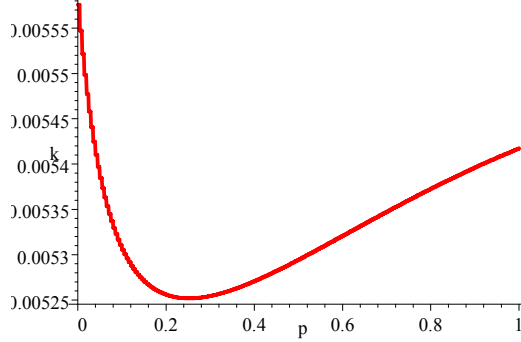
$$\rho(w^2 + \pi f(k_g)) > 1 + \frac{w^2}{\pi f(k_g)} \quad (28)$$

where $\rho(x) \equiv -xu''(x)/u'(x)$ is the Arrow-Pratt coefficient of relative risk aversion. With Von Neumann-Morgenstern preferences, ρ represents both risk aversion and the inverse of the intertemporal elasticity of substitution. In the CRRA case, $\rho(x) = \rho$, for all x , and both crowding-out and diversification effects are increasing in ρ . For a given value of π , and in a neighborhood of this privatization extent, we know from condition (28) that for sufficiently high values of ρ , the diversification effect dominates the crowding-out one: in this case, private investment k is an increasing function of the privatization extent π .

With CRRA utility function, condition (28) says also that, for a given level of the parameter preference ρ , privatization extent π must be sufficiently high, to have $dk/d\pi > 0$ in a neighborhood of this

privatization level. We can sum up both rationales about condition (28) as follows:

$$\frac{dk}{d\pi} > 0 \Leftrightarrow \begin{cases} \pi > \bar{\pi} \text{ for a given level of } \rho \\ \text{or, equivalently} \\ \rho > \bar{\rho} \text{ for a given level of } \pi \end{cases}$$



Von Neumann-Morgenstern preferences (k as a function of π , for a given level of ρ)

From result (26), we know that:

$$\frac{f'(k)}{S} = \frac{u'(c^1)}{\beta u'(w^2 + f(k))}$$

This equation implies that, if k increases (this occurs in the cases described above), private consumption c^1 also increases. As a consequence, from the resource constraint (24), public good provision G^1 is necessarily decreasing in π ! In other words, under Von Neumann-Morgenstern preferences, private investment is locally increasing in privatization extent only in cases where public receipts ($q_g \pi$) and expenses are locally decreasing in privatization extent!

Furthermore, from (27), we know that:

$$k_0 (\pi = 0) \text{ is such that } \frac{f'(k_0)}{S} = \frac{u'(w^1 - nk_0)}{\beta u'(w^2 + f(k_0))}$$

$$k_1 (\pi = 1) \text{ is such that } \frac{f'(k_1)}{S} = \frac{u' \left(w^1 - \left(nk_1 + (N - n) \frac{f(k_g)}{f'(k_1)} \frac{u'(w^2 + f(k_g))}{u'(w^2 + f(k_1))} \right) \right)}{\beta u'(w^2 + f(k_1))}$$

As a consequence, we get that, unambiguously:

$$k_0 (\pi = 0) > k_1 (\pi = 1)$$

In other words, in the Von Neumann-Morgenstern case, in the case of a total privatization (compared to the case where there is no privatization at all), we know that the crowding-out effect dominates the diversification one.

3.5 General case: risk aversion and imperfect intertemporal elasticity of substitution

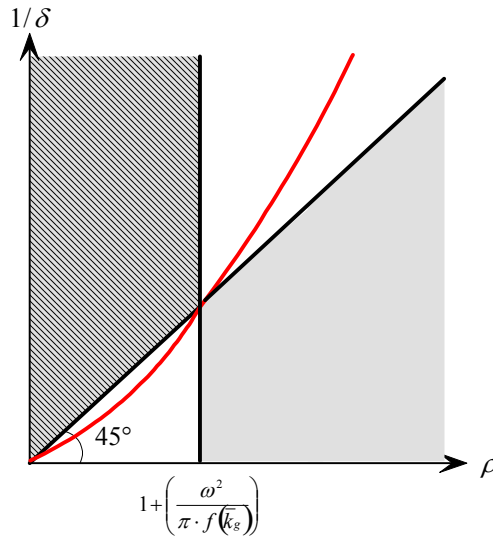
To deal with the general case where there is both some risk aversion and some complementarity between present and future consumption, and where, generically, relative risk aversion may differ from the inverse of the intertemporal elasticity of substitution, we have to specify the utility functions u and v , as well as the production function f . Consider a constant elasticity of substitution (CES) function for u , where δ is the intertemporal elasticity of substitution, and a constant relative risk aversion (CRRA) function for v , where ρ is the Arrow-Pratt coefficient of relative risk aversion, as stated by (3). The functional form for production was given in equation (10). Starting from the system (15)-(23), some computations (given in appendix) lead to sufficient conditions under which private investment is unambiguously increasing (respectively, decreasing) in privatization extent. In other words, we have sufficient conditions under which the diversification effect dominates (respectively, is dominated by) the crowding-out one. More precisely, for a given level of π , we know that, locally:

$$\rho \leq 1 + \frac{w^2}{\pi A (k_g)^\varepsilon} \text{ and } \rho \leq \frac{1}{\delta} \text{ with at least one strict inequality } \Rightarrow dk/d\pi < 0 \quad (29)$$

$$\delta \rightarrow +\infty \Rightarrow dk/d\pi > 0 \quad (30)$$

$$\rho \geq 1 + \frac{w^2}{\pi A (k_g)^\varepsilon} \text{ and } \rho \geq \frac{1}{\delta} \text{ with at least one strict inequality } \Rightarrow dk/d\pi > 0 \quad (31)$$

Notice that these sufficient conditions are consistent with the particular cases listed above for generic utility and production functions (risk neutrality, infinite intertemporal elasticity of substitution, Von-Neumann Morgenstern case).



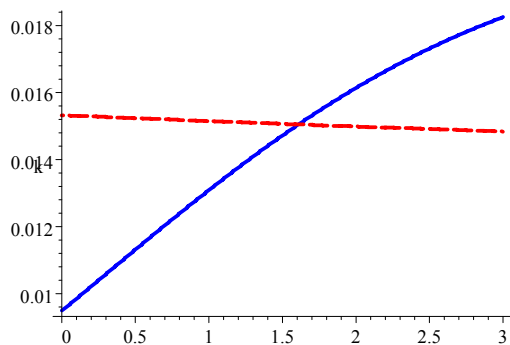
Sign of $(dk/d\pi)$ in the $(\rho, 1/\delta)$ space

Summing up conditions (29)-(31), we have, in the $(\rho, 1/\delta)$ space, for a given level of π :

- a north-western region (hatched on the figure), defined by (29), where $(dk/d\pi) < 0$;
- the horizontal axis, defined by (30), where $(dk/d\pi) > 0$;
- a south-eastern region (shaded on the figure), defined by (31), where $(dk/d\pi) > 0$.

Continuity arguments allow to be sure that there is a curve in the $(\rho, 1/\delta)$ space, such that $(dk/d\pi) = 0$. Above this curve, $(dk/d\pi) < 0$, and below, $(dk/d\pi) > 0$. In words, if risk aversion is sufficiently high (relatively, i.e. compared to the inverse of the elasticity of intertemporal substitution), crowding-out effects are likely to be more than compensated by diversification effects. This is the case below the curve, whereas the opposite proposition (crowding-out effects dominate) holds above the curve. The special case where w^2 tends to zero leads to a similar representation, holding now for all π , and where the vertical line is simply defined by $\rho = 1$.

Another illustration of the balance of power between the two effects is the following.



k_0 ($\pi = 0$) (dashed line) vs k_1 ($\pi = 1$) (solid line), as a function of ρ , for δ given.

The dashed line represents the capital level in the case where there is no privatization ($\pi = 0$) as a function of ρ , for δ given. The solid line represents the capital level in the case where there is a total privatization ($\pi = 1$) as a function of ρ , for δ given. If ρ is relatively low, in case of a total privatization, the crowding-out effect dominates ($k_1 < k_0$), and vice-versa if ρ is sufficiently high. We see clearly on this representation that the balance of power between the two effects moves in a monotonic way.

4 Concluding remarks

Further research should investigate more in detail the case where privatization is used to reduce public debt. The simultaneity of an increase in the supply of risky public assets (i.e. an increase in privatization), compensating a decrease in the supply of public riskless assets (i.e. a decrease in public debt) may affect some of the results described above. In particular, we already know that the crowding-out effect completely disappears, thereby possibly increasing the relative weight of the diversification one, whatever

the specification of preferences. It might also remove the surprising results obtained in the Von Neumann-Morgenstern configuration (public receipts decreasing in privatization extent, crowding-out effect always dominating financial diversification in case of total privatization).

APPENDIX A

The model with public debt ($B > 0$)

Removing the assumption $B = 0$, but setting instead $G^1 = 0$, the system (15)-(23) is replaced by the following one, including $2S + 7$ equations, for $2S + 7$ unknowns.⁹

$S + 3$ equations taken from the consumer first-order conditions:

$$c^1 + B = w^1 - (nk + (N - n)q_g\pi) \quad (32)$$

$$c^2(s) = w^2 + RB + \begin{cases} f(k) & \text{for all } s = 1, \dots, n \\ \pi f(k_g) & \text{for all } s = n + 1, \dots, N \\ 0 & \text{for all } s = N + 1, \dots, S \end{cases} \quad (33)$$

$$\frac{f(k_g)}{q_g} \frac{1}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + RB + \pi f(k_g))} R \quad (34)$$

$$R = \frac{u'(c^1)}{\beta u'(\tilde{c}^2)} \frac{v'(c^2)}{E[v'(c^2(s))]} \quad (35)$$

3 equations taken from firms first-order conditions:

$$\frac{f'(k)}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + RB + f(k))} R \quad (36)$$

$$\eta = \frac{1}{1 - \frac{kf'(k)}{f(k)}} \quad (37)$$

$$q = \frac{f(k)}{f'(k)} - k \quad (38)$$

$S + 1$ equations taken from the government binding constraints:

$$(N - n)k_g = w_g^1 + B + (N - n)q_g\pi \quad (39)$$

$$G^2(s) + RB = w_g^2 + \begin{cases} 0 & \text{for all } s = 1, \dots, n \\ (1 - \pi)f(k_g) & \text{for all } s = n + 1, \dots, N \\ 0 & \text{for all } s = N + 1, \dots, S \end{cases} \quad (40)$$

Notice that equations (32) and (39) give the first-period resource constraint of the economy, now written as follows:

$$c^1 + nk + (N - n)k_g = w^1 + w_g^1$$

Under risk neutrality and infinite intertemporal elasticity of substitution, from the system (32)-(40), we get again that:

$$\frac{f'(k)}{S} = R = \frac{1}{\beta}$$

⁹ $c^1, \eta, \{c^2(s)\}_{s=1}^S, k, q, \{G^2(s)\}_{s=1}^S, q_g, R, B.$

The expected gross interest rate on risky assets is equal to the riskless gross interest rate, and is constant (in the sense that it does not depend on privatization extent π), given by $1/\beta$. Private investment k is also constant, it does not depend on the privatization extent π .

Under risk neutrality but imperfect intertemporal elasticity of substitution, from the system (32)-(40), we get again that:

$$\frac{f'(k)}{S} = R = \frac{u'(c^1)}{\beta u'(E[c^2(s)])}$$

We get also:

$$\begin{aligned} E[c^2(s)] &= w^2 + RB + \frac{n}{S}f(k) + \frac{N-n}{S}\pi f(k_g) \\ RB &= \frac{1}{S}(f'(k)((N-n)k_g - w_g^1) - (N-n)\pi f(k_g)) \end{aligned}$$

This imply that $E[c^2(s)]$ depends only on k and on exogenous variables:

$$E[c^2(s)] = w^2 + \frac{1}{S}f'(k)((N-n)k_g - w_g^1) + \frac{n}{S}f(k)$$

Finally, k is implicitly given by:

$$\frac{f'(k)}{S} = \frac{u'(w^1 + w_g^1 - nk - (N-n)k_g)}{\beta u'(w^2 + \frac{1}{S}f'(k)((N-n)k_g - w_g^1) + \frac{n}{S}f(k))}$$

k does not depend on π . Without risk aversion, if privatization “replaces” public debt, there is no effect on private investment. There is no crowding-out effect. There is no actual increase of public assets supply, hence, no increase in the interest rate, hence no decrease in investment after privatization. Riskless assets are simply replaced by risky ones: there is no effect on the behavior of risk-neutral agents.

APPENDIX B

Derivation of conditions (29)-(31)

In the general case, the system to solve is:

$$\frac{f'(k)}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + f(k))} R \quad (41)$$

$$\frac{f(k_g)}{q_g} \frac{1}{S} = \frac{E[v'(c^2(s))]}{v'(w^2 + \pi f(k_g))} R \quad (42)$$

$$R = \frac{u'(c^1)}{\beta u'(\tilde{c}^2)} \frac{v'(\tilde{c}^2)}{E[v'(c^2(s))]} \quad (43)$$

$$c^1 = w^1 - (nk + (N - n)q_g\pi)$$

$$G^1 + (N - n)k_g = w_g^1 + (N - n)q_g\pi$$

where endogenous variables are k , R , c^1 , q_g and G^1 . $c^2(s)$, η , q and $G^2(s)$, and are simply given as functions of these endogenous variables by equations (16), (20), (21) and (23). Using (43) in (41) and (42), and functional forms for preferences and production, the system reduces to:

$$(c^1)^{1/\delta} \beta \varepsilon A = S k^{1-\varepsilon} (w^2 + A k^\varepsilon)^\rho \Phi \quad (44)$$

$$(c^1)^{1/\delta} \beta A = S q_g (k_g)^\varepsilon (w^2 + \pi A (k_g)^\varepsilon)^\rho \Phi$$

$$c^1 = w^1 - nk - (N - n)\pi q_g \quad (45)$$

$$G^1 + (N - n)k_g = w_g^1 + (N - n)\pi q_g \quad (46)$$

where endogenous variables are c^1 , k , q_g and G^1 and where Φ is defined as follows:

$$\begin{aligned} \Phi &\equiv ((1 - \rho) E[v(c^2)])^{\frac{1/\delta - \rho}{1 - \rho}} \\ &= \left(\frac{1}{S} \left(n (w^2 + A k^\varepsilon)^{1-\rho} + (N - n) (w^2 + \pi A (k_g)^\varepsilon)^{1-\rho} + (S - N) (w^2)^{1-\rho} \right) \right)^{\frac{1/\delta - \rho}{1 - \rho}} \end{aligned}$$

(46) gives:

$$q_g = \frac{1}{\pi} \left(\frac{G^1 - w_g^1}{N - n} + k_g \right)$$

to be used in (44) and (45). The system reduces to:

$$(c^1)^{1/\delta} \beta \varepsilon A = S k^{1-\varepsilon} (w^2 + A k^\varepsilon)^\rho \Phi$$

$$(c^1)^{1/\delta} \beta A = S \frac{G^1 + (N - n)k_g - w_g^1}{(N - n)\pi} (k_g)^\varepsilon (w^2 + \pi A (k_g)^\varepsilon)^\rho \Phi \quad (47)$$

$$G^1 = w^1 + w_g^1 - (c^1 + nk + (N - n)k_g) \quad (48)$$

where endogenous variables are c^1, k and G^1 . Using (48) in (47), the system reduces to:

$$(c^1)^{1/\delta} \beta \varepsilon A = S k^{1-\varepsilon} (w^2 + A k^\varepsilon)^\rho \Phi \quad (49)$$

$$(c^1)^{1/\delta} \beta A = S \frac{w^1 - c^1 - nk}{(N-n)\pi} (k_g)^\varepsilon (w^2 + \pi A (k_g)^\varepsilon)^\rho \Phi \quad (50)$$

where endogenous variables are c^1 and k . (49) allows to define $c(k, \pi)$, giving c^1 as a function of k and π , to be used in (50), such that the system reduces to:

$$\frac{w^1 - c(k, \pi) - nk}{(N-n)\pi} - \frac{1}{\varepsilon} \frac{k^{1-\varepsilon}}{(k_g)^\varepsilon} \left(\frac{w^2 + A k^\varepsilon}{w^2 + \pi A (k_g)^\varepsilon} \right)^\rho = 0$$

where k is the only one remaining endogenous variable. Equivalently, for all $\pi > 0$, the system reduces to the following equation:

$$g(k, \pi) = w^1 - c(k, \pi) - nk - \varphi(k, \pi) = 0$$

where functions c and φ are defined by:

$$\begin{aligned} c(k, \pi) &= \left(\frac{1}{\beta \varepsilon A} S k^{1-\varepsilon} (w^2 + A k^\varepsilon)^\rho \Phi \right)^\delta \\ \varphi(k, \pi) &= (N-n)\pi \frac{1}{\varepsilon} \frac{k^{1-\varepsilon}}{(k_g)^\varepsilon} \left(\frac{w^2 + A k^\varepsilon}{w^2 + \pi A (k_g)^\varepsilon} \right)^\rho \end{aligned}$$

By the implicit function theorem, it is straightforward to check that the following condition holds in a neighborhood of a solution:

$$dk/d\pi \text{ has the same sign as } - \left(\frac{\frac{\partial}{\partial \pi} (c(k, \pi)) + \frac{\partial}{\partial \pi} (\varphi(k, \pi))}{n + \frac{\partial}{\partial k} (c(k, \pi)) + \frac{\partial}{\partial k} (\varphi(k, \pi))} \right) \quad (A)$$

We are first able to prove the following result:

$$\left(n + \frac{\partial}{\partial k} (c(k, \pi)) + \frac{\partial}{\partial k} (\varphi(k, \pi)) \right) > 0 \text{ for all } \rho > 0 \text{ and for all } \delta > 0 \quad (B)$$

Proof. Compute first $\frac{\partial}{\partial k} (\varphi(k, \pi))$:

$$\frac{\partial}{\partial k} (\varphi(k, \pi)) = \frac{\varphi}{k} \left(1 + \varepsilon \left(\frac{\rho A k^\varepsilon}{w^2 + A k^\varepsilon} - 1 \right) \right)$$

A sufficient condition to have this expression turning out to be positive is:

$$\frac{\rho A k^\varepsilon}{w^2 + A k^\varepsilon} > \frac{\varepsilon - 1}{\varepsilon}$$

which is always true, since $\rho > 0$ and $0 < \varepsilon < 1$. As a consequence:

$$\frac{\partial}{\partial k} (\varphi(k, \pi)) > 0 \quad (51)$$

We are interested now in $\frac{\partial}{\partial k} (c(k, \pi))$. Some computations show that a sufficient condition for this expression turning out to be positive is:

$$n(w + A k^\varepsilon)^{-\rho} (\varepsilon - 1) - \frac{(N-n)(w^2 + \pi A (k_g)^\varepsilon)^{1-\rho} + (S-N)(w^2)^{1-\rho}}{w^2 + A k^\varepsilon} < 0$$

which is always true, since $\varepsilon < 1$. As a consequence:

$$\frac{\partial}{\partial k} (c(k, \pi)) > 0 \quad (52)$$

(51) and (52) lead to result (B). ■

Combining results (A) and (B) leads to the following one:

$$dk/d\pi \text{ has the same sign as } - \left(\frac{\partial}{\partial \pi} (c(k, \pi)) + \frac{\partial}{\partial \pi} (\varphi(k, \pi)) \right)$$

The study of the derivatives $\frac{\partial}{\partial \pi} (c(k, \pi))$ and $\frac{\partial}{\partial \pi} (\varphi(k, \pi))$ completes the derivation of conditions (29)-(31), observing that:

$$\begin{aligned} \text{sign} \left(\frac{\partial}{\partial \pi} (c(k, \pi)) \right) &= \text{sign} (1/\delta - \rho) \\ \lim_{\delta \rightarrow +\infty} \frac{\partial}{\partial \pi} (c(k, \pi)) &= -\infty \\ \text{sign} \left(\frac{\partial}{\partial \pi} (\varphi(k, \pi)) \right) &= \text{sign} \left(\frac{w^2}{\pi} + A(k_g)^\varepsilon (1 - \rho) \right) \end{aligned}$$

■

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- (xlii) This paper was presented at the International Workshop on "Climate Change and Mediterranean Coastal Systems: Regional Scenarios and Vulnerability Assessment" organised by the Fondazione Eni Enrico Mattei in co-operation with the Istituto Veneto di Scienze, Lettere ed Arti, Venice, December 9-10, 1999.
- (xliii) This paper was presented at the International Workshop on "Voluntary Approaches, Competition and Competitiveness" organised by the Fondazione Eni Enrico Mattei within the research activities of the CAVA Network, Milan, May 25-26, 2000.
- (xliv) This paper was presented at the International Workshop on "Green National Accounting in Europe: Comparison of Methods and Experiences" organised by the Fondazione Eni Enrico Mattei within the Concerted Action of Environmental Valuation in Europe (EVE), Milan, March 4-7, 2000
- (xlv) This paper was presented at the International Workshop on "New Ports and Urban and Regional Development. The Dynamics of Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, May 5-6, 2000.
- (xlvi) This paper was presented at the Sixth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, January 26-27, 2001
- (xlvii) This paper was presented at the RICAMARE Workshop "Socioeconomic Assessments of Climate Change in the Mediterranean: Impact, Adaptation and Mitigation Co-benefits", organised by the Fondazione Eni Enrico Mattei, Milan, February 9-10, 2001
- (xlviii) This paper was presented at the International Workshop "Trade and the Environment in the Perspective of the EU Enlargement", organised by the Fondazione Eni Enrico Mattei, Milan, May 17-18, 2001
- (xlix) This paper was presented at the International Conference "Knowledge as an Economic Good", organised by Fondazione Eni Enrico Mattei and The Beijer International Institute of Environmental Economics, Palermo, April 20-21, 2001
- (l) This paper was presented at the Workshop "Growth, Environmental Policies and Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001
- (li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001
- (lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001
- (liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001
- (liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002
- (lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001
- (lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy "The International Dimension of Environmental Policy", organised with the collaboration of the Fondazione Eni Enrico Mattei, Acquafredda di Maratea, October 6-11, 2001
- (lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum für Europäische Integrationsforschung (ZEI), Milan, July 5-6, 2001
- (lviii) This paper was presented at the Workshop on "Game Practice and the Environment", jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

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