IEB
Institut
d'Economia
de Barcelona

Document de treball de l'IEB 2015/12

STRATEGIC INVESTMENT IN MERCHANT TRANSMISSION: THE IMPACT OF CAPACITY UTILIZATION RULES

Federico Boffa, Viswanath Pingali, Francesca Sala

Energy Sustainability

Documents de Treball de l'IEB 2015/12

STRATEGIC INVESTMENT IN MERCHANT TRANSMISSION: THE IMPACT OF CAPACITY UTILIZATION RULES

Federico Boffa, Viswanath Pingali, Francesca Sala

The Barcelona Institute of Economics (IEB) is a research centre at the University of Barcelona (UB) which specializes in the field of applied economics. The IEB is a foundation funded by the following institutions: Applus, Abertis, Ajuntament de Barcelona, Diputació de Barcelona, Gas Natural, La Caixa and Universitat de Barcelona.

Within the IEB framework, the **Chair of Energy Sustainability** promotes research into the production, supply and use of the energy needed to maintain social welfare and development, placing special emphasis on economic, environmental and social aspects. There are three main research areas of interest within the program: energy sustainability, competition and consumers, and energy firms. The energy sustainability research area covers topics as energy efficiency, CO2 capture and storage, R+D in energy, green certificate markets, smart grids and meters, green energy and biofuels. The competition and consumers area is oriented to research on wholesale markets, retail markets, regulation, competition and consumers. The research area on energy firms is devoted to the analysis of business strategies, social and corporative responsibility, and industrial organization. Disseminating research outputs to a broad audience is an important objective of the program, whose results must be relevant both at national and international level.

The **Chair of Energy Sustainability of the University of Barcelona-IEB** is funded by the following enterprises ACS, CEPSA, CLH, Enagas, Endesa, FCC Energia, HC Energia, Gas Natural Fenosa, and Repsol) through FUNSEAM (Foundation for Energy and Environmental Sustainability).

Postal Address:
Chair in Energy Sustainability
Institut d'Economia de Barcelona
Facultat d'Economia i Empresa
Universitat de Barcelona
C/John M Keynes, 1-11
(08034) Barcelona, Spain
Tel.: + 34 93 403 46 46
ieb@ub.edu
http://www.ieb.ub.edu

The IEB working papers represent ongoing research that is circulated to encourage discussion and has not undergone a peer review process. Any opinions expressed here are those of the author(s) and not those of IEB.

Documents de Treball de l'IEB 2015/12

STRATEGIC INVESTMENT IN MERCHANT TRANSMISSION: THE IMPACT OF CAPACITY UTILIZATION RULES [*]

Federico Boffa, Viswanath Pingali, Francesca Sala

ABSTRACT: In this paper we look at the relative merits of two capacity utilization regimes in the merchant electricity transmission network: Must offer (Mo) where the entire capacity installed is made available for transmission and Non Must Offer (NMo) where some capacity could be withheld. We look at two specific cases: (i) Demand for transmission varies across time, and (ii) Vertical integration is allowed between investors in transmission network and electricity generators. In the case of time-varying demand under Mo, we find that a monopolist may underinvest in transmission when compared to NMo, although NMo may lead to more capacity withholding. In the case of vertical integration, we find that when the market power is with the generators of the exporting node, without vertical integration no welfare-enhancing merchant investment would occur. Further, if the generators in the importing node have market power, which of the two regimes is welfare enhancing depends on the parameter values. In case vertical integration is better, then Mo is better than NMo. Finally, we also argue that the incentive to collude among various transmission network investors is mitigated with Mo in place.

JEL Codes: L94, D24

Keywords: Electricity transmission, merchant lines, capacity utilization, vertical integration, collusion

Federico Boffa
Free University of
Bolzano & IEB
School of Economics and
Management
Piazza dell Università 1
39100 Bolzano, Italy
Email: fboffa@unibz.it

Viswanath Pingali
Indian Institute of Management
Ahmedabad
Vastrapur, Ahmedabad
India 380015
Email: viswanath@iimahd.ernet.in

Francesca Sala
Competition and Markets Authority
Email: francesca.sala@unibocconi.it

---

[*] Federico Boffa gratefully acknowledges funding from the Free University of Bolzano. We thank Giampaolo Arachi, Carlo Andrea Bollino, Jakub Kastl, Lucia Parisio, Amedeo Piolatto, Paolo Polinori and seminar participants at Bocconi, Universidad de Alicante, Università Bicocca, and session participants at ERSA, SIE, EARIE for comments and suggestions. All errors are ours.

1 Introduction

Till recently, two important segments of electricity markets - transmission and distribution - were regarded as examples of natural monopolies, whose ownership (or at least management) should be left in the hands of public sector/government. However, technological advancements in the transmission sector have spurred the debate on the feasibility of merchant investments, and welfare outcomes thereof in the electricity sector. Merchant investments in the transmission sector refer to investments made by non-governmental (private) investors who are transferred the property rights of the line. As Joskow and Tirole (2005) point out, merchant investments rely, "[O]n competition, free entry and decentralized property-rights based institutions, and market-based pricing of transmission service to govern transmission investment." These merchant lines are regarded as effective means to solve the problem of transmission capacity deficit, which has been a problem for several countries across the world, including the European countries. With the entry, and subsequent expansion of renewable energy supply, which significantly affects energy prices (see, for instance, Clò and D'Adamo, 2014), the economic effects of shortfalls are further exacerbated. For example, a recent report by ENTSO-E (2012) estimates that in Europe alone, 52300 km of high voltage transmission lines have to be added by 2020.

For this reason, while the debate on welfare effects of merchant investments is still on-going, an increasing number of markets, including the EU countries, Australia and Argentina, have moved towards allowing them. Within this policy framework that contemplates merchant transmission, some key questions emerge: How should the transmission market be designed and regulated, should the generators themselves be allowed to invest in the transmission network, etc. Given the importance of the questions pertaining to market design, Joskow and Tirole's (2005) claim that "… there has been surprisingly little research on the institutions governing transmission network," still remains valid.

In this context, our paper contributes to the existing literature by theoretically characterizing welfare effects of two aspects of the market design - the mode of capacity utilization and vertical integration between generators and merchant investors. To elaborate further, we compare the effects on welfare and competitiveness of transmission sector under two alternative settings: (i) The investor has to offer the entire installed capacity for transmission (a 'must offer' (Mo) condition), and (ii) The investor can choose the amount of capacity that can be offered for transmission (a non-must offer (NMo) condition). On the prima facie, it is not clear which of the alternatives is welfare enhancing. An Mo provision prohibits capacity withholding, thereby mandating the line's owner to make available the full line's capacity at the market price. While it has been generally recognized that these constraints have to be imposed on existing non-merchant lines (often built under regulated regimes), it is not clear whether or not such rules should be applicable to the merchant investment case as well. Imposition of 'Must Offer' (Mo) provision can inhibit entry of new investors, or induce investors to inefficiently downsize their investments. On the other hand, it is clear that since a 'Non-Must Offer' (NMo) provision encourages capacity withholding, it can create certain deadweight loss *ex post*. Therefore, characterizing the circumstances under which one alternative is welfare enhancing over the other, and the competitive structure that needs to prevail become important from a policy perspective.

A prominent feature of electricity transmission market is the fluctuating demand across various time periods. The first issue we investigate in this paper is to understand the effects of Mo and NMo in the case where there are multiple periods with varying demand. In this scenario we model both monopoly situation as well as sequential entry. Under monopoly an interesting trade-off emerges with Mo provision. Intuitively, if the first mover installs capacity keeping peak period in mind, then the price of transmission in off-peak period is essentially lower (or even zero). On the contrary, NMo allows the monopolist to plan for peak period, and still serve the lean period by withholding sufficient capacity. Therefore, Mo provision can lead to the monopolist under-investing in the market in order to keep lean period prices higher. We find that the monopoly capacity invested is weakly larger under NMo when compared to Mo. Further, profits under Mo are weakly lower when compared to NMo. When we allow for sequential entry, however, the results are not unambiguous. For some parameter values we show that NMo encourages greater transmission of electricity, and allows more easy entry than when compared to Mo. Brunekreeft and Newbery (2006) answer slightly similar question in the context of single period without demand fluctuations. They show that in a scenario with multiple potential entrants and sequential entry with quantity competition, Mo provision yields mixed results. Mo provides a powerful form of commitment device for a first mover investor in order to deter the entry of other potential investors. Such pre-emptive investment is not always possible under the NMo provision because, if the first mover were to invest in excessive capacity, he might find it in his interest to withhold some capacity should entry indeed take place. While such commitment may lead to higher profit and higher capacity choice of the first mover, the overall economy may suffer because, under certain conditions, it reduces overall investment in the transmission network.

The second issue we investigate is to characterize the effects of vertical integration between merchant investors and electricity generators, and the welfare properties of the capacity utilization regimes Mo and NMo, under these circumstances. In the legal scholarship, the question of the desirability of vertical integration has been analyzed by Nowak (2010), who argues that such integration can hinder efficiency in the market, and by de Hauteclocque and Rious (2011), who argue that such vertical integration ought to be allowed.

Therefore, an important question to understand here is under what conditions is such integration better (or worse) from an economic efficiency standpoint. This question is particularly significant when the nodes are asymmetric in the efficiency of electricity generation, and some generators have market power in one of the nodes. We show that in the case in which the generator in the efficient node has market power (monopoly), the choice regime (Mo or NMo) does not make a difference. Only the vertically integrated generator, and not an independent merchant investor, has an incentive to invest in merchant transmission. This becomes an important result from a policy perspective. The main lesson is that in markets where efficient nodes are characterized by the presence of significant market power to the generators, merchant investment by vertically integrated firms improves welfare, regardless of whichever capacity utilization regime is in place. This result is similar to Van Koten (2011), who, albeit in a very different framework (capacity is allocated through an explicit auction with many bidders with private values) finds that the the value of merchant investment is larger if it is undertaken by an investor who owns an efficient generator in the exporting zone. Sauma and Oren (2009) also obtain a similar result, but their analysis does not consider the differential incentives brought about by Mo and NMo respectively.

When the inefficient node has market power, on the other hand, we find that the results are not so straightforward. There are cases where allowing for vertical integration would lead to reduction in consumer welfare. Further, if there is vertical integration, Mo is generally less harmful than NMo is. This result mirrors that obtained by Joskow and Tirole (2000), although in a different framework, and in particular in comparing financial transmission rights vis-à-vis physical transmission rights. Therefore, our results agree with de Hauteclocque and Rious (2011) - who claim that merchant investment by generators ought to be allowed - only in the case where the generators in efficient zone exhibit market power. In the other case of generators in inefficient node having greater market power, the claim by Nowak (2010) seems more justified.

A final issue we address in this paper concerns collusive behavior on the part of merchant investors. The economics literature has suggested several ways to model collusion. A common insight is that excess capacity left idle, can be used as a threat to punish the defector. Therefore, if there is a fear of collusion among merchant investors, the policy maker should consider imposing Mo as against NMo in order to preclude the usage of excess capacity as a threat.

Finally, observe that, in the context of liberalized electricity markets, the Mo rule on merchant investments corresponds to awarding the merchant investor financial transmission rights (FTRs) on the line, or physical trasnmission rights (PTRs) coupled with a use-it-or-lose-it (UIOLI) provision. On the other hand, NMo may be regarded as equivalent to awarding the merchant investor "unconstrained" (that is, not associated to a use-it-or-lose it provision) PTRs.

The main findings of the paper from a policy perspective, can be summarized as follows: (i) In the case of time-varying demand, more research is required before concluding which policy choice (Mo or NMo) is better. Theoretically speaking, while we see greater capacity installed under NMo it need not necessarily translate into higher transmission. (ii) In the case where efficient node has market power, the regulator has little choice but to allow vertical integration, because only the generator has any incentive to invest in merchant transmission. (iii) In case there is a possibility of collusion, Mo regime should be imposed.

The questions addressed in this paper relate to merchant investments and the ensuing regulation and market design in the context of electricity transmission. However, these questions have broader policy implications beyond electricity industry itself. Any industry that operates significantly through transmission and distribution channels – Oil and Natural Gas, for instance – would find these questions relevant from policy perspective. The natural gas industry has many features similar to the electricity industry, and relies on extensive transmission networks. In the Indian case, for example, a part of the pipeline network is held by the public sector refineries like Indian Oil Corporation and Hindustan Petroleum Corporation. In the US Oil and Natural Gas market, Shell, which is also one of the primary producers of natural gas, owns significant amount of pipeline network. Therefore, welfare implications characterized in this paper become relevant in these cases as well.

In the next section, we sketch our basic model, and characterize the simple equilibrium. In the next section, we look extend the model to consider time varying demand function. Subsequently, in the next section, we extend this further to incorporate what happens when merchant investors also have market power in generating sectors, either in the exporting or the importing node. Finally, we discuss the aspect of collusion among merchant investors. The final section concludes.

2 Model Setup

We consider merchant investments in energy transmission capacity when capacity costs are sunk once incurred, and the production technology exhibits increasing returns to scale. We assume a standard setting for the energy market: a two-node network, with no transmission losses. A transmission line interconnects the two nodes: North (N) and South (S). We denote the aggregate supply of generators in Region I to be q_i, $I = N, S$. Without loss of generality, we assume that N has a more efficent generation sector than S. The aggregate cost function in the N is $C_N(q_N) = c_N q_N$, with $c_N > 0$. Similarly, for S, the aggregate cost function is given by $C_S(q_S) = c_N q_S + \frac{1}{2} c_S q_S^2$, with $c_S > 0$.

Assume that the demand for energy in S is given by: $D_S(p_S) = a - p_S$. There is no demand for electricity in N.[1] In the baseline version of our model, we will assume perfect competition in the generation sector. We will relax this assumption in susbequent extensions. The assumptions of perfect competition in the generation sector and efficient market design (EMD) (Schweppe et al., 1988) yield the following:

$$Q = \frac{a - c_N}{1 + c_S} + \frac{c_S}{1 + c_S} q$$

where Q is the equilibrium energy consumption in the S and q is the overall flow on the transmission line. The total amount of electricity that can flow between the nodes is constrained by total capacity, which is given as sum of capacities installed by individual investors. How investors choose equilibrium capacities under the two modes of capacity utilization (Mo versus NMo) forms the main point this paper intends to make. Further, the equilibrium nodal price difference

---

[1] Another way to interpret this is to say that the demand in Node N is normalized to zero. Therefore, this assumption is without loss of generality.

$\eta = p_S - p_N$, is given by:

$$\eta = (a - c_N)\frac{c_S}{1+c_S} - \frac{c_S}{1+c_S}q$$

Let us define $\alpha = a - c_N$, with $\alpha > 0$, and $\beta = c_S/(1+c_S)$, with $0 < \beta < 1$. Substituting these, we obtain:

$$Q(q) = \alpha(1-\beta) + \beta q \tag{1}$$

and

$$\eta(q) = \alpha\beta - \beta q \tag{2}$$

The equation 2 can be considered as the demand for transmission.

We assume that all the firms in the transmission market share the same affine cost function. For installing a capacity level k, every firm faces the following cost function:

$$C\left(k\right) = F + rk$$

where r is the constant per-unit cost of capacity expansion, and F represents the fixed cost incurred. We adopt the standard simplifying assumption that $r \leq \frac{\alpha\beta}{2}$.

There are two potential investors in the market: a first mover (represented by I) and an entrant (represented by E). We consider the following timeline of the game:

1. In the first stage the first mover chooses a transmission capacity and incurs a sunk variable cost, rk_I.
2. A potential entrant observes this and chooses to enter only if it is profitable to do so. In case he enters, he incurs a fixed cost of F.
3. Firm E, if it enters, chooses capacity k_E and, simultaneously, the two firms choose the transmission flows $q_j \leq k_j$, for $j = I, E$. Observe that Mo imposes the additional restriction that $q_j = k_j$ unless if the capacity is not fully required.

The first mover and the entrant (if it decides to enter) choose their output levels (i.e., their actual transmission flows) simultaneously. These output levels are bound upwards by their respective installed capacities.

In this game, the first mover may be in one of the following situations. He could prevent entry by simply installing the monopoly capacity. In this case, using Dixit's (1980) terminology, entry is blockaded. If entry is not blockaded, two (sub-game perfect Nash) equilibria exist, involving different actions by the first mover: accommodation and deterrence. Under accommodation, the first mover selects the optimal capacity knowing that the potential entrant will enter the market. Under deterrence, on the other hand, the first mover installs a sufficiently high level of capacity, and manages to prevent the entrant's entry in the market.

Both the feasibility and the relative profitability of accommodation and deterrence crucially depend on the ability of the first mover to credibly commit, since the capacity installation stage. Under NMo, the first mover's commitment device depends on the sunk capacity cost. Credibility is restricted (on the upper bound) to flows that can be sustained in asymmetric Cournot equilibria, where capacity costs are sunk for the first mover, while they are variable for the potential entrant. Therefore, under NMo, credibility hinges on the magnitude of sunk costs. On the other hand, under Mo, the rule itself guarantees that the installed capacity will be used, and will therefore be reflected into a transmission flow. As a result, Mo expands the set of transmission flows to which the first mover can credibly commit since the stage of capacity investment. As a result, Mo (weakly) increases the scope for deterrence vis-à-vis NMo.

The structure of our game is slightly different from Brunekreeft and Newbery (2006). In our game, capacity decision by E and decisions on the transmission flow by both firms occurs simultaneously. In their game, instead, after I's capacity choice, first E chooses capacity, and subsequently the two firms set the transmission flow. Our modelling choice reflects the notion that, in electricity markets, long-term contracts between transmission operators and end-users of transmisison network and can be signed (and are often mandated by the regulator), and this decision occurs at the time of investment itself. This is further reflected in the fact that the first mover's quantity choice and the entrant's capacity choice (and quantity choice) happen simultaneously. Despite the game being different than the one considered in Brunekreeft and Newbery (2006), the analysis of a single stage game shows that the results are qualitatively not different. In particular, we find that:

- Entry is relatively easily deterred or blockaded under Mo, as above illustrated.

- Mo (weakly) increases the first mover's profit. In this game, Mo (weakly) increases the options available to the first mover, by (weakly) expanding the set of transmission flows to which it can credibly commit.

- Capacity installation is higher under Mo than under NMo under two circumstances: i) when the fixed cost F is low enough that accommodation prevails under both capacity utilization regimes. In this case, the commitment power provided by Mo increases, with respect to NMo, the first mover's aggressiveness, and, as a result, the first mover's profit as well as total output (at the expenses of the entrant's profits); ii) for a subset of parameters for which deterrence prevails under Mo, while accommodation under NMo. In these cases, the first mover under Mo installs a higher capacity than the combined flows (by the first mover and the new entrant) under NMo, in order to deter entry, and, therefore, to be the only claimant of the profit from trasnmission. [2]

3 Time Varying Demand

Next, we incorporate the assumption of time varying demand in the above model. Electricity demand varies over time, with demand being highest during

---

[2] In the interest of space, we do not replicate these results here. The results are available with the authors upon request.

the peak demand periods and lowest during the off-peak periods, which is further reflected in the corresponding variation in the transmission demand. The introduction of time-varying demand has significant effects on the incentives faced by merchant investors, and alters the tradeoff of Mo vis-a-vis NMo. The most significant changes can be identified even in a setting with a monopolistic transmission investment. Therefore, we start by looking at a monopolistic merchant investor, and subsequently characterize the equilibrium under sequential entry. Let period 1 (denoted by subscript 1) denote the peak period and period 2 (denoted by subscript 2) be the off-peak or lean period. Also, let the transmission (inverse) demand be:

$$\begin{aligned}\eta_1 &= \alpha_1\beta_1 - \beta_1 q_1 \\ \eta_2 &= \alpha_2\beta_2 - \beta_2 q_2\end{aligned}$$

in period 1 and 2 respectively. We assume: i) $\beta_1 < \beta_2$ to reflect peak demand in 1. Also, for simplicity, we set ii) $\alpha_1\beta_1 = \alpha_2\beta_2 = \alpha\beta$. The combination of i) and ii) implies assuming $\alpha_1 > \alpha_2$.

3.1 The Case of Monopoly

Consider monopoly in the merchant investment. In the NMo structure, the investor solves the following maximization problem:

$$\max_{q_1,q_2} \eta_1(q_1)\,q_1 + \eta_2(q_2)\,q_2 - rk$$

where he optimally sets $q_1 = k$. The problem can therefore be rewritten as:

$$\begin{aligned} & \max_{k,q_2} \eta_1 (k) k + \eta_2 (q_2) q_2 - rk \\ s.t. q_2 & \leq k \end{aligned}$$

In the Mo structure, the investor is constrained to set $q_1 (\eta) = k$, and $q_2 (\eta) = \max (k, q_2 (0))$. It solves the following:

$$\max_{k} \eta_1 (k) k + \max \{ (\eta_2 (k) k), 0 \} - rk$$

NMo provides the investor with the opportunity to withhold capacity in the offpeak period. As a result, the investor can set both $q_1^{UM} = k$ and $q_2^{UM} \leq k$ at the profit-maximizing uncontrained monopoly level. Here, the superscript UM stands for unconstrained monopoly and q_t^{UM} represents output level in period t under NMo. In order to compare the two regimes, consider the differential effects (between Mo and NMo) on the investor's revenue stemming from a marginal increase in capacity as a function of the initial capacity level (k). Three regions emerge:

1. When k is sufficiently small, then the marginal increase in revenue for the investor as capacity increases is the same across both regimes. We call this Region 1

2. When k gets larger, then under NMo capacity is withheld in the offpeak period (and used only in peak period); since such option is not available

under Mo, the marginal benefit to the investor is greater under NMo than it is under Mo. We call this Region 2

3. When k gets even larger, to the point that $\eta_2(k) = 0$, additional capacity is used only in the peak period and not off-peak even under Mo. Therefore, the marginal benefit for the investor is, once again, identical across the two regimes. We call this Region 3.

We now characterize conditions under which the equilibrium falls in each of the three regions described above. Equilibrium falls in Region 1 when $q_1^{UM} = q_2^{UM}$, that is, the infrastructure cost r is large relative to the difference in demand across the two periods, and, as a result, even under NMo it is efficient to build capacity only as long as it is optimal to use it in both periods. In terms of the parameters of our model, this occurs when $r > \alpha_2(\beta_2 - \beta_1)$. In this case, capacity installation as well as the transmission quantity made available both in the peak period and offpeak is the same across the two regimes. As a result, even profits are equal across the two arrangements.

Equilibrium falls in Region 2 when the infrastructure cost is at an intermediate level relative to the difference in demand across the two periods. In terms of the parameters of the model, this happens when $\alpha_2\left(\beta_2 - \beta_1 - \sqrt{\beta_1^2 + \beta_1\beta_2}\right) < r < \alpha_2(\beta_2 - \beta_1)$. In this region, the following two conditions hold: (i) $q_1^{UM} > q_2^{UM}$ and (ii) $\eta_2(k) > 0$. Condition 1 implies that the capacity installed optimally without any utilization constraints (hence prevailing under NMo) is not fully utilized in the off-peak period; so, there is capacity withholding under NMo. Condition 2 implies that there is positive price differential across nodes, and hence the installed capacity has to be fully utilized even in the off-peak period under Mo. In this case, under Mo, new capacity installation exhibits a tradeoff, since a marginal increase in k increases peak period profit (π_1), but reduces off-peak period profit (π_2). Thus, the marginal revenue is larger under NMo (where capacity withholding is allowed) than under Mo. As a result, installed capacity as well as transmission quantity in the peak period are larger under NMo, while capacity utilization offpeak is larger under Mo (due to capacity withholding under NMo). Combining the various effects, total welfare (along with investor's profit) turns out to be strictly higher under NMo.

Finally, equilibrium falls in Region 3 when the infrastructure cost is low (in the parameter of our model, when $r < \alpha_2 \left(\beta_2 - \beta_1 - \sqrt{\beta_1^2 + \beta_1\beta_2}\right)$) relative to the difference in demand across the two periods. In this region, $\eta_2(k) = 0$, hence the marginal revenue, and therefore investment in capacity, in the same across the two regimes. Even under Mo, it is optimal for the investor to install capacity keeping the peak period in mind, giving up revenue from the off-peak period. In this case, installed capacity as well as transmission quantity in the peak period are the same across the two arrangements. However, under Mo there is more capacity utilization offpeak, and, as a result, welfare is strictly higher under Mo, while profits are strictly higher under NMo.

The Figure below, where the solid line illustrates the marginal benefit under NMo, while the dotted line displays benefits under Mo, depicts the intuition behind these results more clearly:

INSERT FIGURE 1 HERE

The results discussed above can be summarized in the following proposition

Proposition 1 *Monopoly investment in capacity is (weakly) larger under* NMo *than it is under* Mo*. However, equilibrium transmission may be greater or lower under* NMo *vis-a-vis* Mo*.*

It is also important to note that the profit of the monopolist is higher under NMo when compared to Mo because the constrained optimization always yields inferior solution when compared to the unconstrained solution.

In terms of consumer surplus, the two regimes are equivalent when both conditions i) and ii) hold. When condition i) does not hold, the larger investment entailed by NMo increases consumer surplus under NMo. Finally, when condition ii) does not hold, the higher capacity utilization entailed by Mo increases consumer surplus under Mo.

Therefore, since the theory is ambiguous on which regime improves consumer welfare, it really becomes an empirical question. From a policy maker's perspective, it is important to ascrtain the parameter values before a policy decision is implemented.

3.2 Sequential Entry

Next, we characterize the case of sequential entry with time-varying demand, where the pattern of entry is as described in Section 2. In particular, in Stage 3 (if the entrant has decided to enter in Stage 2), the entrant chooses k_E and, simultaneously, $q_{t,E} \leq k_E$, for $t = 1, 2$ along with the first mover. Observe that Mo imposes the additional constraint here that $q_{t,j}(\eta_t) = \max(k_j, q_{t,j}(0))$

for $j = I, E$; that is, under Mo, the transmission flow has to be equal to capacity unless the full capacity is not needed. We consider block, deterrence and accommodation separately for each of the three regions.

When $q_1^{UM} = q_2^{UM} = k$, then investment and capacity utilization are the same under Mo and NMo in monopoly. Due to the additional commitment (and the corresponding profit reduction) induced by Mo, there is less incentive to enter when the first mover plays the monopoly output; hence entry is more easily blockaded. Also, due to the same logic, entry deterrence prevails for a larger series of parameters under Mo. Under NMo, there is more entry. The welfare effect of entry deterrence is more subtle. For some parameter values, entry deterrence may be welfare enhancing over accommodation; in order to be able to deter entry, the first mover may have to install more capacity than the aggregate capacity that would be installed under NMo. The first mover's profits, along with welfare, would increase (at the expense of the potential entrant, who is left out of the market).

When $q_1^{UM} > q_2^{UM}$, and $\eta_2(k_{Mo}^*) = 0$, in monopoly, investment is the same across the two regimes, but under Mo capacity utilization is higher. Under Mo, entry when the first mover installs the monopoly capacity is less profitable than under NMo because: first, the tranmission flow chosen by the first mover is higher; second, the potential entrant faces additional constraints when it enters. Therefore, entry is more easily blockaded. The same logic can be applied to deterrence, which occurs more frequently under Mo. A tradeoff clearly emerges between NMo that induces (weakly) more entry (whose welfare effects have been illustrated above), and Mo that induces more capacity utilization.

Finally, when $q_1^{UM} > q_2^{UM}$, and $\eta_2\left(k_{Mo}^*\right) = 0$, Mo involves lower capacity installation. In this case, which of the two arrangements induces more entry is less clear. We first consider blockaded entry. Monopoly capacity is lower under Mo, and this suggests more room for entry under Mo. On the other hand, the additional constraint imposed by Mo hurts the potential entrant's profit. The parameter values determine which of the effects prevails. A similar logic can also be applied to incentives to deter entry.

Our last case (when $q_1^{UM} > q_2^{UM}$, and $\eta_2\left(k_{Mo}^*\right) = 0$) shows that there may be instances in which, Mo can encourage greater entry. This effect results from the disincentives to invest under Mo due to the constraint of using the available capacity even in the offpeak period, thereby hurting the corresponding profits. In other words, in such circumstances, under Mo deterring entry through excess capacity installation might be too costly for the first mover because it might mean low prices during the lean period. Hence, NMo produces more entry. Instead, in the two other cases (i.e., $q_1^{UM} = q_2^{UM} = k$, and $q_1^{UM} > q_2^{UM}$ & $\eta_2\left(k_{Mo}^*\right) = 0$), NMo encourages greater entry, with the above discussed welfare effects.

Proposition 2 *In the setup involving time-varying demand, for certain parameter values, it is possible that NMo encourages greater entry.*[3]

---

[3] *The result follows from the computation of the equilibria. Detailed calculations are available upon request.*

4 Vertical Integration and Market Power

One of the major concerns among the policy makers is that the merchant lines built and operated by firms that are active in the generation sector can be harmful from the public welfare standpoint. In fact, the European Union has per se banned any generating firm from investing in transmission network. However, from an economic standpoint, the debate on allowing generators to invest in merchant transmission is not yet been robustly analyzed. The litertaure so far has mostly focused on the legal and international relations perspectives (de Hauteclocque and Rious (2011) and Nowak (2010)). One of the crucial reasons behind the concerns of the EU is that the merchant investors involved in generation may have an incentive to behave anti-competitively by restricting the available capacity in the market.[4] In this context there are some important questions that need to be addressed: How valid are these concerns of the EU keeping in mind consumer welfare? Under what conditions would allowing vertical integration lead to a loss/gain in consumer surplus? In this section we analyze these broad questions under the assumption that the generators hold some market power. We show that the answer drastically differs depending upon where the market power for the generators really is (efficient/exporting or inefficient/importing nodes).

Formally, we consider two regions with differing efficiency. The cost structure is analogous to our baseline version. For firms operating in the N is $C\left(Q_N\right) =$

---

[4] One assumption we make throughout this section is that even if merchant investor owns a generator, he cannot bar other generators from utilising his transmission line to export/import electricity.

$c_N Q_N$, while for firms in the S it is $C(Q_S) = c_N Q_N + \frac{c_S Q_N^2}{2}$, and the electricity demand is concentrated in Node S. The demand function for electricity in S is:

$$D_S(p_S) = a - p_S$$

We then analyze two different situations, one in which the more efficient region (N) has a monopoly in generation with the other zone being competitive, and vice versa. For each of the two instances, we analyze two sequential games (whose structure parallels that described in Section 2), one in which the generator with market power is banned (B) from investing in transmission, and a second one in which the generator with market power does invest in transmission (NB). Under this assumption, we consider two interrelated questions. First, under what conditions a generator may find it profitable to invest in building additional transmission capacity; second, to what extent a Mo rule could be useful in preventing episodes of abuse of dominant positions on the transmission line by generators with market power.

If the market power is vested in the hands of the generator in the efficient (exporting) node, then only that generator has an incentive to invest in transmission network. The intuition behind this result is as follows: the only source of revenue for the transmission network operator is the price differential between the nodes. Further, since the investment in setting up transmission network is sunk, and the marginal cost is zero, the transmission network owner is going to open up the line for transmission as long as the price differential is positive.

Given this, the generator in the efficient node is going to set the prices very close the ones prevailing in the inefficient node. This is not sufficient for the transmission network owner to recover his sunk investment, which in turn, leads to lack of incentive to invest. If vertical integration is allowed, then the generator with market power is interested in investing in the transmission network, as long as the aggreate net profit is positive. On the other hand, we argue that if the market power is vested in the hands of the generator in the inefficient node, then the results are not that unambiguous. It is possible that allowing for vertical integration would harm welfare. The main intuition for this result is that the generator in the inefficient node would under-invest in order to limit the competition from the efficient node. Further, the generator could build capacity and leave it unused, while preventing entry of other merchant investors. Therefore, we also argue that Mo is a more suitable provision than NMo because the option of using excess capacity as a deterrent is eliminated.

We start by analyzing the case of market power in the exporting (N) node.

4.1 Market Power in the Exporting Node

Suppose, node S is competitive. The firms in this node sell at a price $p_S = c_N + c_S q_S$. Therefore, $q_S = \frac{p_S - c_N}{c_S}$. Also, assume that there is a single firm, a residual demand monopolist in node N, whose quality is q_N and a price p_N.[5] In order to avoid arbitrage, we need to have $p_N = p_S = p$.The overall demand for Node S is given by $q_S + q_N = a - p$. Therefore, the demand for the residual

---

[5] Observe that, given the assumption of residual demand monopolist, the assumption of whether the firm sets prices or quantities does not really matter.

demand monopolist in node N is given by: $q_N = a - p - q_S = a - p - \left(\frac{p - c_N}{c_S}\right) = \frac{1}{c_S}\left(ac_S + c_N - p - pc_S\right)$ or $p = \frac{1}{c_S+1}\left(c_N + ac_S - c_S q_N\right)$.

Observe that, as expected, residual demand increases in c_N, since c_N decreases q_S. Consider the case where the monopolist in N is using an existing network (of sufficiently high capacity) to export electricity to S. Since there is no indigenous demand in Node S, whatever he produces is for the export market.In such case, he would be solving the following problem:

$$\begin{aligned}\frac{\partial\left(\left(\frac{1}{c_S+1}\left(c_N + ac_S - c_S q_N\right)\right) q_N - c_N q_N\right)}{\partial q_N} &= 0 &(3)\\ \text{This implies } q_N &= \frac{1}{2}a - \frac{1}{2}c_N \text{ if } k > \frac{1}{2}a - \frac{1}{2}c_N \\ \text{or } q_N &= k \text{ if } k \leq \frac{1}{2}a - \frac{1}{2}c_N\end{aligned}$$

The total price prevailing in the market is:

$$p = \frac{1}{c_S + 1}\left\{c_N + \frac{1}{2}c_S a + \frac{1}{2}c_N c_S\right\}$$

At this quantity, the total supply by the competitive market in S is:

$$q_S = \frac{p - c_N}{c_S} = \frac{\frac{1}{c_S+1}\left\{c_N + \frac{1}{2}c_S a + \frac{1}{2}c_N c_S\right\} - c_N}{c_S}$$

If, on the other hand, the merchant investor were to invest in vertical integration, then he solves the following problem:

$$\begin{aligned} \frac{\partial\left(\left(\frac{1}{c_S+1}\left(c_N+ac_S-c_Sq_N\right)\right)q_N-c_Nq_N-rq_N\right)}{\partial q_N} &= 0 \qquad (4)\\ \text{This implies } q_N &= \frac{1}{2c_S}\left(ac_S-r-rc_S-c_Nc_S\right) \end{aligned}$$

Observe that $q_N \geq 0$ if $r \leq \frac{1}{c_S+1}\left(ac_S-c_Nc_S\right)$. For the rest of the analysis, we assume that this condition is satisfied.

This implies

$$p=\frac{1}{c_S+1}\left(\frac{1}{2}r+c_N+\frac{1}{2}ac_S+\frac{1}{2}rc_S+\frac{1}{2}c_Nc_S\right).$$

Further,

$$q_S=\frac{p-c_N}{c_S}=\frac{\frac{1}{c_S+1}\left(\frac{1}{2}r+c_N+\frac{1}{2}ac_S+\frac{1}{2}rc_S+\frac{1}{2}c_Nc_S\right)-c_N}{c_S}$$

Proposition 3 *Only the firm involved in exporting has the incentive to build the transmission line as a merchant investor. All the other parties (including the independent merchant investors) do not have an incentive to invest because they would incur a loss. Allowing generators to invest in transmission capacity increases total welfare. Whether Mo is in place or not is indifferent for our results*

Proof. If the generator in the exporting node with market power is not vertically integrated, it has the following strategy that allows it to extract the full surplus from the transmission network under perfect information: produce q_N and charge $p_N = p_S - \epsilon$. The operator on the transmission network will obtain close to zero net profit from transmission, as the firm in the exporting node will internalize the full profit. Given the presence of fixed costs, any investor other than the generator has no incentive to invest. When the generator invests, he has an incentive to fully use capacity, regardless of whether he is forced to do so by a Mo provision. Using capacity is valuable for the investor. ■

Does it make sense for the generator in N to invest in the first place? The answer would be trivial because, if there is no interconnection between the nodes, then the generator in node N will not be able to produce anything because of the lack of indigenous demand, and the inefficient generators in the S would have to cater to the entire demand. Also, notice that given the structure of the game, the choice of regime: Mo or NMo really does not matter since capacity will be optimally used in both cases.

Van Koten (2011) and Sauma and Oren (2009), while considering a different framework than ours (involving financial transmission rights in Sauma and Oren, and an explicit auction for the capacity allocation in Van Koten), obtain similar results to those obtained in our paper.

4.2 Market Power in the Importing Node

When the firm in the importing node has market power, then vertical integration may not be an unambiguous answer if looked at from an economic efficiency stand point. Further, the regime of capacity utilization (Mo vs. NMo) does play a role in determining the degree of efficiency in this case. Given the tediousness of calculations involved, we do not present the entire proofs here, but will provide a general intuition for why that is the case. The detailed calculations necessary to prove these arguments are available with the authors.

Consider the case where there is a monopolist generator in the inefficient node, S. Node N, the efficient one has several firms that generate electricity and there is perfect competition in place. Like earlier, there is no market for electricity in N, and the entire consumption happens in the South. In such case, it is clear that the monopolist in S would prefer that the interconnection not exist, or that an inefficiently low level of interconnection prevails. If interconnection does exist and can accommodate a high enough capacity, then the monopoly generator would face competition from the N market.

Hence, a vertically integrated potential merchant investor, who faces no competition by other merchant investors, has an incentive to set an inefficiently low level of merchant capacity.

When we move to a sequential entry game, it turns out that the capacity utilization mode becomes crucial. We consider two alternative structures of the game. In the first one, vertical integration is not allowed, and two independent (i.e., not involved in the generation business) merchant investors sequentially invest before electricity generation takes place. In the second one, the first merchant investor is the monopolistic generator, who is followed by an independent merchant investor (second mover). Subsequently, electricity generation takes place. The reason why the vertically integrated investor moves first is that the major policy concerns (e.g., with European authorities) arise precisely when there is no other line in place; in such a situation, the vertically integrated investor would be the first mover.

The objective function of the vertically integrated merchant in a sequential entry game is:

$$\max_{q_1} \left(a - q_I - q_E - q_{el}\right) q_{el} - C\left(q_{el}\right) + q_I \left(p_S - c_N\right)$$

where q_{el} stands for the electricity quantity, while q_1 and q_2 stand for the interconnection capacity made available respectively by firm 1 (the vertically integrated company) and by firm 2.

Under NMo, if vertical integration is allowed, then the generator in node S has an incentive to invest in interconnection, and leave the transmission line idle. Should there be an entry into the transmission market, then the monopolist can credibly threaten to use the invested capacity and compete in quantities, as above. If the fixed cost is very low, then there is an incentive for another merchant investor to actually invest in interconnection, and connect the efficient and inefficient nodes. However, if the fixed cost is sufficiently high (more than the profits that the other investor would make in the duopoly market), then under NMo entry does not take place, and the transmission capacity does not translate into actual transmission of electricity. Therefore, the presence of efficient generators in Node N does not make any difference to the consumer welfare for the demanders of electricity in node S.

Mo, instead, does not allow the strategy of building capacity and leaving it idle. As a result, Mo is preferable to NMo under market power in the importing node.

Joskow and tirole (2000) show a similar result, albiet in an alternative setting comparing financial rights of transmission vis-a-vis physical transmission rights.. They show that physical transmission rights reduce welfare vis-à-vis financial transmission rights, as the former allow for capacity withholding.

5 Collusion

In this section we do not provide a fully specified model on relative performance of the two regines when there is a possibility of collusion among the transmission networks. However, we provide some theoretical arguments on the merits of either regime when collusion can be a realistic possibility. For that reason, we move back to the market where there are several generators in each node that are perfectly competitive. We provide some intuition on how the Mo arrangement may affect results in a dynamic context.

The economic literature thus far has been able to document the role of excess (idle) capacity in a duopoly as a means to sustain collusion (Davidson and Deneckere (1990)). The argument is that a low capacity increases profit, which, in a Nash-reversion setting represents represents the profit that prevails after a firm deviates from the collusive agreement. The threat of punishment in response to deviation is therefore, less severe. Therefore, temptation to deviate increase making the sustinance of cartel tougher. Larger capacity (even if kept idle) would ensure that the deviation can be punished, thereby reducing the temptation to deviate making cartel more sustainable. A regulatory regime like Mo does not allow idle capacity to exist. Therefore, while there might be under-investment *ex ante*, the possibility of collusion itself reduces. In this sense, Mo is better suited than NMo when one suspects collusion.

As Benoit and Krishna (BK) (1991) point out "commitments that make predatory behavior in the post-entry game credible also increase the prospects for collusion. This is because in a dynamic setting, a greater degree of collusion may be supported by the increased severity of available threats. The entrant may view the first mover's choice as a commitment to collude". While in a static setting high capacity provides the first mover with a commitment towards aggressive behavior if entry occurred, in a dynamic setting this same strategy may be interpreted as a commitment to collude. This is because it reduces continuation profit after deviation.

At the same time, however, Mo may benefit the first mover. By providing credibility to the use of capacity, it may allow the first mover to play the monopoly output, while leaving the new entrant out.

6 Policy Implications and Conclusion

In this paper we investigate which of the capacity utilization regimes: Mo or NMo is better suited from a welfare standpoint. First, we look at relative trade-offs of these two regimes in the case where the demand is fluctuating across various time periods. A major policy implication of the results we have developed in this section is that it is not *ex ante* clear which of the capacity utilization regimes: Mo or NMo, is better suited from a consumer welfare point of view. While capacity investment is likely to be higher in NMo than under Mo, it is not necessary that the installed capacity actually results in transmission capacity being made available. The answer to the question of which regime is better really depends on not only the difference in efficiency levels between the generators in either node, the extent of demand for electricity, and the difference in the demand for interconnection across different time periods. Therefore, from a policy perspective, the appropriate choice of regime becomes an empirical question. An appropriate research design needs to first estimate the demand functions in both zones, and the pattern of competition in the market in order to estimate the demand for transmission. Next, the using the estimated market structure, the *but-for* market needs to be simulated under the two capacity utilization regimes in order to calculate consumer welfare under both regimes. A similar approach was used in Boffa, Pingali and Vannoni (2010) in order to estimate the welfare measures pertaining to transmission network in the Italian electricity market.

The next issue we investigate in this paper is that of vertical integration where generators of electricity are also allowed to invest in transmission network. Within the context of merchant investment, one policy recommendation is that in case the generator in the most efficient node has market power, vertical integration is the only way to achieve welfare enhancing investment in transmission network. This is irrespective of which capacity utilization regime (Mo orNMo) is in vogue. Another pertinent question to ask is whether the regulated investement in transmssion network yields better results vis-a-vis merchant investment. Our model clearly demonstrates that there is a private party (monopolist in the efficient zone) who has finanical incentives to build interconnection. Further, the regulated investment may also suffers from asymmetric information in terms of costs of the building interconnection, lack of knowledge in terms of ideal location to build interconnection, etc. A merchant investor, on the other hand, is likely to have superior knowledge of these issues; and if the merchant investor also happens to be the monopolist generator in the efficient zone, then right financial incentives as well. Therefore, it is reasonable to conclude that merchant investment (via vertical integration) is indeed preferable! Littlechild (2012), in the context of Australian electricity market points out that, "Merchant Transmisison has generally not exhibited the standard examples of market failure but regulated transmission generally has exhibited the standard examples of regulatory failure." To this extent we agree with the claims in de Hauteclocque and Rious (2011) and Van Koten (2013) who showed that a generator would be relatively more aggressive in bidding for merchant investment.

On the other hand, when the generator in the importing node has market power, the claims of de Hauteclocque and Rious (2011) need to be caveated further. Our analysis shows that vertical integration is not unambiguously welfare enhancing, and the answer does depend on the parameter values. Further, what can be claimed unambiguously is that, if vertical integration is indeed the superior alternative, then Mo is a better framework than NMo. This is because the monopolist generator in the inefficient node has an incentive to build interconnection capacity, and leave it unused in order to prevent competition. Adopting the Mo regime precludes such behavior. Therefore, in such situation, the claims made by Nowak (2010) seem more valid.

As an extension, a natural question to ask is what happens when generators in both zones have market power. As long as one node is more efficient than the other, our conclusions do not change qualitatively. An interesting case emerges when there is market power in both zones, and the generators are equally efficient. In such situation, interconnection leads to higher consumer welfare, not because of efficiency reasons, but because of increase in competition from the generators in the other node. While we do not model this question explicitly in this paper, literature on transmission capacities in economics does provide some answers. Borenstein, Bushnell and Stoft (1997) argue that the provision of interconnection between the two nodes, even with limited capacity, is enough to mitigate exploitation of market power.[6]

---

[6] However, they also show that for a small transmission capacity, then only mixed strategy equilibrium exists in terms of quantity setting on the part of the firms. Since mixed strategies are difficult to interpret from a policy perspective, we can only conclude that even with limited investment in transmission capacity, there should be huge gains from consumer welfare point of view.

A final issue we address in this paper pertains to the possibility of collusion among various transmission network investors. The economic literature on collusion does suggest that excess capacity can be effectively used as a mechanism to sustain a cartel because idle capacity can be used as a threat to punish anyone deviating from cartel. Given that capacity augmentation in the transmission network is not instantaneous, lack of excess capacity could hinder the ability of a cartel to punish any deviations. Therefore, a policy recommendation in this context is that, in order to pre-empt strategic exploitation of excess (but idle) capacity, Mo does appear to be a superior alternative when compared to NMo.

As for our original question of which capacity utilization regime (NMo or Mo) is better, the answer is contextual. Fluctuations in demand for transmission, degree of relative efficiencies in electricity generation, and competitive structure of electricity generation (degree of market power and feasibility of collusion), determine which regime is superior. Therefore, from a policy maker's perspective, a careful and structured assessment of market conditions in these directions is required before finalizing the choice of regime.

References

[1] Boffa, Federico, Viswanath Pingali and Davide Vannoni. "Increasing Market Interconnection: An Analysis of the Italian Electricity Spot Market," *International Journal of Industrial Organization* 28, no. 3 (2010): 311-322.

[2] Borenstein, Severin, James Bushnell and Steven Stoft. "The Competitive Effects of Transmission Capacity in Deregulated Electricity Industry," *Rand Journal of Economics* 31, no. 2 (2000): 294-325.

[3] Brunekreeft, Gret and David Newbery. "Should Merchant Transmission Investment be Subjected to a Must-Offer Provision?" *Journal of Regulatory Economics* 30, no. 3 (2006): 233-260.

[4] Clò, Stefano and Gaetano D'Adamo. "The Impact of Solar Penetration on Solar and Gas Market Value: an Application to the Italian Power Market", Working Paper, University of Alicante.

[5] de Hauteclocque, Adrien and Vincent Rious. "Reconsidering the European Regulation of Merchant Transmission Investment in Light of the Third Energy Package: The Role of Dominant Generators," *Energy Policy* 39, no. 11 (2011): 7068-7077.

[6] Joskow, Paul and Jean Tirole. "Transmission Rights and Market Power on Electric Power Networks, " *Rand Journal of Economics* 31, no.3 (2000): 450-587.

[7] Joskow, Paul and Jean Tirole. "Merchant Transmission Investment," *The Journal of Industrial Economics* 53, no. 2 (2005): 233-264.

[8] Littlechild, Stephen. "The Process of Negotiating Settlements at FERC," *Energy Policy* 50 (2012): 174-191.

[9] Nowak, Bartlomiej. "Equal Access to the Energy Infrastructure as a Precondition to Promote Competition in the Energy Market. The Case of European Union," *Energy Policy* 38 (2010): 3691-3700.

[10] Sauma, Enzo and Shmuel Oren. "Do Generation Firms in Restructred Electricity Markets have Incentives to Support Social-Welfare-Improving Transmission Investments, " *Energy Economics* 31, no.5 (2009): 676-689.

[11] Van Koten, Silvester. "Merchant Interconnection Projects by Generators in the EU: Profitability and Allocation Capacity," *Energy Policy* 41 (2012): 748-758.

2011

2011/1, Oppedisano, V; Turati, G.: "What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"
2011/2, Dahlberg, M; Edmark, K; Lundqvist, H.: "Ethnic diversity and preferences for redistribution"
2011/3, Canova, L.; Vaglio, A.: "Why do educated mothers matter? A model of parental help"
2011/4, Delgado, F.J.; Lago-Peñas, S.; Mayor, M.: "On the determinants of local tax rates: new evidence from Spain"
2011/5, Piolatto, A.; Schuett, F.: "A model of music piracy with popularity-dependent copying costs"
2011/6, Duch, N.; García-Estévez, J.; Parellada, M.: "Universities and regional economic growth in Spanish regions"
2011/7, Duch, N.; García-Estévez, J.: "Do universities affect firms' location decisions? Evidence from Spain"
2011/8, Dahlberg, M.; Mörk, E.: "Is there an election cycle in public employment? Separating time effects from election year effects"
2011/9, Costas-Pérez, E.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Corruption scandals, press reporting, and accountability. Evidence from Spanish mayors"
2011/10, Choi, A.; Calero, J.; Escardíbul, J.O.: "Hell to touch the sky? Private tutoring and academic achievement in Korea"
2011/11, Mira Godinho, M.; Cartaxo, R.: "University patenting, licensing and technology transfer: how organizational context and available resources determine performance"
2011/12, Duch-Brown, N.; García-Quevedo, J.; Montolio, D.: "The link between public support and private R&D effort: What is the optimal subsidy?"
2011/13, Breuillé, M.L.; Duran-Vigneron, P.; Samson, A.L.: "To assemble to resemble? A study of tax disparities among French municipalities"
2011/14, McCann, P.; Ortega-Argilés, R.: "Smart specialisation, regional growth and applications to EU cohesion policy"
2011/15, Montolio, D.; Trillas, F.: "Regulatory federalism and industrial policy in broadband telecommunications"
2011/16, Pelegrín, A.; Bolancé, C.: "Offshoring and company characteristics: some evidence from the analysis of Spanish firm data"
2011/17, Lin, C.: "Give me your wired and your highly skilled: measuring the impact of immigration policy on employers and shareholders"
2011/18, Bianchini, L.; Revelli, F.: "Green polities: urban environmental performance and government popularity"
2011/19, López Real, J.: "Family reunification or point-based immigration system? The case of the U.S. and Mexico"
2011/20, Bogliacino, F.; Piva, M.; Vivarelli, M.: "The impact of R&D on employment in Europe: a firm-level analysis"
2011/21, Tonello, M.: "Mechanisms of peer interactions between native and non-native students: rejection or integration?"
2011/22, García-Quevedo, J.; Mas-Verdú, F.; Montolio, D.: "What type of innovative firms acquire knowledge intensive services and from which suppliers?"
2011/23, Banal-Estañol, A.; Macho-Stadler, I.; Pérez-Castrillo, D.: "Research output from university-industry collaborative projects"
2011/24, Ligthart, J.E.; Van Oudheusden, P.: "In government we trust: the role of fiscal decentralization"
2011/25, Mongrain, S.; Wilson, J.D.: "Tax competition with heterogeneous capital mobility"
2011/26, Caruso, R.; Costa, J.; Ricciuti, R.: "The probability of military rule in Africa, 1970-2007"
2011/27, Solé-Ollé, A.; Viladecans-Marsal, E.: "Local spending and the housing boom"
2011/28, Simón, H.; Ramos, R.; Sanromá, E.: "Occupational mobility of immigrants in a low skilled economy. The Spanish case"
2011/29, Piolatto, A.; Trotin, G.: "Optimal tax enforcement under prospect theory"
2011/30, Montolio, D; Piolatto, A.: "Financing public education when altruistic agents have retirement concerns"
2011/31, García-Quevedo, J.; Pellegrino, G.; Vivarelli, M.: "The determinants of YICs' R&D activity"
2011/32, Goodspeed, T.J.: "Corruption, accountability, and decentralization: theory and evidence from Mexico"
2011/33, Pedraja, F.; Cordero, J.M.: "Analysis of alternative proposals to reform the Spanish intergovernmental transfer system for municipalities"
2011/34, Jofre-Monseny, J.; Sorribas-Navarro, P.; Vázquez-Grenno, J.: "Welfare spending and ethnic heterogeneity: evidence from a massive immigration wave"
2011/35, Lyytikäinen, T.: "Tax competition among local governments: evidence from a property tax reform in Finland"
2011/36, Brülhart, M.; Schmidheiny, K.: "Estimating the Rivalness of State-Level Inward FDI"
2011/37, García-Pérez, J.I.; Hidalgo-Hidalgo, M.; Robles-Zurita, J.A.: "Does grade retention affect achievement? Some evidence from Pisa"
2011/38, Boffa, f.; Panzar. J.: "Bottleneck co-ownership as a regulatory alternative"

2011/39, González-Val, R.; Olmo, J.: "Growth in a cross-section of cities: location, increasing returns or random growth?"
2011/40, Anesi, V.; De Donder, P.: "Voting under the threat of secession: accommodation vs. repression"
2011/41, Di Pietro, G.; Mora, T.: "The effect of the l'Aquila earthquake on labour market outcomes"
2011/42, Brueckner, J.K.; Neumark, D.: "Beaches, sunshine, and public-sector pay: theory and evidence on amenities and rent extraction by government workers"
2011/43, Cortés, D.: "Decentralization of government and contracting with the private sector"
2011/44, Turati, G.; Montolio, D.; Piacenza, M.: "Fiscal decentralisation, private school funding, and students' achievements. A tale from two Roman catholic countries"

2012

2012/1, Montolio, D.; Trujillo, E.: "What drives investment in telecommunications? The role of regulation, firms' internationalization and market knowledge"
2012/2, Giesen, K.; Suedekum, J.: "The size distribution across all "cities": a unifying approach"
2012/3, Foremny, D.; Riedel, N.: "Business taxes and the electoral cycle"
2012/4, García-Estévez, J.; Duch-Brown, N.: "Student graduation: to what extent does university expenditure matter?"
2012/5, Durán-Cabré, J.M.; Esteller-Moré, A.; Salvadori, L.: "Empirical evidence on horizontal competition in tax enforcement"
2012/6, Pickering, A.C.; Rockey, J.: "Ideology and the growth of US state government"
2012/7, Vergolini, L.; Zanini, N.: "How does aid matter? The effect of financial aid on university enrolment decisions"
2012/8, Backus, P.: "Gibrat's law and legacy for non-profit organisations: a non-parametric analysis"
2012/9, Jofre-Monseny, J.; Marín-López, R.; Viladecans-Marsal, E.: "What underlies localization and urbanization economies? Evidence from the location of new firms"
2012/10, Mantovani, A.; Vandekerckhove, J.: "The strategic interplay between bundling and merging in complementary markets"
2012/11, Garcia-López, M.A.: "Urban spatial structure, suburbanization and transportation in Barcelona"
2012/12, Revelli, F.: "Business taxation and economic performance in hierarchical government structures"
2012/13, Arqué-Castells, P.; Mohnen, P.: "Sunk costs, extensive R&D subsidies and permanent inducement effects"
2012/14, Boffa, F.; Piolatto, A.; Ponzetto, G.: "Centralization and accountability: theory and evidence from the Clean Air Act"
2012/15, Cheshire, P.C.; Hilber, C.A.L.; Kaplanis, I.: "Land use regulation and productivity – land matters: evidence from a UK supermarket chain"
2012/16, Choi, A.; Calero, J.: "The contribution of the disabled to the attainment of the Europe 2020 strategy headline targets"
2012/17, Silva, J.I.; Vázquez-Grenno, J.: "The ins and outs of unemployment in a two-tier labor market"
2012/18, González-Val, R.; Lanaspa, L.; Sanz, F.: "New evidence on Gibrat's law for cities"
2012/19, Vázquez-Grenno, J.: "Job search methods in times of crisis: native and immigrant strategies in Spain"
2012/20, Lessmann, C.: "Regional inequality and decentralization – an empirical analysis"
2012/21, Nuevo-Chiquero, A.: "Trends in shotgun marriages: the pill, the will or the cost?"
2012/22, Piil Damm, A.: "Neighborhood quality and labor market outcomes: evidence from quasi-random neighborhood assignment of immigrants"
2012/23, Ploeckl, F.: "Space, settlements, towns: the influence of geography and market access on settlement distribution and urbanization"
2012/24, Algan, Y.; Hémet, C.; Laitin, D.: "Diversity and local public goods: a natural experiment with exogenous residential allocation"
2012/25, Martinez, D.; Sjögren, T.: "Vertical externalities with lump-sum taxes: how much difference does unemployment make?"
2012/26, Cubel, M.; Sanchez-Pages, S.: "The effect of within-group inequality in a conflict against a unitary threat"
2012/27, Andini, M.; De Blasio, G.; Duranton, G.; Strange, W.C.: "Marshallian labor market pooling: evidence from Italy"
2012/28, Solé-Ollé, A.; Viladecans-Marsal, E.: "Do political parties matter for local land use policies?"
2012/29, Buonanno, P.; Durante, R.; Prarolo, G.; Vanin, P.: "Poor institutions, rich mines: resource curse and the origins of the Sicilian mafia"
2012/30, Anghel, B.; Cabrales, A.; Carro, J.M.: "Evaluating a bilingual education program in Spain: the impact beyond foreign language learning"

2012/31, Curto-Grau, M.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Partisan targeting of inter-governmental transfers & state interference in local elections: evidence from Spain"
2012/32, Kappeler, A.; Solé-Ollé, A.; Stephan, A.; Välilä, T.: "Does fiscal decentralization foster regional investment in productive infrastructure?"
2012/33, Rizzo, L.; Zanardi, A.: "Single vs double ballot and party coalitions: the impact on fiscal policy. Evidence from Italy"
2012/34, Ramachandran, R.: "Language use in education and primary schooling attainment: evidence from a natural experiment in Ethiopia"
2012/35, Rothstein, J.: "Teacher quality policy when supply matters"
2012/36, Ahlfeldt, G.M.: "The hidden dimensions of urbanity"
2012/37, Mora, T.; Gil, J.; Sicras-Mainar, A.: "The influence of BMI, obesity and overweight on medical costs: a panel data approach"
2012/38, Pelegrín, A.; García-Quevedo, J.: "Which firms are involved in foreign vertical integration?"
2012/39, Agasisti, T.; Longobardi, S.: "Inequality in education: can Italian disadvantaged students close the gap? A focus on resilience in the Italian school system"

2013

2013/1, Sánchez-Vidal, M.; González-Val, R.; Viladecans-Marsal, E.: "Sequential city growth in the US: does age matter?"
2013/2, Hortas Rico, M.: "Sprawl, blight and the role of urban containment policies. Evidence from US cities"
2013/3, Lampón, J.F.; Cabanelas-Lorenzo, P-; Lago-Peñas, S.: "Why firms relocate their production overseas? The answer lies inside: corporate, logistic and technological determinants"
2013/4, Montolio, D.; Planells, S.: "Does tourism boost criminal activity? Evidence from a top touristic country"
2013/5, Garcia-López, M.A.; Holl, A.; Viladecans-Marsal, E.: "Suburbanization and highways: when the Romans, the Bourbons and the first cars still shape Spanish cities"
2013/6, Bosch, N.; Espasa, M.; Montolio, D.: "Should large Spanish municipalities be financially compensated? Costs and benefits of being a capital/central municipality"
2013/7, Escardíbul, J.O.; Mora, T.: "Teacher gender and student performance in mathematics. Evidence from Catalonia"
2013/8, Arqué-Castells, P.; Viladecans-Marsal, E.: "Banking towards development: evidence from the Spanish banking expansion plan"
2013/9, Asensio, J.; Gómez-Lobo, A.; Matas, A.: "How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain"
2013/10, Jofre-Monseny, J.: "The effects of unemployment benefits on migration in lagging regions"
2013/11, Segarra, A.; García-Quevedo, J.; Teruel, M.: "Financial constraints and the failure of innovation projects"
2013/12, Jerrim, J.; Choi, A.: "The mathematics skills of school children: How does England compare to the high performing East Asian jurisdictions?"
2013/13, González-Val, R.; Tirado-Fabregat, D.A.; Viladecans-Marsal, E.: "Market potential and city growth: Spain 1860-1960"
2013/14, Lundqvist, H.: "Is it worth it? On the returns to holding political office"
2013/15, Ahlfeldt, G.M.; Maennig, W.: "Homevoters vs. leasevoters: a spatial analysis of airport effects"
2013/16, Lampón, J.F.; Lago-Peñas, S.: "Factors behind international relocation and changes in production geography in the European automobile components industry"
2013/17, Guío, J.M.; Choi, A.: "Evolution of the school failure risk during the 2000 decade in Spain: analysis of Pisa results with a two-level logistic mode"
2013/18, Dahlby, B.; Rodden, J.: "A political economy model of the vertical fiscal gap and vertical fiscal imbalances in a federation"
2013/19, Acacia, F.; Cubel, M.: "Strategic voting and happiness"
2013/20, Hellerstein, J.K.; Kutzbach, M.J.; Neumark, D.: "Do labor market networks have an important spatial dimension?"
2013/21, Pellegrino, G.; Savona, M.: "Is money all? Financing versus knowledge and demand constraints to innovation"
2013/22, Lin, J.: "Regional resilience"
2013/23, Costa-Campi, M.T.; Duch-Brown, N.; García-Quevedo, J.: "R&D drivers and obstacles to innovation in the energy industry"

2013/24, Huisman, R.; Stradnic, V.; Westgaard, S.: "Renewable energy and electricity prices: indirect empirical evidence from hydro power"
2013/25, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"
2013/26, Lambertini, L.; Mantovani, A.: "Feedback equilibria in a dynamic renewable resource oligopoly: pre-emption, voracity and exhaustion"
2013/27, Feld, L.P.; Kalb, A.; Moessinger, M.D.; Osterloh, S.: "Sovereign bond market reactions to fiscal rules and no-bailout clauses – the Swiss experience"
2013/28, Hilber, C.A.L.; Vermeulen, W.: "The impact of supply constraints on house prices in England"
2013/29, Revelli, F.: "Tax limits and local democracy"
2013/30, Wang, R.; Wang, W.: "Dress-up contest: a dark side of fiscal decentralization"
2013/31, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"
2013/32, Saarimaa, T.; Tukiainen, J.: "Local representation and strategic voting: evidence from electoral boundary reforms"
2013/33, Agasisti, T.; Murtinu, S.: "Are we wasting public money? No! The effects of grants on Italian university students' performances"
2013/34, Flacher, D.; Harari-Kermadec, H.; Moulin, L.: "Financing higher education: a contributory scheme"
2013/35, Carozzi, F.; Repetto, L.: "Sending the pork home: birth town bias in transfers to Italian municipalities"
2013/36, Coad, A.; Frankish, J.S.; Roberts, R.G.; Storey, D.J.: "New venture survival and growth: Does the fog lift?"
2013/37, Giulietti, M.; Grossi, L.; Waterson, M.: "Revenues from storage in a competitive electricity market: Empirical evidence from Great Britain"

2014

2014/1, Montolio, D.; Planells-Struse, S.: "When police patrols matter. The effect of police proximity on citizens' crime risk perception"
2014/2, Garcia-López, M.A.; Solé-Ollé, A.; Viladecans-Marsal, E.: "Do land use policies follow road construction?"
2014/3, Piolatto, A.; Rablen, M.D.: "Prospect theory and tax evasion: a reconsideration of the Yitzhaki puzzle"
2014/4, Cuberes, D.; González-Val, R.: "The effect of the Spanish Reconquest on Iberian Cities"
2014/5, Durán-Cabré, J.M.; Esteller-Moré, E.: "Tax professionals' view of the Spanish tax system: efficiency, equity and tax planning"
2014/6, Cubel, M.; Sanchez-Pages, S.: "Difference-form group contests"
2014/7, Del Rey, E.; Racionero, M.: "Choosing the type of income-contingent loan: risk-sharing versus risk-pooling"
2014/8, Torregrosa Hetland, S.: "A fiscal revolution? Progressivity in the Spanish tax system, 1960-1990"
2014/9, Piolatto, A.: "Itemised deductions: a device to reduce tax evasion"
2014/10, Costa, M.T.; García-Quevedo, J.; Segarra, A.: "Energy efficiency determinants: an empirical analysis of Spanish innovative firms"
2014/11, García-Quevedo, J.; Pellegrino, G.; Savona, M.: "Reviving demand-pull perspectives: the effect of demand uncertainty and stagnancy on R&D strategy"
2014/12, Calero, J.; Escardíbul, J.O.: "Barriers to non-formal professional training in Spain in periods of economic growth and crisis. An analysis with special attention to the effect of the previous human capital of workers"
2014/13, Cubel, M.; Sanchez-Pages, S.: "Gender differences and stereotypes in the beauty"
2014/14, Piolatto, A.; Schuett, F.: "Media competition and electoral politics"
2014/15, Montolio, D.; Trillas, F.; Trujillo-Baute, E.: "Regulatory environment and firm performance in EU telecommunications services"
2014/16, Lopez-Rodriguez, J.; Martinez, D.: "Beyond the R&D effects on innovation: the contribution of non-R&D activities to TFP growth in the EU"
2014/17, González-Val, R.: "Cross-sectional growth in US cities from 1990 to 2000"
2014/18, Vona, F.; Nicolli, F.: "Energy market liberalization and renewable energy policies in OECD countries"
2014/19, Curto-Grau, M.: "Voters' responsiveness to public employment policies"
2014/20, Duro, J.A.; Teixidó-Figueras, J.; Padilla, E.: "The causal factors of international inequality in co2 emissions per capita: a regression-based inequality decomposition analysis"
2014/21, Fleten, S.E.; Huisman, R.; Kilic, M.; Pennings, E.; Westgaard, S.: "Electricity futures prices: time varying sensitivity to fundamentals"
2014/22, Afcha, S.; García-Quevedo, J,: "The impact of R&D subsidies on R&D employment composition"
2014/23, Mir-Artigues, P.; del Río, P.: "Combining tariffs, investment subsidies and soft loans in a renewable electricity deployment policy"

2014/24, Romero-Jordán, D.; del Río, P.; Peñasco, C.: "Household electricity demand in Spanish regions. Public policy implications"
2014/25, Salinas, P.: "The effect of decentralization on educational outcomes: real autonomy matters!"
2014/26, Solé-Ollé, A.; Sorribas-Navarro, P.: "Does corruption erode trust in government? Evidence from a recent surge of local scandals in Spain"
2014/27, Costas-Pérez, E.: "Political corruption and voter turnout: mobilization or disaffection?"
2014/28, Cubel, M.; Nuevo-Chiquero, A.; Sanchez-Pages, S.; Vidal-Fernandez, M.: "Do personality traits affect productivity? Evidence from the LAB"
2014/29, Teresa Costa, M.T.; Trujillo-Baute, E.: "Retail price effects of feed-in tariff regulation"
2014/30, Kilic, M.; Trujillo-Baute, E.: "The stabilizing effect of hydro reservoir levels on intraday power prices under wind forecast errors"
2014/31, Costa-Campi, M.T.; Duch-Brown, N.: "The diffusion of patented oil and gas technology with environmental uses: a forward patent citation analysis"
2014/32, Ramos, R.; Sanromá, E.; Simón, H.: "Public-private sector wage differentials by type of contract: evidence from Spain"
2014/33, Backus, P.; Esteller-Moré, A.: "Is income redistribution a form of insurance, a public good or both?"
2014/34, Huisman, R.; Trujillo-Baute, E.: "Costs of power supply flexibility: the indirect impact of a Spanish policy change"
2014/35, Jerrim, J.; Choi, A.; Simancas Rodríguez, R.: "Two-sample two-stage least squares (TSTSLS) estimates of earnings mobility: how consistent are they?"
2014/36, Mantovani, A.; Tarola, O.; Vergari, C.: "Hedonic quality, social norms, and environmental campaigns"
2014/37, Ferraresi, M.; Galmarini, U.; Rizzo, L.: "Local infrastructures and externalities: Does the size matter?"
2014/38, Ferraresi, M.; Rizzo, L.; Zanardi, A.: "Policy outcomes of single and double-ballot elections"

2015

2015/1, Foremny, D.; Freier, R.; Moessinger, M-D.; Yeter, M.: "Overlapping political budget cycles in the legislative and the executive"
2015/2, Colombo, L.; Galmarini, U.: "Optimality and distortionary lobbying: regulating tobacco consumption"
2015/3, Pellegrino, G.: "Barriers to innovation: Can firm age help lower them?"
2015/4, Hémet, C.: "Diversity and employment prospects: neighbors matter!"
2015/5, Cubel, M.; Sanchez-Pages, S.: "An axiomatization of difference-form contest success functions"
2015/6, Choi, A.; Jerrim, J.: "The use (and misuse) of Pisa in guiding policy reform: the case of Spain"
2015/7, Durán-Cabré, J.M.; Esteller-Moré, A.; Salvadori, L.: "Empirical evidence on tax cooperation between sub-central administrations"
2015/8, Batalla-Bejerano, J.; Trujillo-Baute, E.: "Analysing the sensitivity of electricity system operational costs to deviations in supply and demand"
2015/9, Salvadori, L.: "Does tax enforcement counteract the negative effects of terrorism? A case study of the Basque Country"
2015/10, Montolio, D.; Planells-Struse, S.: "How time shapes crime: the temporal impacts of football matches on crime"
2015/11, Piolatto, A.: "Online booking and information: competition and welfare consequences of review aggregators"

Dos campus d'excel·lència internacional

ieb@ub.edu
www.ieb.ub.edu

Energy Sustainability