Overlapping Ownership, R&D Spillovers, and Antitrust Policy[*]

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Abstract

This paper considers cost-reducing R&D investment with spillovers in a Cournot oligopoly with minority shareholdings. We find that, with high market concentration and sufficiently convex demand, there is no scope for cross-ownership to improve welfare regardless of spillover levels. Otherwise, there *is* scope for overlapping ownership provided that spillovers are sufficiently large. The socially optimal degree of overlapping ownership increases with the number of firms, with the elasticity of demand and of the innovation function, and with the extent of spillover effects. In terms of consumer surplus standard, the scope for overlapping ownership is greatly reduced even under low market concentration.

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1 Introduction

In many industries, minority shareholdings are prevalent in the form of cross-shareholding agreements among firms or common ownership by investment funds. The tendency of such arrangements to reduce price competition has been documented in the airline and banking industries (Azar et al. 2015, 2016), and it has raised antitrust concerns. However, cross-ownership arrangements (COAs) may have a beneficial effect on investment provided there are positive spillovers across firms. The reason is that COAs help to internalize the spillover externality, which is especially important for highly innovative industries. To what extent, and by what means, should antitrust authorities limit the "partial" mergers that result from cross-ownership in innovative industries? In this paper we provide a welfare analysis of COAs—when firms compete in quantities and invest in cost reduction—in the presence of spillovers; we also derive some implications for competition policy. The analysis may help elucidate whether the documented increase in cross-ownership arrangements has outrun its social value.

We consider a general symmetric model of cross-ownership; this model allows for a range of corporate control and for distinguishing between stock acquisitions made by investors and those made by other firms. In our benchmark model, we consider *simultaneous* R&D and output decisions. That approach aids tractability while helping to capture the imperfect observability of firms' R&D investment levels.[1] We test the robustness of results by way of a two-stage specification. The model subsumes earlier contributions to the literature that were based on linear or constant elasticity of demand and on specific innovation functions (Dasgupta and Stiglitz 1980; Spence 1984; d'Aspremont and Jacquemin 1988; Kamien et al. 1992). Perhaps the work closest to ours in spirit is the paper by Leahy and Neary (1997). More recently, Spulber (2013) studies how competition affects the incentives to innovate depending on the degree of appropriability of intellectual property.

Our paper seeks to answer the following questions: How do R&D and output levels vary with minority shareholdings? What are the key determinants of the socially optimal extent of cross-ownership? How is that optimal level affected by structural parameters (demand and cost conditions, industry technological opportunity, extent of spillovers) and

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[1]Simultaneous models—in the presence or absence of R&D spillovers—are analyzed by, among others, Dasgupta and Stiglitz (1980), Levin and Reiss (1988), Ziss (1994), Leahy and Neary (1997), Cabral (2000), and Vives (2008).

by the competition authority's objective (to maximize total or rather consumer surplus)?

The main results can be summarized as follows. If demand is not too convex, then increasing the partial ownership interest in rivals will increase (resp. decrease) both R&D and output when spillovers are high (resp. low); for intermediate levels of spillovers, an increase in such ownership interest will increase R&D but reduce output. These are testable predictions. We identify the key determinants of a welfare-optimal degree of cross-ownership: the curvature of demand, the degree of market concentration, and the extent of spillovers. A sufficient (but not necessary) condition for the *absence* of minority shareholdings to be optimal—from either the total surplus (TS) or consumer surplus (CS) perspective, and for any extent of spillover—is that the relative degree of convexity of demand be greater than the inverse of the Herfindahl–Hirschman index (HHI). Otherwise, the range of spillovers is typically partitioned into three regions: one optimally with no cross-ownership for low levels of spillovers; one optimally with positive cross-ownership (by TS and CS standards) for high levels of spillovers; and one optimally with positive cross-ownership (by the TS standard only) in an intermediate region. We remark that the consumer surplus standard is always more stringent than the total surplus standard. We also find that, if the effectiveness of R&D is independent of the degree of cross-ownership, then under the CS standard there is a "bang bang" solution: either independent ownership or cartelization is optimal. Numerical results reveal that the (TS-based) socially optimal extent of cross-ownership is increasing in the number of firms, in the elasticity of demand and of the innovation function, and in the level of spillover effects. Qualitatively similar results hold for the CS-based optimal extent, except that the scope for minority shareholdings is much reduced.

The context analyzed here is of more than theoretical interest. Minority shareholdings are widespread in many industries (e.g., automobiles, airlines, financial, energy, and steel) and have attracted increasing antitrust attention (see EC 2013). There is growing interest among competition authorities in assessing the competitive effects of partial stock acquisitions. This increased attention stems mainly from two factors: (i) the rapid growth of private equity investment firms, which often hold partial ownership interests in competing firms (Wilkinson and White 2007); and (ii) some notorious cases, such as Ryanair's acquisition of Aer Lingus's stock and the Renault–Nissan alliance (under which

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Renault owns 44.3% of Nissan even as Nissan owns 15% of Renault).[2] These factors have triggered a debate in Europe over the possibly anticompetitive effects of partial ownership. Yet the European Commission (EC) is not authorized to examine the acquisition of minority shareholdings,[3] and it has proposed extending the scope of its merger regulations so that it can intervene in cases involving minority shareholdings among competitors or in a vertical relationship (EC 2014).[4] In Canada and the United States, cross-ownership is scrutinized under prevailing merger control rules. More specifically, minority shareholdings in the latter country are often examined with reference to the Clayton Act and the Hart–Scott–Rodino Act.[5] However, there is an exception to antitrust scrutiny if the participation is "solely for investment" purposes, although it is subject to interpretation whether institutional investors can hold as much as 15% without needing to notify. These US provisions are important because common ownership by investment funds is widespread in many sectors.[6]

The extant literature, most of which focuses on the potential benefits of cooperative R&D or on how innovation is affected by mergers, has largely ignored the topic of how innovation is affected by minority shareholdings—despite clear evidence that antitrust policy attends closely to innovation. During the period 2008–2014, 36% of the mergers challenged by the US Department of Justice or the US Federal Trade Commission were characterized as harmful to innovation; of the challenged mergers, 76% were in high–

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[2] As Gilo (2000) delineates, four other cases that have attracted considerable interest are as follows: (i) a $150 million investment by Microsoft in the nonvoting stock of Apple in 1997; (ii) the purchase by Northwest Airlines (fourth-largest US airline) of 14% of the common stock of Continental Airlines (the fifth-largest) while agreeing to limit its voting power (however, an antitrust suit forced Northwest to sell back nearly half of its purchased stake); (iii) the purchase by TCI (largest US cable operator) of a 9% stake in Time Warner (the second-largest); (iv) the acquisition by Gillette of more than a fifth of the nonvoting stock (and more than a tenth of the debt) of Wilkinson Sword, one of its main competitors.

[3] In some European countries (e.g., Austria, Germany, the United Kingdom), national merger control rules give competition authorities the scope to examine minority shareholdings. Currently, the EC can consider the effects on competition only of (pre-existing) minority shareholdings in the context of a notified merger (and in which the merging firms each have stakes in a third firm).

[4] The European Commission (EC 2014) has proposed a "targeted transparency" system under which the EC and its member states must be notified of potentially harmful acquisitions. Included in this category would be acquisitions of a minority shareholding—in a competitor or vertically related company— when either the acquired shareholding amounts to 20% *or* ranges between 5% and 20% but allows the acquirer "a de-facto blocking minority, a seat on the board of directors, or access to commercially sensitive information of the target" (p. 13).

[5] Section 7 of the Clayton Act prohibits acquisitions (of any part) of a company's stock that "may" substantially lessen competition either by (a) enabling the acquirer to manipulate, directly or indirectly, prices or output or by (b) reducing its own incentives to compete. Although there is no clearly established threshold, acquisitions of less than 25%—but of at least 15%—have been adjudged to be in violation (Salop and O'Brien 2000).

[6] See Azar et al. (2015, 2016).

R&D intensity industries. The anticompetitive effects of minority shareholdings tend to be weaker than those of a merger; at the same time, minority shareholdings seldom yield the efficiencies (e.g., rationalization, fewer duplicated costs) that may arise from a merger. The commonly held view is that, overall, minority shareholdings tend to lessen competition. Nonetheless, the evidence of spillover-induced underinvestment in R&D suggests that cross-ownership could be beneficial.[7]

The paper proceeds as follows. We review the literature in Section 2. In Section 3, we describe the different types of minority shareholdings that can be analyzed via our model, which is presented in Section 4. That section characterizes the equilibrium responses of output and R&D in response to a change in the degree of cross-ownership. In Section 5, we examine the socially optimal degree of cross-ownership and then illustrate the results with three leading specifications from the literature: the d'Aspremont–Jacquemin and Kamien–Muller–Zang models, and a constant elasticity model as in Dasgupta and Stiglitz (1980). Section 6 extends our model to allow for strategic R&D commitments in a two-stage game. Section 7 explores an alternative interpretation of our model when cooperation in R&D extends to the product market; with regard to this case there is empirical evidence, antitrust case study evidence, and also experimental evidence. We conclude in Section 8. Unless noted otherwise, all proofs are given in Appendix A. Appendix B provides details on our analysis of the three model specifications considered. Note that we offer application software (available on the Web), which the reader can use to conduct simulations with the models.

2   Review of the literature

Previous literature has analyzed the anticompetitive effects of cross-ownership (Bresnahan and Salop 1986; Reynolds and Snapp 1986). These researchers show that the presence of partial ownership interests in a Cournot industry may result in less output and higher prices (even if those interests are relatively small). This is because the competitive decisions of one firm—with stakes in a competitor's profit—will take those stakes into account by reducing output (or raising the price) so as to increase that competitor's

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[7]For example, Bloom et al. (2013) report underinvestment in R&D (because of spillovers) in a panel of US firms from 1981 to 2001. These authors find that (i) the effects of technology spillovers are much greater than those of product market spillovers and (ii) the socially optimal level of R&D is 2–3 times as high as the observed level of R&D.

profit and hence its own financial profit. Azar et al. (2015) document the substantial common ownership interests of institutional investors (e.g., BlackRock, Vanguard, State Street, Fidelity) in competing technology firms (Apple, Microsoft), pharmacies (CVS, Walgreens), and banks (JP Morgan Chase, Bank of America, Citigroup). In that study of how passive investments by institutional investors affect market outcomes in the US airline industry, the authors find that ticket prices are about 10% higher on the average route than they would be with no cross-ownership (or if strategy decisions were made without regard to the investors' minority shareholdings). Similar results are obtained for the banking industry (Azar et al. 2016).

There is an extensive literature on the effects of cooperation and competition in R&D with spillovers, starting from the seminal articles of Brander and Spencer (1984), Spence (1984), Katz (1986), and d'Aspremont and Jacquemin (1988). Leahy and Neary (1997) present a general analysis of the effects of strategic behavior and cooperative R&D in the presence of price and output competition; they also study optimal public policy toward R&D in the form of subsidies.[8] One of this literature's primary objectives is to examine underprovision of R&D and the welfare effects of moving from a noncooperative to a cooperative regime in R&D. For example, d'Aspremont and Jacquemin (1988) show that, when spillovers are high enough, R&D cooperation (with subsequent competition at the output stage) leads to increased output, innovation, and welfare. Cooperative R&D enables firms to internalize their externalities and thus preserves the incentives to invest in R&D.

We shall identify the conditions under which minority shareholdings may increase total surplus, and even consumer surplus, in industries where R&D investment is important and spillovers are significant. Farrell and Shapiro (1990) show that passive financial stakes may be welfare increasing in asymmetric oligopolies; here we demonstrate the possibility in a symmetric oligopoly. There is some evidence that common ownership improves efficiency. He and Huang (2014), using data on US public firms from 1980 to 2010, estimate the effect of common ownership on market performance and report that firms increase their market share (up to 3.2%) through common ownership.[9]

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[8]Suzumura (1992) extends the analysis to multiple firms and general demand and cost functions in Cournot competition. Ziss (1994) does likewise but also considers product differentiation and price competition. Kamien et al. (1992) analyze the effects of R&D cartelization and joint research ventures. For a survey, see Gilbert (2006).

[9]This result is consistent with Giannetti and Laeven (2009), who show that stock acquisitions by

The results that we derive complement those in the extant literature. For instance, Leahy and Neary (1997) find that R&D cooperation leads both to more output and to more R&D when spillovers are positive. Yet we show that, when there are minority shareholdings, this result holds only when spillovers are high enough. We also identify conditions under which a cartelized Research Joint Venture (RJV) is optimal, generalizing Kamien et al. (1992) and finding that this result depends on the innovation function having little curvature.

The empirical literature finds a negative relationship between spillovers and patent protection levels in a range of industries. That is, industries with low patent protection tend to have higher spillover levels than do industries with high patent protection (Griliches 1990).[10] The result is that the intensity of the spillover effects is heterogeneous across industries. Spulber (2013) shows that competitive pressure may decrease the incentives to innovate when intellectual property (IP) is not fully appropriable but this will not happen when IP is appropriable. Our results are therefore consistent with Spulber (2013) since the intensity of competition is inversely linked to the extent of cross-ownership, and we find that for high levels of spillovers an increase in cross-ownership is beneficial for innovation while it is detrimental for low spillover levels.

3 Minority shareholdings

We may consider two types of acquisitions: when investors acquire firms' shares, called *common ownership* or (partial) *cross-ownership by investors*; and when firms acquire other firms' shares, called *cross-ownership by firms*. We discuss two cases of cross-ownership by investors (common ownership) and one case of cross-ownership by firms. In each case we show that, when the stakes are symmetric, the firm-i manager's problem is to maximize

$$\phi_i = \pi_i + \lambda \sum_{k \neq i} \pi_k, \tag{1}$$

where the value of λ depends on the type of ownership and corresponds to what Edgeworth (1881) termed the coefficient of "effective sympathy" among firms. The analysis is

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pension funds enhance firm valuation.

[10]Galasso and Schankerman (2015) find that patent rights block knowledge spillovers and downstream innovation in industries such as computers, electronics, and medical instruments (but not in others such as drugs or chemicals).

developed in Appendix A.

3.1   Cross-ownership by investors (common ownership)

In this situation, firms' stakes are held only by investors—for example, large institutional investors such as pension or mutual funds, which now have stakes in nearly three fourths of all publicly traded US firms. Consider an industry with n firms and n investors;[11] we let i and j index (respectively) investors and firms. The share of firm j owned by investor i is v_{ij}, and the parameter ζ_{ij} captures the extent of i's control over firm j (Salop and O'Brien 2000). The total (portfolio) profit of owner i is $\pi^i = \sum_k v_{ik}\pi_k$, where π_k are the profits of portfolio firm k. The manager of firm j takes into account shareholders' incentives (through the control weights ζ_{ij}) and maximizes

$$\phi_j = \pi_j + \sum_{k \neq j}^{n} \lambda_{jk}\pi_k,$$

where

$$\lambda_{jk} \equiv \frac{\sum_{i=1}^{n} \zeta_{ij}v_{ik}}{\sum_{i=1}^{n} \zeta_{ij}v_{ij}}.$$

We next discuss two important cases: silent financial interests (a.k.a. passive investments) and proportional control.[12]

Silent Financial Interest (SFI). In this case, each owner (i.e., the majority or dominant shareholder) i retains full control of the acquiring firm and is entitled to a share of the acquired firm's profits—but exerts no influence over the latter's decisions. If i owns j, then (i) $\zeta_{ij} = 1$ and $\zeta_{ik} = 0$ for $k \neq j$ and (ii) firm i maximizes $\sum_{k=1}^{n} v_{ik}\pi_k$. We consider the symmetric case, in which each investor i receives a share α in the acquired firms; hence $v_{ij} = 1 - (n-1)\alpha$ and $v_{ik} = \alpha$ for $k \neq j$. Then $\lambda^{\text{SFI}} \equiv \alpha/(1 - (n-1)\alpha)$. The upper bound of cross-ownership is $\alpha = 1/n$, in which case $\lambda^{\text{SFI}} = 1$ and n identical firms will maximize total joint profit.

Proportional Control (PC). Under proportional control, the firm's manager accounts

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[11]We make this assumption solely to simplify notation. In fact, we need only that the total number of investors, say I, be no less than the total number of firms (n). Then the expressions that follow for λ^{SFI} and λ^{PC} hold if we replace n with I. However, this assumption also has the benefit of facilitating comparisons with the case of cross-ownership by firms.

[12]Other governance structures are total control, partial control, fiduciary obligation, Coasian joint control, and one-way control. For a discussion of these structures, see Salop and O'Brien (2000).

for shareholders' own-firm interests in *other* firms in proportion to their respective stakes. Suppose that each investor acquires a share α of those other firms. Then, to compute λ_{jk} for a given $k \neq j$, we first note that if i is the majority shareholder of j then $\zeta_{ij} = 1 - (n-1)\alpha$ and $\upsilon_{ik} = \alpha$. Yet if instead $i+1$ were the majority shareholder of k, then that investor has control over j equal to $\zeta_{(i+1)j} = \alpha$ and receives an own-firm profit share of $\upsilon_{(i+1)k} = 1 - (n-1)\alpha$. Finally, there are $n-2$ investors who are minority shareholders of j and k; for these investors, the *combination* of their profit shares (and control) is equal to α. Thus we obtain

$$\lambda^{\text{PC}} \equiv \frac{2[1 - (n-1)\alpha]\alpha + (n-2)\alpha^2}{[1 - (n-1)\alpha]^2 + (n-1)\alpha^2}.$$

As with any silent financial interest, here $\lambda^{\text{PC}} = 1$ when $\alpha = 1/n$. If $\alpha < 1/n$, then λ is increasing in both n and α.

3.2 Cross-ownership by firms

In this situation, firms may acquire their rivals' stock in the form of passive investments with no control rights (e.g., nonvoting shares; see Gilo et al. 2006). This setting features a complex, chain-effect interaction between the profits of firms. Here α_{jk} denotes firm j's ownership stake in firm k, and the strategy decisions are made by the controlling shareholder; thus the profit of firm j is given by $\phi_j = \pi_j + \sum_{k \neq j} \alpha_{jk}\phi_k$. We can derive the profit of each firm by solving for a fixed point of a matrix equation. In the symmetric case, $\alpha_{jk} = \alpha_{kj} = \alpha$ for all $j \neq k$ and $\alpha_{jj} = 0$ for all j. It can be shown that firm j will maximize $\pi_j + \lambda \sum_{k \neq j} \pi_k$, where $\lambda^{\text{PCO}} \equiv \alpha/[1 - (n-2)\alpha]$ (we use PCO to index partial cross-ownership). It follows that the upper bound of cross-ownership is $\alpha = 1/(n-1)$, in which case λ^{PCO} tends to 1 as α approaches $1/(n-1)$. Just as in the two previous cases, λ is increasing in the number of firms and in the firms' stakes.

3.3 Comparative statics on the degree of cross-ownership (λ)

Table 1 summarizes the value of λ according to the type of cross-ownership. We can see that more firms and higher investment stakes are both positively associated with λ. In addition, it is straightforward to show that $\lambda^{\text{PC}} > \lambda^{\text{SFI}} > \lambda^{\text{PCO}}$. The implication is that, in order to attain the same degree of cross-ownership (and for a given number of firms),

the symmetric investment stake with proportional control must be *lower* than with silent financial interests, which in turn must be lower than with partial cross-ownership by firms: $\alpha^{\mathrm{PC}} < \alpha^{\mathrm{SFI}} < \alpha^{\mathrm{PCO}}$.

Table 1: Comparative Statics on λ

	Common Ownership, Silent Financial Interests	Common Ownership, Proportional Control	Cross-ownership (by firms)
λ	$\frac{\alpha}{1-(n-1)\alpha}$	$\frac{2\alpha[1-(n-1)\alpha]+(n-2)\alpha^2}{[1-(n-1)\alpha]^2+(n-1)\alpha^2}$	$\frac{\alpha}{1-(n-2)\alpha}$
$\partial\lambda/\partial n$	$+$	$+$	$+$
$\partial\lambda/\partial\alpha$	$+$	$+$	$+$

4 Framework and equilibrium

We consider an industry consisting of $n \geq 2$ identical firms, where each firm $i = 1, \ldots, n$ chooses simultaneously their R&D intensity (x_i) and production quantity (q_i). Firms produce a homogeneous good characterized by a smooth inverse demand function $f(Q)$, where $Q = \sum_i q_i$. We make the following three assumptions.

A.1. $f(Q)$ is twice continuously differentiable, where (i) $f'(Q) < 0$ for all $Q \geq 0$ such that $f(Q) > 0$ and (ii) the elasticity of the *slope* of the inverse demand function,

$$\delta(Q) \equiv \frac{Q f''(Q)}{f'(Q)},$$

is constant and equal to δ.

The parameter δ is the curvature (relative degree of concavity) of the inverse demand function, so demand is concave for $\delta > 0$ and is convex for $\delta < 0$. Furthermore, demand is log-concave for $1 + \delta > 0$ and is log-convex for $1 + \delta < 0$. If $1 + \delta = 0$, then demand is both log-concave *and* log-convex.[13] Assumption A.1 is always satisfied by inverse demand functions that are linear or constantly elastic. In particular, the family of inverse demand

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[13]We remark that δ is also related to the marginal consumer surplus from increasing output—that is, to MS $= -f'(Q)Q$. After setting ϵ_{MS} as the elasticity of the *inverse* marginal consumer surplus function (so that $\epsilon_{\mathrm{MS}} = \mathrm{MS}/(\mathrm{MS}'Q)$), Weyl and Fabinger (2013) argue that ϵ_{MS} measures the curvature of the logarithm of demand. Under A.1, we can write $1/\epsilon_{\mathrm{MS}} = 1 + \delta$.

functions for which $\delta(Q)$ is constant can be represented as

$$f(Q) = \begin{cases} a - bQ^{\delta+1} & \text{if } \delta \neq -1, \\ a - b\log Q & \text{if } \delta = -1; \end{cases}$$

here a is a nonnegative constant and $b > 0$ (resp., $b < 0$) if $\delta \geq -1$ (resp., $\delta < -1$).

A.2. The marginal production cost or innovation function of firm i, or c_i, is independent of output and is decreasing in both own and rivals' R&D as follows: $c_i = c(x_i + \beta \sum_{j \neq i} x_j)$, where $c' < 0$, $c'' \geq 0$, and $0 \leq \beta \leq 1$ for $i \neq j$.

A.3. The cost of investment is given by the function $\Gamma(x_i)$, where $\Gamma(0) = 0$, $\Gamma' > 0$, and $\Gamma'' \geq 0$.

The parameter β represents the spillover level of the R&D activity. Since we focus on symmetric firms, we assume symmetric spillover levels; moreover, R&D outcomes are imperfectly appropriable to an extent that varies between 0 and 1.

Firm i's profit is given by

$$\pi_i = f(Q)q_i - c\left(x_i + \beta \sum_{j \neq i} x_j\right)q_i - \Gamma(x_i),$$

and the objective function for firm i is $\phi_i = \pi_i + \lambda \sum_{k \neq i} \pi_k$ (i.e., equation (1)). The model represents distinct scenarios depending on the values of β and λ. When $\lambda \in (0,1)$ and $\beta \in [0,1)$, firms compete in the presence of partial ownership interests and the R&D outcomes are again imperfectly appropriable. When $\lambda \in (0,1)$ and $\beta = 1$, firms form a Research Joint Venture under which all R&D outcomes are fully shared among RJV members and the duplication of R&D efforts is avoided. When $\lambda = \beta = 1$, firms form a "cartelized" RJV. If $\lambda = 0$ then there are no minority interests.

For markets with cross-shareholdings, a modified HHI is proposed by Bresnahan and Salop (1986). This index corresponds to the market share–weighted Lerner index in a Cournot market, and we write MHHI $= \left(\sum_i s_i L_i\right)\eta$. Here s_i and L_i are (respectively) the market share and Lerner index of firm i; the term η denotes the demand price elasticity).[14]

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[14]Azar et al. (2015) use the MHHI (in terms of control and share rights) to measure anticompetitive incentives stemming from financial interests in the US airline industry. These authors find that, in year 2013, the market concentration generated by such financial interests was more than 10 times greater than the HHI changes above which mergers are likely to generate antitrust concerns.

In our case it is easy to see that, for a given common marginal cost, $(p - c)/p = \text{MHHI}/\eta$ at a symmetric Cournot equilibrium; here $\text{MHHI} = \Lambda/n$ for $\Lambda = 1 + \lambda(n - 1)$, which is monotone in λ. When $\lambda = 0$ we have the standard HHI for a symmetric solution, $1/n$, and if $\lambda = 1$ then the modified HHI is equal to 1.

Now we consider symmetric solutions. Let $B = 1 + \beta(n - 1)$; then Bx is the "effective" investment that lowers costs for a firm. Let $\tau = 1 + \lambda(n - 1)\beta$. Then $-c'(Bx)q\tau$ is the marginal effect of investment by a firm on its internalized profit ϕ_i. A symmetric interior equilibrium $(Q^* = nq^*, x^*)$ must solve the first-order necessary conditions for the maximization of ϕ_i:

$$\frac{f(Q^*) - c(Bx^*)}{f(Q^*)} = \frac{\text{MHHI}}{\eta(Q^*)}; \tag{2}$$

$$-c'(Bx^*)\frac{Q^*\tau}{n} = \Gamma'(x^*). \tag{3}$$

Here $\eta(Q^*) = -f(Q^*)/(Q^* f'(Q^*))$ is the elasticity of demand. Equation (2) is the modified Cournot–Lerner pricing formula; expression (3) equates the marginal benefit and marginal cost of investment by a firm with its internalized profit ϕ_i. Note that both MHHI and τ are increasing in λ and therefore respectively exert pressure to reduce output (or increase prices and margins) and to increase investment.

Let second-order derivatives and cross-derivatives be defined, at symmetric solutions, by $\partial_{zz}\phi_i \equiv \partial^2\phi_i/\partial z_i^2$, $\partial_{z_{i,j}}\phi_i \equiv \partial^2\phi_i/\partial z_i\partial z_j$, $\partial_{hz}\phi_i \equiv \partial^2\phi_i/\partial h\partial z_i$ (with $h = \beta$, λ, and $z = q, x$), and $\partial_{xq}\phi_i \equiv \partial^2\phi_i/\partial x_i\partial q_i$ ($i \neq j$; $i, j = 1, 2, \ldots, n$).[15] We assume that the following stability conditions hold:

$$\Delta_q \equiv \partial_{qq}\phi_i + (n - 1)\partial_{q_{i,j}}\phi_i < 0,$$
$$\Delta_x \equiv \partial_{xx}\phi_i + (n - 1)\partial_{x_{i,j}}\phi_i < 0,$$

and

$$\Delta \equiv \Delta_q\Delta_x - (\partial_{xq}\phi_i)^2\tau B > 0. \tag{4}$$

Together these conditions imply that (2) and (3) both have a unique solution. It is noteworthy that $\Delta_x < 0$ requires that at least one of c'' and Γ'' be positive (see Table 7 in Appendix A). If $\Delta(Q^*, x^*) > 0$ then we say that the equilibrium is *regular*; the ratio-

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[15]See Table 7 in Appendix A for the full expressions of these variables.

Table 2: Model Specifications

	AJ	KMZ	CE
Demand	$f(Q) = a - bQ$	$f(Q) = a - bQ$	$f(Q) = \sigma Q^{-\varepsilon}$
	$\delta = 0;\ a, b > 0$	$\delta = 0;\ a, b > 0$	$\delta = -(1 + \varepsilon);\ a = 0,\ b = -\sigma < 0$
$c(\cdot)$	$\bar{c} - x_i - \beta \sum_{j \neq i} x_j$	$\bar{c} - \left[(2/\gamma)(x_i + \beta \sum_{j \neq i} x_j) \right]^{1/2}$	$\kappa \left(x_i + \beta \sum_{j \neq i} x_j \right)^{-\alpha}$
$\Gamma(x)$	$(\gamma/2)x^2$	x	x

nale for this terminology will become clear in the comparative statics analysis to follow. In particular, we assume that there is a unique regular symmetric interior equilibrium (Q^*, x^*). The focus of our paper is on characterizing that equilibrium.

4.1 Model specification examples

We will consider the well-known R&D model specifications—with linear (and therefore log-concave) demand—of d'Aspremont–Jacquemin (AJ) and Kamien–Muller–Zang (KMZ); we also consider a constant elasticity (CE) model with log-convex demand that is similar to the Dasgupta and Stiglitz (1980) model but with spillover effects. Table 2 summarizes these model specifications, and Table 8 (in Appendix B) gives sufficient second-order conditions and also the regularity condition for each model specification. Table 9 (in Appendix B) presents the equilibrium values of output and R&D that are obtained by solving equations (2) and (3).

4.2 Comparative statics on the degree of cross-ownership (λ)

We are interested in how output and R&D respond, in equilibrium, to a change in λ. The sign of the derivatives $\frac{\partial q^*}{\partial \lambda}$ and $\frac{\partial x^*}{\partial \lambda}$ can be ambiguous. For a given x, the extent of cross-ownership λ has a negative effect on output: $\partial_{\lambda q} \phi_i = f'(Q) q (n-1) < 0$. This is the well-known effect of reducing output so as to increase price when the profit of rivals is being taken into account. For a given q, however, λ has a positive effect on investment: $\partial_{\lambda x} \phi_i = -\beta q (n-1) c'(xB) > 0$. This is the internalizing effect of spillovers with a higher λ, and its strength depends directly on the size (β) of those spillovers. The total impact of λ on the equilibrium values of per-firm output and R&D will depend on which of the two previous effects dominates. What is clear is that, if $\partial x^*/\partial \lambda \leq 0$, then $\partial q^*/\partial \lambda < 0$ because $\partial_{xq} \phi_i > 0$. That is, an increase in R&D investment is necessary (but

not sufficient) for output to rise with increasing λ. When β is small, the positive effect on investment is small and so the negative effect on output dominates. Then q^* decreases with λ and, as a result, firms invest less also when λ increases—given that the benefit to firms from investing in R&D decreases proportionally with output.

We shall use R_I to denote the region in which $\partial q^*/\partial\lambda < 0$ and $\partial x^*/\partial\lambda \leq 0$. If β is sufficiently high, then the positive effect on R&D reduces significantly the unit cost of production, which in turn stimulates output. Two effects are present in this case. On the one hand, firms want to reduce output in order to increase competitors' profit and hence their own financial profit. On the other hand, firms now have incentives to produce more because they are more efficient. If the first effect dominates, then $\partial q^*/\partial\lambda < 0$ and $\partial x^*/\partial\lambda > 0$ (we label this region R_II). But if the second effect dominates, then $\partial q^*/\partial\lambda > 0$ and $\partial x^*/\partial\lambda > 0$ (region R_III). Which of these two cases arises in equilibrium will depend on the extent of the spillovers. We find that, whereas R_I always exists, regions R_II and R_III might not exist.

We next derive the conditions and threshold values (in terms of β) that define the boundaries of the regions characterizing the signs of $\partial x^*/\partial\lambda$ (Lemma 1) and $\partial q^*/\partial\lambda$ (Lemma 2).

LEMMA 1 *At equilibrium,*

$$\mathrm{sign}\left\{\frac{\partial x^*}{\partial\lambda}\right\} = \mathrm{sign}\{\beta(1 + n + \delta\Lambda) - 1\}.$$

COROLLARY 1 *For any fixed λ and for any $\beta \in [0,1]$, only R_I exists (with $\partial x^*/\partial\lambda \leq 0$) if and only if demand is convex enough—that is, iff $\delta \leq -n/\Lambda$.*[16] *This statement holds for any λ in the interval $[0,1]$ provided that $\delta \leq -n$.*

We can interpret the critical spillover threshold for β in terms of the cost pass-through coefficient (i.e., the rate at which the price changes with marginal cost). This threshold is equal to the industry-wide per-firm cost pass-through coefficient ($P'(c)/n$) multiplied by the internalized cost-reducing effect of a unit increase in R&D expenditures by a firm (τ); formally, we have $\mathrm{sign}\left\{\frac{\partial x^*}{\partial\lambda}\right\} = \mathrm{sign}\{\beta - P'(c)\tau/n\}$. Note that the threshold is decreasing in the pass-through coefficient because firms are less interested in reducing costs when

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[16]When $\delta > -(n+1)/\Lambda$, there exists a positive threshold of spillover above which $\partial x^*/\partial\lambda > 0$; however, that threshold exceeds unity unless $\delta > -n/\Lambda$.

doing so translates, in effect, into lower prices.[17]

A consequence of Lemma 1 is that the threshold for spillovers to induce $\partial x^* / \partial \lambda \leq 0$ is decreasing (resp. increasing) in λ when demand is concave (resp. convex)—that is, when $\delta > 0$ (resp. $\delta < 0$).[18]

If demand is extremely convex, then increases in cross-ownership are so restrictive of output that they induce $\partial x^* / \partial \lambda < 0$, in which case only R_I exists for any β. And since MHHI $= \Lambda / n$, the applicable condition is that $\delta \leq -(\mathrm{MHHI})^{-1}$. Corollary 1 implies that the degree of demand convexity required for only R_I to exist is decreasing in the concentration measured by MHHI; in other words, the condition is less restrictive in markets that are more concentrated. The corollary implies also that R_II can exist only when quantities are strategic *substitutes*. Indeed, if quantities are instead strategic *complements* (i.e., if $\partial_{q_{i,j}} \phi_i > 0$, which holds when $\delta < -n(1+\lambda)/\Lambda$), then the condition $\delta < -n/\Lambda$ also holds and only R_I exists. When δ is such that $-n(1+\lambda)/\Lambda < \delta < -n/\Lambda$, quantities are strategic substitutes (as e.g. when demand is log-concave) but again only R_I exists. If $\delta > -n/\Lambda$, then quantities are strategic substitutes and so R_II exists (see Figure 8 in Appendix A).

As regards the comparative statics on output, totally differentiating the first-order condition (FOC) with respect to λ yields

$$\mathrm{sign}\left\{ \frac{\partial q^*}{\partial \lambda} \right\} = \mathrm{sign}\left\{ \partial_{\lambda q} \phi_i + (\partial_{xq} \phi_i) B \frac{\partial x^*}{\partial \lambda} \right\}; \tag{5}$$

here $B = 1 + \beta(n-1)$ captures the effect, on each firm's marginal cost, of a unit increase in R&D by all firms. At equilibrium, the impact on output of a higher degree of cross-ownership depends directly on its effect on marginal profit with respect to output $(\partial_{\lambda q} \phi_i)$ and indirectly through its effect on the R&D effort of each firm at equilibrium. Recall that, since $\partial_{xq} \phi_i > 0$, it follows that if $\partial x^* / \partial \lambda \leq 0$ then $\partial q^* / \partial \lambda < 0$ (R_I). By Lemma 1 we know that, if spillovers are sufficiently high and demand is not too convex, then $\partial x^* / \partial \lambda > 0$; however, the sign of $\partial q^* / \partial \lambda$ can be negative (R_II) or positive (R_III).

We derive an *inverse* measure of R&D effectiveness in terms of the model's basic

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[17]Let $P(c) \equiv f(nq^*(c))$; then $P'(c) = f'(nq^*)n\left(\frac{dq^*}{dc}\right) = \frac{n}{\Lambda(1+\delta)+n}$. Since the stability condition $\Delta_q < 0$ holds when $\Lambda(1+\delta) + n > 0$, it follows that $P'(c) > 0$. Furthermore, the pass-through increases with the number of firms when demand is log-concave $(\delta > -1)$. See, for example, Weyl and Fabinger (2013).

[18]So for $\delta > 0$, if $\partial x^* / \partial \lambda > 0$ for some λ then that inequality must hold also for larger values of λ. Analogously: for $\delta < 0$, if $\partial x^* / \partial \lambda < 0$ for some λ then that inequality holds also for larger values of λ.

elasticities. This measure H is a function of β and provides the appropriate threshold for the positive effect of minority shareholdings on R&D investments to dominate its negative effect on output. Let $\chi(Bx^*) \equiv -c''(Bx^*)Bx^*/c'(Bx^*) \geq 0$ be the elasticity of the slope of the innovation function (i.e., the relative convexity of $c(\cdot)$) evaluated at the effective R&D, Bx^*; and let $y(x^*) \equiv \Gamma''(x^*)x^*/\Gamma'(x^*) \geq 0$ be the elasticity of the slope of the investment cost function. Our regularity assumptions imply that either $c'' > 0$ or $\Gamma'' > 0$ (or both). If $\Gamma''(x^*) > 0$, let $\xi(Q^*, x^*) \equiv -\beta(c'(Bx^*))^2/(f'(Q^*)\Gamma''(x^*)) > 0$ measure the relative effectiveness of R&D,[19] weighted by β. Then H can be written as

$$H = \frac{1}{\xi(Q^*, x^*)}\left(1 + \frac{\chi(Bx^*)}{y(x^*)}\right),$$

evaluated at the equilibrium (Q^*, x^*) for $\beta > 0$. Note that $\lim_{\beta \to 0} H = \infty$.

LEMMA 2 *Let $B = 1 + \beta(n - 1)$. At equilibrium,*

$$\text{sign}\left\{\frac{\partial q^*}{\partial \lambda}\right\} = \text{sign}\{B - H\}. \tag{6}$$

Just as it does for β, the term H provides the appropriate threshold for B, or the effect (on each firm's marginal cost) of a unit increase in R&D by all firms. Therefore, if $B > H$ then the positive effect of minority shareholdings on R&D investments dominates its negative effect on output. At equilibrium, a higher degree of cross-ownership increases output. The values of H, χ, and y for each model specification are presented in Table 3. Note that H is independent of λ under the AJ and KMZ models but is strictly increasing in λ under the CE model. As we shall discuss later, the relationship between H and λ has important consequences for the optimal welfare policy.[20]

Table 3: H, χ, and y

	AJ	KMZ	CE
H	$\frac{b\gamma}{\beta}$	$\frac{b\gamma B}{\beta}$	$\frac{B}{\beta}\left(\frac{\alpha+1}{\alpha}\right)\frac{\varepsilon}{n-\varepsilon\Lambda}\tau$
χ	0	$\frac{1}{2}$	$\alpha + 1$
y	1	0	0

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[19] As defined by Leahy and Neary (1997, Sec. V, p. 654).

[20] The *sign* of the effect of changes in the degree of cross-ownership on equilibrium values can be computed explicitly (see Lemma 10 in Appendix B).

We introduce the following mild assumption on $H \colon (0,1] \to \mathbb{R}^+$ (considered as a function of β).

A.4. The slope of $H(\beta)$ is less than $n-1$.

Under Assumption A.4, the equation $B = H(\beta)$ has a unique positive solution (since $\lim_{\beta \to 0} H = \infty$). Denote that solution by β'; then, for $\beta > \beta'$ we have that $\partial q^*/\partial \lambda > 0$. Assumption A.4 seems not to be restrictive in light of the model specifications typically used in the literature. In AJ, KMZ, and CE, for example, an even stronger condition holds—namely, that $H(\beta)/B$ is strictly decreasing in β. Assumption A.4 does not guarantee that $\beta' < 1$, so R_{III} may fail to exist. We have that $\beta' < 1$ if $n > H(1)$. Our next corollary states the results formally.

COROLLARY 2 *Under A.4, if $n > H(1)$ then region R_{III} exists when $\beta > \beta'$ with $\beta' < 1$ (where β' is the unique positive solution to $B - H(\beta) = 0$).*

Using Lemmas 1 and 2—and observing that $\delta > -n/\Lambda$ implies that $1 + n + \delta\Lambda > 0$—we obtain the following result.

PROPOSITION 1 *Let $\Lambda = 1 + \lambda(n-1)$. Under assumptions A.1–A.3, if demand is sufficiently convex ($\delta \leq -n/\Lambda$) then only region R_{I} exists. Otherwise, assume A.4 and let β' be the unique positive solution of $B = H(\beta)$. Then the following statements hold:*

(i) *if $\beta \leq 1/(1 + n + \delta\Lambda)$, then $\frac{\partial x^*}{\partial \lambda} \leq 0$ and $\frac{\partial q^*}{\partial \lambda} < 0$ (R_{I});*

(ii) *if $1/(1 + n + \delta\Lambda) < \beta \leq \beta'$, then $\frac{\partial q^*}{\partial \lambda} \leq 0$ and $\frac{\partial x^*}{\partial \lambda} > 0$ (R_{II});*

(iii) *if $\beta > \beta'$, then $\frac{\partial q^*}{\partial \lambda} > 0$ and $\frac{\partial x^*}{\partial \lambda} > 0$ (R_{III}).*

This proposition implies that, for demand that is convex enough, the equilibrium is always in R_{I}. Otherwise, the equilibrium is in R_{I} for only a low level of spillovers. It is instructive to compare these results with those reported by Leahy and Neary (1997, Prop. 3), in which there are no minority shareholdings and where R&D cooperation leads to more R&D and output (as in our R_{III}) whenever spillovers are positive. Yet in our case, R_{III} obtains only when spillovers are sufficiently high. Thus the "output cooperation" induced by minority shareholdings requires sufficiently high spillovers in order to increase R&D and output.

Finally, we are interested in analyzing the effect of λ on each firm's profit. We have that

$$\text{sign}\{\pi^{*\prime}(\lambda)\} = \text{sign}\left\{ -\beta c'(Bx^*)\frac{\partial x^*}{\partial \lambda} + f'(Q^*)\frac{\partial q^*}{\partial \lambda} \right\}. \tag{7}$$

Given that $\partial x^*/\partial\lambda > 0$ and $\partial q^*/\partial\lambda < 0$ in R_{II}, we can use (7) to show that—in this region—$\pi^{*\prime}(\lambda) > 0$. The sign of the effect of λ on π^* is less clear in R_{I} (since in that region, $\partial x^*/\partial\lambda < 0$ and $\partial q^*/\partial\lambda < 0$) and in R_{III} (where $\partial x^*/\partial\lambda > 0$ and $\partial q^*/\partial\lambda > 0$). Nevertheless, in Appendix B we prove the following result.

PROPOSITION 2 *At the symmetric equilibrium, the profit per firm (π^*) increases with λ.*

According to this proposition, the positive effect on price dominates the negative effect on R&D in R_{I}, and conversely in R_{III}, so that profits in both regions rise with the extent of cross-ownership. Hence firms are incentivized to acquire (minority) shareholdings in the industry—provided the agreements they enter are *binding* ones, because that feature allows them to increase profits.[21] Before proceeding with the welfare analysis, we examine the effect of β on equilibrium values.

4.3 Comparative statics on spillovers (β)

A sufficient (but not necessary) condition for increases in β to raise per-firm R&D and output is that $\partial_{\beta x}\phi_i > 0$. It is not difficult to see that $\text{sign}\{\partial_{\beta x}\phi_i\} = \text{sign}\{\lambda B/\tau - \chi(Bx^*)\}$; here χ is the elasticity of the slope of the innovation function, which is nonnegative. For a positive λ, we have $\partial_{\beta x}\phi_i > 0$ when the curvature (relative convexity) of the innovation function is sufficiently low. The term $\lambda B/\tau$ increases with β, so it suffices that $\chi < \lambda$ (since $B/\tau = 1$ for $\beta = 0$). Our next proposition follows.

PROPOSITION 3 *If the curvature χ of the innovation function is sufficiently low ($\chi < \lambda$ would be low enough), then $\partial q^*/\partial\beta > 0$ and $\partial x^*/\partial\beta > 0$.*

We can view the following results as corollaries. In AJ (where $\chi = 0$), stronger spillover effects raise the equilibrium values of output and R&D; in KMZ (where $\chi = 1/2$), the

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same dynamic is observed when cross-ownership induces a high enough λ ($\lambda > 1/2$) and always in the case of a cartel (for which $\lambda = 1$). In the CE model, $\chi = \alpha + 1 > 1$. In this case, some tedious algebra shows that, for any positive λ, (i) $\partial q^*/\partial \beta > 0$ (with $\partial q^*/\partial \beta = 0$ when $\lambda = 0$) and (ii) x^* increases (resp. decreases) with β for high (resp. low) values of λ.

5 Welfare analysis

Welfare in equilibrium is given by the sum of consumer surplus and industry profits:

$$W(\lambda) = \int_0^{Q^*} f(Q)\, dQ - c(Bx^*)Q^* - n\Gamma(x^*).$$

We are interested in studying the effect of λ on welfare. Using the equilibrium conditions (2) and (3), we can write

$$W'(\lambda) = \left(-\Lambda f'(Q^*)\frac{\partial q^*}{\partial \lambda} - (1-\lambda)\beta(n-1)c'(Bx^*)\frac{\partial x^*}{\partial \lambda} \right)Q^*. \tag{8}$$

An increase in cross-ownership alters equilibrium values of quantities and R&D investments, and each additional unit of output and R&D has social value equal to (respectively) $\Lambda(-f'(Q^*))Q^*$ and $(1-\lambda)\beta(n-1)(-c'(Bx^*))Q^*$. Here Proposition 1 is useful. In R_{I} we have that $W'(\lambda) < 0$ because $\partial x^*/\partial \lambda \leq 0$ and $\partial q^*/\partial \lambda < 0$; in R_{III}, $W'(\lambda) > 0$ because $\partial x^*/\partial \lambda > 0$ and $\partial q^*/\partial \lambda > 0$. In R_{II}, however, the effect of λ on welfare is positive or negative according as whether the positive effect of minority shareholdings on R&D does or does not dominate its negative effect on output level. Moreover, from

$$\operatorname{sign}\{\mathrm{CS}'(\lambda)\} = \operatorname{sign}\left\{ \frac{\partial q^*}{\partial \lambda} \right\} \tag{9}$$

it follows that the effect of λ on consumer surplus is positive (i.e., $\mathrm{CS}'(\lambda) > 0$) only in R_{III}. So even as consumers suffer from a higher degree of cross-ownership in R_{I} and R_{II}, it benefits them in R_{III}. One consequence is that optimal antitrust policy will tend to be stricter under the CS standard.

5.1 Socially optimal degree of cross-ownership

Let λ_{CS}^o and λ_{TS}^o denote the optimal degree of cross-ownership under the (respectively) consumer surplus and total surplus standard. Let $\beta'(\lambda)$ denote the dependence of β' on λ. Then it is easy to see that H is increasing in λ if and only if $\beta'(\lambda)$ is also increasing in λ. Recall that H is weakly increasing in λ under the all three model specifications: in AJ and KMZ, H is independent of λ; in the CE model, H is strictly increasing in λ. Furthermore, in these three specifications $W(\lambda)$ is single peaked:[22] a mild additional condition is required in KMZ (as we discuss later). In the CE model, numerical simulations show that—for the parameter range in which the second-order condition (SOC) and the regularity condition are satisfied—$W(\lambda)$ is strictly concave.

We know from Proposition 1 that if demand is convex enough then only R_{I} exists, in which case no cross-ownership is optimal regardless of spillover levels. Otherwise (and under some mild assumptions): if spillovers β are low enough then cross-ownership is also not optimal; and if spillovers are high enough then the degree of cross-ownership should be positive in terms of both total surplus and consumer surplus (i.e., $\lambda_{\text{TS}}^o > 0$ and $\lambda_{\text{CS}}^o > 0$). For intermediate values of β we have that $\lambda_{\text{TS}}^o > \lambda_{\text{CS}}^o = 0$. It follows that more cross-ownership should be allowed under the total surplus standard (i.e., $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o$). These results are stated formally in our next proposition.

PROPOSITION 4 *Suppose that Assumptions A.1–A.4 hold. Then we have the following statements.*

(i) *If $\delta \leq -n$ (convex enough demand), then $\lambda_{\text{TS}}^o = \lambda_{\text{CS}}^o = 0$.*

(ii) *Otherwise, if H is weakly increasing in λ and $W(\lambda)$ is single peaked, then there are threshold values $\bar{\beta}$ and $\beta'(0)$ (with $\bar{\beta} < \beta'(0)$) such that*

- *$\lambda_{\text{TS}}^o = \lambda_{\text{CS}}^o = 0$ if $\beta \leq \bar{\beta}$;*

- *$\lambda_{\text{TS}}^o > \lambda_{\text{CS}}^o = 0$ if $\beta \in (\bar{\beta}, \beta'(0))$; and*

- *$\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o > 0$ if $\beta > \beta'(0)$.*

(iii) *In all cases, $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o$.*

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[22]In other words, $W(\lambda)$ is a function of one variable with only one stationary point that is a maximum (and hence a global maximum).

Figure 1 depicts the critical spillover threshold values stated in Proposition 4.
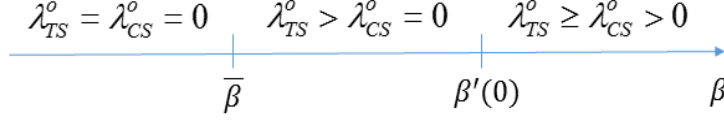
$$\lambda_{TS}^o = \lambda_{CS}^o = 0 \qquad \lambda_{TS}^o > \lambda_{CS}^o = 0 \qquad \lambda_{TS}^o \geq \lambda_{CS}^o > 0$$

$$\bar{\beta} \qquad\qquad \beta'(0) \qquad\qquad \beta$$

Fig. 1. Critical spillover threshold values when
$$\delta > -n.$$

Remark 1. We have that $\bar{\beta} < 1$ if $n+(n-1)(\delta+n) > H(1)$ (see Lemma 6 in Appendix A). If $\bar{\beta} \geq 1$ then $\lambda_{TS}^o = \lambda_{CS}^o = 0$ for all $\beta \leq 1$.

Remark 2. Our single-peakedness assumption on $W(\lambda)$ ensures that $\bar{\beta}$ is the minimum threshold above which total surplus increases with λ (i.e., for which $\beta \leq \bar{\beta}$ implies $\lambda_{TS}^o = 0$).

Remark 3. The assumption that H is weakly increasing in λ ensures that $\beta < \beta'(0)$ implies $\lambda_{CS}^o = 0$ and that $\lambda_{TS}^o \geq \lambda_{CS}^o$. In the particular case where $\beta = \beta'(0)$ we have that $\lambda_{TS}^o \geq \lambda_{CS}^o \geq 0$ (see the proof of Proposition 4 in Appendix A).

If we relax the assumptions that $W(\lambda)$ be single peaked and that H be monotonic in λ, then we can provide a weaker characterization of the regions where cross-ownership is socially optimal (Proposition 5) and can also characterize the extreme solution regions where $\lambda_{CS}^o = 0$ or $\lambda_{CS}^o = \lambda_{TS}^o = 1$ (Proposition 6).

PROPOSITION 5 *Let A.1–A.4 hold. If $\delta > -(1+n)/n$, then there exist threshold values $\underline{\beta} < \bar{\beta} < \beta'(0)$ (where $\underline{\beta} = \inf\{1/(1 + n + \Lambda\delta) : \lambda \in [0,1]\}$) such that: (i) $\lambda_{CS}^o = \lambda_{TS}^o = 0$ for $\beta \leq \underline{\beta}$; (ii) $\lambda_{TS}^o > 0$ for $\beta > \bar{\beta}$; and (iii) $\lambda_{CS}^o > 0$ for $\beta > \beta'(0)$.*[23]

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[23] Here is a sketch of the argument behind the proposition. From Proposition 1 it now follows that, when $\beta \leq \underline{\beta}$, only R_I exists because $\delta > -(1 + n)/n$ implies that $1 + n + \delta\Lambda > 0$ and $\delta > -n$. The threshold $\underline{\beta}$ depends on the sign of δ. If demand is concave ($\delta > 0$), then $\underline{\beta} = 1/(1+n(1+\delta))$; if demand is convex ($\delta < 0$), then $\underline{\beta} = 1/(1 + n + \delta)$. In both cases, $\underline{\beta}$ decreases with n (and tends to 0 with n). Note that in AJ and KMZ, demand is linear; hence $\underline{\beta} = 1/(1+n)$. Under CE, $\delta < 0$ when $\varepsilon > -1$ and so $\underline{\beta} = 1/(n - \varepsilon)$; in contrast, $\underline{\beta} = 1/(1 - n\varepsilon)$ when $\varepsilon < -1$. Parts (ii) and (iii) follow as in Proposition 4: part (ii) because if $\beta > \bar{\beta}$ then $W'(0) > 0$ and so $\lambda_{TS}^o > 0$; and part (iii) because if $\beta > \beta'(0)$ then $\partial q^*/\partial\lambda|_{\lambda=0} > 0$ and $\lambda_{CS}^o > 0$. (See Appendix B for details.)

PROPOSITION 6 *Under A.1–A.4, the following statements hold*:

(i) $\beta \leq \beta'_{\min}$ *implies* $\lambda^o_{\text{CS}} = 0$; *and*

(ii) $\beta > \beta'_{\max}$ *implies* $\lambda^o_{\text{CS}} = \lambda^o_{\text{TS}} = 1$ *provided that* $\beta'_{\max} \leq 1$.[24]

We can now make the following claims. (a) If H is strictly *decreasing in* λ, then $\beta'(\lambda)$ also is: $\beta'_{\min} = \beta'(1)$ and $\beta'_{\max} = \beta'(0)$. (b) If H is strictly *increasing in* λ, then $\beta'(\lambda)$ also is: $\beta'_{\min} = \beta'(0)$ and $\beta'_{\max} = \beta'(1)$. (c) If H is *independent of* λ, then β' also is: $\beta'_{\min} = \beta'_{\max} = \beta'$.

Proposition 6 determines when the monopoly outcome ($\lambda = 1$) is optimal in terms of both consumer and total surplus (in those cases, we are in R_{III} and welfare is increasing in λ). In AJ and KMZ, the term H is independent of λ; thus case (c) applies and, as a result, the consumer surplus solution is bang-bang under either model specification. In both specifications it is clear that if $\lambda^o_{\text{CS}} > 0$ then necessarily $\lambda^o_{\text{TS}} = \lambda^o_{\text{CS}} = 1$. In the CE model, however, H and β' are strictly increasing in λ and so case (b) applies; hence solutions of the form $\lambda^o_{\text{TS}} > \lambda^o_{\text{CS}} > 0$ are possible.[25]

The scope for a Research Joint Venture.

An RJV can be understood as a situation where spillovers are fully internalized (i.e., $\beta = 1$). If the RJV is "cartelized" then also $\lambda = 1$. This arrangement can be optimal only if R_{III} exists for β large (with $\beta'_{\max} \leq 1$) and if $\partial q^*/\partial \beta > 0$ and $\partial x^*/\partial \beta > 0$ (which, by Proposition 3, requires that $\chi < 1$). Our next corollary states the result.

COROLLARY 3 *Again assume that A.1–A.4 hold. If $\beta'_{\max} \leq 1$ and if the innovation function's curvature is not too large ($\chi < 1$), then a cartelized RJV ($\lambda = \beta = 1$) is optimal in terms of consumer surplus and welfare.*

The assumptions of the corollary are fulfilled in the AJ and KMZ models, where $\gamma b < n$ and $\gamma b < 1$ are needed (respectively) to ensure that β'_{AJ} and β'_{KMZ} are less

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[24] This proposition is proved by noting that $\beta'(\lambda)$ is a continuous function on $[0, 1]$ and so achieves a maximum ($\beta'_{\max}$) and a minimum ($\beta'_{\min}$) within that interval. If $\beta \leq \beta'_{\min}$, then $\partial q^*/\partial \lambda < 0$ for all $\lambda > 0$ and so $\lambda^o_{\text{CS}} = 0$; if $\beta > \beta'_{\max}$, then $\partial q^*/\partial \lambda > 0$ for all λ. Since $\partial q^*/\partial \lambda > 0$ implies $\partial x^*/\partial \lambda > 0$ by equation (5), it follows that $W'(\lambda) > 0$ for all λ by equation (8). Therefore, $\lambda^o_{\text{CS}} = \lambda^o_{\text{TS}} = 1$ provided that $\beta'_{\max} \leq 1$.

[25] In the proof of Proposition 4 we show that, in the CE case, CS is globally concave in λ when $B > H(\beta)|_{\lambda=0}$. Letting λ^* denote the unique value for λ such that $\partial q^*/\partial \lambda = 0$, we have that $\lambda^*_{\text{CS}} = 1$ when $\lambda^* > 1$; hence $\lambda^*_{\text{CS}} = \min\{\lambda^*, 1\}$, which yields $\lambda^*_{\text{TS}} > \lambda^*_{\text{CS}} > 0$.

than unity; recall that $\chi = 0$ in AJ and $\chi = 1/2$ in KMZ. In CE, $\lambda = 1$ is never socially optimal because $\beta'_{\text{CE}}(1) < 1$ only if $\varepsilon < \alpha/(1+2\alpha)$—which would contradict the regularity condition (see Table 8 in Appendix B).

Under some different conditions, an RJV with no cross-ownership ($\lambda = 0$ and $\beta = 1$) can be socially optimal in all three models (see Proposition 7 in Appendix B). To determine when an RJV with no cross-ownership is socially optimal, we use that—when $W(\lambda)$ is single peaked—$\bar{\beta}$ is the minimum threshold above which allowing some cross-ownership *increases* welfare (Proposition 4), so no cross-ownership is optimal if $\bar{\beta} \geq 1$. Satisfying that inequality requires $\gamma b \geq n^2$ in AJ, $\gamma b \geq n$ in KMZ, and a more involved condition in CE. In contrast with the AJ model, in both KMZ and CE we find that if $\lambda = 0$ then greater R&D spillovers reduce R&D expenditures ($\partial x^*/\partial \beta < 0$) while having no effect on output ($\partial q^*/\partial \beta = 0$). Although R&D expenditures are lower with higher β, the production costs of all firms are also lower. In both cases, the greater R&D spillover's negative effect on R&D expenditures is dominated by its positive effect on the innovation function; as a result, $\beta = 1$ is also socially optimal.

5.2 Comparative statics by model

We are interested in the comparative statics of the regions determining the scope for cross-ownership as described in Proposition 4. We are also interested in the comparative statics on λ^o_{CS} and λ^o_{TS} in the specified models.

Comparative statics on β'. Table 4 summarizes the comparative static results on $\beta'(0)$ in the models with respect to basic parameters. The threshold $\beta'(0)$ is weakly decreasing in n and is strictly decreasing in demand elasticity; however, the effect of the innovation function's elasticity is ambiguous. In terms of consumer surplus, in AJ it is optimal to suppress minority shareholdings for any level of spillovers when firm entry is insufficient—that is, when $n < \gamma b$ (since then $\beta'_{\text{AJ}} > 1$); in CE, suppression is optimal when $n < \varepsilon(2\alpha + 1)/\alpha$ (since $\beta'_{\text{CE}} > 1$ for $n < \varepsilon(2\alpha + 1)\Lambda/\alpha$).[26]

Table 10 (in Appendix B) reports the spillover thresholds for AJ, KMZ and CE models. To obtain some further insights into the comparative statics on the spillover

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[26]In AJ, $\partial H/\partial n = 0$ and so increasing the number of firms reduces the β' threshold ($\partial \beta'_{\text{AJ}}/\partial n < 0$); in KMZ, however, firm entry has no effect on β' ($\partial \beta'_{\text{KMZ}}/\partial n = 0$). In the CE model, the direction of the effect of entry on the β' threshold depends on the value of λ. In particular, β'_{CE} decreases (resp. increases) with n when λ is low (resp. high).

Table 4: Comparative Statics on $\beta'(0)$

	AJ	KMZ	CE
Number of firms (n)	$-$	0	$-$
Elasticity of demand $(b^{-1}, \varepsilon^{-1})$	$-$	$-$	$-$
Elasticity of innovation function (γ^{-1}, α)		$-$	$+$ iff $\varepsilon > 1$
Slope of investment cost function (γ)	$+$		

threshold $\bar{\beta}$ and on the socially optimal degree of cross-ownership, we conducted some numerical simulations.[27] The results are described next.

Results I: Comparative statics on $\bar{\beta}$. First, $\bar{\beta}$ decreases with n in AJ and KMZ, and it also decreases in the CE model (according to numerical simulations). Second, for those models the simulations also reveal that $\bar{\beta}$ increases with the slope of demand and with the investment cost—and that $\bar{\beta}$ may take values greater than 1 when there are only a few firms in the market.[28] Third, in the CE model we find that $\bar{\beta}$ decreases with the (curvature) elasticity of the innovation function, α, and with the elasticity (and curvature) of demand, ε^{-1}. In this model, too, $\bar{\beta}$ may take values greater than 1 when there are few firms in the market. (See Appendix B.2 for more details.)

Therefore, for highly concentrated markets, no cross-ownership should be allowed for a wide range of spillovers. The reason is that the incentives for firms to "free ride" are stronger when the number of firms increases because each firm can then appropriate the R&D efforts of a greater number of participants.

Results II: Comparative statics on the socially optimal degree of cross-ownership. Our simulations generate three main findings. First, the socially optimal level of cross-ownership increases with the size of the spillovers, with the number of firms, and with the elasticity of demand and of the innovation function. Second, if the objective is to maximize consumer surplus, then the comparative statics are qualitatively similar but the scope for minority shareholdings is much lower. Third, increasing the number of firms may not in itself be sufficient for consumers to benefit from cross-ownership; in fact, this is the case in KMZ.

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[27] Values for parameters are chosen so that the regularity condition and the SOCs are satisfied.

[28] In particular, from Table 10 (in Appendix B) it is straightforward to show that, in a duopoly, $\bar{\beta} > 1$ when $\gamma b > 4$ in AJ, when $\gamma b > 2$ in KMZ, and when $\alpha > 2\varepsilon/(\varepsilon^2 - 7\varepsilon + 6)$ in CE.

Table 5 summarizes the comparative statics results from our numerical simulations. Please note that we have made available an *application program for readers to perform their own simulations.*[29]

Table 5: Effect of Parameters on $\bar{\beta}$, λ_{TS}^o, and λ_{CS}^o

| | $\bar{\beta}$ | | | λ_{TS}^o | | | λ_{CS}^o | | |
	AJ	KMZ	CE	AJ	KMZ	CE	AJ	KMZ	CE
Number of firms (n)	$-$	$-$	$-$	$+$	$+$	$+$	$\langle + \rangle$	0	$(+)$
Elasticity of demand (b^{-1}, ε^{-1})	$-$	$-$	$-$	$+$	$+$	$+$	$\langle + \rangle$	$\langle + \rangle$	$[+]$
Elasticity of innovation function (γ^{-1}, α)		$-$	$-$		$+$	$+$		$\langle + \rangle$	$[+]$
Slope of investment cost function (γ)	$+$			$-$			$\langle - \rangle$		
Degree of spillover (β)				$+$	$+$	$+$	$(+)$	$(+)^*$	$[+]$

Key: $\langle + \rangle$, the parameter enlarges the region where $\lambda_{\text{CS}}^o = 1$; $\langle + \rangle$, the parameter reduces the region where $\lambda_{\text{CS}}^o = 1$; $(+)$, the effect is positive only if both β and n are sufficiently large (otherwise there is no effect); $(+)^*$, the effect is positive only if the parameter is sufficiently large and γb is sufficiently small (otherwise there is no effect); $[+]$, the effect is positive when n is sufficiently large (otherwise there is no effect).

We next provide graphical descriptions of the simulation results, first in the CE model and then in the AJ and KMZ models.

Constant elasticity model (Figure 2)**.** When the number of firms is small (less than five, in our example), it is never optimal to allow minority ownership interests (since then the equilibrium is in R_{I}). As the spillover effects and the number of firms increase, λ_{TS}^o also increases; however, any increase in λ_{CS}^o is considerably smaller. The equilibrium is then in R_{II}, where firms benefit and consumers suffer from a higher degree of cross-ownership (because output is lower). Even so, the overall effect on welfare of increasing λ is positive because the positive effect on x^* dominates the negative impact on q^*. Finally, we discover that raising λ *slightly* may be optimal from the consumer's standpoint when the number of firms in the market is sufficiently large (since then the equilibrium is in R_{III}).

Table 6 gives the socially optimal value for λ_{TS}^o in AJ and KMZ.[30]

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[29] www.angelluislopez.net

[30] See Appendix B for a proof that welfare is single peaked and for the derivation of the value for λ_{TS}^* in AJ—and also in KMZ if a mild condition (which, as compared with the regularity condition, is slightly stricter in duopoly and looser in an oligopoly of three or more firms) holds. In particular, $\gamma b > 0.62$ ensures that welfare is single peaked for any number of firms under the KMZ model specification.

Table 6: Optimal Degree of Cross-ownership in AJ and KMZ

$$\lambda^o_{\text{TS}}$$

AJ $\quad \min\left\{\max\left\{0, \dfrac{[(n+2)(n-1)\beta-(n-2)]\beta-b\gamma}{(n-1)[2(\beta-1)\beta+b\gamma]}\right\}, 1\right\}$

KMZ $\quad \min\left\{\max\left\{0, \dfrac{[(n+2)(n-1)\beta-b\gamma(n-1)-(n-2)]\beta-b\gamma}{(n-1)\{[2\beta+b\gamma(n-1)-2]\beta+b\gamma\}}\right\}, 1\right\}$

Optimal degree of cross-ownership in terms of total surplus and consumer surplus

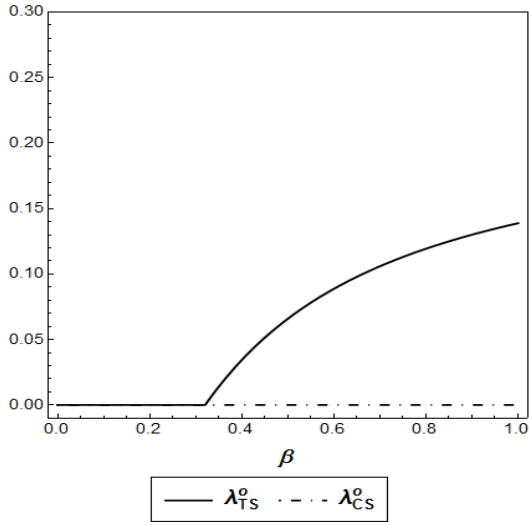Fig. 2a. Constant elasticity model.
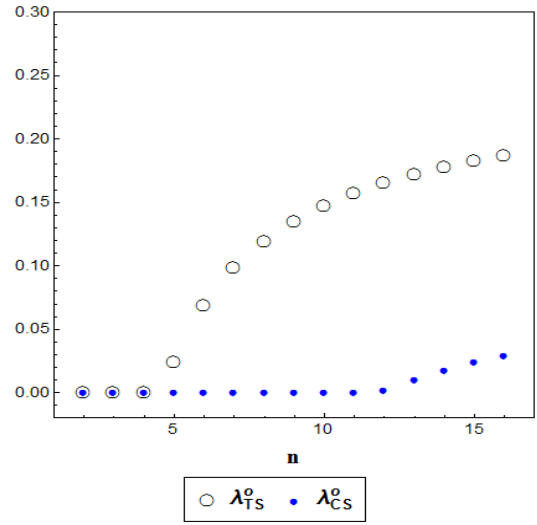$(\alpha = 0.1,\ \varepsilon = 0.8,\ \sigma = \kappa = 1,\ n = 8)$

Fig. 2b. Constant elasticity model.
$(\alpha = 0.1,\ \varepsilon = 0.8,\ \sigma = \kappa = 1,\ \beta = 0.8)$

AJ model (Figure 3). Figure 3a is a snapshot of the application program. We see how, in the simulation considered (with $\beta = 0.5$ and $n = 6$), price increases whereas cost decreases with λ—and, correspondingly, how output per firm decreases while R&D per firm increases (two lower panels of the figure). The welfare translation of the increase in λ is given in the upper right panel, with decreasing consumer surplus and increasing per-firm profit that results in an interior solution for welfare of $\lambda^o_{\text{TS}} > 0$. The upper left panel plots λ^o_{TS} increasing smoothly with β and λ^o_{CS} increasing in a bang-bang fashion to reach $\beta > 0.82$, where $\lambda^o_{\text{TS}} = \lambda^o_{\text{CS}} = 1$. Figure 3b shows that λ^o_{TS} increases with the number of firms, although λ^o_{CS} does so weakly and only if n is sufficiently large (our example, where $\beta = 0.8$, requires $n > 6$). We have $\lambda^o_{\text{TS}} = \lambda^o_{\text{CS}} = 1$.

Optimal degree of cross-ownership in terms of total surplus and consumer surplus
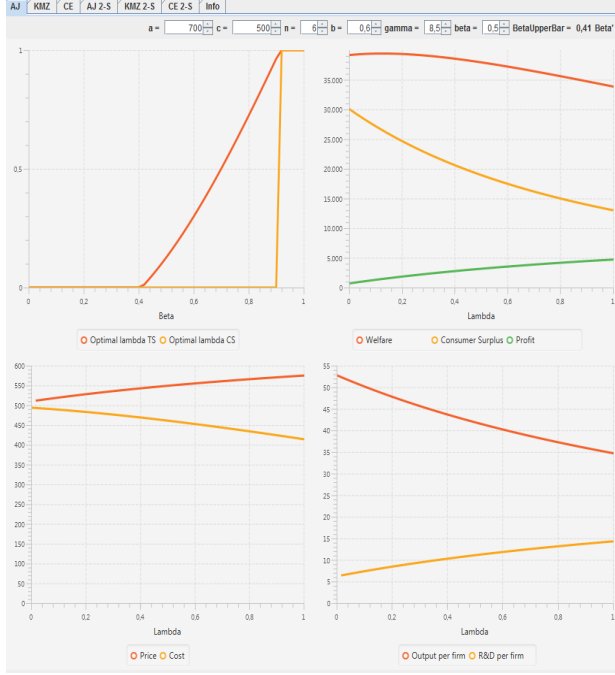

Fig. 3a. AJ model specification. Snapshot of
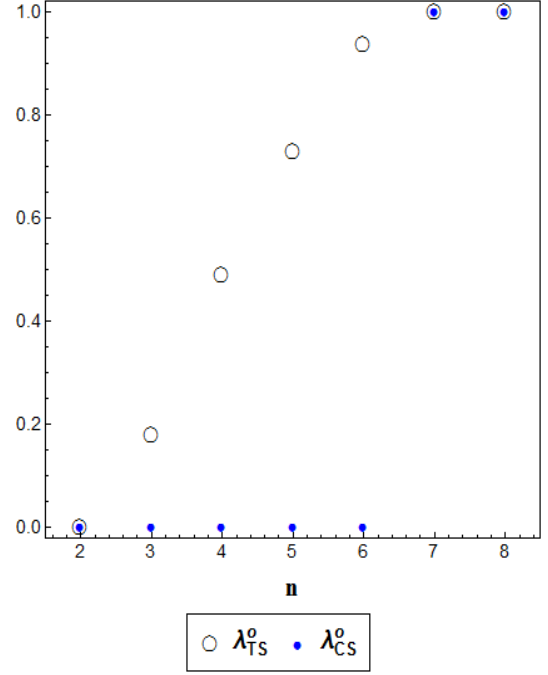the Application. ($\gamma = 8.5$, $\beta = 0.5$, $b = 0.6$.)

Fig. 3b. AJ model specification.
($\gamma = 7$, $\beta = 0.8$, $b = 0.6$.)

KMZ model (Figure 4). Figure 4a plots the socially optimal degree of cross-ownership for different values of β when $\gamma b = 0.9$ (so that $\gamma b < 1$ and the assumptions of Corollary 3 are fulfilled); in this case, $\lambda_{\text{TS}}^o = 1$ when $\beta > \beta'_{\text{KMZ}} = 0.9$. Considering values of γb that are greater than 1, we find that λ_{TS}^o still increases with β; yet as expected, $\lambda_{\text{CS}}^o = 0$ even when $\beta = 1$. Figure 4b considers the effect of increasing n when $\beta = 0.8$. In KMZ, increasing the number of firms affects neither β' nor (as a result) sign$\{CS'(\lambda)\}$. Therefore, consumer surplus in KMZ is constantly decreasing in the degree of cross-ownership whenever $\beta < \beta'_{\text{KMZ}}$.
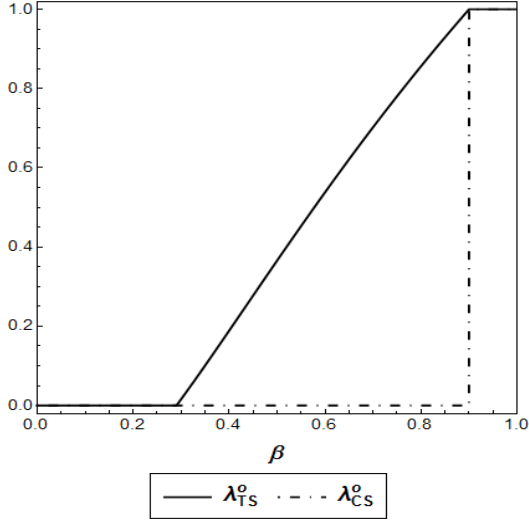
Optimal degree of cross-ownership in terms of total surplus and consumer surplus

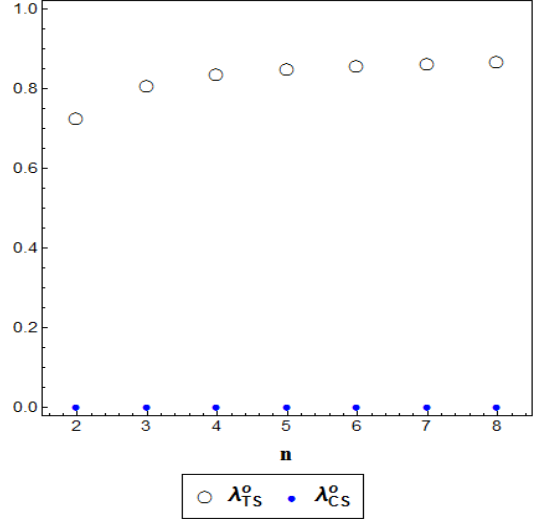Fig. 4a. KMZ model specification.

$(\gamma = 3, n = 6$ and $b = 0.3.)$

Fig. 4b. KMZ model specification.

$(\gamma = 3, \beta = 0.8, b = 0.3.)$

6 Two-stage model

In this section we consider two-stage competition. In the first stage, every firm i commits to investing an amount x_i into R&D. In the second stage—and for given observable level of R&D expenditures—firms compete in the product market. In each stage we solve for the model's subgame-perfect equilibrium in terms of λ, or the degree of cross-ownership.

6.1 Equilibrium and strategic effects

Let $\mathbf{x} = [x_1, x_2, \ldots, x_n]$ be the first-stage R&D profile and let $\mathbf{q} = [q_1, q_2, \ldots, q_n]$ be the second-stage output profile. Let $q_i^*(\mathbf{x})$ denote firm i's (interior) output equilibrium value of the second-stage game associated with the R&D profile $\mathbf{x}$. Then, for all i, we have

$$\frac{\partial}{\partial q_i} \phi_i(\mathbf{q}^*(\mathbf{x}), \mathbf{x}, \lambda) = 0. \tag{10}$$

In the first stage, the first-order necessary conditions for an interior equilibrium are (for $i \neq j$ and $i, j = 1, 2, \ldots, n$)

$$\frac{\partial}{\partial x_i} \phi_i(\mathbf{q}^*(\mathbf{x}), \mathbf{x}, \lambda) + \sum_{j \neq i} \frac{\partial}{\partial q_j} \phi_i(\mathbf{q}^*(\mathbf{x}), \mathbf{x}, \lambda) \frac{\partial}{\partial x_i} q_j^*(\mathbf{x}) = 0. \tag{11}$$

The equilibrium R&D profile $\mathbf{x}^*$ is characterized by the system of equations (10) and (11)—provided the second-order conditions hold. Let $\mathbf{q}^* = \mathbf{q}^*(\mathbf{x}^*)$; then $\{\mathbf{x}^*, \mathbf{q}^*\}$ is the subgame-perfect equilibrium path of the two-stage game. The second term in equation (11) is the *strategic* effect on profits of investment. Building on Suzumura (1992) and Leahy and Neary (1997), we can show (using A.1) that $\partial q_j^*/\partial x_i$—when evaluated at a symmetric equilibrium, where $q_i^* = q^*$ and $x_i^* = x^*$ for all i—is given (for $\lambda < 1$) by

$$\frac{\partial q_j^*}{\partial x_i} = \frac{-c'(Bx^*)}{f'(Q^*)}\left[\frac{1}{n(1-\lambda)}\right]\left[\frac{2n+\Lambda\delta}{n+\Lambda(\delta+1)}\right](\tilde{\beta}(\lambda)-\beta); \tag{12}$$

here

$$\tilde{\beta}(\lambda) = \frac{n(1+\lambda)+\Lambda\delta}{2n+\Lambda\delta}.$$

Note that the threshold $\tilde{\beta}$ depends only on λ, n, and δ. The inequality $\tilde{\beta}(\lambda) > 0$ holds only if production decisions are strategic substitutes (i.e., only if $\partial_{q_{i,j}}\phi_i < 0$).[31] Note that $\tilde{\beta}(\lambda) < 1$ for $\lambda < 1$ and that $\tilde{\beta}(\lambda) \to 1$ as $\lambda \to 1$.

Evaluating $\partial\phi_i/\partial q_j$ at a symmetric equilibrium, we can rewrite the strategic effect of investment as follows:

$$\psi \equiv \frac{\partial\phi_i}{\partial q_j}\left(\frac{\partial q_j^*}{\partial x_i}\right) = (-c'(Bx^*))q^*\omega(\lambda)(\tilde{\beta}(\lambda)-\beta), \tag{13}$$

where[32]

$$\omega(\lambda) = \frac{\Lambda}{n}\left[\frac{2n+\Lambda\delta}{n+\Lambda(1+\delta)}\right] > 0.$$

Hence we may write the FOC (11) for $\lambda \in [0,1)$ as

$$-c'(Bx^*)\big[\tau + (n-1)\omega(\lambda)(\tilde{\beta}(\lambda)-\beta)\big]\frac{Q^*}{n} - \Gamma'(x^*) = 0. \tag{14}$$

When the stability condition in output is satisfied ($\Delta_q < 0$), we have $\partial q_i^*/\partial x_i > 0$. So if a firm increases its investment in R&D in the first stage, then it will increase its output

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[31] This is so when $\delta > -(1+\lambda)n/\Lambda$ (see Table 7 in Appendix A), which holds for all λ and n when $\delta > -2$—in other words, the convexity of inverse demand must not be too high, which in turn implies that marginal revenue is strictly decreasing in output. It is worth noting that, in order for the concavity of ϕ_i with respect to q_i ($\partial_{qq}\phi_i < 0$) at a symmetric equilibrium to be guaranteed for *all* λ, we need the condition $\delta > -2$ (which guarantees strategic substitutability for all λ and n). The concavity condition is $\delta > -2n/\Lambda$, and it is strictest for $\lambda = 1$ (in which case it reduces to $\delta > -2$).

[32] The SOC, $\partial_{qq}\phi_i < 0$, requires that $2n + \Lambda\delta > 0$; the stability condition, $\Delta_q < 0$, requires that $n + \Lambda(1+\delta) > 0$. Therefore, $\omega(\lambda) > 0$.

in the second stage. At the same time, by equation (12) we have that

$$\text{sign}\left\{\frac{\partial q_j^*}{\partial x_i}\right\} = \text{sign}\{\beta - \tilde{\beta}(\lambda)\}$$

and that $\partial q_j^*/\partial x_i > 0$ when quantities are strategic complements (since then $\tilde{\beta} < 0$). In the case of strategic substitutes, $\partial q_j^*/\partial x_i > 0$ only if $\beta > \tilde{\beta}(\lambda)$. When a firm increases the amount invested in R&D, it exerts two opposite effects on the output decision of rival firms. There is a positive effect because rival firms become more efficient owing to the presence of spillovers. Yet there is also a negative effect because the reaction of rivals to firm i's higher quantity is to reduce their own output via competing in the market for strategic substitutes. If spillover effects are strong enough that $\beta > \tilde{\beta}(\lambda)$, then the positive effect outweighs the negative effect; this outcome implies that $\partial q_j^*/\partial x_i > 0$.

We can also conduct comparative statics on the threshold value $\tilde{\beta}(\lambda)$. Under Assumption A.1 and from the expression for $\tilde{\beta}$, it is straightforward to show the following result. This lemma highlights the crucial role played by demand curvature.

LEMMA 3 *For $\lambda < 1$, the threshold $\tilde{\beta}$: decreases (resp. increases) with the number of firms if demand is concave (resp. convex); increases with the degree of cross-ownership $(\partial\tilde{\beta}/\partial\lambda > 0)$ if $\delta > -2$; and increases with the curvature of the inverse demand function δ (i.e., $\partial\tilde{\beta}/\partial\delta > 0$).*

Since $\partial\phi_i/\partial q_j < 0$, it follows that the sign of the strategic effect is opposite to the sign of $\partial q_j^*/\partial x_i$; that is,

$$\text{sign}\{\psi\} = -\text{sign}\left\{\frac{\partial q_j^*}{\partial x_i}\right\} = \text{sign}\{\tilde{\beta}(\lambda) - \beta\}.$$

Thus the strategic effect is positive if production decisions are substitutes and if β is below the threshold $\tilde{\beta}$. In this case, there are incentives to overinvest because increasing investment reduces the rival's output. Then, as shown by Leahy and Neary (1997, Prop. 1) for $\lambda = 0$, equations (10) and (14) together imply that output and R&D are higher in the two-stage model than in the static model.[33] It is intuitive that, if $\beta < \tilde{\beta}$, then each

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[33] This result is derived under assumptions yielding a unique equilibrium and such that the two models' respective profit functions satisfy the Seade stability condition with respect to R&D—namely, that the marginal profit of each firm with respect to R&D must decrease with a uniform increase in R&D by all firms.

firm expects a higher first-stage investment in R&D to reduce the second-stage output of rival firms. The implication is that $\psi \equiv (\partial\phi_i/\partial q_j)(\partial q_j^*/\partial x_i) > 0$ and so each firm is led to increase their first-stage R&D investments, which in turn boosts output in the second stage $(\partial q_i^*/\partial x_i > 0)$. Observe that $\tilde{\beta}(1) = 1$: if there is no RJV $(\beta < 1)$ then, for high levels of cross-ownership, the strategic effect is always positive $(\beta < \tilde{\beta})$. In contrast, if β exceeds $\tilde{\beta}$ then the strategic effect is negative; hence both output and R&D are lower in the two-stage model than in the static model.

6.2 Comparative statics on cross-ownership

Next we analyze how the degree of cross-ownership affects the decisions on output and R&D that are made in equilibrium. By using (13) and by totally differentiating the system formed by (10) and (11) before evaluating it at a symmetric equilibrium, we can solve both for $\partial q^*/\partial\lambda$ and for $\partial x^*/\partial\lambda$ under regularity conditions. Let $s(\lambda) = \omega(\lambda)\left(\tilde{\beta}(\lambda) - \beta\right)$. We obtain the following result.

LEMMA 4 *In the two-stage model*:

$$\text{sign}\left\{\frac{\partial x^*}{\partial\lambda}\right\} = \text{sign}\left\{(\beta + s'(\lambda))P'(c)^{-1}n - [\tau + (n-1)s(\lambda)]\right\}; \tag{15}$$

$$\text{sign}\left\{\frac{\partial q^*}{\partial\lambda}\right\} = \text{sign}\left\{(\beta + s'(\lambda))B - \beta H(\beta)\right\}. \tag{16}$$

Moreover, if $\partial x^*/\partial\lambda \leq 0$ then $\partial q^*/\partial\lambda < 0$.

So once again we find that allowing for some additional degree of cross-ownership will increase output only if it also boosts R&D. In particular, from (15) we obtain that $\partial x^*/\partial\lambda > 0$ if and only if $\beta > \underline{\beta}^{2S}$ (see the proof of this lemma for more on $\underline{\beta}^{2S}$).

We are now in a position to derive the threshold values of spillovers that determine the *sign* of the effect, at equilibrium, of λ on R&D and output. In this we assume that there is a unique positive β, denoted $\beta^{2S'}$, that solves the equation $(\beta + s'(\lambda))B = \beta H(\beta)$.[34]

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[34]To streamline the discussion, here we shall refer simply to the left-hand side (LHS, $(\beta + s'(\lambda))B$) and the right-hand side (RHS, $\beta H(\beta)$) of this equation. RHS is a constant in AJ (see Table 3), but it increases with β in KMZ and CE. Numerical simulations show that LHS is also increasing in β and that it takes a lower value (than RHS) at $\beta = 0$. In AJ there exists a unique $\beta^{2S'} < 1$ when n is sufficiently large—or when γ and b are sufficiently low—and λ is sufficiently large. In KMZ, RHS increases more slowly than LHS when γ and b are smaller whereas LHS increases more rapidly for higher values of λ. It follows that, for high λ and sufficiently low γ and b, there exists a unique $\beta^{2S'}$ that is nearly (but still less than) 1. In CE, RHS increases faster than LHS and there seems to be no solution, in which case region R_{III} does not exist.

Then we have $\partial q^*/\partial \lambda \leq 0$ for $\beta \in [0, \beta^{2S\prime}]$ and $\partial q^*/\partial \lambda > 0$ for $\beta \in (\beta^{2S\prime}, 1]$. Therefore: R_{I} (where $\partial x^*/\partial \lambda \leq 0$ and $\partial q^*/\partial \lambda < 0$) occurs when $\beta \leq \underline{\beta}^{2S}$; R_{II} (where $\partial q^*/\partial \lambda \leq 0$ and $\partial x^*/\partial \lambda > 0$) occurs for $\beta \in (\underline{\beta}^{2S}, \beta^{2S\prime}]$; and R_{III} (where $\partial q^*/\partial \lambda > 0$ and $\partial x^*/\partial \lambda > 0$) occurs when $\beta > \beta^{2S\prime}$.

These results extend Proposition 1 to the two-stage model. A direct application of (15) and (16) allows us to derive the threshold values for each of the model specifications considered in the paper (see Appendix B.2).

Our findings are comparable to those of Leahy and Neary (1997, Prop. 3). Those authors show that if cooperation does not extend to output (i.e, with collusion only at the R&D level) then the result is reduced output and R&D—unless spillovers are high enough, in which case firms increase both output and R&D. These two results correspond to regions R_{I} and R_{III}, respectively. In addition, we identify region R_{II}: where cooperation driven by minority shareholdings leads to less output and more R&D. Another difference is that, in Leahy and Neary's model, the spillover threshold above which cooperation leads to more output and R&D lies *strictly* between 0 and 1. In contrast, here (as in the simultaneous choice case) there is no guarantee that R_{III} exists; that is, $\beta^{2S\prime}$ may lie above 1.

In the proof of Lemma 7 (see Appendix B.1) we show that, in the two-stage model,

$$
W'(\lambda) = \left\{ -\Lambda f'(Q^*) \frac{\partial q^*}{\partial \lambda} \right.
$$
$$
\left. - \big((1-\lambda)\beta - \omega(\lambda)(\tilde{\beta}(\lambda) - \beta)\big)(n-1)c'(Bx^*)\frac{\partial x^*}{\partial \lambda} \right\} Q^*.
$$

Hence the strategic effect of investment, $\omega(\lambda)(\tilde{\beta}(\lambda) - \beta)$, plays an important role in determining the impact of cross-ownership on welfare. When the strategic effect is negative $(\beta > \tilde{\beta}(\lambda))$, the two-stage model behaves like the simultaneous model: $W'(\lambda) < 0$ in R_{I}, $W'(\lambda) > 0$ in R_{III}, and $W'(\lambda)$ either positive or negative (depending on the extent of spillovers) in R_{II}. Yet when the strategic effect is positive and spillovers are sufficiently low (though not necessarily close to zero), $W'(\lambda) < 0$ in R_{II} and $W'(\lambda)$ can be positive or negative in R_{I} and in R_{III}. A consequence of some interest is that, in R_{III}—where $\partial x^*/\partial \lambda > 0$ and $\partial q^*/\partial \lambda > 0$, so consumer surplus increases with λ (indeed, $\lambda = 1$ is

optimal for consumers)—total surplus can be decreasing in λ for sufficiently high λ.[35]
Then, in stark contrast to the simultaneous model and owing to the strategic effect of
investment, for some spillover values it may be that $\lambda^o_{CS} = 1 > \lambda^o_{TS} > 0$. We illustrate
this case under the AJ and KMZ model specifications in the simulations that follow (see
Figure 6a and Figure 7).[36] Similarly as in the simultaneous case, there is a threshold
value $\bar{\beta}^{2S}$ for which $\lambda^o_{TS} > 0$ if $\beta > \bar{\beta}^{2S}$; the condition under which $\bar{\beta}^{2S} < 1$ is given by
Lemma 7 (in Appendix A).[37]

6.3   Simulations

This section presents our simulations of the three considered models.[38] These simulations
confirm the qualitative results obtained in the static model, but with two caveats: (i) in
the two-stage model, the socially optimal level of cross-ownership tends to be higher
when spillovers are high; and (ii) in some cases the consumer surplus standard may
call for more cooperation than does the total surplus standard (i.e., $\lambda^o_{CS} > \lambda^o_{TS} > 0$).
Result (i) indicates that the strictness of antitrust policy (in terms of limiting cross-
ownership) should be moderated in the two-stage model when spillovers are high. The
reason underlying both results is the strategic effect. When β is high, the strategic effect
is negative and so there are incentives to underinvest; then it pays to increase λ in order
to stimulate investment and output (result (i)). We have already observed that result (ii)
may obtain when the strategic effect is positive (which happens for intermediate levels of β
when λ is large, since $\tilde{\beta}(\lambda) \to 1$ as $\lambda \to 1$ and so $\tilde{\beta}(\lambda) > \beta$); the resulting overinvestment
increases output (and is good for consumer surplus) but comes at the cost of reducing
firms' profits, reducing total surplus, and "overshooting" marginal cost reductions.

Constant elasticity model. As in the simultaneous case, we observe here that if n
is small then the equilibrium is in R_I, which implies that no cross-ownership is socially
optimal. Yet as β and n increase, λ^o_{TS} also increases. This result is consistent with the
literature.[39]   Note that λ^o_{TS} in the two-stage game is above the static level in a large

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[35]For $\beta < 1$, we have $(1 - \lambda)\beta - \omega(\lambda)(\tilde{\beta}(\lambda) - \beta)|_{\lambda=1} = -(1 - \beta) < 0$.

[36]In CE, as in the simultaneous model, λ^*_{CS} is usually zero or very close to zero.

[37]If the condition holds then $W'(0)|_{\beta=1} > 0$, in which case there exists a sufficiently large spillover
value for which some degree of cross-ownership is welfare enhancing. (In Appendix B.2 we compute $\bar{\beta}^{2S}$
for the model specifications considered in this paper.)

[38]Appendix B.2 provides complementary results, explanations, and figures.

[39]For example, in a model with no cross-ownership Spence (1984) used numerical simulations to demon-

region of spillovers. For low values of β and λ, the strategic effect is positive. Then, as stated previously, the two-stage model behaves differently than the static model in that welfare can *increase* with the degree of cross-ownership (in R_{I}). This case is illustrated in Figure 5, where—for low β—λ^o_{TS} in the two-stage model is larger than in the static model. For intermediate values of spillovers, the strategic effect becomes negative (but remains close to zero); for higher spillover values, λ^o_{TS} increases with β more rapidly (i.e., convexly) when the strategic effect is strong.

Comparative static results with respect to α and ε^{-1} are similar to those in the static model. In the CE model, however, λ^o_{CS} is independent of the number of firms and may be positive if spillovers are extensive enough.

Optimal degree of cross-ownership in terms of total surplus and consumer surplus
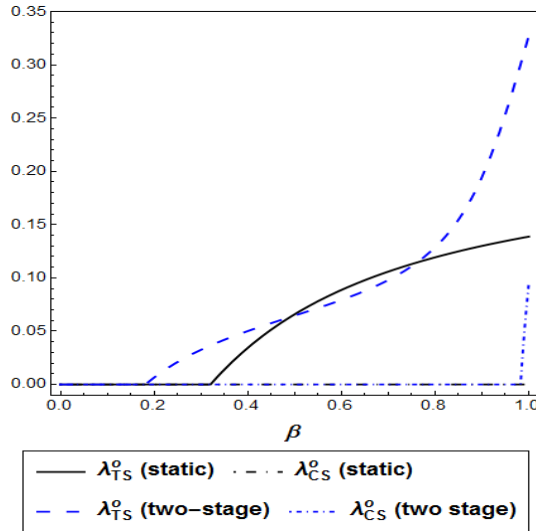

Fig. 5a. Constant elasticity model.

$(\alpha = 0.1,\ \varepsilon = 0.8,\ \sigma = \kappa = 1,\ n = 8.)$

AJ model. Figure 6a plots welfare, consumer surplus, profit, price, cost, q^*, and x^* as functions of λ (for $\beta = 0.65$ and $n = 6$). In contrast with the static model, the simulations indicate that prices may be hump-shaped when cost decreases with λ; correspondingly, this figure shows how output per firm is U-shaped when R&D per firm increases (two lower panels). The welfare translation of the increase in λ is given in the upper right panel; it shows U-shaped consumer surplus and increasing profit per firm, with the result of an interior solution for welfare that features a large value of $\lambda^o_{\mathrm{TS}} > 0$. The upper left panel

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strate that an increase in β reduces x^* and that, for a given β and $n \geq 2$, the incentives for cost reduction relative to the social optimum decline with n (see Spence 1984, Table I).

shows how, for an intermediate range of spillovers, $\lambda_{\mathrm{CS}}^o = 1 > \lambda_{\mathrm{TS}}^o > 0$. This relation is corroborated in Figure 6b, which also confirms that in the two-stage model it is socially desirable to induce more cooperation that in the static model under the TS standard and also under the CS standard.

Optimal degree of cross-ownership in terms of total surplus and consumer surplus
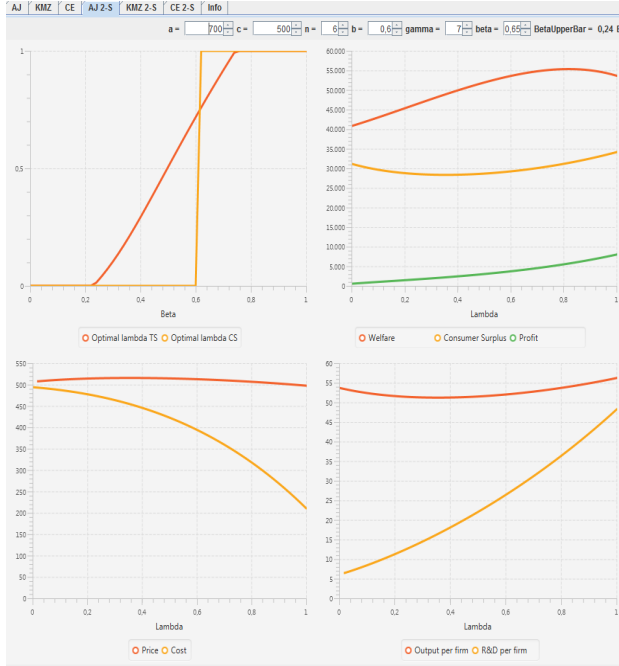

Fig. 6a. AJ model specification. Snapshot of the Application. ($a = 700$, $c = 500$, $\gamma = 7$, $n = 6$ and $b = 0.6$.)
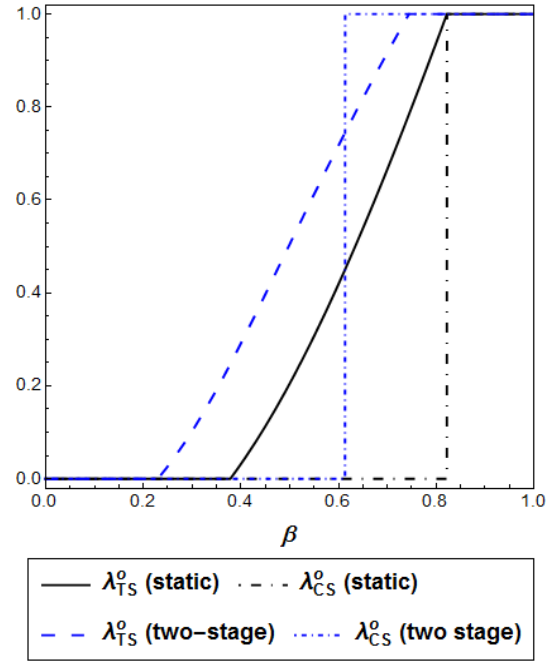
Fig 6b. AJ model specification. ($a = 700$, $c = 500$, $\gamma = 7$, $n = 6$ and $b = 0.6$.)

Satisfying the expression $\lambda_{\mathrm{CS}}^o = 1 > \lambda_{\mathrm{TS}}^o > 0$ becomes possible when the strategic effect is positive and strong enough. Then there is overinvestment in R&D during the first stage, which boosts output in the second stage. The strategic effect becomes positive for intermediate values of β when λ is sufficiently high. For an intermediate level of spillovers, total surplus is not maximized with full cooperation because that would entail too much production (reducing firms' profits). In Figure 6a we see that output increases with increasing λ and also how fast R&D per firm increases with λ. Only when the spillover is large enough ($\beta > 0.75$ in our example) are firms efficient enough to benefit from such high production quantities.

More precisely, since $\beta^{2S\prime}$ decreases with λ, it follows that—for a given β and a sufficiently high λ—we have $\beta > \beta^{2S\prime}$ and so the equilibrium is then in R_{III}, where CS increases with λ.[40] In particular: for $\beta = 0.62$, the equilibrium is in R_{III} when $\lambda > 0.41$ (see Figure 6a). Here the strategic effect is positive since $\tilde{\beta}(\lambda) > 0.62$ for $\lambda > 0.24$. Furthermore, if $\lambda > 0.69$ then the strategic effect is strong enough to *reverse* the sign of the effect of $\partial x^*/\partial \lambda$ on $W'(\lambda)$ (i.e., to make it negative); as a result, in a neighborhood of $\beta = 0.62$ there is a global maximum for $W(\lambda)$: even if the equilibrium is in R_{III} we have that $W'(\lambda) < 0$ for high values of λ, which implies $\lambda_{\mathrm{TS}}^o \in (0, 1)$.

KMZ model. Finally, the optimal degree of cross-ownership in terms of total surplus is increasing in β also under the KMZ model specification. With regard to consumer surplus, numerical simulations suggest that normally no cross-ownership is optimal; however, $\lambda_{\mathrm{CS}}^o = 1$ can be optimal for low n, b, and γ (see Figure 7). As in AJ, we can have $\lambda_{\mathrm{CS}}^o > \lambda_{\mathrm{TS}}^o$ for intermediate spillover values (because of the strategic effect).

Optimal degree of cross-ownership in terms of total surplus and consumer surplus
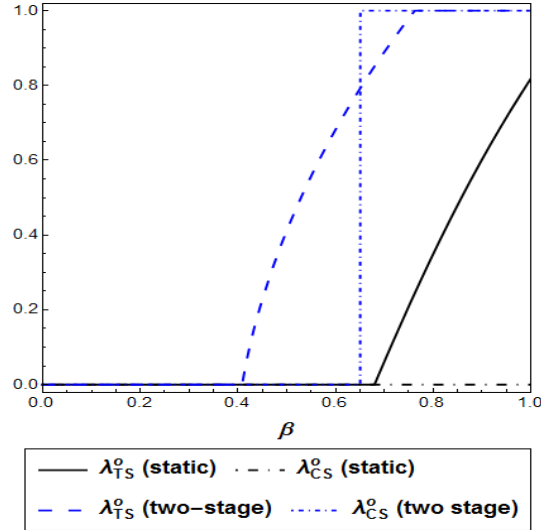

Fig. 7. KMZ model specification.
($a = 700$, $c = 500$, $\gamma = 5.5$, $n = 2$ and

$b = 0.2$.)

The pattern of results in our comparative statics analysis of the other parameters in AJ, KMZ, and CE is similar to that for the one-stage game (see Table 5). The only exceptions we have found are as follow. In AJ: although decreasing b enlarges the region

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[40]That is, CS is strictly convex in λ and so $\lambda_{\mathrm{CS}}^* = 1$ when $\mathrm{CS}(1) > \mathrm{CS}(0)$.

where $\lambda_{\text{CS}}^o = 1$ is optimal (as in the static case), λ_{CS}^o can be lower than 1 (for a sufficiently low b) when spillovers are sufficiently high. In KMZ: although λ_{CS}^o is independent of n in the static case, in the two-stage game it can decrease with n when there are few firms in the market.

7 Alternative interpretation: R&D cooperation extending to the product market

The "sympathy coefficient" λ can be viewed also as a measure of the intensity of competition; for example, a low λ may be the result of firms' limited scope for collusion owing to a low discount factor. Note that this parameter has an empirical counterpart in the estimation of market power because it corresponds to a constant elasticity of conjectural variation, which can be used to estimate the degree of industry cooperation.[41] Intermediate degrees of cooperation may arise from the strictness of antitrust policy: in terms of limiting not only cross-shareholdings but also collusion in the product market. The latter scenario is relevant given the long-standing suspicion that R&D cooperation facilitates coordination in the product market. This outcome may reflect the existence of ancillary restraints (or of other channels through which cooperative R&D may lead to coordination in the product market)[42] or the existence of multimarket contacts.[43] There is also growing evidence that R&D cooperation facilitates product market cooperation from empirical studies (Duso et al. 2014; Goeree and Helland 2010), from experiments

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[41] Michel (2016) estimates the degree of profit internalization after ownership changes in differentiated product industries. He allows each firm's objective function to depend on other firms' profits by incorporating the parameter λ_{ij}, which is the extent to which brand i accounts for brand j's profits when setting the optimal brand-i price.

[42] As when, for example, an RJV stipulates downstream market division for any patents that may result from the venture or when there are collateral agreements that impose cross-licensing of old patents (or a per-unit output royalty for using new patents)—since these circumstances reduce the incentives of firms to increase their output (Grossman and Shapiro 1986; Brodley 1990). The various channels through which cooperative R&D may facilitate coordination in the product market are analyzed by Martin (1995), Greenlee and Cassiman (1999), Cabral (2000), Lambertini et al. (2002), and Miyagiwa (2009). Rey and Tirole (2013) examine how both independent marketing and joint marketing alliances (e.g., patent pools) can lead to tacit collusion.

[43] See the related evidence in Parker and Röller (1997) for mobile telephony and in Vonortas (2000) for US RJVs.

(Suetens 2008),[44] and from antitrust cases.[45]

Our analysis therefore extends the traditional framework in two directions: no separation between coordination in R&D and output, whether because of cross-ownership or because R&D cooperation naturally extends to product market cooperation; and the presence of intermediate degrees of cooperation in response to the strictness of competition policy. Antitrust authorities affect the parameter λ by limiting cross-shareholdings; we can also interpret λ as a measure of the intensity with which collusion is scrutinized.[46] From a policy perspective, our results highlight the tension between a CS standard as proclaimed by many competition authorities and the fact that R&D cooperation is widely allowed (and even encouraged) by those same public authorities. Whenever cooperation in R&D extends to competition in the product market, policy must in general be much stricter if the aim is to increase consumer surplus.

8   Concluding remarks

In the context of a general symmetric oligopoly Cournot model with cost-reducing R&D investment, spillovers, and symmetric partial ownership interests, we have identified tight conditions—in terms of the curvature of demand, market concentration, and the extent of spillovers—under which cross-ownership is welfare enhancing. We also find that the socially optimal degree of cross-ownership is positively associated with the number of firms, with the elasticity of demand and of the innovation function, and with the extent of spillovers. Yet if the objective is to maximize consumer surplus then (i) the scope for partial ownership interests is greatly reduced and (ii) firm entry need not induce, at the welfare optimum, a higher degree of cross-ownership. We say that an antitrust policy is *strict* to the extent that it limits minority shareholdings, and (alternatively) when it is increasingly activated as cooperation in R&D extends to cooperation in output. The

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[44]Suetens (2008) uses a two-stage duopoly model to confirm that cooperation in reducing R&D costs facilitates price collusion. Agents engage in cooperative R&D projects more than once, and they interact repeatedly in the product market. For both small and large spillovers this author finds that cooperativeness in the pricing stage is generally higher when subjects can make binding R&D agreements than in the baseline treatments without the possibility of such agreements.

[45]Goeree and Helland (2010) gather a number of cases in the petroleum industry, the computer industry, the market for semiconductor memory, and the telecommunications sector.

[46]Besanko and Spulber (1989) show that, if collusive behavior is unobservable and if production costs are private information, then the antitrust authority may optimally induce some intermediate degree of collusion among firms.

competition-reducing effect of cross-ownership justifies policy intervention, as forcefully underscored by the empirical work of Azar et al. (2015, 2016). However, some degree of cross-ownership may actually be welfare enhancing, and may even increase consumer surplus, for an industry that exhibits sufficiently large R&D spillovers. In the extreme, it may be socially optimal to form a cartelized RJV when the curvature of the innovation function is not too large. This paper stipulates precise conditions that can be checked to see—in industries with significant R&D spillovers—whether cross-ownership is (or is not) still improving social welfare. Our results imply that competition policy and patent policy are complementary (as in Spulber (2013) but in a very different model) whenever high patent protection goes together with a low level of spillovers. This is so since then with a low (high) level of spillovers we want to tighten (relax) competition policy.

We extend the "simultaneous action" (static) model of R&D investment to a strategic commitment (two-stage) model and find that our results are (with some caveats) robust to this extension. It turns out that, when spillovers are above a given threshold, firms invest less in R&D and produce less in the two-stage than in the static model; hence the strategic effect of investment becomes negative. In this case, the social gains—from a higher degree of cross-ownership that induces firms to invest and approach more nearly the socially optimal production levels—are even greater. We also characterize how these gains are affected by the number of firms, the extent of cross-ownership, and the curvature of the inverse demand function. Numerical simulations corroborate that, when spillovers are high, an antitrust policy should be less strict in the two-stage model than in the static model. In this case, it need no longer be true that the consumer surplus standard calls for reduced cross-ownership: cooperation may be needed to induce the investment required for high output, despite that level of investment possibly being excessive from the total surplus standpoint.

$\partial_{qq}\phi_i = (\partial^2\phi_i/\partial q_i^2)\|_{q^*,x^*} =$	$f'(Q^*)(2 + \delta\Lambda/n)$
$\partial_{q_{i,j}}\phi_i = (\partial^2\phi_i/\partial q_i\partial q_j)\|_{q^*,x^*} =$	$f'(Q^*)(1 + \lambda + \delta\Lambda/n)$
$\partial_{xx}\phi_i = (\partial^2\phi_i/\partial x_i^2)\|_{q^*,x^*} =$	$-(c''(Bx^*)\tilde{\lambda}q^* + \Gamma''(x^*))$
$\partial_{x_{i,j}}\phi_i = (\partial^2\phi_i/\partial x_i\partial x_j)\|_{q^*,x^*} =$	$-c''(Bx^*)\beta q^*\{1 + \lambda[1 + (n-2)\beta]\}$
$\partial_{xq}\phi_i = (\partial^2\phi_i/\partial x_i\partial q_i)\|_{q^*,x^*} =$	$-c'(Bx^*)$
$\partial_{\lambda q}\phi_i = (\partial^2\phi_i/\partial\lambda\partial q_i)\|_{q^*,x^*} =$	$f'(Q^*)(n-1)q^*$
$\partial_{\lambda x}\phi_i = (\partial^2\phi_i/\partial\lambda\partial x_i)\|_{q^*,x^*} =$	$-\beta(n-1)c'(Bx^*)q^*$
$(\partial_{qq}\phi_i)(\partial_{xx}\phi_i) - (\partial_{xq}\phi_i)^2 =$	$f'(Q^*)(2 + \Lambda\delta/n)[c''(Bx^*)(Q^*/n)\tilde{\lambda} + \Gamma''(x^*)] - c'(Bx^*)^2$
$\Delta_q = \partial_{qq}\phi_i + \partial_{q_{i,j}}\phi_i(n-1) =$	$f'(Q^*)[n + \Lambda(\delta+1)]$
$\Delta_x = \partial_{xx}\phi_i + \partial_{x_{i,j}}\phi_i(n-1) =$	$-(c''(Bx^*)B\tau q^* + \Gamma''(x^*))$
$\Delta(Q^*,x^*) =$	$-[c''(Bx^*)B\tau(Q^*/n) + \Gamma''(x^*)]\{f'(Q^*)[\Lambda(1+\delta) + n]\} - c'(Bx^*)^2\tau B$
$\psi_q =$	$-c'(Bx^*)s(\lambda)$
$\psi_x =$	$-c''(Bx^*)Bs(\lambda)q^*$
$\psi_\lambda =$	$-c'(Bx^*)s'(\lambda)q^*$
$\tilde{\Delta}(Q^*,x^*) =$	$-(c''(Bx^*)Bq^*\mu + \Gamma'')f'(Q^*)[\Lambda(1+\delta) + n] - c'(Bx^*)^2\mu B$
$H =$	$-[f'(Q^*)/(\beta c'(Bx^*)^2)](-c''(Bx^*)B\Gamma'(x^*)/c'(Bx^*) + \Gamma''(x^*))$
(one-stage) $\partial x^*/\partial\lambda =$	$[(n-1)(Q^*/n)f'(Q^*)c'(Bx^*)/\Delta]\{\beta[\Lambda(1+\delta) + n] - \tau\}$
(one-stage) $\partial q^*/\partial\lambda =$	$[(n-1)(Q^*/n)/\Delta]\{c'(Bx^*)^2\beta B + f'(Q^*)[c''(Bx^*)(Q^*/n)B\tau + \Gamma''(x^*)]\}$
	$= [(n-1)(Q^*/n)/\Delta]c'(Bx^*)^2\beta(B - H(\beta))$
(two-stage) $\partial x^*/\partial\lambda =$	$\xi f'(Q^*)c'(Bx^*)\{(\beta + s'(\lambda))[\Lambda(1+\delta) + n] - [\tau + (n-1)s(\lambda)]\}$
(two-stage) $\partial q^*/\partial\lambda =$	$\xi((\beta + s'(\lambda))c'(Bx^*)^2B + f'(Q^*)\{c''(Bx^*)(Q^*/n)B[\tau + (n-1)s(\lambda)] + \Gamma''(x^*)\})$

with $B = 1 + \beta(n-1)$, $\Lambda = 1 + \lambda(n-1)$, $\tau = 1 + \lambda(n-1)\beta$, $\tilde{\lambda} = 1 + \lambda(n-1)\beta^2$, $\mu \equiv \tau + s(\lambda)(n-1)$ and $\xi \equiv (n-1)(Q^*/n)/\tilde{\Delta}$.

9 Appendix A

9.1 Minority shareholdings

9.1.1 Common-ownership

Letting v_{ij} be the ownership share of firm j owned by owner/investor i, the total (portfolio) profit of owner i is: $\pi^i = \sum_k v_{ik}\pi_k$, where π_k are the profits of portfolio firm k. Since each firm takes into account its shareholders' incentives through the control weights ζ_{ij}, firm j maximizes a weighted average of its shareholders' portfolio profits:

$$\sum_{i=1}^{n} \zeta_{ij}\pi^i = \sum_{i=1}^{n} \zeta_{ij} \sum_{k=1}^{n} v_{ik}\pi_k.$$

A variety of governance structures may be considered by assigning different values to the control rights. Note that the above expression is equivalent to

$$\sum_{i=1}^{n} \zeta_{ij}v_{ij}\pi_j + \sum_{i=1}^{n} \zeta_{ij} \sum_{k \neq j}^{n} v_{ik}\pi_k,$$

and dividing by $\sum_{i=1}^{n} \zeta_{ij}v_{ij}$ we obtain $\pi_j + \sum_{i=1}^{n} \zeta_{ij} \sum_{k \neq j}^{n} v_{ik}\pi_k / \sum_{i=1}^{n} \zeta_{ij}v_{ij}$, or, equivalently,

$$\pi_j + \sum_{k \neq j}^{n} \frac{\sum_{i=1}^{n} \zeta_{ij}v_{ik}}{\sum_{i=1}^{n} \zeta_{ij}v_{ij}}\pi_k.$$

Thus, the model of common-ownership with control weights can be re-written in the form of maximizing $\phi_j = \pi_j + \sum_{k \neq j}^{n} \lambda_{jk}\pi_k$, where $\lambda_{jk} \equiv \sum_{i=1}^{n} \zeta_{ij}v_{ik} / \sum_{i=1}^{n} \zeta_{ij}v_{ij}$.

9.1.2 Cross-ownership by firms

The profit of firm j is given by $\phi_j = \pi_j + \sum_{k \neq j} \alpha_{jk}\phi_k$, where α_{jk} is the firm j's ownership stake in firm k. One can derive the profit for each firm by denoting $\boldsymbol{\phi} = (\phi_1, ..., \phi_n)'$ and $\boldsymbol{\pi} = (\pi_1, ..., \pi_n)'$, and solving the equation: $\boldsymbol{\phi} = \boldsymbol{\pi} + \mathbf{A}\boldsymbol{\phi}$, where $\mathbf{A}$ is the $n \times n$ matrix with the ownership stakes with 0's in the diagonal and α_{jk} off-diagonal. Thus, $\boldsymbol{\phi} = \boldsymbol{\Theta}\boldsymbol{\pi}$, where $\boldsymbol{\Theta} = (\mathbf{I} - \mathbf{A})^{-1}$ is the inverse of the Leontief matrix; its coefficients θ_{jk} represent the effective or imputed stake in firm k's profits received by a "real" equity holder with a 1% direct stake in firm j.[47] We examine the symmetric case: $\alpha_{jk} = \alpha_{kj} = \alpha$ for all

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[47]Gilo et al. (2006, Lemma 1, p.85) also show that $\theta_{jj} \geq 1$ for all j, and $0 \leq \theta_{jk} < \theta_{jj}$ for all j and all $k \neq j$.

$j \neq k$, and $\alpha_{jj} = 0$ for all j. The general formula for the coefficients of matrix Θ when stakes are symmetric is, for $\alpha < 1/(n-1)$, $\theta_{jj} = \frac{1-(n-2)\alpha}{[1-(n-1)\alpha](\alpha+1)}$ and $\theta_{jk} = \frac{\alpha}{[1-(n-1)\alpha](\alpha+1)}$ for all j and all $j \neq k$ (see Lemma 8 in Appendix B.1).

Hence, the profit of firm j with symmetric stakes is given by

$$\phi_j = \frac{1-(n-2)\alpha}{[1-(n-1)\alpha](\alpha+1)}\pi_j + \frac{\alpha}{[1-(n-1)\alpha](\alpha+1)}\sum_{k \neq j}\pi_k.$$

Maximizing the above expression is equivalent to maximizing $\pi_j + \lambda\sum_{k \neq j}\pi_k$, where $\lambda = \lambda^{\mathrm{PCO}} \equiv \alpha/[1-(n-2)\alpha]$.

9.2 Simultaneous model

Proof of Lemma 1. If we totally differentiate the two first-order necessary conditions, then after some manipulations we get

$$\frac{\partial q^*}{\partial \lambda} = \frac{1}{\Delta}[(\partial_{\lambda x}\phi_i)(\partial_{xq}\phi_i)B - (\partial_{\lambda q}\phi_i)\Delta_x] \tag{17}$$

$$\frac{\partial x^*}{\partial \lambda} = \frac{1}{\Delta}[(\partial_{\lambda q}\phi_i)(\partial_{xq}\phi_i)\tau - (\partial_{\lambda x}\phi_i)\Delta_q]. \tag{18}$$

Using equation (18) and Table 7 we obtain

$$\frac{\partial x^*}{\partial \lambda} = \frac{c'(Bx^*)f'(Q^*)(n-1)q^*}{\Delta}\{\beta[\Lambda(1+\delta)+n]-\tau\}.$$

Since $\Delta > 0$ and $\Delta_q < 0$ (so $\Lambda(1+\delta)+n > 0$):

$$sign\left\{\frac{\partial x^*}{\partial \lambda}\right\} = sign\{\beta[\Lambda(1+\delta)+n]-\tau\}$$

$$= sign\left\{\beta - \frac{\tau}{\Lambda(1+\delta)+n}\right\} = sign\left\{\beta - P'(c)\frac{\tau}{n}\right\},$$

where $P'(c) = n/[\Lambda(1+\delta)+n]$. Finally, by substituting

$$sign\{\beta[\Lambda(1+\delta)+n]-\tau\} = sign\{\beta(1+\Lambda\delta+n)-1\}.\blacksquare$$

Proof of Corollary 1. From Lemma 1 we have that if $\delta \leq -(1+n)/\Lambda$, so $n+1+\delta\Lambda \leq 0$, then $\partial x^*/\partial \lambda < 0$, which, using equation (5), in turn implies that $\partial q^*/\partial \lambda < 0$: for all

β only R_I exists. If $\delta > -(n+1)/\Lambda$, then in addition to R_I, region R_II exists only if $\delta > -n/\Lambda$ also holds. The reason is that when $1 + n + \delta\Lambda > 0$, then, from Lemma 1, $\partial x^*/\partial \lambda > 0$ requires that $\beta > 1/(1 + n + \delta\Lambda)$. However, $1/(1 + n + \delta\Lambda) < 1$ only if $\delta > -n/\Lambda$, in which case there exists some region of feasible spillover values for which $\partial x^*/\partial \lambda > 0$. Note that for a given n, the condition $\delta > -n/\Lambda$ is stricter than the condition $\delta > -(n+1)/\Lambda$. Thus, for $\delta \leq -n/\Lambda$ only R_I exists, and since $-n/\Lambda$ increases with λ, the result holds for any λ if $\delta \leq -n$.∎
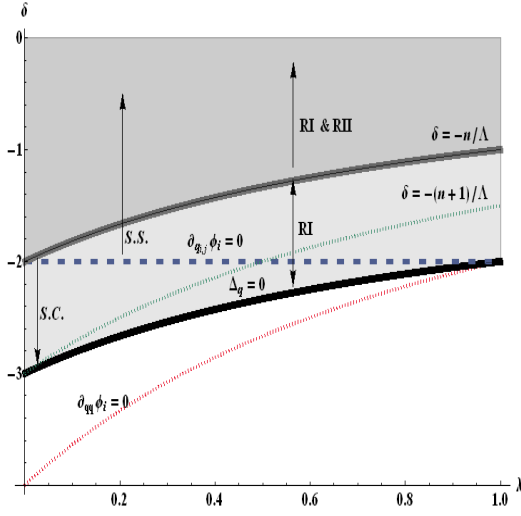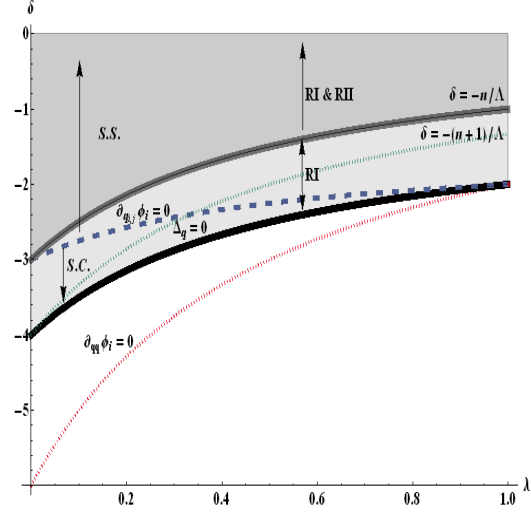

Fig. 8a. $n = 2$.   Fig. 8b. $n = 3$.

Fig. 8. Existence of regions R_I and R_II with second-order, stability and strategic complements/substitutes output competition conditions.

Proof of Lemma 2. If we totally differentiate the two-first order conditions and solve for $\partial q^*/\partial \lambda$, we obtain

$$\frac{\partial q^*}{\partial \lambda} = \frac{(n-1)(Q^*/n)}{\Delta}\beta\left(c'(Bx^*)\right)^2\left\{B + \frac{f'(Q^*)}{\beta c'(Bx^*)^2}\left[c''(Bx^*)(Q^*/n)B\tau + \Gamma''(x^*)\right]\right\}.$$

Let $H \equiv \frac{\partial_{\lambda q}\phi_i}{\partial_{\lambda x}\phi_i}\frac{\Delta_x}{\partial_{xq}\phi_i} = -\left[f'(Q^*)/(\beta\left(c'(Bx^*)\right)^2)\right]\left[c''(Bx^*)(Q^*/n)B\tau + \Gamma''(x^*)\right]$, evaluated at

the equilibrium (Q^*, x^*) for $\beta > 0$. From the requirement that either $c'' > 0$ or $\Gamma'' > 0$ (or both) we obtain that $\lim_{\beta\to 0} H = \infty$. The above expression can be rewritten as

$$\frac{\partial q^*}{\partial \lambda} = \frac{(n-1)(Q^*/n)}{\Delta}\beta\left(c'(Bx^*)\right)^2(B - H).∎$$

Proof of Corollary 2. Under A.4, $\partial q^*/\partial \lambda > 0$ (so R_III exists) if $\beta > \beta'$. We now

show that the condition $n > H(1)$ guarantees that $\beta' < 1$. First, note that $\lim_{\beta \to 0} H = \infty$ (when $c'' > 0$ or $\Gamma'' > 0$), while $B = 1$ at $\beta = 0$. Since $H(\beta)$ has slope less than $n-1$ and $dB/d\beta = n-1$, by continuity there exists only one value for $\beta(=\beta')$ at which $H(\beta) = B$. If the condition $H(\beta) - B < 0$ holds at $\beta = 1$ (which is equivalent to the condition $n > H(1)$), then necessarily H intersects B at some β less than 1, thus $\beta' < 1$.∎

Proof of Proposition 3. By totally differentiating the two FOCs with respect to β, we obtain

$$\frac{\partial q^*}{\partial \beta} = \frac{1}{\Delta}[(\partial_{\beta x}\phi_i)(\partial_{xq}\phi_i)B - (\partial_{\beta q}\phi_i)\Delta_x] \tag{19}$$

$$\frac{\partial x^*}{\partial \beta} = \frac{1}{\Delta}[(\partial_{\beta q}\phi_i)(\partial_{xq}\phi_i)\tau - (\partial_{\beta x}\phi_i)\Delta_q]. \tag{20}$$

Since $\partial_{xq}\phi_i > 0$ and $\partial_{\beta q}\phi_i > 0$, $\Delta > 0$, $\Delta_x < 0$ and $\Delta_q < 0$, the sign of the impact of β on output and R&D in equilibrium depends on the sign of $\partial_{\beta x}\phi_i$. It can be shown that

$$\partial_{\beta x}\phi_i = -c'(Bx^*)\frac{(n-1)q^*}{B}\tau\left(\frac{\lambda B}{\tau} - \chi(Bx^*)\right) \tag{21}$$

and the result follows.∎

Proof of Proposition 4. To prove Proposition 4 a few preliminary lemmata (assuming A.1-A.4) are useful.

LEMMA 5 *Suppose that $\delta > -n$, then $W'(\lambda) > 0$ if $\beta > \hat{\beta}(\lambda)$ where $\hat{\beta}$ is the unique positive solution to the equation*

$$H(\beta) - B = [(n-\Lambda)/\Lambda][(n+1+\delta\Lambda)\beta - 1]. \tag{22}$$

Proof. We first derive the condition that determines the spillover threshold value $\hat{\beta}$ above which welfare is increasing in the degree of cross-ownership. By inserting $\partial q^*/\partial\lambda$ and $\partial x^*/\partial\lambda$ (given in Table 7) into (8) we obtain:

$$W'(\lambda) = -\Lambda f'(Q^*)\frac{(n-1)q^*}{\Delta}c'(Bx^*)^2\beta(B - H(\beta))Q^*$$
$$-(1-\lambda)\beta(n-1)c'(Bx^*)\frac{(n-1)q^*}{\Delta}f'(Q^*)c'(Bx^*)\{\beta[\Lambda(1+\delta)+n] - \tau\}Q^*,$$

which can be rewritten as:

$$W'(\lambda) = \vartheta_w \left(\Lambda \left(B - H(\beta) \right) + (1 - \lambda)(n-1) \left\{ \beta \left[\Lambda(1 + \delta) + n \right] - \tau \right\} \right),$$

where $\vartheta_w \equiv [(n-1)q^*/\Delta]c'(Bx^*)^2(-f'(Q^*))\beta Q^*$ is positive. Note that $(1 - \lambda)(n-1) = n - \Lambda$, thus for $\beta > 0$, $W'(\lambda) > 0$ if

$$H(\beta) - B < \frac{n - \Lambda}{\Lambda} \left[(n + 1 + \delta\Lambda)\beta - 1 \right]. \tag{23}$$

Note that $\lim_{\beta \to 0} H = \infty$ and (by Assumption A.4) the left-hand side of (23) is decreasing in β. The right-hand side of (23) is increasing in β (since $n + 1 + \delta\Lambda > 0$ holds when R_{II} and R_{III} exist) and finite at $\beta = 0$. Thus, there exists a unique positive threshold $\hat{\beta}$ that solves the equation (22), and for any $\beta > \hat{\beta}$ condition (23) holds, that is, $W'(\lambda) > 0$.∎

LEMMA 6 *We have that $\hat{\beta}(\lambda) < \beta'(\lambda)$ for all λ, which implies that $\bar{\beta} < \beta'(0)$ where $\bar{\beta} = \hat{\beta}(0)$. Furthermore, $\bar{\beta} < 1$ if*

$$n + (n-1)(\delta + n) - H(1) > 0. \tag{24}$$

Proof. We first show that $\beta'(\lambda) > \hat{\beta}(\lambda)$ for any λ, and as a result $\beta'(0) > \bar{\beta} = \hat{\beta}(0)$. Suppose that for a given λ, $\hat{\beta} > \beta'$, then from (6) we have that for $\beta \in (\beta', \hat{\beta})$ it holds that $\partial q^*/\partial \lambda > 0$. Thus, from equation (5) it also holds that $\partial x^*/\partial \lambda > 0$, which implies from equation (8) that $W'(\lambda) > 0$. However, from equation (22) we have that $W'(\lambda) < 0$ for $\beta < \hat{\beta}$, a contradiction. Suppose now that $\hat{\beta} = \beta'$, then we can pick β such that $\beta = \hat{\beta} = \beta'$, and as a result $H - B|_{\beta = \beta'} = 0$, thus from equation (22) we have that $\hat{\beta} = \beta' = 1/(n+1+\delta\Lambda)$, which implies that $\partial x^*/\partial \lambda = 0$ (see Table 7), and from equation (5) this in turn implies that $\partial q^*/\partial \lambda < 0$. However, at $\beta = \beta'$, $B - H = 0$, so $\partial q^*/\partial \lambda = 0$ (see Table 7), a contradiction.

The proof of Lemma 5 shows that $W'(\lambda) > 0$ for some λ if the spillover is larger than the threshold value $\hat{\beta}(\lambda)$, where $\hat{\beta}$ is the unique positive solution to the equation (22). Furthermore, $\hat{\beta} < 1$ if condition (23) evaluated at $\beta = 1$ holds since $\lim_{\beta \to 0} H(\beta) = \infty$ and $H(\beta) - B$ decreases with β (by Assumption A.4), while the right-hand side of (23) increases with β (for $\lambda < 1$) and takes finite value at $\beta = 0$. Therefore, by evaluating (23) also at $\lambda = 0$ we obtain the condition that ensures that $\bar{\beta} < 1$, $n + (n-1)(\delta + n) - H(1) >$

0.■

We turn now to prove successively each of the statements of Proposition 4.

i) The result follows from Proposition 1: if $-\delta \geq \mathrm{HHI}^{-1}$, then only R_I exists, where $\partial x^*/\partial\lambda < 0$ and $\partial q^*/\partial\lambda < 0$, and thus $CS'(\lambda) < 0$ and $W'(\lambda) < 0$ for all λ.

ii) Next we consider the case in which $-\delta < n$:

ii.1) $\lambda^o_\mathrm{TS} = \lambda^o_\mathrm{CS} = 0$ if $\beta \leq \bar{\beta}$. First, we have to show that there does not exist $\beta < \bar{\beta}$ such that $W'(\lambda) > 0$ for some positive λ. However, this follows trivially from the assumption that $W(\lambda)$ is single peaked: since for any $\beta < \bar{\beta}$, $W'(0) < 0$, we have that $W'(\lambda) < 0$ for all positive λ, otherwise there would exist another stationary point that is a (local) minimum, a contradiction. Similarly, if $\beta = \bar{\beta}$, then $W'(0) = 0$, and the assumption that $W(\lambda)$ is single peaked guarantees that $W'(\lambda) < 0$ for any positive λ. In addition, if $\beta \leq \bar{\beta}$, then $\lambda^o_\mathrm{CS} = 0$: from Lemma 6 we know that $\beta'(\lambda) > \bar{\beta} = \hat{\beta}(0)$ for all λ; since β is assumed to be equal to or lower than $\bar{\beta}$, it follows that $CS'(\lambda) < 0$ for all λ, thus $\lambda^o_\mathrm{CS} = 0$.

ii.2) $\lambda^o_\mathrm{TS} > \lambda^o_\mathrm{CS} = 0$ if $\beta \in \left(\bar{\beta}, \beta'(0)\right)$. Noting again that $\bar{\beta} = \hat{\beta}(0)$, the result that $\lambda^o_\mathrm{TS} > 0$ when $\beta > \bar{\beta}$ follows immediately from Lemma 5. In addition, $\beta < \beta'(0)$ yields $\lambda^o_\mathrm{CS} = 0$: when H is weakly increasing in λ, $\beta'(\lambda)$ also is, and consequently if $\beta < \beta'(0)$, then $\beta < \beta'(\lambda)$ for all λ, i.e., $\partial q^*/\partial\lambda < 0$ for all λ, thus $\lambda^o_\mathrm{CS} = 0$.

ii.3) We first show that $\lambda^o_\mathrm{TS} > 0$ and $\lambda^o_\mathrm{CS} > 0$ if $\beta > \beta'(0)$. From Lemma 6 it follows that $\beta > \beta'(0) > \bar{\beta}$, which yields $\lambda^o_\mathrm{TS} > 0$. From Lemma 2 we know that if for some given λ, $\beta > \beta'(\lambda)$, then $\partial q^*/\partial\lambda > 0$. Hence if $\beta > \beta'(0)$, we have that $\partial q^*/\partial\lambda > 0$ at $\lambda = 0$, which using (9) implies that $CS'(0) > 0$, and therefore $\lambda^o_\mathrm{CS} > 0$

Next we show that $\lambda^o_\mathrm{TS} \geq \lambda^o_\mathrm{CS}$ when H is weakly increasing in λ. Note that $B > H$ (since $\partial q^*/\partial\lambda > 0$) at $\lambda = 0$. When H is weakly increasing in λ, we may face the following three cases:

- There does not exist some $\lambda < 1$ at which $H = B$; as a result $\partial q^*/\partial\lambda > 0$ and, by (5), $\partial x^*/\partial\lambda > 0$ for all λ, which from equation (8) yields $W'(\lambda) > 0$ for all λ; thus $\lambda^o_\mathrm{TS} = \lambda^o_\mathrm{CS} = 1$.

46

- There exists an interval subset L of the continuum of values of λ in $(0,1]$ at which $H = B$ but (a) H never crosses B, so there is no λ at which $H > B$, or (b) there exists some λ above which $H > B$. In both cases, in the region of values for λ where $H = B$ we have $\partial q^* / \partial \lambda = 0$ (or, equivalently, $CS'(\lambda) = 0$), while $\partial x^* / \partial \lambda > 0$, consequently $W'(\lambda) > 0$. It follows that if H never crosses B or does it for some $\lambda > 1$, then $\lambda_{\text{TS}}^o = 1$, while any $\lambda \in L$ is optimal in terms of CS (even if L is a singleton) since $\partial q^* / \partial \lambda > 0$ for any λ lower than the lower bound of L, thus $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o$; by the same token, if $H > B$ for some $\lambda < 1$, then any $\lambda \in L$ is optimal in terms of CS (even if L is a singleton), while λ_{TS}^o is larger or equal than the upper bound of L, thus $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o$.

iii) In ii.1) $\lambda_{\text{TS}}^o = \lambda_{\text{CS}}^o = 0$, in ii.2) $\lambda_{\text{TS}}^o > \lambda_{\text{CS}}^o = 0$, and in ii.3) $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o > 0$. Therefore, in the three cases $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o$.

For the sake of completeness, next we consider the particular case where $\beta = \beta'(0)$.

- Case $\beta = \beta'(0)$. If H (as a function of λ) is increasing at some value of λ, then β' also is. Thus, for any larger value of λ, $\beta < \beta'(\lambda)$, which implies that $\partial q^* / \partial \lambda < 0$; as a result, any smaller value of λ, where $\beta = \beta'$, and therefore $\partial q^* / \partial \lambda = 0$, is optimal in terms of consumer surplus. Similarly, when H (and therefore β') is independent of λ for all λ, we have that $\partial q^* / \partial \lambda = 0$ for all λ since $\beta = \beta'$. Hence CS is independent of λ, and any λ is optimal in terms of CS. In both cases, for all λ where $H = B$ we have $\partial x^* / \partial \lambda > 0$, since $\partial q^* / \partial \lambda = 0$, which implies that $W'(\lambda) > 0$. Therefore, $\lambda_{\text{TS}}^o \geq \lambda_{\text{CS}}^o \geq 0$.∎

9.3 Two-stage model

Proof of Lemma 4. Using (13), by totally differentiating the system formed by (10; 11) in a symmetric equilibrium, and solving for $\partial q^* / \partial \lambda$ and $\partial x^* / \partial \lambda$, we obtain

$$\frac{\partial q^*}{\partial \lambda} = \frac{1}{\tilde{\Delta}} \left\{ [\partial_{\lambda x} \phi_i + (n-1) \psi_\lambda] (\partial_{xq} \phi_i) B - \partial_{\lambda q} \phi_i [\Delta_x + \psi_x (n-1)] \right\} \qquad (25)$$

$$\frac{\partial x^*}{\partial \lambda} = \frac{1}{\tilde{\Delta}} \left\{ \partial_{\lambda q} \phi_i [\partial_{xq} \phi_i \tau + (n-1) \psi_q] - [\partial_{\lambda x} \phi_i + (n-1) \psi_\lambda] \Delta_q \right\}, \qquad (26)$$

where $\psi_z \equiv \partial\psi/\partial z$ with $z = q, x, \lambda$, and

$$\tilde{\Delta}(Q^*, x^*) = \Delta_q \left[\Delta_x + \psi_x(n-1) \right] - \partial_{xq}\phi_i \left[\partial_{xq}\phi_i\tau + \psi_q(n-1) \right] B,$$

which is assumed to be strictly positive.[48] By rewriting equation (26) as follows

$$\frac{\partial x^*}{\partial \lambda} = \xi f'(Q^*)c'(Bx^*) \left\{ (\beta + s'(\lambda)) \left[\Lambda(1+\delta) + n \right] - \left[\tau + (n-1)s(\lambda) \right] \right\}, \qquad (27)$$

where $\xi \equiv (n-1)(Q^*/n)/\tilde{\Delta}$ and $s(\lambda) = \omega(\lambda)(\tilde{\beta}(\lambda) - \beta)$, we get that $sign\left\{\partial x^*/\partial\lambda\right\}$ is given by (15). Let us now turn to the impact of λ on output in equilibrium. Equation (25) can be rewritten as follows

$$\frac{\partial q^*}{\partial \lambda} = \xi \left((\beta + s'(\lambda))c'(Bx^*)^2 B + f'(Q^*) \left\{ c''(Bx^*)(Q^*/n)B \left[\tau + (n-1)s(\lambda) \right] + \Gamma''(x^*) \right\} \right). \tag{28}$$

By inserting the first-order necessary condition (11) evaluated at the symmetric equilibrium into the above expression, after some manipulations we get that $sign\left\{\partial q^*/\partial\lambda\right\}$ is given by (16). Finally, note that the first-order condition with respect to output is identical to the one associated to the static case. Therefore, by totally differentiating the FOC with respect to output and solving for $\partial q^*/\partial\lambda$, we obtain again equation (5), which implies that if $\partial x^*/\partial\lambda \leq 0$, then $\partial q^*/\partial\lambda < 0$. From (15), we obtain that $\partial x^*/\partial\lambda > 0$ if and only if

$$\beta > \underline{\beta}^{2S} \equiv \frac{1 - (\omega'(\lambda)\tilde{\beta}(\lambda) + \omega(\lambda)\tilde{\beta}'(\lambda))P'(c)^{-1}n + \omega(\lambda)(n-1)\tilde{\beta}(\lambda)}{(1+n+\Lambda\delta) + (n-1)\omega(\lambda) - P'(c)^{-1}n\omega'(\lambda)}. \blacksquare$$

LEMMA 7 *Under assumptions A.1.-A.4, in the two-stage model, there is a sufficiently large spillover value $(\bar{\beta}^{2S} < 1)$ for which allowing some cross-ownership is socially optimal $(\lambda_{\mathrm{TS}}^o > 0)$ if*

$$(1 + s'(0))n + (1 - s(0))(n-1)((1 + s'(0))(1 + \delta + n) - [1 + (n-1)s(0)] - H(1) > 0. \tag{29}$$

Proof. See Appendix B.1.∎

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3

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6

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Monitoring European Integration: The Making of Monetary Union (with D. Begg, P-A. Chiappori, F. Giavazzi, C. Mayer, D. Neven, L. Spaventa, and C. Wyplosz), CEPR, 1991, pp. 30.

Books and Symposium Issues (Editor):

Symposium Issue on Information, Competition, and Market Frictions (co-editor with A. Pavan), *Journal of Economic Theory*, 2015.

Symposium Issue on Financial Economics (co-editor with F. Allen and D. Vayanos), *Journal of Economic Theory*, 2014, pp. 310.

Football Economics. Proceedings of the Armand Carabén Workshop on Sports Economics (coeditor with J. Galí), *Reports of the Public-Private Sector Research Center*, 2010, pp. 155.

Social Networks and Peer Effects: Theory and Applications, in Memory of Antoni Calvó–Armengol*, Journal of the European Economic Association* (coeditor with M. O. Jackson), 2010.

Competition Policy in the EU. Fifty Years on From the Treaty of Rome (ed.), Oxford University Press, 2009.

Complementarities and Information, Symposium issue, *Journal of the European Economic Association* (coeditor with D. Gale), 2009.

Corporate Governance; Theoretical and Empirical Perspectives (ed.), Cambridge University Press, Cambridge, 2000.

Globalizació i Localizació de l'Activitat Econòmica (co-editor with J. Brandts), Institut Català de Finances, 2000.

El Govern de l'Empresa (ed.), Institut Català de Finances, 1998.

Financial Intermediation, Symposium issue, *European Economic Review* (coeditor with F. Bourguignon), 1995.

Crecimiento y Convergencia Regional en España y Europa (co-editor with J. Mª Esteban), IAE, 1994, Vol. I. pp. 244 and Vol. II pp. 558.

Capital Markets and Financial Intermediation (co-editor with C. Mayer), Cambridge University Press, Cambridge, 1993, pp. 357.

Concentración empresarial y competitividad: España en la CE (ed.), ARIEL, 1990.

Book Reviews, Short Articles and Comments:

"El Nobel a los Incentivos", Economistas, 1996, 73, 160-161.

Review of M. Dewatripont and J. Tirole, "The Prudential Regulation of Banks" (Cambridge and London: MIT Press, 1994), Journal of Economic Literature, 1996, 34, 1365-1366.

"Economía, Ciencia y Tecnología", Fronteras de la Ciencia y la Tecnología, 1995, 9.

Correspondence: "American and European Economists", Journal of Economic Perspectives, 1995, 9, 1, 203-215.

Discussion of "El Tratamiento de los Problemas Éticos en las Instituciones y los Mercados Financieros" by Antonio Argandoña, in La Dimensión Ética de las Instituciones y Mercados Financieros A. Argandoña (Ed.), Fundación BBV, 1995, 51-57.

Discussion of "Speculative Behavior and the Functioning of Risk Markets" by. R. Shiller, Moneda y Crédito, 1995.

Discussion of "Capital Market Imperfections and Regional Economic Development" by B. Greenwald, A. Levinson, and J. Stiglitz, in Finance and Development: Issues and Experiences, A. Giovanini (ed.), Cambridge University Press, 1993, 94-96.

Review of L. White, "The S&L Debacle" (Oxford University Press, Oxford, 1991), <u>International Journal of Industrial Organization</u>, 1992, 139-140.

Unpublished Research:

"Endogenous Public Information and Welfare in Market Games", 2015, IESE Working Paper 925, CESifo Working Paper 3492, CEPR Discussion Paper 8437, *Review of Economic Studies*, forthcoming.

"A Model of Costly Interpretation of Asset Prices" (with L. Yang), 2016, mimeo.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), 2016, CEPR Discussion Paper 11731.

"Cross-ownership, R&D Spillovers and Antitrust Policy" (with A. López), 2016, IESE Working Paper 1140, CEPR Discussion Paper 11315, CESifo Working Paper 5935.

"The Welfare Impact of High Frequency Trading" (with G. Cespa), 2016, CEPR Discussion Paper 11732.

"Supply Function Competition, Market Power and the Generalised Winner's Curse: A Laboratory Study" (with A. Bayona and J. Brandts), 2016, IESE Working Paper 1146, CEPR Discussion Paper 11378, CESifo Working Paper 6005.

"Information, Hedging and Welfare" (with L. Medrano), 2009, mimeo.

"Allocative and Productive Efficiency in REE with Asymmetric Information" (with S. Messner), 2001, CEPR Discussion Paper 2678.

"Excess Entry in Monopolistic Competition Revisited" (with K-U.Kühn), mimeo, 1995.

"Competing Exchanges" (with T. Gehrig and K. Stahl), mimeo, 1993.

"Dimensión, Costes y Eficiencia en la Banca Española" (with J. Gual and S. Jiménez), Documento de trabajo de FIES NO. 62, 1990.

"Nash Equilibrium in Oligopoly Games with Monotone Best Responses", CARESS W.P. #85-10, University of Pennsylvania, 1985.

Main Invited Lectures:

"Competition and Stability in Banking. The Role of Regulation and Competition Policy", 4th EBA Policy Research Workshop, London, November 2015.

"Cooperation, R&D Spillovers, and Antitrust Policy", 3rd Phd-Student Workshop in Industrial and Public Economics (WIPE), Universitat Rovira i Virgili, Tarragona, February 2015.

"Financial Stability, Regulation and Public Intervention", Arne Ryde Memorial Lecture, Lund University, November 2014.

"Banking, Fragility and Regulation", 8th Annual meeting of the Portuguese Economic Journal, Universidade da Minho, Braga, July 2014.

"Can Markets Be Informationally Efficient?", Schumpeter Lecture, XXVIII Meeting of the European Economic Association, Gothenburg, August 2013.

"Competition, Regulation and Fragility in Banking", J.J. Laffont Lecture, 8th International Conference on Competition and Regulation, CRESSE, Corfu, July 2013.

"Strategic Complementarity, Fragility, and Regulation", UECE Lisbon Meetings in Game Theory and Applications, Lisbon, November 2012.

"Innovation and Competitive Pressure", V Stackelberg Lecture, Intertic Conference, Venice, October 2011.

"Globalization, Crisis and Industrial Policy", Annual EUNIP Conference, Reus, June 2010.

"Information Aggregation in Markets", Presidential Address, Simposio de Análisis Económico, Sevilla, December 2008.

"Oligopoly Pricing and Strategic Complementarities", 7th annual INFORMS Revenue Management and Pricing Section Conference, Barcelona, June 2007.

"Monotone Equilibrium in Bayesian Games of Strategic Complementarities", Latin American Meeting of the Econometric Society, Mexico, November 2006.

"Information and Learning in Markets", Far Eastern Meeting of the Econometric Society, Beijing, July 2006.

"Complementarities and Games: New Developments", European Summer Symposium on Economic Theory, Gerzensee, July 2005.

"The Location of Headquarters", Revista de Economía Aplicada Lecture, Simposio de Análisis Económico, Pamplona, December 2004.

"Complementarities and Games: New Developments", Far Eastern Meeting of the Econometric Society, Seoul, June 2004.

"Games with Strategic Complementarities", 50th European Meeting of the Econometric Society ESEM/18th Annual Congress of the European Economic Association EEA, Stockholm, August 2003.

"Games with Strategic Complementarities: New Applications to Industrial Organization", EARIE, Madrid, September 2002.

"Games with Strategic Complementarities: New Applications", Spanish Economic Review Lecture, Simposio de Análisis Económico, Alicante, December 2001.

"Imperfect Competition, Risk Taking, and Regulation in Banking", Jornadas Anuales de Economía, Banco de Uruguay, Uruguay, July 2001.

"Dollarization, Bailouts, and the Stability of the Banking System", Latin American Meeting of the Econometric Society, Buenos Aires, July 2001.

"Oligopoly Pricing with Strategic Complementarities", Opening Conference, XVI Jornadas de Economía Industrial, Fundación Empresa Pública, Madrid, September 2000.

"Banking Supervision in the European Monetary Union", King Juan Carlos I of Spain Center, New York University, November 1999.

"Competition and Regulation in Banking", XVII Latin American Meeting of the Econometric Society, Cancun, Mexico, August 1999.

"Social Learning and Costly Information Acquisition", ENTER Jamboree, Université des Sciences Sociales, Toulouse, January 1996.

Last updated January 2017

"Competition and Regulation in Banking", 21st Annual Conference, EARIE, Crete, September 1994.

"La Competencia", Opening Conference, Doctorate Program, Departamento de Economía Aplicada, Universidad Autónoma de Barcelona, October 1993.

"La Competencia en la Perspectiva Europea", Tribuna Joven, Real Academia de Ciencias Morales y Políticas, Madrid, May 1993.

"Learning from Others", Econometric Society Summer Meeting, Brussels, August 1992.

"Economía Industrial y Teoría de Juegos", Terceras Jornadas de Economía Industrial, Fundación Empresa Pública, Madrid, September 1987.

Presentations at Professional Meetings:

"The Financial Crisis's Impact on Common Ownership and Competition" (with A. Banal-Estanol and J. Seldeslachts), Annual Meeting of the American Economic Association, Chicago, January 2017.

"Market Power and Welfare in Asymmetric Divisible Good Auctions", ESSET, Studienzentrum Gerzensee, Gerzensee, July 2016.

"Endogenous Public Information and Welfare in Market Games", Society for Economic Dynamics Annual Meeting, Toulouse, June 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), in The Industrial Economics of Private-Public Relations, Barcelona GSE Summer Forum, Barcelona, June 2016.

"Endogenous Public Information and Welfare in Market Games", The 30th Annual Congress of the European Economic Association, University of Mannheim, Mannheim, August 2015.

"Endogenous Public Information and Welfare in Market Games", Econometric Society 2015 World Congress, Palais des Congrés, Montreal, August 2015.

"Endogenous Public Information and Welfare in Market Games", 15th SAET Conference on Current Trends in Economics, University of Cambridge, Cambridge, July 2015.

"The Welfare Impact of High Frequency Trading" (with G. Cespa), Workshop on "Information Frictions and Learning", Barcelona GSE Summer Forum, Universitat Pompeu Fabra, Barcelona, June 2015.

"The Beauty Contest and Short-Term Trading" (amb G. Cespa), The Financial Intermediation Research Society (FIRS) Annual Meeting, Reykjavic, May 2015.

"Expectations, Liquidity, and Short-term Trading" (with G. Cespa), Annual Meeting of the American Finance Association, Boston, January 2015.

"The Beauty Contest and Short-term Trading" (with G. Cespa), Annual American Meeting of the American Finance Association, Westin Copley, Essex Center, Boston, January 2015.

"Cooperation, R&D Spillovers and Antitrust Policy" (with A. L. López), Annual Meeting of the American Economic Association, Boston, January 2015.

"Cooperation, R&D Spillovers and Antitrust Policy" (with A. L. López), 7th Annual Searle Center Conference on Antitrust Economics and Competition Policy, Northwestern Univesity School of Law, Chicago, September 2014.

19

"Cooperation, R&D Spillovers and Antitrust Policy" (with A. L. López), 41st Annual Conference of the European Association for Research in Industrial Economics (EARIE), Università Bocconi, Milan, August 2014.

"Strategic Complementarity, Fragility, and Regulation", PIMS Workshop on The Economics and Mathematics of Systemic Risk and the Financial Networks, University of British Columbia, Vancouver, July 2014.

"Endogenous Public Information and Welfare in Market Games", Information and Market Frictions, Barcelona GSE Summer Forum, Universitat Pompeu Fabra, Barcelona, June 2014.

"Endogenous Public Information and Welfare in Market Games", European Summer Symposium in International Macroeconomics (ESSIM), Universitat Rovira I Virgili, Tarragona, May 2014.

"Endogenous Public Information and Welfare in Market Games", ESSET, Studienzentrum Gerzensee, Gerzensee, July 2013.

"Strategic Complementarity, Fragility, and Regulation", Financial Intermediation, Risk & Liquidity Management Conference", Barcelona GSE Summer Forum, Barcelona, June 2013.

"Endogenous Public Information and Welfare", North American Meeting of the Econometric Society, University of California, San Diego, January 2013.

"Endogenous Public Information and Welfare", LACEA-LAMES Annual Meeting, Universidad del Pacífico, Lima, November 2012.

"Strategic Complementarity, Fragility, and Regulation", Cesifo-Deutsche Bundesbank conference "The Banking Sector and the State", Cesifo Conference Center, Munich, September 2012.

"Expectations, Liquidity, and Short-Term Trading" (with G. Cespa), European Economic Association Annual Meeting, Universidad de Málaga, Málaga, August 2012.

"Competitive Rational Expectations Equilibria without Apology" (with A. Kovalenkov), Econometric Society European Meeting, Universidad de Málaga, Málaga, August 2012.

"A Large Market Rational Expectations Equilibrium Model", ESSET, Studiezcentrum Gerzensee, Gerzensee, July 2012.

"Strategic Complementarity, Fragility, and Regulation", XVV Workshop in International Economics and Finance, Universitat Pompeu Fabra, Barcelona, July 2012.

"Strategic Supply Function Competition with Private Information", European Financial Management Association Annual Conference, Universitat de Barcelona, Barcelona, June 2012.

"Public and Private Learning from Prices, Strategic Substitutability and Complementarity, and Equilibrium Multiplicity" (with C. Manzano), European Summer Symposium on Economic Theory (ESSET), Studienzentrum Gerzensee, Gerzensee, July 2011.

"Strategic Complementarity, Fragility, and Regulation", European Finance Association Annual Meeting, Stockholm, August 2011.

"Strategic Complementarity, Fragility, and Regulation", European Economic Association Annual Meeting, University of Oslo, Oslo, August 2011.

"A Large-Market Rational Expectations Equilibrium Model", European Meeting of the Econometric Society, University of Oslo, Oslo, August 2011.

"Strategic Complementarity, Fragility, and Regulation", Simposio de Análisis Económico, Universidad Autónoma de Madrid, Madrid, December 2010.

"Strategic Complementarity, Fragility, and Regulation", SUERF/Banco de España/UPF Conference on Disclosure and Market Discipline, Universitat Pompeu Fabra, Barcelona, December 2010.

"Strategic Supply Function Competition with Private Information", World Congress of the Econometric Society, Shanghai Jiao Tong University, Shanghai, August 2010.

"Strategic Complementarity, Fragility, and Regulation", European Summer Symposium on Financial Markets (ESSFM), Studienzentrum Gerzensee, Gerzensee, July 2010.

"Stress, Crises, and Policy", FIRS Conference on Banking, Insurance and Intermediation, Badia Fiesolana European University Institue, Florence, June 2010.

"Endogenous Public Information and Welfare", Simposio de Análisis Económico, Universitat de València, Valencia, December 2009.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Foro de Finanzas, Madrid, November 2009.

"Endogenous Public Information and Welfare", European Meeting of the Econometric Society, Universitat Pompeu Fabra, Barcelona, August 2009.

"Asset Auctions and Liquidity", European Economic Association Annual Meeting, Universitat Pompeu Fabra, Barcelona, August 2009.

"How Can We Deal with Herding and Other Behavioural Issues?", Conference "The Future of Quantitative Finance", Isaac Newton Institute for Mathematical Sciences, Cambridge, June 2009.

"Strategic Supply Function Competition with Private Information", XVIII European Workshop on General Equilibrium Theory EWGET, Universitat Pompeu Fabra, Barcelona, June 2009.

"Strategic Supply Function Competition with Private Information", Tenth CEPR Conference on Applied Industrial Organization, Centre for European Economic Research, Mannheim, May 2009. Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), North American Meeting of the Econometric Society, San Francisco, January 2009.

"Strategic Supply Function Competition with Private Information", Workshop on Frontiers in Game Theory and Networked Control Systems, MIT, Cambridge, MA, October 2008.

"Strategic Supply Function Competition with Private Information", Encuentro Teoría de Juegos-Empresa, Centro de Investigación Operativa, Universidad Miguel Hernández, Elche, September 2008.

"Strategic Supply Function Competition with Private Information", European Summer Meeting of the Econometric Society, Bocconi University, Milan, August 2008.

"Competitive Rational Expectations Equilibria Without Apology" (with A. Kovalenkov), European Summer Symposium on Financial Markets (ESSFM), Studienzentrum Gerzensee, Gerzensee, July 2008.

"Rational Expectations and Supply Function Competition", European Summer Symposium on Economic Theory (ESSET), Studienzentrum Gerzensee, Gerzensee, July 2008.

"Strategic Supply Function Competition with Private Information", Workshop on Industrial Organization, IESE, Barcelona, June 2008.

"Strategic Supply Function Competition with Private Information", North American Meeting of the Econometric Society, New Orleans, January 2008.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Simposio de Análisis Económico, Universidad de Granada, Granada, December 2007.

"Strategic Supply Function Competition with Private Information", EARIE, Universidad de València, Valencia, September 2007.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), European Meeting of the Econometric Society, Central European University, Budapest, August 2007.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), European Finance Association Annual Meeting, University of Ljubljana, Ljubljana, August 2007.

"Strategic Supply Function Competition with Private Information", European Summer Symposium on Economic Theory (ESSET), Studienzentrum Gerzensee, Gerzensee, July 2007.

"Strategic Supply Function Competition with Private Information", Conference on The Economics of Energy Markets, Toulouse School of Economics, Toulouse, January 2007.

"Strategic Complementarity in Multi-stage Games", European Meeting of the Econometric Society, University of Vienna, Vienna, August 2006.

"Innovation and Competitive Pressure", Far Eastern Meeting of the Econometric Society, Tsinghua University, Beijing, July 2006.

"Monotone Equilibria in Bayesian Games of Strategic complementarities", University of Mannheim, Mannheim, May 2006.

"Banking and Regulation in Emerging Markets: The Role of External Discipline", CFS, European Central Bank and Deutsche Bundesbank, University of Frankfurt, May 2006.

"Monotone Equilibria in Bayesian Games of Strategic complementarities", UCL-ELSE Economic Theory Seminar Series, London's Global University, London, March 2006.

"Innovation and Competitive Pressure", Universidad de Granada, Granada, January 2006.

"Informational and Economic Efficiency in REE with Asymmetric Information" (with S. Messner), Laffont Memorial Conference, Toulouse School of Economics, Toulouse, June 2005.

"Monotone Equilibria in Bayesian Games of Strategic Complementarities" (with T. Van Zandt), NBER General Equilibrium Debreu Memorial, UC Berkeley, Berkeley, October, 2005.

"Monotone Equilibria in Bayesian Games of Strategic Complementarities" (with T. Van Zandt), Caltech Conference, Laguna Beach, October, 2005.

"Monotone Equilibria in Bayesian Games of Strategic Complementarities" (with T. Van Zandt), Econometric Society Congress, University College, London, August 2005.

"Competition, Market Structure and Innovation", European Science Foundation and CEPR, IESE Business School, Barcelona, September 2003.

"Coordination Failures and the Lender of Last Resort: Was Bahehot Right after all?" (with J.-C. Rochet), Financial Structure and Monetary Policy Channels, CEPR-CREI, Universitat Pompeu Fabera, Barcelona, July 2003.

"Coordination Failures and the Lender of Last Resort: Was Bagehot Right after all?" (with J.-C. Rochet), Econometric Society European Meeting, International University of Venice, Venice, August 2002.

"Regulating Insider Trading when Investment Matters", European Summer Symposium on Financial Markets, Studienzentrum Gerzensee, Gerzensee, July 2002.

"Industrial Organisation of Banking, Bank Competition and Bank Market Integration", Launching Workshop of the ECB-CFS Research Network on "Capital Markets and Financial Integration in Europe", Center of Financial Studies, Frankfurt, April 2002.

"Dollarization, Bailouts, and the Stability of the Banking System" (with D. Gale), Econometric Society European Meeting, University of Lausanne, Lausanne, August 2001.

"Dollarization, Bailouts, and the Stability of the Banking System" (with D. Gale), European Finance Association Meeting, University of Pompeu Fabra, Barcelona, August 2001.

"Strategic Incentives in Dynamic Duopoly", First World Congress of the Game Theory Society, Palacio de Euskalduna, Bilbao, July 2000.

"Dollarization, Bailouts, and the Stability of the Banking System", European Summer Symposium of Economic Theory, Studienzentrum Gerzensee, Gerzensee, July 2000.

"Lessons from European Banking Liberalization and Integration", Annual Meeting of the American Economic Association, Boston Marriott Copley Place, Boston, January 2000.

"Dynamic Price Competition and Stackelberg Warfare" (with B. Jun), North American Winter Meeting of the Econometric Society, Boston, January 2000.

"Strategic Behavior and Price Discovery" (with L. A. Medrano), European Economic Association Annual Congress, Universidade de Santiago de Compostela, Santiago de Compostela, August-September 1999.

"Dynamic Price Competition and Stackelberg Warfare" (with B. Jun), Econometric Society European Meeting, Universidade de Santiago de Compostela, Santiago de Compostela, August-September 1999.

"Information Aggregation, Strategic Behavior and Efficiency", Econometric Society European Meeting, Humbdolt-Univesität, Berlin, August-September 1998.

"Information Aggregation, Strategic Behavior and Efficiency", European Summer Symposium on Economic Theory, Studienzentrum Gerzensee, Gerzensee, July 1998.

"Strategic Behavior and Price Discovery" (with L. A. Medrano), Annual Meeting of the Western Finance Association, Monterey, California, June 1998.

"Dynamic Price Competition and Stackelberg Warfare" (with B. Jun), Third Spanish Meeting on Game Theory, Universitat de Barcelona, Barcelona, June 1998.

"Price Dynamics and Consumer Learning" (with R. Caminal), Econometric Society European Meeting, University of Toulouse, Toulouse, August 1997.

23

"Strategic Behavior and Price Discovery" (with L. A. Medrano), Northwestern University Microeconomics Theory Summer Workshop, Evanston, August 1997.

"Strategic Behavior and Price Discovery" (with L. A. Medrano), European Summer Symposium Financial Markets, Studienzentrum Gerzensee, Gerzensee, July 1997.

"Dynamic Price Competition with Costly Production Adjustment" (with B. Jun), III International Conference on Economic Theory and Applications, SAET, Antalya, June 1997.

"Social Learning and Costly Information Acquisition", North American Winter Meeting of the Econometric Society, New Orleans, January 1997.

"Imperfect Competition, Risk-Taking and Regulation in Banking", II Jornadas de Economia Financiera, Fundación BBV, Bilbao, June 1995.

"Imperfect Competition, Risk-Taking and Regulation in Banking" (with C. Matutes), Financial Intermediation Workshop, CEPR and CEMFI, Madrid, January 1995.

"Herding and Information Acquisition: Private Effort vs. Riding on Public Information", ECARE, Human Capital and Mobility Network Meeting, Brussels, February 1995.

"Dynamic Duopoly Pricing" (with B. Jun), European Summer Symposium in Economic Theory, Gerzensee, June-July 1994.

"Competition for Deposits, Risk of Failure and Regulation in Banking", Symposium on Financial Intermediation and Corporate Finance, Univ. of Amsterdam, BRC and Tinbergen Institute, Hilversum, May 1994.

"Learning and Rational Expectations Equilibria with Persistent Shocks", Conference on Learning (IAE-UPF), Barcelona, May 1994.

"Learning from Others", Winter Meetings of the Economic Society, Boston, January 1994.

"Learning and Convergence to Rational Expectations with Persistent Shocks", ASSET meeting, Barcelona, October 1993.

"Why Do Market Shares Matter?: An Information-Based Theory", European Economic Association VIII Congress, Helsinki, August 1993.

"Short Term Investment and the Informational Efficiency of the Market", European Network in Financial Markets, Summer Workshop, Gerzensee, July, 1993.

"Short-Term Investment and the Informational Efficiency of the Market", I Jornadas de Economía Financiera ,Fundación BBV, Bilbao, June 1993.

"Convergence to Rational Expectations with Persistent Shocks", XVII Simposio de Análisis Económico, Barcelona, December 1992.

"Convergence to Rational Expectations with Persistent Shocks", Econometric Society Summer Meeting, Brussels, August 1992.

"Competition for Deposits, Risk of Failure and Regulation in Banking", European Economic Association VII Congress, Dublin, August 1992.

"Short Term Investment and the Informational Efficiency of the Market", European Summer Symposium of Economic Theory, Gerzensee, July 1992.

"Why Does Market Share Matter? An Information-based Theory", European Summer Symposium of Economic Theory, Gerzensee, July 1992.

"Dynamic Trading and Rational Expectations in Financial Markets", XVI Simposio de Análisis Económico, Barcelona, December 1991.

"Financial Market Dynamics with Risk Averse Agents", European Economic Association VI Congress, Cambridge, September 1991.

"Banking Competition", Information Economics Meeting, Tilburg, June 1991.

"Banking Competition", XV Simposio de Análisis Económico, Barcelona, December 1990.

"How Fast Do Rational Agents Learn?", International Game Theory Conference, Lumini, October 1990.

"How Fast Do Rational Agents Learn?", Econometric Society World Meeting, Barcelona, August 1990.

"Financial Markets Dynamics with Risk Averse Agents", Econometric Society World Meeting, Barcelona, August 1990.

"How Fast Do Rational Agents Learn?", XIV Simposio de Análisis Económico, Barcelona, December 1989.

"Trade Association Disclosure Rules, Incentives to Share Information and Welfare", Jornadas de Economía Industrial, Madrid, September 1989.

"Collusion with Asymmetrically Informed Firms" (with R. Kihlstrom), Econometric Society Summer Meeting, Munich, September 1989.

"Transmission of Information in Large Markets", Econometric Society Summer Meeting, Bolonia, August 1988.

"Trade Association Disclosure Rules, Incentives to Share Information and Welfare", European Economic Association Third Annual Congress, Bolonia, August 1988.

"Information Transmission in Large Markets", Toledo Meeting of ASSET, Toledo, December 1987.

"Elección Estratégica y Políticas de Precios", Simposio de Análisis Económico, Universidad Autónoma de Barcelona, Barcelona, September 1987.

"Aggregation of Information in Large Cournot Markets", Econometric Society Summer Meeting, Copenhagen, August 1987.

"Information, Flexibility and Competition", European Economic Association, Second Annual Congress, Copenhagen, August 1987.

"On the Strategic Choice of Spatial Price Policy", Econometric Society Summer Meeting, Budapest, September 1986.

"On the Strategic Choice of Spatial Price Policy", European Economic Association, First Annual Congress, Vienna, August 1986.

"Sequential Entry and Welfare with Quantity Commitments", European Association for Research in Industrial Economics Meeting, West Berlin, August 1986.

"Flexibility, Uncertainty and Oligopoly", Econometric Society Winter Meeting, New York, December 1985.

"Nash Equilibrium in Oligopoly Games with Monotone Best Responses", Fifth World Congress of the Econometric Society, Cambridge, MA, August, 1985.

"Entry Deterrence and the Free Rider Problem", European Meeting of the Econometric Society, Madrid, September, 1984.

"Small Income Effects: A Marshallian Theory of consumer Surplus and Downward Sloping Demand", Econometric Society Summer Meeting, Stanford University, Standford, June, 1984.

"Capacity Pre-commitment, Technology Flexibility and Oligopoly Outcomes", Winter Meeting of the Econometric Society, San Francisco, December 1983.

Invited Presentations at Conferences and Seminars:

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", European Breakfasts Seminar at The Peterson Institute for International Economics, Washington, January 2017.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", Seminar at the Office of Financial Research, Washington, January 2017.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), Economic Theory Workshop joint with Applied Theory Workshop, Chicago University, November 2016.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", MEDs Seminar at the Bank of International Settlements, Basel, November 2016.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", Seminar at the Bank of England, London, November 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions", CET/CMS-EMS Kellogg School Theory Seminar Series, Evanston, November 2016.

"Competition and Stability in Banking", Workshop on Economic and Financial Stability, International Monetary Fund, Washington, October 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions", Seminar at the Board of Governors of the Federal Reserve Board, Washington, October 2016.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", Development Economics Conference, The World Bank, Washington, October 2016.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", Macroeconomic Theory Workshop, Rutgers University, New Brunswick, October 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions", Civitas Foundation Finance Seminar, Bendheim Center for Finance, Princeton University, New Haven, October 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), Columbia Decision, Risk and Operations Seminar, Columbia University, New York, October 2016.

"Competition and Regulation in Banking after the Crisis, a Global Perspective", Breakfast Leadership Session, IESE Business School, New York, October 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions", Wharton Finance Micro Seminar, Philadelphia, October 2016.

"High Frequency Trading and Fragility" (with G. Cespa), Wharton Conference on Liquidity and Financial Crises, Wharton Financial Institutions Center, Philadelphia, October 2016.

"Competition and Stability in Banking", Center for Financial Studies, Goethe University, Frankfurt, September 2016.

"High Frequency Trading and Fragility" (with G. Cespa), Swedish House of Finance Seminar, Stockholm School of Economics, September 2016.

"Competition and Stability in Banking: The Role of Regulation and Competition Policy", IIES/SNS Seminar, Stockholm, September 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), Spring 2016 Workshop in Economic Theory, Queen Mary University of London, May 2016.

"Market Power and Welfare in Asymmetric Divisible Good Auctions" (with C. Manzano), UPF Microseminar Series, Barcelona, May 2016.

"Banking and Asset Auctions", Seminar at the European Central Bank, European Central Bank, Frankfurt, July 2015.

"The Beauty Contest and Short-Term Trading", Finance Seminar, Institute of Economics Research (KIER), Kyoto University, April 2015.

"Endogenous Public Information and Welfare in Market Games", Microeconomics/Game Theory Seminar, Institute of Economic Research (KIER), Kyoto University, Kyoto, April 2015.

"Endogenous Public Information and Welfare in Market Games", Microeconomics Workshop Seminar Series, University of Tokyo, Tokyo, April 2015.

"Strategic Complementarity, Fragility, and Regulation", Bank of Japan, Seminar Series, Tokyo, April 2015.

"Endogenous Public Information and Welfare in Market Games", Conference on "Time, Uncertainties & Strategies", Cité Internationale Universitaire de Paris, Paris, December 2014.

"Endogenous Public Information and Welfare in Market Games", École Polytechnique, Paris, December 2014.

"The Welfare Impact of High Frequency Trading", High Frequency Trading Conference, Brevan Howard Centre for Financial Analysis & CEPR Event, London, December 2014.

"Strategic Complementarity, Fragility, and Regulation", Cass Business School, London, September 2014.

"On the Possibility of Informationally Efficient Markets: A Large-Market Rational Expectations Equilibrium Model", Micro lunch seminar series, Chicago Booth School of Business, Chicago, September 2014.

"Endogenous Public Information and Welfare in Market Games", Economic Theory Seminar series, UC Berkeley, Berkeley, April 2014.

"Strategic Complementarity, Fragility, and Regulation", Federal Reserve Bank of San Francisco Seminar series, San Francisco, April 2014.

"Expectations, Liquidity, and Short-term Trading", Finance Seminar, Stanford GSB, Stanford, April 2014.

"Endogenous Public Information and Welfare in Market Games", Economic Theory Seminar series, Stanford GSB, Stanford, April 2014.

"Expectations, Liquidity, and Short-term Trading", Finance Seminar, Haas School of Business, Berkeley, April 2014.

"Endogenous Public Information and Welfare in Market Games", Microeconomics Seminar series, Cambridge University, Cambridge, October 2013.

"Strategic Complementarity, Fragility, and Regulation", 5th Financial Stability Conference, European Banking Center and CEPR, Tilburg, October 2013.

"Strategic Complementarity, Fragility, and Regulation", The Structure of Banking Systems and Financial Stability", Max Planck Institute for Research on Collective Goods, Bonn, September 2013.

"Expectations, Liquidity, and Short-term Trading" (with G. Cespa), Duisenberg School of Finance and Tinbergen Institute Finance Seminar series, Amsterdam, September 2013.

"Expectations, Liquidity, and Short-term Trading" (with G. Cespa), Sciences Po Dpt. of Economics Seminar Series, Paris, September 2013.

"Endogenous Public Information and Welfare in Market Games", Roy-Adres Seminar, PSE-EMS-MSE, Paris, September 2013.

"Endogenous Public Information and Welfare in Market Games", INSEAD Economics and Political Science Seminar Series, Fontainebleau, September 2013.

"R&D Cooperation, Spillovers & Antitrust Policy" (with A. López), Mannheim University Microeconomics Seminar Series, Mannheim, September 2013.

"Endogenous Public Information and Welfare in Market Games", Toulouse School of Economics IO Seminar, Toulouse, May 2013.

"Informational Externalities in Market Games", USC Marshall Finance & Economics Dpt. Seminar Series, Los Angeles, January 2013.

"R&D Cooperation, Spillovers & Antitrust Policy" (amb A. López), Informal IO Workshop, Universitat Pompeu Fabra, Barcelona, January 2013.

"Endogenous Public Information and Welfare", Barcelona GSE Microeconomics Winter Workshop, Barcelona GSE, Barcelona, December 2012.

"Endogenous Public Information and Welfare", Seminario en el Banco de Italia, Roma, October 2012.

"Endogenous Public Information and Welfare", MIT Macro Series Seminar, Cambridge, MA, October 2012.

"Expectations, Liquidity, and Short-term Trading" (with G. Cespa), Sloan School of Management Finance Seminar series, Cambridge, MA, October 2012.

"Endogenous Public Information and Welfare", Seminar at Dpt. of Economics, Yale University, New Haven, October 2012.

"R&D Cooperation, Spillovers & Antitrust Policy" (with A. López and R. Faulí-Oller), Industrial Organization and Spatial Economics Conference, National Research University Higher School of Economics, Saint Petersburg, October 2012.

28

"Estabilidad Financiera, Competencia y Regulación", Seminario de Verano de la Universidad del País Vasco, San Sebastián, July 2012.

"Competition and Financial Stability, Regulation, and the Crisis", Seminar at Financial Services Authority, London, July 2012.

"Strategic Complementarity, Fragility, and Regulation", Seminar at the Bank of England, London, July 2012.

"Competencia, Regulación e Integración Financiera", Seminar BBVA, Madrid, July 2012.

"A Large-market Model of Rational Expectations Equilibria", Arizona State University Theory Seminar Series, Phoenix, April 2012.

"A Large-market Model of Rational Expectations Equilibria", Caltech Bray Theory Workshop, California Institute of Technology, Pasadena, April 2012.

"Endogenous Public Information and Welfare", Seminar in UCLA, Los Angeles, April 2012.

"The Challenges in the Energy Sector: A Look at Europe", keynote speech at the IESE Global Energy Day Conference, Madrid, February 2012.

"El Paradigma de la Competencia en el Sector Bancario después de la Crisis", keynote speech at the workshop "The Future of the Financial Industry", FUNCAS, Madrid, January 2012.

"Strategic Complementarity, Fragility, and Regulation", Banca d'Italia-CEPR Conference on Money, Banking and Finance, Rome, December 2011.

"Higher Order Expectations, Illiquidity, and Short-term Trading", CNMV Conference on Securities Markets, Madrid, November 2011.

"Strategic Complementarity, Fragility, and Regulation", CAREFIN Conference, Università Bocconi, Milan, October 2011.

"Endogenous Public Information and Welfare", Seminar at Stockholm School of Economics, Stockholm, October 2011.

"Strategic Complementarity, Fragility, and Regulation", Seminar at Institute for International Economic Studies, Stockholm University, Stockholm, October 2011.

"Strategic Complementarity, Fragility, and Regulation", Seminar at Kellogg School of Economics, Chicago, September 2011.

"Endogenous Public Information and Welfare", Workshop on Applied Theory Seminar, Booth School of Economics, Chicago, September 2011.

"Competition Policy and Regulation in Banking", Searle Antitrust Conference, Northwestern University, Chicago, September 2011.

"Public and Private Learning from Prices, Strategic Substitutability and Complementarity, and Equilibrium Multiplicity" (with C. Manzano), Conference on Information and Coordination, London Business School, London, May 2011.

"Strategic Supply Function Competition with Private Information", Kellogg Management and Strategy Seminars, Evanston, April 2011.

"Strategic Supply Function Competition with Private Information", Economic Theory Workshop Series, University of Chicago, Chicago, April 2011.

"Public and Private Learning from Prices, Strategic Substitutability and Complementarity, and Equilibrium Multiplicity" (with C. Manzano), Economic Theory Seminar Series, Princeton University, Princeton, April 2011.

"Strategic Supply Function Competition with Private Information", ORFE Seminar Series, Princeton University, Princeton, April 2011.

"Endogenous Public Information and Welfare", UPF Internal Micro and Behavioral Economics Seminar Series, Universitat Pompeu Fabra, Barcelona, March 2011.

"Strategic Supply Function Competition with Private Information", Nuffield Economic Theory Series Seminar, Oxford University, Oxford, October 2010.

"Strategic Supply Function Competition with Private Information", Hong Kong University of Science and Technology Economics Seminar Series, Hong Kong, August 2010.

"Regulation After the Crisis", Finlawmetrics Annual Conference, Bocconi Universtiy, Milan, June 2010.

"Stress, Crises, and Policy", Federal Reserve Bank of New York Financial Intermediation Seminar Series, New York, April 2010.

"Stress, Crises, and Policy", Workshop on IO and Banking, IESE Business School, Barcelona, March 2010.

"Strategic Supply Function Competition with Private Information", Centro de Economía Aplicada Regular Seminar Series, Universidad de Chile, Santiago de Chile, November 2009.

"Competition and Stability in Banking", Annual Conference of the Central Bank of Chile, Santiago de Chile, November 2009.

"Competencia y Estabilidad en el Sector Bancario", Comisión Nacional de la Competencia, Madrid, October 2009.

"Asset Auctions, Information and Liquidity", European Central Bank Seminar Series, Frankfurt, October 2009.

"Competition and Stability in Banking. A New World for Competition Policy?", CEPR/ESI 13th Annual Conference "Financial Supervision in an Uncertain World", Venice, September 2009.

"Asset Auctions, Information and Liquidity", International Monetary Fund Brown Bag Seminar Series, Washington D.C., September 2009.

"Asset Auctions, Information and Liquidity", Board of Governors of the Federal Reserve System, Washington D.C., September 2009.

"Competition in Supply Functions", US Department of Justice, Washington D.C., September 2009.

"Information Aggregation in Markets", Yale University, New Haven, September 2009.

"Information Aggregation in Markets", Massachussets Institute of Technology (MIT), Cambridge, CA, July 2009.

"Information Aggregation in Markets", London School of Economics, London, June 2009.

"Competition and Stability in Banking", Office of Fair Trading Seminar Series, London, May 2009.

"Competition and Stability in Banking", UK Competition Commission External Speaker Series, London, May 2009.

"Strategic Supply Function Competition with Private Information", STICERD Economic Theory Seminar, London, May 2009.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Finance Seminar Series, UCLA, Los Angeles, January 2009.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Finance Seminar Series, Haas School of Business, UC Berkeley, Berkeley, January 2009.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Seminar, Stanford, January 2009.

"Strategic Supply Function Competition with Private Information", MIT/Harvard Theory Seminar, Boston, New, Haven, October 2008.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Wharton Finance Seminar, Pennsylvania, October 2008.

"Strategic Supply Function Competition with Private Information", Columbia Industrial Organization Seminars, New York, October 2008.

"Strategic Supply Function Competition with Private Information", Yale Microeconomic Theory Workshop, New Haven, October 2008.

"Dynamic Trading and Asset Prices: Keynes vs. Hayek" (with G. Cespa), Yale Finance and Accounting Faculty Seminars, New Haven, October 2008.

"Regulation and Competition Policy in Banking", CESifo Conference on Financial Market Regulation in Europe, Munich, January 2008.

"Dynamic Trading, Asset Prices, and Bubbles" (with G. Cespa), at HEC-INSEAD-PSE joint workshop, Paris School of Economics, Paris, April 2007.

"Monotone Bayesian Equilibrium in games of Strategic Complementarities", in Conference in honor of Jim Friedman, Duke University, Raleigh, November 2006.

"Information Sharing: Economics and Antitrust", The Pros and Cons of Information Sharing, Swedish Competition Authority, Stockholm, November 2006.

"Why and Where Do Headquarters Move?" (with V. Strauss-Kahn), Seminar "The Importance of Headquarters to National Economies", Amsterdam Center for Law and Economics, Amsterdam, October 2006.

"Innovation and Competitive Pressure", Antitrust Seminar of the Netherlands Competition Authorities, The Hague, October 2006.

"Integration of European Banking: the way forward", Fundación BBVA-IVIE, Valencia, September 2006.

"Integration of European Banking: The Way Forward" (with P. Barros, E. Berglöf, P. Fulghieri, J. Gual and C. Mayer), Conference on Competition, Stability and Integration in European Banking, CEPR, Brussels, May 2005.

"Innovation and Competitive Pressure", CEPR conference on Applied IO "The Role of Competition in the New Economy", Hydra, May 2004.

"Globalizació i Economia", Clausura, Programa de Cooperació Educativa Universitat-Empresa, Universitat Autònoma de Barcelona i Cambra de Comerç de Barcelona, Barcelona, July 2003.

"Innovation and Competitive Pressure", CEPR Workshop on "Competition Policy in International Markets", Toulouse, October 2003.

"Coordination Failures and the Lender of Last Resort: Was Bagehot Right after all?" (con J.-C. Rochet), Center for Financial Studies, Financial Institution Center, Eltville, June 2003.

"Stock Market and Information", Colloque Marché Bouseir, Collège de France, Féderation Paris-Jourdan, Paris, May 2003.

"Globalizació i Geografia del Poder Econòmic", Summer Course on "Costos i Beneficis de la no-Espanya: una Perspectiva Econòmica", Universitat Catalana d'Estiu, Prada, August 2002.

"Dollarization, Bailouts, and the Stability of the Banking System", IV Foro de Finanzas, Colegio Universitario de Segovia, Segovia, July 2002.

"Globalización, Centros de Decisión Empresarial y Localización de la Actividad Económica", Seminar on "Cap a un Model d'Equilibri Territorial a Espanya", UIMP, Barcelona, July 2002.

"Industrial Organization of Banking, Bank Competition and Bank Market Integration", Launching Workshop of the ECB-CFS Research Network on Capital Markets and Financial Integration in Europe, Frankfurt am Main, April 2002.

"Private Information, Strategic Behavior and Efficienty in Cournot Markets", en Competition Strategies and Competition Policy in the Information Economy, Yrjö Jahnsson Foundation, Helsinki, April 2002.

"External Discipline and Financial Stability", EEA Congress, Lausanne, September 2001.

"Imperfect Competition, Risk Taking, and Regulation in Banking" (with C. Matutes), Jornadas Anuales de Economía, Banco de Uruguay, Uruguay, July 2001.

"Competencia en los Servicios Financieros", Summer course on "Competencia y Regulación en la Economía Española", Universidad Complutense de Madrid, Madrid, July 2001.

"Insider Trading and its Regulation", International Seminar on New Institutional Economics, Max Planck Project Group Common Goods: Law, Politics and Economics (Bonn) and University of Bonn, Schloss Ringberg, Rottach-Egern, June 2001.

"Restructuring Financial Regulation in the European Monetary Union", Financial Supervision of Banks and Specialized Banks in the EU Conference, European University Institute, Florence, December 2000.

"Information Aggregation, Strategic Behavior, and Efficiency in Cournot Markets", 9th Annual WZB Conference on Industrial Organization "Antitrust Issues in International Markets", Berlin, November-December 2000.

"Imperfect Competition, Risk Taking and Regulation in Banking", Annual Bank conference and Development Economics, World Bank, Washington D.C., April 2000.

"Banking Supervision in the European Monetary Union", Sveriges Riksbank Workshop on Challenges for Modern Central Banking, Stockholm, January 2000.

"Banking Supervision in the European Monetary Union", CEPR European Summer Institute 1999 "Conference on Fiscal Policy, Imbalances, the Monetary Transmission Mechanism and Prudential Supervision: Issues Facing Europe's Central Bankers", Lisbon, September 1999.

"La Supervisión Bancaria en la UME", Encuentro Internacional "El Euro y sus repercusiones sobre la Economía Española", Fundación BBV, San Sebastián, November 1998.

"La Regulació dels Sectors Privatitzats", Jornada dels Economistes sobre "Els reptes de l'Economia davant la Globalització", Col·legi d'Economistes, Barcelona, October 1998.

"Imperfect Competition, Risk Taking and Regulation in Banking", Conference on "The Monetary Transmission Mechanism and Financial Integration", Banco de Portugal, Lisbon, November 1996.

"Social Learning and Rational Expectations", European Economic Association X Congress, Prague, September 1995.

"Regional Convergence and its Sources: Evidence from Spain", Economic Policy Twentieth Panel Meeting, Frankfurt, October 1994.

"Banking Competition and Regulation", Conference on Money and Intermediation, Paribas, Paris, December 1993.

"Concentración y Competencia", VII Jornadas de Defensa de la Competencia, Tribunal de Defensa de la Competencia, Alcalá de Henares, November 1993.

"Estado Actual y Perspectivas Futuras del Marco Regulador de las Entidades Financieras", Seminar "Las entidades Financieras y la Competitividad", Summer University of San Sebastián, September 1993.

"The Speed of Learning in Rational Expectations", European Summer Symposium of Economic Theory, Gertzensee, July 1993.

"The Supervisory Function of the ESCB", Paolo Baffi Center Conference, Universitá Commerciale Luigi Bocconi, Milano, February 1993.

"Edgeworth and Modern Oligopoly Theory", European Economic Association VII Congress, Dublin, August 1992.

"Aspectos Microeconómicos del Futuro Banco Central Europeo", Simposium on Economía y Finanzas Internacionales: Una Perspectiva Europea, Fundación Banco Exterior, Madrid, December 1991.

"European Central Bank: Safe and Sound", Paolo Baffi Center Conference Macroeconomic Policy at Stage Two, Milano, September 1991.

"Competition for Deposits, Risk of Failure and Regulation in Banking", European Network in Financial Markets, Summer Workshop, Gerzensee, July 1991.

"Banking Competition and European Integration", CEPS Conference on European Banking and Financial Integration, Brussels, November 1990.

"Learning Dynamics in Real and Financial Markets", Game Theory Seminar, Universidad Internacional Menéndez Pelayo, Alicante, November 1990.

"Regulatory Reform in European Banking", European Economic Association V Congress, Lisboa, September 1990.

"Banking Competition", European Network in Financial Markets, Summer Workshop, Gerzensee, July 1990.

"Aggregation of Information and Learning", Bonn Workshop in Mathematical Economics, Bonn, June 1990.

"Financial Market Dynamics with risk averse agents", Financial Contracting Conference, Banque de France, Paris, June 1990.

"Banking Competition and European Integration", CEPR/IMI Conference on European Financial Integration, Rome, January 1990.

"Deregulation and Competition in Spanish Banking", Fourth Annual Congress of the European Economic Association, Ausburg, September 1989.

"Competition in Spanish Banking", Seminario sobre Perspectivas del Sector Bancario Español, Universidad Internacional Menéndez y Pelayo, Barcelona, July 1990.

"Competition in Spanish Banking", Conference European Banking after 1992, Solomon Brothers Center for Research in Financial Institutions, New York, April 1989.

"Competition in Spanish Banking", Conference European Banking after 1992, INSEAD, Paris, February 1989.

"Collusion by Asymmetrically Informed Firms", Conference Dynamiques des Marchés et Structures Industrielles, Paris, November 1988.

"Cournot and the Oligopoly Problem", Third Annual Congress of the European Economic Association, Bolonia, August 1988.

"La Industria Española en el Horizonte de 1992. Problemas y Factores de Competitividad", Workshop on Public Spending, Universidad Internacional Menéndez Pelayo, Santander, August 1988.

"Information, Flexibility and Competition", Information Economics Conference, Paris, June 1987.

"Information Transmission and Monopolistic Competition: A Mechanism Approach", Resource Allocation Seminar, Fundación Ortega y Gasset, Madrid, June 1987.

"Aggregation of Information in Large Cournot Markets", C.S.O.I. Conference on Theoretical Industrial Organization, University of Pennsylvania, Philadelphia, May 1986.

"Aggregation of Information in Large Cournot Markets", ORSA/TIMS Joint National Meeting, Los Angeles, CA, April 1986.

"Competencia Estratégica en la Teoría de la Organización Industrial", Workshop on Industrial Organization, Universidad Internacional Menéndez Pelayo, Santander, July 1985.

"Commitment, Flexibility and Market Outcomes", Workshop on Monopolistic Competition and Oligopoly Theory, Universidad Internacional Menéndez Pelayo, Segovia, August 1984.

"Entry Deterrence and the Free Rider Problem", Workshop on Strategic Competition, Northwestern University, Evanston, August 1984.

Selected Talks and Panels:

"Competition Policy and Regulation in the Banking Sector", talk at Bruegel, Brussels, November 2016.

"Regulatory Reform. Where to From Here?" (roundtable), 19thAnual International Banking Conference, Federal Reserve Bank of Chicago, November 2016.

"Can we have both Competitive and Stable Banking?", public talk, London School of Economics, London, November 2016.

"La economía en un incierto 2007", Programa de continuidad Alumni, IESE Business School, Barcelona, October 2016.

"Implications of the New Resolution Regimes for Regulators" (roundtable), Executive Seminar on Banking Resolution, European University Institute, Florence, July 2016.

"Competition and Banking Stability" (roundtable), Competition Policy in Financial Markets, Centre for Competition Policy, Norwich, June 2016.

Presentation of the V Reform Monitor on the Project Spanish Reforms, FUNCAS, Madrid, April 2016.

"Microeconomic Lessons for Public Policy" (roundtable), International Scientific Symposium on Hans-Werner Sinn's Retirement, CESifo, Munich, January 2016.

"Tendències que afavoreixen el creixement empresarial" (roundtable), XV Jornada del Col·legi d'Economistes de Catalunya, Barcelona, November 2015.

"Will Basel III work?" talk at the European Commission DG Financial Markets, Brussels, February 2015.

"Perspectivas de la Economía Mundial para 2015: Crecimiento, Energía y Trabajo", (roundtable) Programa de Continuidad de Alumni, IESE Business School, Barcelona December 2014.

"Banking Structure, Financial Stability and International Competition" (roundtable), in "Challenges for the Future of Banking. Regulation, Supervision and the Structure of Banking", London, November 2014.

"Reforma Económica i Cohesió Social", talks with Germà Bel, "Diàlegs: Desigualtat i Democràcia", CaixaForum, Barcelona, November 2014.

"Roundtable on the Electricity Market" (roundtable), XXIX Jornades en Economia Industrial, BGSE, Barcelona, September 2014.

"Institutional Architecture of Competition and Regulation" (roundtable), 18th Centre for Competition and Regulatory Policy Workshop, UAB, Barcelona, 11 July 2014.

"El Posicionament de Barcelona", XIII Coloquio PPSRC, IESE, Barcelona, June 2014.

"La Agenda de las Reformas del Sector Público para la Recuperación", lecture at IESE Business School, Barcelona, March 2014.

"El Paper de l'Estat i la Política Econòmica", "Visions Econòmiques de Futur", Obra Social de la Caixa, Barcelona, February 2014.

"El Model Barcelona" (roundtable), a Universitat Opina, Associació d'Amics de la UAB, Barcelona, February 2014.

"Financial System Regulation" (roundtable), at Barcelona GSE Winter workshops, Barcelona, October 2013.

"Banking, Fragility, and Regulation", lecture to PhD students, Cambridge University, Cambridge, October 2013.

"Retomando la Senda del Crecimiento" (roundtable), in program "Creando la Empresa del 2020", IESE Business School, Barcelona, April 2013.

"Competition, Innovation and the Single Market" (roundtable), in "European Competition Forum", European Commission, Brussels, February 2013.

"El Horizonte de las Reformas Regulatorias en el Marco de la Unión Europea" (roundtable), in "Encuentro del Sector Energético", Madrid, February 2013.

"L'Energia en l'Economia Global: Competitivitat, Subministrament i Medi Ambient", Seminario de Gestión Ambiental, Fundación Gas Natural Fenosa, Barcelona, December 2012.

"Arquitectura Financiera: Internacional y Europea", Borsa de Barcelona, November 2012.

"Globalización e Innovación en las Empresas", X Meeting of Asian and Spanish Women, Casa Asia, Barcelona, November 2012.

"Management of Liquidity Regulation in Times of International Crisis" (roundtable), in LACEA-LAMES Annual Meeting, Lima, November 2012.

"Situación del Mercado de la Energía" (roundatable), in Foro de Energía, Parlament de Catalunya, Barcelona, September 2012.

"Reopening the Industrial Policy Debate", East Forum 2012, Rome, July 2012.

"Políticas Públicas para la Reactivación", Lecture, XII Coloquio "Servicio Público-Gestión Privada: Políticas Públicas para la Reactivación", IESE Business School, Public-Private Sector Research Center, Barcelona, June 2012.

"The Euro Crisis and Greece: What is Next?" (with G. Hardouvelis y M. Olsen), Programa de Continuidad de Alumni, IESE Business School, Barcelona, June 2012.

"Quo Vadis, Europa" (with J. Reed), Sessión de Continuidad de Alumni, IESE Business School, Barcelona, April 2012.

"El Panorama Global, el Caos del Euro y el Laberinto Español" (with A. Argandoña y A. Pastor), Programa de Continuidad de Alumni, IESE Business School, Barcelona, April 2012.

"Climate Change Regulation: Energy Efficiency in Buildings in Europe", Madrid, April 2012.

"Las Salidas a la Crisis", Ciencia para Directivos Seminar Series, APD y Madrid, Madrid, April 2012.

"Climate Change Regulation: Energy Efficiency in Buildings in Europe", Public-Private Sector Research Center, IESE Business School, Madrid, April 2012.

"Presentación del Informe Cesifo 2012", Fundación BBVA, Madrid, April 2012.

"Per ser Més Industrials", Panel in Círculo de Economía, Barcelona, April 2012.

"Perspectives Econòmiques a Europa després de 10 anys de l'Euro" (with A. Mas-Colell and J. Oliu), Presentation of the EEAG report 2012, Círculo de Economía, Barcelona, March 2012.

Moderator of "PYMES y Administración: Remando Juntas", Public-Private Sector Research Center, IESE Business School, Barcelona, March 2012.

"Políticas Económicas para Salir de Una Crisis", Programa de Continuidad de Alumni, IESE Business School, Barcelona, February 2012.

"Gestió del Patrimoni de la Generalitat de Catalunya", Special Session of the Public-Private Sector Research Center, Barcelona, January 2012.

"¿Saldremos de la Crisis? Políticas y Previsiones", Programa de Continuidad de Alumni, IESE Business School, Barcelona, October 2011.

"Cómo Salir Reforzados de la Crisis", XI Coloquio Servicio Público-Gestión Privada, IESE Business School, Barcelona, June 2011.

"Los Retos del Sector Energético: Europa y España", IX Encuentro del Sector Energético, IESE Business School, Madrid, May 2011.

"Una Perspectiva de la Economía Global" (roundtable), en XXIV Reunión Anual de Empresas Patrono, Cátedras y Centros de Investigación, IESE Business School, Barcelona, May 2011.

"La Crisis del Euro", Programa de Continuidad de Alumni, IESE Business School, Barcelona, May 2011.

"The EEAG Report on the European Economy 2011", Cercle d'Economia, Barcelona, March 2011.

"The EEAG Report on the European Economy 2011", Fundación BBVA, Madrid, March 2011.

"Futuro y Retos de la Moneda Única Europea", Programa de Continuidad de Alumni, IESE Business School, February 2011.

"Economia i Sector Financer", Ateneu Barcelonès, Barcelona, September 2010.

"La Competitivitat a Catalunya", Esmorzars amb Jordi Pujol, Barcelona, September 2010.

"The Governance and Regulation of Financial Institutions. Lessons from the Crisis", (panelist at) ECGI-CEPR-IESE, Madrid, June 2010.

"Joan M. Esteban's Contributions" (roundtable), at Universitat Autònoma de Barcelona, Bellaterra, May 2010.

"Los Retos de la Política Energética en Europa", Foro Permanente de la Energía, Bilbao, May 2010.

"La Crisis y Salidas", Observatorio Económico de Andalucía, Sevilla, April 2010.

"The EEAG Report on the European Economy 2010", Cercle d'Economia, Barcelona, April 2010.

"La Competitividad en Cataluña. Temas Escogidos", IESE Business School, Barcelona, March 2010.

"The EEAG Report on the European Economy 2010", Fundación BBVA, Madrid, March 2010.

"Competition, Concentration and Stability in the Banking Sector", OCDE, Paris, February 2010.

"Competitivitat a Catalunya", Societat Catalana d'Economia, Barcelona, February 2010.

"Competitivitat a Catalunya", Esmorzars del Cercle pel Coneixement, Barcelona, December 2009.

"The New Role of Government in Corporate Governance", panelist in session "Government as Investor", ECGI-Brookings Trasantlantic Corporate Governance Dialogue Annual Conference, Washington D.C., September 2009.

"Financial Regulation Reform: A European Perspective", FinReg21 web seminar, Stanford, June 2009.

"Reforming Financial Regulation and Supervision: Going Back to Basics", panelist in session "Why Did Regulation Fail?", Banco de España and World Bank, Madrid, June 2009.

"El Reto del Sector Público ante la Crisis", talk at the IX Coloquio Sector Público-Gestión Privada, IESE Business School, Barcelona, June 2009.

"Crisis Financiera y Propuestas de Reforma del Sistema", talk at the Fundació Ernest Lluch, Barcelona, May 2009.

"Lessons from the Regulatory Crisis and Regulatory Reform", talk at the PSC conference "Fer front a la crisi", Barcelona, February 2009.

"Temas Avanzados en Economía Energética" (roundtable), at the AEEE annual meeting, Seville, January 2009.

"The Financial Crisis – Its Impact in Spain" (roundtable), CNMV in Foro de Finanzas, ESADE, Barcelona, November 2008.

"El Momento Económico Internacional" (roundtable), Cercle d'Economia, Barcelona, October 2008.

"El Sector Financiero ante la Crisis de Liquidez", talk at the Encuentro de Verano de la Universidad Internacional Menéndez Pelayo "Los Retos de la Economía Española. La Crisis Global de Liquidez y sus Efectos Económicos", Santander, July 2008.

"El Sistema de Peatges a Catalunya. Análisi i Avaluació d'Estratègies" (roundtable), Cambra de Comerç de Barcelona, Barcelona, June 2008.

"La Colaboración Público-Privada: Principios y Reglas Aplicables a la Materia" (roundtable), in conference "Concesiones públicas en la Unión Europea", Cercle d'Economia, Barcelona, June 2008.

"Infraestructures i Competitivitat", Talk at Jornada de la Secretaria per a la Mobilitat de la Generalitat de Catalunya, S'Agaró, Barcelona, February 2008.

"Liberalització del Sector Energètic. Oportunitats per a les Empreses", talk at conference "Gestió Eficient dels Recursos Energètics en l'Empresa", APD, Barelona, October 2007.

Conference in Orkestra, Instituto Vasco de Competitividad, Deusto, October 2007.

"Els Grans Reptes de País"; Closing speech at the II Jornada Generacional d'Economia, Grup Hayek, Associació Catalana de Professionals I Espai Vicenç Vives, ESADE, Barcelona, October 2007.

"Banking and Finance Session", panelist, LECG Summit at Como, "A discussion of Competition Policy, Law and Economics", Como, October 2007.

Last updated January 2017

"L'AMB en el Món: Posicionament Nacional i Internacional" (roundtable), at V Jornada Tècnica del Pla Estratègic Metropolità de Barcelona, "Les Bases del Nou Model Metropolità Barcelona 2020", Barcelona, July 2007.

"La Regulación del Sector Energético", talk at the conference "Los Retos de la Economía Española: el Sector Energético", Cursos de Verano de la Universidad Internacional Menéndez Pelayo", Santander, July 2007.

"Comunitats Autònomes i Infraestructures", talk at the course "Comunitats Autònomes: Finançament, Solidaritat i Polítiques de Despesa", CUIMPB-Centre Ernest Lluch, Barcelona, July 2007.

"La Empresa y la Defensa de la Competencia" (roundtable), at Seminar "Competencia y Empresa", Foment del Treball Nacional-Tribunal Català de Defensa de la Competència, Barcelona, May 2007.

"Regulación, Competencia y Fusiones en Europa"; Seminar at the Oficina Económica del Presidente del Gobierno, Madrid, May 2007.

"Dynamic Trading, Asset Prices, and Bubbles", Seminar at Università Bocconi, Milan, May 2007.

"Roundtable on Energy" at Eighth CEPR Conference on Applied Industrial Organization, "Imperfect Competition and Dynamics in the New Economy", Tarragona, May 2007.

"El Modelo de Competencia a Examen; la Visión desde los Distintos Mercados", Pannelist in "XII Encuentro del Sector de las Telecomunicaciones: El futuro del sector a debate", Madrid, May 2007.

Presentation of the EEAG Report on the European Economy 2007, Fundación BBVA, Madrid, and Cercle d'Economia, Barcelona, March 2007.

"¿Qué Podemos Esperar del 2007?", Jornada de Continuidad, IESE, Barcelona, February 2007.

"The Assessment for Non-Horizontal Mergers", CRA Competition Conference, Brussels, December 2006.

"Dynamic Trading, Asset Prices and Bubbles", Seminar at New York University, New York, November 2006.

"Banking and Regulation in Emerging Markets: the Role of External Discipline", Seminar at the Federal Reserve Bank, New York, November 2006.

"Information Sharing, Economics and Antitrust", at "The Pros and Cons of Information Sharing" conference, Swedish Competition Authority, Stockholm, November 2006.

"L'Atracció d'Inversió Estrangera: Factors Clau perquè Barcelona i Catalunya Puguin Competir en el Mercat Internacional" (roundtable), at "Metrópolis Barcelona, el projecte comú", Pla Estratègic Metropolità de Barcelona, Barcelona, November 2006.

"Banking and Regulation in Emerging Markets: The Role of External Discipline", Bank of China, Pekin, July 2006.

"Globalización, Fusiones y Competencia", Observatorio PyME, Universidad de Bolonia, Argentina, April 2006.

Presentation of the EEAG Report on the European Economy 2006, Fundación BBVA, Madrid, and Cercle d'Economia, Barcelona, March 2006.

"Virtual Capacity as a Remedy – Electricity Mergers" (Roundtable Chair), ACE Annual Meeting, Copenhaguen, December 2005.

"Implicaciones del Crecimiento Asiático para Europa", Foro Casa Asia, Barcelona, December 2005.

"Economic Models and Simulations", European Competition Authorities, CRA International, Brussels, December 2005.

"Merger Control and Competition Policy", CEPR conference, Paris, November 2005.

"Mergers: GE/Instrumentarium", Annual Meeting of the Association for Competition Economics, Siena, December 2004.

"Unilateral and Coordinated Behavior", Annual Meeting of the Association for Competition Economics, Madrid, November 2003.

"Competition Policy in Banking", Meeting of European Competition Authorities, Dublin, September 2001.

"Ha Perdut Barcelona la Capitalitat Econòmica d'Espanya? Ha Guanyat la del Sud d'Europa?" (roundtable), XI Symposium on l'Economia Catalana i la Unió Europea, Barcelona, June 2001.

"Preventing International Financial Vulnerability" (roundtable), at European Summer Symposium of Economic Theory, Gerzensee, Switzerland, July 2000.

"Globalización y Localización de la Actividad Económica", 3º Jornada Nuevas Fronteras de la Política Económica, CREI (UPF), Barcelona, May 2000.

"Banking Competition in Spain", Panel IV on Markets, Competition and Regulation. Conference on Spain in Europe: Economic Perspectives and Challenges, King Juan Carlos I of Spain Center, New York University, New York, December 1999.

"La Regulación Arbitraria y la Restricción de la Competencia en los Mercados", comments on the Seminar "Raíces Históricas de los Problemas de la Economía Actual", Real Academia de Ciencias Morales y Políticas, Madrid, April 1999.

"Corporate Governance in Spain" (roundtable), at International Conference in Corporate Governance, Institut Català de Finances, Sitges, October 1998.

"EMU and Regional Asymmetry", International Workshop on Devolution of Power to Regions and Cities, New York University, New York, May 1998.

"La Banca ante la UME", Jornadas Ahorro Corporación, Las Palmas de Gran Canaria, March 1998.

"Las Regiones ante la Unión Monetaria" (roundtable), Workshop Fundación Argentaria, Madrid, November 1997.

"La Unión Monetaria Europea" (roundtable), XXI Simposio de Análisis Económico, Barcelona, December 1996.

"El Tráfico de Información Privilegiada: Economía, Política y Ética", VI Coloquio de Ética Empresarial y Económica, IESE, Barcelona, October 1996.

"La Competencia en la Banca Española", La Banca Mañana Meeting, Euroforum, Madrid, April 1996.

"El Efecto del FEDER en la Desigualdad Regional en España", informative session of the communication about "Aplicación y evaluación de los Fondos Europeos de la Comisión General de las Comunidades Autónomas", Palacio del Senado, Madrid, May 1995.

"Macro-Economics Imbalances", Panel of the Conference Twenty Years of Iberian Democracy: an Assesment, Harvard University Center for European Studies, Cambridge, MA, April 1995.

"La Dimensión Etica de las Instituciones y Mercados Financieros", Fundación BBV Meeting, Madrid, June 1994.

"Política industrial", Cátedra Gumersindo de Azcárate Meeting, Universidad Carlos III, Madrid, November 1993.

"Política industrial" (roundtable), CEPR-Fundación Barbié de la Maza Seminar, Universidad Internacional Menéndez Pelayo, Santander, July 1993.

"Separation of Authority in Financial Regulation" (roundtable), European Network in Financial Markets Workshop, Institut d'Economie Industrielle, Toulouse, June 1993.

"Problemas y Perspectivas en el Proceso de Integración Monetaria Europea", Real Colegio Complutense, Harvard University, Cambridge MA, December 1992.

"Directions for Future Research" (roundtable), in "Competition and Industrial Policies, Industrial Organization and Competition Policy Conference", CEPR-Institut Anàlisi Econòmica, Barcelona, April 1992.

"Banking Competition and Regulation", ESF Industrial Organization Conference, Toulouse, January 1992.

"Microeconomic Aspects of the European Central Bank", Center for European Studies, Harvard University, Cambridge, MA, November 1991.

"The Industrial Organization of Banking Markets", Ecole d'Eté Mediterranéenne d'Economie Industrielle, Corsica, September 1991.

"El Sistema Bancario Español en el Contexto Internacional" (roundtable), Colegio de Economistas, Madrid, Junio 1991.

"Estrategia Regional i Integració Europea", III Simposi sobre Economia Catalana, Barcelona, January 1991.

"Estrategias de la Banca en la Perspectiva de 1992", Instituto de Empresa, Madrid, November 1990.

"Regulación e Integración Financiera", Seminario CEPR-Fundación Barbié de la Maza sobre Integración Europea, Universidad Internacional Menéndez Pelayo, Santander, July 1990.

"La Nueva Competencia", Seminary on Perspectivas del Sector Financiero, Universidad de Málaga, Málaga, April 1990.

"Impacto del Mercado Único en los Sectores Industriales Españoles", Seminary on "Modelos Cuantitativos de la Economía Española", Instituto de Estudios Fiscales, Madrid, February 1990.

"The Impact of "1992" on Banking Competition in Europe", CEPR Lunchtime Meeting, Jean Monnet House, London, February 1990.

"El Impacto de la Integración Europea en el Sector Real", Seminar on CEPR-Fundación Barbié de la Maza sobre Integración Europea, Universidad Internacional Menendez Pelayo, Santander, August 1989.

"Información y Mercados de Futuros", Seminar on Mercados de Futuros Financieros, Instituto de Análisis Económico, UAB, Barcelona, June 1989.

"El Impacto de la Integración Europea en los Sectores Industriales Españoles", Seminar on Armonización Fiscal y Mercado Unico, Instituto de Estudios Fiscales-Euroforum, El Escorial, Madrid, June 1989.

Courses Taught, *UC Berkeley, U. Pennsylvania, Harvard U., NYU, INSEAD (Fointainebleau), UAB, IESE and UPF (Barcelona):*

Graduate (Ph. D.)
Game Theory
Industrial Organization
Information Economics
Microeconomics
Behavioral Microeconomics

Graduate (topics)
Information and Learning
Banking
Market Microstructure
Oligopoly and Monopolistic Competition Theory
Pricing in Financial Markets with Asymmetric Information
Financial Crises and Crashes

MBA
Competition Policy and Business Strategy

Global Executive MBA
Markets, Competition and Government

Undergraduate
Game Theory
Industrial Organization
Intermediate Microeconomics

Short Courses (Banking, Information and Learning, Game Theory, Oligopoly, Systemic Risk, Financial Stability):

BGSE (2015, 2016), Studycenter Gerzensee (2013), University of Mannheim (2008), University of Tokio (2004), Banco de Uruguay (2001), Studycenter Gerzensee (1998, 2014), University of Pennsylvania (1994), New York University (1999), Université Louis Pasteur (Strasbourg, 1992), Bank of Finland (1991), Universidad de Alicante (1989), Université de Marseille (G.R.E.C) (1989). Universidad de Zaragoza (1989).

Ph.D. Thesis Supervised:

Luis Ángel Medrano, "Elección Endógena de Órdenes Límite y Órdenes de Mercados en Modelos de Expectativas Racionales", Universitat Autònoma de Barcelona, 1995.

Ramon Faulí, "Incentivos y Competencia en Oligopolios", Universitat Autònoma de Barcelona, 1995.

Lluís Bru, "Vertical Relationships and Productive Efficiency", Universitat Autònoma de Barcelona, 1999.

Simon Messner, "Market Design under Asymmetric Information and Stock Market Efficiency", Universitat Autònoma de Barcelona, 1999.

Giovanni Cespa, "Three Essays in Market Microstructure Theory", Universitat Autònoma de Barcelona, 1999.

Albert Banal, "Effects of Information Sharing, Internal Organisation and Risk Aversión on Horizontal Mergers", Universitat Autònoma de Barcelona, 2003.

Ugur Akgün, "Analyses of Mergers in Oligopolistic Markets", Universitat Autònoma de Barcelona, 2004.

Ioana Chioveanu, "Pricing implications of some actual business practices", Universitat Autònoma de Barcelona, 2004.

Jose-Luis Peydro-Alcalde, "Essays on Financial Distress", INSEAD, Fontainebleau, 2005.

Rajkamal Iyer, "Essays in Banking and Financial Intermediation", INSEAD, Fontainebleau, 2005.

Anna Bayona, "Essays on Incomplete Information in Markets", IESE Business School, 2014.

Ph.D. Thesis (Member of the Committee):

Byoung Jun, "Essays on Market Structure and Performance", University of Pennsylvania, 1987.

Yasushi Asami, "A Game-Theoretic Approach to the Theory of Rent", University of Pennsylvania, 1987.

Jordi Roca, "Política de Rendes i Neocorporativisme a la Transició Política Espanyola", Universitat Autònoma de Barcelona, 1990.

David Pérez, "Essays on Research and Development", DELTA, ENSAE, Paris, 1991.

Svend Albaek, "Essays on Industrial Organization and Incomplete Information", CORE, Université Catholique de Louvain, 1991.

Murat Yildizoğu, "Barriéres à l'Entrée et Flexibilité", Université Louis Pasteur, Paris, 1992.

Isabel Grilo, "Essays on Price Competition and Product Differentiation", CORE, Université Catholique de Louvain, 1993.

Frédéric Palomino, "Speculation and Market Selection with Imperfect Competition", Institut Universitaire Europeen, Florencia, 1994.

Mariano Ventosa, "Modelado de la Explotación de la Generación en Mercados Eléctricos Liberalizados Mediante el Problema Complementario", Universidad Pontificia Comillas de Madrid, 2000.

Bruno Deschamps, "Essays on Strategic Forecasting and Hyperbolic Discounting", Université Libre de Bruxelles, 2006.

Aitor Erce, "Sovereign Debt Crises: On Causes and Remedies", European University Institute, 2007.

Francesco Sangiorgi, "Essays in Information and Asset Pricing", Universitat Pompeu Fabra, 2007.

Gastón Llanes, "Essays on the Economics of Innovation", Universidad Carlos III de Madrid, 2008.

Peter Hoffmann, "Pre-Trade Transparency in Closing Call Auctions", Universitat Pompeu Fabra, 2008.

Andrés Hervás, "Essays on the Economics of Telecommunications and Digital Business", Universitat Autònoma de Barcelona, 2009.

Daniel Ferrés, "Essays on Corporate Governance and Cartel Prosecution", IESE Business School, 2014.

Jun Chen, "Essays on Information Acquisition", Stockholm School of Economics, 2016.

Master Thesis Supervised:

Alfredo Font, "Efectos de la Información Pública en los Mercados Financieros", Universitat Autònoma de Barcelona, 1989.

Josep Manel Comajuncosa, "Efecto del Coeficiente de Caja en Condiciones de Competencia Imperfecta", Universitat Autònoma de Barcelona, 1989.

Antonio Avila, "Medidas de concentración en los sectores industriales", Universitat Autònoma de Barcelona, 1990.

Lluís Bru, "Integración Vertical, Estructuras de Mercado y Bienestar", Universitat Autònoma de Barcelona, 1991.

Antonia Díaz, "Incentivos a los Gestores de Empresas Públicas en Mercados Oligopolísticos", Universitat Autònoma de Barcelona, 1990. Premio al Desarrollo de la Investigación, 1990.

Ramon Faulí, "Incentivos y Competencia en Oligopolio", Universitat Autònoma de Barcelona, 1990.

Luis Angel Medrano, "Integración Vertical y Comercio Internacional", Universitat Autònoma de Barcelona, 1991.

José Vicente Rodríguez, "Desregulación en Mercados Financieros: una modelización de los efectos de los coeficientes de caja y de la desaparición de barreras institucionales a la entrada", Universitat Autònoma de Barcelona, 1990.

Lluís Torrens, "Aspectos Estratégicos en Integración Horizontal", Universitat Autònoma de Barcelona, 1991. Premio al Desarrollo de la Investigación, 1991.

Luis Angel Medrano, "Ódenes Límite y Órdenes de Mercado", Universitat Autònoma de Barcelona, 1992.

Simon Messner, "Welfare Properties of Rational Expectation Equilibria", Universitat Autònoma de Barcelona, 1996.

Ugur Akgün, "Mergers with Supply Function Competition", Universitat Autònoma de Barcelona, Septiembre 2001.

Ioana Chioveanu, "Competition in Complementary Goods Markets", Universitat Autònoma de Barcelona, 2001.

Sevinc Cukurova, "Hedge Fund Characteristics and Optimal Portfolio Allocation with Hedge Funds", Universitat Pompeu Fabra, 2008.

Rodrigo Escudero, "Essays in Applied Economics", IESE Business School, 2009.

Funded Research Projects:

"Avances en Organización Industrial, Finanzas y Economía Experimental", Plan Nacional de I+D+I, Ministerio de Economía y Competitividad, 2016-2018.

"Avances en Economía Industrial y Finanzas", Plan Nacional de I+D+I, Ministerio de Economía y Competitividad, 2012-2014.

"Information and Competition", European Research Council Advanced Grant, 2009-2014.

"Avances en Economía Industrial, Teoría de Juegos y Finanzas", Plan Nacional de I+D+I, Ministerio de Educación y Ciencia, 2008-2011.

"Building Economics", Consolider Program, Ministerio de Educación y Ciencia, 2007 -2010.

"Innovación, juegos dinámicos y mercados financieros", CICYT, Ministerio de Educación y Ciencia, 2005.

"Information and Financial Markets", PriceWaterhouse Coopers INSEAD Initiative, 2003-2005.

"Information Release During a Crisis", INSEAD R&D, 2003.

"Information and Learning in Markets", INSEAD R&D, 2002.

"Competition Efficiency and Innovation", INSEAD R&D, 2002.

"Globalization and location of economic activity", INSEAD R&D, 2002.

Dirección General de Investigación Científica y Técnica, Spain, 1999-2001: "Information Aggregation and Market Microstructure".

Institut d'Estudis Autonòmics - Fundación BBVA, Spain, 1999-2000: "Políticas autonómicas y equilibrio territorial".

Fundación ICO, Spain, 1998-1999: Monografía sobre Teoría del Oligopolio.

Comisión Nacional del Sistema Eléctrico, Spain, 1997-2000: "Competencia y regulación en el sector eléctrico".

TMR Network, European Commission, 1998-2002: "The Evolution of Market Structure in Network Industries".

TMR Network, European Commission, 1998-2002: "The Industrial Organization of Banking and Financial Markets in Europe", Scientific coordinator.

Ministerio de Economía y Hacienda, Spain and EFRD, 1997-1999: "Determinantes del crecimiento a nivel nacional y regional".

Fundación COTEC, Spain, 1996-1997: "Innovación y Crecimiento".

Human Capital Program, 1996-1997: "Frontiers in Institutional Economics", Network of Research Institutes.

Fundación BBV, Spain, 1995: "Competencia imperfecta, selección de inversiones y regulación en el sector bancario español".

Dirección General de Investigación Científica y Técnica, Spain, 1994-1999: "Avances en la Microeconomía Aplicada de Mercados y Organización: Competencia Dinámica, Interacción Estratégica y Regulación".

EC Human Capital Program, 1994-1997: "Consolidating Research Excellency in Southern Europe II".

EC Human Capital Program, 1994-1996 Euroconference: "European Symposium in Economic Theory".

Comissió Interdepartamental de Recerca i Innovació Tecnològica, Generalitat de Catalunya, Spain, 1994-1995: "Grup de Recerca de Qualitat".

Comissió Interdepartamental de Recerca i Innovació Tecnològica, Generalitat de Catalunya, Spain, 1994: "Integració Europea i Evolució Industrial".

Comissió Interdepartamental de Recerca i Innovació Tecnològica, Generalitat de Catalunya, Spain, 1994: "Catalunya, les Regions Europees i la Integració Econòmica".

EC Human Capital Program, 1993-1996: "Consolidating Research Excellency in Southern Europe I".

EC Human Capital Program, 1993-1994: "Frontiers in Institutional Economics", Network of Research Institutes.

Comisión Asesora de Investigación Científica y Técnica, IAE (CSIC), Spain, 1992-1995: "Competencia y Regulación en Mercados No Competitivos".

Ministerio de Economía y Hacienda, Spain and EFRD, 1992-1994, "Los efectos del mercado único en el desarrollo regional y su incidencia sobre la planificación a largo plazo en las regiones del objetivo nº 1-España".

Comisión Asesora de Investigación Científica y Técnica, Spain, 1991-1993: "Competencia Imperfecta y Mercados Financieros".

Fundación BBV, Spain, 1991-1992: "Competencia Bancaria".

Instituto de Estudios Fiscales, Spain, 1991: "Impacto de la Integración Europea en la Industria Española".

Comisión Asesora de Investigación Científica y Técnica, Spain, 1988: "Competencia Imperfecta y Regulación Pública".

Comisión Asesora de Investigación Científica y Técnica, Spain, 1988-1991: "Comportamiento Racional y Estructuras de Mercado".

Instituto de Estudios Fiscales y FEDEA, Spain, 1989: "Impacto de Mercado Único en los Sectores Industriales Españoles".

Fundación FIES, Spain, 1988-1989: "Dimensión y Eficiencia de la Empresa Financiera".

Fishman-Davidson Center Grant, University of Pennsylvania, 1987-1990: "Regulating Information Agencies".

Last updated January 2017

Instituto de Estudios Fiscales, Spain, 1987: "Taxonomía y Modalidades de Funcionamiento de Mercados".

Fishman-Davidson Center Grant, University of Pennsylvania, 1987: "Information and Competitive Advantage".

N.S.F. Information Science IST-8519672, 1986 - 1988: "Uncertainty, Information and Oligopoly".

Research Fund Grant, University of Pennsylvania, 1986 - 1987: "Entry Deterrence and Industry Structure".

Last updated January 2017

Fellowships:

Summer Research Fellowship, Department of Economics, University of Pennsylvania, 1985: "Strategic Competition in Industrial Organization".

Summer Research Fellowship, University of Pennsylvania, 1984: "Small Income Effects and Marshallian Theory".

D.O. Sumek and S.M. Tasheira Scholarship, University of California, Berkeley, 1982-83.

Wilson and Albert M. Flagg Scholarship, University of California, Berkeley, 1981-82.

Beca Ampliación Estudios, Banco de España, 1979-81.

Organization of Professional Meetings:

Member of the Organizing Committee, European Summer Symposium in Economic Theory, Studienzentrum Gerzensee, Gerzensee, July 1992-

Organizer, session "Information Aggregation and Welfare" in 16th SAET Conference on Current Trends in Economics, IMPA, Rio de Janeiro, July 2016.

Member of the Program Committee and Organizer session "The Monitoring and Regulation of Banks", in Conference Financial Intermediation Research Society (FIRS), Lisboa, June 2016.

Organizer, session "Perspectivas del sector energético e implicaciones para la economía", IESE Business School, Barcelona, June 2016.

Organizer, XV Coloquio Servicio Público-Gestión Privada: Fronteras de la Economía Digital, IESE Business School, Public-Private Sector Research Center, Barcelona, June 2016.

Organizer, session "Information Aggregation in Markets" in 15th SAET Conference on Current Trends in Economics, University of Cambridge, Cambridge, July 2015.

Coorganizer, "Information Frictions and Learning", Barcelona GSE Summer Forum, Barcelona June 2015.

Member of the Program Committee, Conference Financial Intermediation Research Society (FIRS), Reykjavik, May 2015.

Coorganizer, Information and Market Frictions, Barcelona GSE Summer Forum, Barcelona, June 2014.

Coorganizer, Conference on Financial Stability and Regulation, IESE Barcelona, March 2014.

Member of the Program Committee, Conference Financial Intermediation Research Society (FIRS), Quebec City, June 2014.

Coorganizer, Workshop on Information, Competition and Market Frictions, Barcelona GSE Summer Forum, Barcelona, June 2013.

Member of the Program Committee, Conference Financial Intermediation Research Society (FIRS), Dubrovnik, June 2013.

Coorganizer, Jornada sobre la Reforma del Sector Eléctrico, IESE Business School, Barcelona, March 2013.

Member of the Scientific Committee, "Jornades ACCO sobre els Efectes No Desitjats de la Regulació", Catalan Competition Authority, Barcelona, October 2012.

Last updated January 2017

Member of the Scientific Committee, "The Second CNMV International Conference on Securities Markets", Madrid, September 2012.

Organizer, XII Coloquio Servicio Público-Gestión Privada: Políticas Públicas para la Reactivación, IESE Business School, Public-Private Sector Research Center, Barcelona, June 2012.

Coorganizer, 4th Barcelona IO Workshop, Public-Private Sector Research Center, IESE Business School, Barcelona, March 2012.

Organizer, XI Coloquio Servicio Público-Gestión Privada: Cómo Salir Reforzados de la Crisis Económica, IESE Business School, Barcelona, June 2011.

Organizer, Workshop on Industrial Organization: Energy and Climate Economics, IESE Business School, Barcelona, June 2011.

Organizer, Research Workshop on Industrial Organization: Internationalization, Innovation and Firm Performance, IESE Business School, Barcelona, March 2011.

Coorganizer, V Meeting of the Association for Competition Economics in Spain, Centro SP-SP, IESE Business School, and Fundación Rafael del Pino, Madrid, November 2010.

Coorganizer, II Workshop "Armand Carabén" on Football Economics, Centro SP-SP, IESE Business School, Barcelona, October 2010.

Organizer, VII Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, October 2010.

Coorganizer, X Coloquio Sector Público-Gestión Privada, Centro SP-SP, IESE Business School, Barcelona, June 2010.

Member of the Organizing Committee, Conference ECGI-CEPR-IESE "The Governance and Regulation of Financial Institutions. Lessons from the Crisis", Madrid, June 2010.

Coorganizer, III Conference on the Economics of Advertising and Marketing, Centro SP-SP, IESE Business School, Barcelona, June 2010.

Coorganizer, Research Workshop on Industrial Organization: Search and Matching, Centro SP-SP, IESE Business School, Barcelona, June 2010.

Coorganizer, Research Workshop on Industrial Organization and Banking, Centro SP-SP, IESE Business School, Barcelona, March 2010.

Coorganizer, I Workshop "Armand Carabén" on Football Economics, Centro SP-SP, IESE Business School, Barcelona, November 2009.

Coorganizer, IV Meeting of the Association for Competition Economics in Spain, Centro SP-SP, IESE Business School, and Fundación Rafael del Pino, Madrid, November 2009.

Coorganizer, III Jornada del Sector Audiovisual: Regulación y Mercados", Centro SP-SP, IESE Business School, Barcelona, November 2009.

Organizer, IX Coloquio Servicio Público-Gestión Privada, Centro SP-SP, IESE Business School, Barcelona, June 2009.

Organizer, VI Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, June 2009.

Member of the Organizing Committee, "Liquidity and Volatility in Today's Markets", NYSE Euronext Amsterdam & Tinbergen Institute Workshop, Amsterdam, June 2009.

Member of the Organizing Committee, Conference in honor of Andreu Mas-Colell, Barcelona, June 2009.

Organizer, Foro Energético, "La Energía en España a Debate", Centro SP-SP, IESE Business School, Madrid, March 2009.

Organizer, V Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, March 2009.

Coorganizer, Research Workshop on Industrial Organization: Markets and Society, Centro SP-SP, IESE Business School, Barcelona, March 2009.

Coorganizer, Research Workshop on Telecommunications, Centro SP-SP, IESE Business School, Barcelona, February 2009.

Coorganizer, II Jornada del Sector Audiovisual: Regulación y Mercados", Centro SP-SP, IESE Business School, Barcelona, November 2008.

Coorganizer, III Meeting of the Association for Competition Economics in Spain, Centro SP-SP, IESE Business School, and Fundación Rafael del Pino, Madrid, November 2008.

Member of the Organizing Committee, Final Conference of the European Corporate Governance Training Network, ECGP, Barcelona, September 2008.

Organizer, VII Coloquio Sector Público-Gestión Privada: Infraestructuras de Obra Civil y Vivienda, Centro SP-SP, IESE Business School, Barcelona, July 2008.

Organizer, IV Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, May 2008.

Organizer, III Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, April 2008.

Member of the Organizing Committee, Conference on Privatization, Partnership and Public Delivery (PPPSD), "Government and Governance", CEPR and SP-SP, IESE Business School, Barcelona, April 2008.

Organizer, Conference "Fifty Years of the Treaty: Assessment and Perspectives of Competition Policy in Europe", Centro SP-SP, IESE Business School, Barcelona, November 2007.

Coorganizer, I Jornada del Sector Audiovisual: "Regulación y Mercados", Centro SP-SP, IESE Business School, Barcelona, November 2007.

Coorganizer, II Meeting of the Association for Competition Economics in Spain, Madrid, November 2007.

Organizer, VII Coloquio Servicio Público-Gestión Privada, "El Crecimiento Económico y el Sistema de Pensiones", Centro SP-SP, IESE Business School, Barcelona, June 2007.

Coorganizer, Conference on Complementarities and Information, Centro SP-SP, IESE Business School and CesIFO, Barcelona, June 2007.

Organizer, Research Workshop on Industrial Organization and Finance, Centro SP-SP, IESE Business School, Barcelona, June 2007.

Organizer, XII Meeting of the Telecommunications Industry, Centro SP-SP, IESE Business School, Madrid, May 2007.

Coorganizer, VIII CEPR Conference on Applied Industrial Organisation. "Imperfect Competition and Dynamics in the New Economy", IESE Business School and CEPR, Tarragona, May 2007.

Organizer, II Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, May 2007.

Organizer, I Forum on Regulation and Competition, Centro SP-SP, IESE Business School, Barcelona, April 2007.

Organizer, Research Workshop on Industrial Organization and Finance, Centro SP-SP, IESE Business School, December 2006.

Coorganizer, I Meeting of the Association for Competition Economics in Spain, Madrid, November 2006.

Organizer, 6º Meeting Public Sector-Private Management, Centro SP-SP, IESE Business School, Barcelona, October 2006.

Coorganizer of the Conference about "Corporate Finance and Industrial Organization", école Normale Supérieur, Paris, December 2003.

Organizer of "Competition Policy and Regulation in International Markets, BBVA Foundation, Madrid, February 2003.

Member of the Organizing Committee, "The Firm and its Stakeholders: The Evolving Role of Corporate Finance", CEPR/CERP/Fondazione Courmayeur-CNPDS/FEEM Conference, Courmayeur, March 2001.

Organizer, Conference on Spain in Europe: Economic Perspectives and Challenges, King Juan Carlos I of Spain Center, New York University, New York, December 1999.

Member of the Program Committee for the 26th Anniversary Meeting of the European Finance Association, Helsinki, August 1999.

Member of the Program Committee for the Annual Meeting of the European Financial Management Association, Paris, June 1999.

Organizer, Conference on New Ideas on Corporate Governance, IAE and Institut Català de Finances, Barcelona, October 1998.

Member of the Program Committee for the 25th Anniversary Meeting of the European Finance Association, Fontainebleau, August 1998.

Organizer, Competition and Regulation in Network Industries, IAE and Fundación Ramon Areces, Barcelona, June 1998.

Organizer, International Workshop on Market and Credit Risk Management: New Evaluating Techniques, Fundación BBV, San Sebastian, October 1996.

Organizer, Conference on Market Microstructure, CEPR-IAE, Barcelona, February 1996.

Member of the Program Committee of the World Congress of the Econometric Society, Tokyo, August 1995.

Organizer, Conference on Learning, UPF-IAE, Barcelona, May 1994.

Organizer, Industrial Organization and Finance, CEPR-Fundación BBV Conference, San Sebastian, April 1994.

Organizer, Conference CEPR-Institute of Análisis Económico-Universitat Pompeu Fabra, Regional Trade and Growth, Barcelona, November 1993.

Organizer, Financial Intermediation in the Construction of Europe, CEPR-Fundación BBV Conference, San Sebastian, March 1992.

Chairman Program Committee (Economics), Econometric Society European Meeting, Cambridge, September 1991.

Member of the Program Committee, ASSET, Florence, October 1989.

Member of the Program Committee, Econometric Society European Meeting, Munich, August 1989.

Member of the Program Committee, European Economic Association Bologna Meeting, Bologna, August 1988.

Member of the Program Committee, Annual Meeting of European Association for Research in Industrial Economics, Madrid, August 1987.

Director, Workshop on "Concentración empresarial y competitividad: España ante la CEE", Universidad Internacional Menéndez Pelayo, Santander, August 1988.

Organizer, 1988 European Information Economics Meeting, Bank of Spain, Madrid, June 1988.

Organizer, Symposium on European Industrial Policy, Consejo Superior de Investigaciones Científicas, Barcelona, June 1987.

Organizer, Concentration Year in Industrial Organization, Universitat Autònoma de Barcelona, January-June 1987.

Organizer, Conference on Theoretical Industrial Organization, University of Pennsylvania, Philadelphia, May 2-3, 1986.