Cooperation between firms for infrastructure

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INTRODUCTION

In many sectors, firms involved in the market are both competitors and partners. This is the case when these firms are present both upstream and downstream in different products. This is also the case when these firms use common resources to provide goods or services. These resources can be tangible (such as infrastructure) or intangible (such as ideas). The aim of this report is therefore to propose an analysis of these situations in order to understand the consequences of this cooperation both on the general structure of the industry (the amount of investments) but also on the ultimate welfare of consumers.

In the telecommunications sector, there are many forms of direct or indirect cooperation between telecoms operators. Recent examples can be found in the different types of agreements or arrangements between operators for the rollout of next generation networks (NGN). But it can also be considered that the provision of access to an infrastructure by a vertically integrated firm for a firm operating only downstream is a form of cooperation. Indeed, the conditions of access (quantity, price) have an influence on the type or intensity of downstream competition and therefore on the welfare of consumers. Moreover from a dynamic perspective, these access conditions have an impact on incentives to build, renovate or maintain infrastructure.

Network sharing between telecom operators and the related economic debates emerged following the introduction of competition in the 1990s, and as a result of the need for new entrants to benefit, at least in part, from the networks that were set up and retained by incumbents. In the United States, the 1996 Telecommunications Act imposed access obligations on incumbents as well as local exchange carriers. This sharing of infrastructures is asymmetric, since only some of the participants initially invested. Similarly, European regulation imposed access to the copper pair at a cost-oriented rate[1]. This first phase of developing competition through access was followed by a push to develop competition through infrastructure. This has led to the encouragement of unbundling at different levels, with, in the case of new generation networks, the possibility of integrating a risk premium into the rates[2]. But the difficulty of triggering investment, particularly in low-density areas or to allow the entry of new players, has led the authorities to foster network-sharing agreements or even co-investment. The French telecoms regulator (ARCEP) has distinguished between high-density

[1] See the European Regulation 2000/2887/EC.
[2] See recommendation 2010/572/EU on access to next generation networks.

and low-density areas.[3] In the former, each operator deploys his network horizontally (up to the foot of the building) and has in each building a dedicated fiber installed by the operator who installed the network in this building. It should be noted that the operator responsible for the installation in a building may apply for financing *ab initio*, and subject operators who have chosen later financing to a risk premium. For the low-density areas, the first investor should propose co-investing agreements on the last mile to the other firms. The latter can buy blocks of 5% of the total capacity, with quantity rebates and also better deals for those co-financing *ab initio*. In France, agreements between operators have been put in place to co-invest in NGNs (for example, the agreements signed between Orange and Free in 2011 for the areas covered by Orange, or between SFR and Bouygues Telecom in 2010 in which SFR deploys the network on behalf of both operators) or to allow a new entrant to use the mobile network of another (for example, the agreement between Free and Orange in 2012 allowing the former to use the network of the latter).

These agreements between operators are not the prerogative of France and can take various forms. In 2009, a global network-sharing agreement for four European countries was signed by Telefonica and Vodafone. In Spain, various agreements (2013, 2017) between Vodafone, Telefonica and Orange have also been designed to allow co-investment in fiber. In the United Kingdom, 3UK and T-Mobile have established a joint venture (Mobile Broadband Network Ltd) for antenna sharing, while Vodafone and O2 have an agreement through Cornerstone to share sites but not antennas. The recent proposal (2016) for the revision of the European regulatory framework takes note of the existence of such agreements, in so far as this contributes to sustainable competition.

Economic issues related to infrastructure cooperation are twofold. First, to the extent that the duplication of infrastructure is often inefficient, what are the cost-sharing rules that provide the right incentives for investment? Secondly, how can we prevent these rules, which would develop a form of coordination between firms, from weakening downstream competition to the detriment of consumers?

One way to analyze this situation is to draw parallels with the research and development agreements that lead firms which compete downstream to act in a cooperative way upstream. Firms choose their levels of investment together, to share costs then compete normally in the second period. In this first framework developed by C. d'Aspremont and A. Jaquemin (1988), there is no formal contract between the firms and there is no uncertainty. Furthermore, firms

[3] See ARCEP decision 2009-1106.

are symmetrical whereas there is often a leader, the historical monopoly, and the question is then the relationship between that firm and potential entrants.

An alternative way of analyzing the cooperation between upstream firms is to adopt the idea of an asymmetry between firms, with a leading firm (the incumbent operator) initially in place and a firm that comes later and which must contribute to the infrastructure. This is the purpose of the article by Nitsche and Wiethaus (2011), analyzing the role of access prices on investment and *ex post* competition. This is also the approach followed by Inderst and Peitz (2014), but the latter focus more on the timing of offers, pre-investment or post-investment, and the nature of the contracts.[4]

Previous contributions make it possible to properly account for cases where there is an initially established firm that might decide whether to allow access to its infrastructure. They are less appropriate for cases in which firms are more symmetric, as in the case of new generation networks. When both firms can invest, two approaches have been followed. In the first, investment increases the quality of the good and this investment can have the feature of a public good. In this approach, followed by Cambini and Silvestri (2013), different modes of cost-sharing (cost-sharing according to use, joint venture, etc) are compared as well as their consequences for investment and the welfare of downstream consumers. A second approach, developed by Bourreau, Cambini and Hoernig (2016), consists of a more geographical analysis in which investment is assimilated to a coverage rate and different firms may have different coverage rates. Again, the aim is to understand the effects of different cooperation rules (regulated or not) on investment and consumer welfare. In this report, we will discuss these different contributions in detail and attempt to synthesize their lessons in the conclusion.

RESOURCE SHARING AND COMPETITION

One way to see the stakes associated with upstream cooperation is to draw a parallel with studies on research and development cooperation. This parallel is coherent because in both cases large investments must be made initially with random profitability, due to uncertain

[4] We note, however, that this literature is more about cost sharing than risk sharing, whether it is related to regulation or demand. Thus, the important issue of the choice of regulation rates, *ex ante* or *ex post*, is ultimately rather undeveloped.

demand or uncertain cost. Moreover, in the case of infrastructure investments as in the case of R&D investments, this initial phase is followed by a competition phase, which is influenced by the decisions taken during the investment phase. While the benefits of upstream cooperation are well identified (it avoids unnecessary duplication and allows sharing of knowledge), there are also consequences downstream, with a potential reduction in competition. This is the object of the approach followed by C. d'Aspremont and A. Jaquemin (1988).

The analytical framework looks at the competition between two firms whose production costs depend not only on the quantities produced downstream but also on investments made upstream. A crucial element is the positive externalities between investments. Indeed, the investments made by firm 1 not only decrease the costs of this firm but also of firm 2, albeit to a lesser extent. These externalities may be due to the difficulty of partitioning inventions among firms, but also because an improvement over part of the network makes it easier to provide a better quality product for all firms. Once these investments are chosen, the two firms engage in Cournot competition, choosing the quantities proposed, and the prices adjust so that the supply is equal to the demand.

Thus, each firm must both choose its initial investments and choose the final production after observing the investments of all the players in the market. Three types of configuration can be compared. A first in which firms do not cooperate at any level, a second where firms cooperate upstream but compete *ex post*, and a third in which cooperation upstream goes hand in hand with cooperation downstream.

A first comparison focuses on the first two types of configuration. The upstream cooperation, which is that each firm maximizes the joint profit in its choice of investment, has two contradictory effects. On the one hand, each investment unit has a higher return, which encourages firms to invest more. On the other hand, downstream competition is even stronger as marginal costs are low. Therefore, to protect the margins of the two firms, it may be worthwhile to keep the costs of its competitor high, and thus to invest less than in the absence of cooperation. C. D'Aspremont and A. Jaquemin (1988) show that the first effect dominates if and only if the externalities are important, in other words, if the investment of each firm has a rather significant influence on the costs of the other firm.

A second comparison focuses on the effects of cooperation at both the upstream and downstream levels. This type of situation deserves to be considered because it is often difficult, once the conditions for cooperation are in place, to avoid “spillovers” in the downstream

competition. The analysis of d'Aspremont and Jaquemin (1988) shows that in this case the damage to investment is limited but the damage to the quantities finally produced, and therefore on welfare, is substantial. Indeed, since the two firms are now a *de facto* monopoly on the market, they have an interest in sharply lowering production costs and therefore investing upstream. Other things being equal, investments are maximized in the framework of upstream and downstream cooperation. But the desire to take advantage of the monopolistic position in the downstream market leads to lower production and hence to higher prices than in the case of partial cooperation or in the absence of cooperation.

ACCESS RATE, INVESTMENT AND WELFARE

The analysis of the consequences of upstream cooperation is complex because there are effects on both upstream and downstream competition. In particular, a study of the exact form of cooperation agreements is fundamental to understanding the consequences for consumers. We will mainly distinguish two frameworks of analysis. In the first, one of the firms is a leader and proposes a co-financing agreement to the other firms concerned; this framework corresponds to co-financing constrained by rules of regulated access. In the second, the two firms are more symmetrical and they can decide to invest together, simultaneously or separately in the different markets of interest.[5]

The approach of Nitsche and Wiethaus (2011) makes it possible to compare different modes of co-financing of infrastructures, with a focus on issues related to access rates. The analysis framework is similar to the one chosen by d'Aspremont and Jaquemin (1988), since there are two stages: firms invest first, then engage in Cournot competition. But in the approach of Nitsche and Wiethaus (2011), only one firm is able to invest, the other participating in financing in forms that vary according to the chosen mode of regulation. Moreover, the authors assume that there is uncertainty as to the success of the investment which is supposed to increase the value of the good for consumers. In other words, there is a likelihood that the investment will not lead to any benefit for consumers, and therefore cannot be profitable for the firms.

[5] Note that here we are not discussing the standard ECPR access rules or other options for the regulation of wholesale prices, and the related replicability issues. On these subjects see J.J. Laffont and J. Tirole (2001), and B. Jullien, P. Rey and C. Saavedra (2014).

Among the different modes of financing, the authors focus on the following: 1) pricing of access at long-term marginal cost, such that only the units actually used are paid for; 2) a full-cost allocation in which the firm that invested recovers an access rate related to its investment even if the asset is not valued more as a result of the investment; 3) an upstream cost-sharing system that leads firms to participate together in financing, and therefore to have the right to use the *ex post* infrastructure at a zero rate.These three modes of financing have different implications for downstream competition and therefore on incentives to invest *ex ante*.

Consider the first mode, namely the pricing of access at long-term marginal cost. This constrained form of co-financing consists in imposing a *pro rata* rate on the actual use of the infrastructure. Thus, the access rate is equal to the total cost divided by the quantities produced by the two firms. What is the effect of this rule in the second period? While for the firm that invested, each unit produced by the other firm increases its revenue, the same effect appears negatively in the profit of the firm benefiting from the access. Despite this, the two firms choose the same production. This result is due to the fact that an access not sold to the entrant increases the investment fraction born by the investing firm. Therefore, the use of the networks generates the same economic cost for the incumbent and for the entrant and both firms end up producing the same amount when the technology is successful. But since the cost is only perceived in this case, the investing firm only gets access revenue if demand is high. It therefore faces a very significant risk, in terms of both consumer demand and indirect revenue. The second mode of coordination also leads to identical productions for the two firms, but with a perceived marginal cost that is different. Indeed, whether the investment is successful or not, the firm that invested recovers its investment. Moreover, since demand is lower in case of investment failure, the access rate per unit consumed will be higher. This increase in cost tends to lower the intensity of competition and therefore the quantities produced. Thus, in the second mode of co-financing, the total production (for a given investment) is lower than in the first. The third mode of co-financing, *ex ante* risk sharing, leads to maximum production, at least for a given investment. Indeed, investment costs are paid *ex ante* and therefore have no influence on the marginal cost perceived by the firms. With marginal costs at a minimum, competition is high and total production is high.

What are the implications of these three modes for upstream investment choices? As the risk-sharing system induces very strong downstream competition, the firm will choose to limit its investment compared with the situation where the cost is fully distributed through the access rates. On the other hand, investment with *ex ante* risk sharing will be higher than in the case of

access rates based on the long-term marginal cost, at least if there is a sufficient risk that the investment may not be a success. Indeed, if investment is always a success, access rates are always positive, which reduces competition and encourages investment at the initial stage.

What conclusions can we draw about welfare? *Ex ante* risk sharing allows more investment and more competition than an access-rate system based on the long-term marginal cost. However, this mode of cooperation is not always preferable to a system of full-cost pricing because the latter provides a higher investment even if the degree of competition is reduced.

Inderst and Peitz (2014) adopt a very similar framework with some nuances. In particular, they assume that if access is not given, the firm that has not invested continues to benefit from the old technology, so that competition is now between differentiated goods. We also note that the choice of investment here is binary (at a cost I). As in Nitsche and Wiethaus (2011), there is uncertainty about the value to consumers of the new technology (but it is now a continuous parameter). The first difference between the different types of co-financing lies in the timing, before or after the investment; in other words, before or after the resolution of the uncertainty. The second difference is related to the structure of access prices, be they fixed or linear.

A first co-financing option consists of a fixed payment made *ex ante* by the firm seeking access. This payment must satisfy two conditions, to encourage both the leading firm to invest and the other firm to change technology.[6] It should be noted that these two conditions cannot be met at the same time unless the new technology is sufficiently valued in itself and that, when the two firms use it, it reduces the degree of competition so that the investment costs may be amortized by new income. It should also be noted that the cost must be shared according to usage, but that this depends on the valuation of the good, which is unknown at the outset. Here, the authors retain a cost-sharing system based on the expected production of the two firms.

A second co-financing option consists of an optional fixed rate, paid after the uncertainty is resolved and only if the firm seeking access decides to use the new technology. This will be the case if the new technology is attractive enough. Otherwise, there will be asymmetric competition between the firms, and only the firm that has invested will bear the costs of its investment. This may lead to an increase in the price offered to benefit from the new technology, further reducing the situations in which this technology is widely disseminated. We see here that one of the consequences of the conditionality is to make investment much rarer because only the leading firm bears the risk of losses.

[6] Note that there is no cost associated with the old technology.

Finally, the types of contracts available between the two firms can be expanded, always focusing on situations where negotiation takes place after the uncertainty about consumer interest in the new technology is resolved. It is assumed that it is the leading firm that makes a take-it-or-leave-it offer to the firm seeking access to the new technology. This offer is adjusted to the quality of the new technology and can also be calibrated to allow the leading firm to recover the entire surplus created. For example, the leading firm can set a fair price equal to the difference between the profit that the other firm would make with the new technology and its profit without that technology. This allows the leading firm to finance more projects, that is, to satisfy more easily both the participation constraint of the other firm and its own constraint of *ex ante* investment.

A commonly considered option is to use an access price per consumer. But one retains the idea that the terms of the contract are proposed after the uncertainty is resolved. With this variable access rate, the intensity of competition is reduced. Indeed, the leading firm has fewer incentives to increase its market share because its opportunity cost is higher with the access rate. Thus, an access rate above marginal cost reduces competition, and reduces welfare as soon as demand is price-elastic. On the other hand, this increases the profit of the industry. Thus, with an access price fixed *ex post*, not only is the share recovered by the leading firm higher than in the case of a fixed rate, but competition is lower and thus the profit of the industry as a whole is higher. The regulator must therefore balance the positive effect of more frequent adoption of the new technology against a lower surplus for consumers conditionally on adoption.

SHARING COST, COVERAGE AND COMPETITION

In the above models, one of the firms is always first to invest. We can look at more symmetrical cases where the two firms are initially more on an equal footing. This is probably better suited to the current situation of investment in new networks.

A first approach, developed by C. Cambini and V. Silvestri (2013), is to look at a situation where two firms compete in the broadband market, one of the firms initially owning the network. To renovate this network, different options are possible: the incumbent firm owning the network invests and must offer access to the second firm; the two firms sign a joint-venture

agreement, paying jointly the investment cost and a price to use the infrastructure; or a pure cost-sharing agreement that does not involve any payment for use of the equipment. We note that if the first solution is chosen, the access price will be chosen *ex post* by the regulator.

The investment increases consumer satisfaction in different ways from one consumer to another, even if these consumers have an identical assessment of basic services. The analysis is conducted in a Cournot competition framework, so that an increase in the quality offered by the two firms is not completely dissipated by competition.

Let us assume first that only the firm that owns the initial network participates in the building of the new generation network. This firm may anticipate that the regulator will in the future choose an access price equal to the short-term marginal cost. In this case, when choosing their production, the two companies face the same formal problem, the firm owning the network not earning access revenue. The investment decision in this case will just integrate the revenues related to the increase in profits in this framework, where the increase in quality is not completely dissipated by competition.

Suppose now that the two firms share production costs fairly before competing on the market *ex post*. In this case, the outputs are exactly the same as before, because each firm incurs its marginal cost of production. On the other hand, the investment is coordinated and internalizes the profits of the two firms. It is therefore twice as high as in the previous case.

Finally, we can examine the implications of a financing system through a joint venture, with each firm then paying a transfer price to use the common infrastructure. Even if the firms compete *ex post*, they cooperate *ex ante*. They will then choose a positive transfer price to soften the competition between them. As the two firms cooperate, they will choose a higher level of investment than in the two previous cases.

Comparing the different solutions gives the following results. Whether it is for consumers or social welfare, the second solution of simple cost-sharing is optimal. It is the solution that combines a good level of investment and low prices for consumers.

Thus, the work of Cambini and Silvestri (2013) confirms, by specifying them, the results obtained by Nitsche and Wiethaus (2011). These results are obtained by assuming that the regulator chooses *ex post* optimal prices (equal to the marginal cost), which indicates an inability to commit *ex ante*. But Cambini and Silvestri (2013) also analyze the *ex ante* rules

when the future entry of a third firm is anticipated. There are therefore potentially two access rates in this case, depending on whether the firm participated in the financing or afterwards.

Let us first analyze the case of pure investment sharing in which the investing firms can then freely benefit from the infrastructure. The price of access that firms will offer may block the entry of the new firm. This will be the case if the investment cost is not too high and therefore the help of a third firm is barely needed. On the contrary, the choice of a regulator in this situation will guarantee access to the new firm at marginal cost, leaving *de facto* the two firms initially in place to bear all the costs. The investment of firms will be lower in this second case.

In the case of a joint venture between two incumbent firms, these firms may again want to exclude the new firm. It is up to them to set an external access price equal to the monopoly price and an internal access price equal to the marginal cost. They can also accommodate the entry of the new firm by setting an access rate that makes this firm indifferent to the choice between the old technology and the new one. If the access charge is set by a regulator, it will choose an access charge equal to the marginal cost, whether internally or externally. And here again, this access charge is lower than that which the investing firms would have chosen. This is what drives these firms to invest less when the access price is controlled by a regulator than when it is chosen by the firms.

The comparison of these different cases confirms the major trade-offs discussed in the case without a firm entering *ex post*. At the given investment level, simple cost-sharing allows for more *ex post* competition and therefore lower prices. But the joint-venture agreements, by ensuring higher profits for firms, encourage them to invest more. An analysis of welfare reveals similarities with the case where all firms invest *ex ante*. Indeed, for the consumers, the system of simple cost-sharing generates more surplus than the joint ventures. On the other hand, it is more complicated to classify these two regimes in terms of social welfare. But these two regimes, if the investing firms are able to freely set access rates, are preferable to solutions where the access rate is regulated at the short-term marginal cost.

This approach confirms two important results. First, there is a tension between *ex ante* investment and intensity of *ex post* competition. The forms that most incentivize *ex ante* investment are those most likely to reduce *ex post* competition. But basing access rates only on marginal cost has such a depressive effect on investment that it is preferable not to regulate access prices, although this may lead to barriers to entry for new firms. Another reading of this result, which is certainly more reasonable, is that co-investment agreements should be allowed

and, during the first years of activity, investing firms should be lightly regulated regarding the proposed access price for late entrants.

It is important to note that the needs or opportunities in terms of co-investment are not uniform in this domain. Indeed, financing problems arise in different forms depending on the characteristics of different geographical areas. The article by Marc Bourreau, Carlo Cambini and Steffen Hoernig (2016) considers this diversity of situations in order to understand the stakes associated with the choice of the various financing methods.

To this end, the authors consider a multi-zone framework, in which each zone is characterized by its cost of coverage. Since the areas are identical in terms of demand, a firm will start by covering the low-cost areas before possibly covering the high-cost areas. As in the approaches discussed above, there is a firm in place that decides the extent of the areas covered and an incoming firm that then decides either to request access to the investments made by the first firm or to co-invest with the first firm.

The authors begin by analyzing, in terms of coverage, the implications when one or the other solution is imposed by the regulator.

In the case of a pure access-rate system, the potential profits of the firms will be either the monopoly profit if only the incumbent firm is present in the zone; or the profits of asymmetric duopoly if the other firm has asked for access, because this firm will pay the rate while the other will receive the corresponding income. At the level of coverage chosen by the firm in place, the other firm has an interest in requesting access in all zones if the access rate is not too high, or in none, because they are all identical from its point of view. What is the investment decision of the incumbent firm? This firm will recover the profits of duopoly increased by the access revenues. Since the access rate both has a positive impact on direct income and limits the intensity of competition, the number of zones covered by the firm will be an increasing function of the level of the access rate. In the case where the co-investment rules are in place, the choices are a little different. It is assumed that the leading firm begins by choosing which areas will be covered, then the entering firm proposes to co-invest in some of these areas. Let us note two important points. First, in the case of co-investment, cost sharing is done fairly between the two firms. Second, this rule means that in some areas (those with co-investment), the two firms compete while in others the leading firm is in a monopoly. The entrant will choose to co-invest in all areas where duopoly profit is larger than half the investment costs. As for the leading firm, it earns monopoly profits in the most expensive areas, and duopoly profits

in the others. It is easy to show that co-investment leads to covering a larger number of areas. Indeed, the last areas the leading firm will choose to cover in this regime are those profitable for a monopoly whereas they are the profitable areas for a duopoly in a regime with an access rate (a subset of the first group as the monopoly profit exceeds the duopoly profit). In addition, co-investment leads to increased competition in low-cost areas, benefiting consumers in this area. In a third option, the incoming firm can decide for each zone either to co-invest or simply to benefit from the network by paying an access rate. The ability to enter the market by simply asking for access creates an opportunity cost for the decision to co-invest. Areas with co-investment will therefore be less common. When the incoming firm does not co-invest, it can request access to earn duopoly profits and it is in this firm's interest to do so in all areas where there is a network. This therefore reduces the incentives of the leading firm to invest compared to the case of pure co-investment. Ultimately, if the access price is low there will be areas where the incoming firm only requests access; but if the price is high (but inferior to the price triggering exclusion of the firm seeking access), there will only be areas with co-investment or no investment.

Regarding welfare, these different regimes can be ranked quite easily, at least if we assume that the access rates are chosen (implicitly by a regulator) to maximize the difference between surpluses and investment costs for all areas covered. Indeed, it is clear that a co-investment regime with access generates more surplus than a pure access regime since competition is higher in co-investment areas and the areas covered are at least as numerous as in a regime with pure access. As for the comparison between the pure co-investment regime and the co-investment and access regime, it also favors the second scheme. Indeed, by choosing a high access rate, the first regime can be replicated with the second. If the chosen access rate is too low, incentives for investment will be low and welfare will be reduced compared to pure co-investment. But if the rate is chosen at an intermediate level, adding the possibility of access to co-investment makes it possible to increase competition in certain areas. This may lead to lower overall coverage, but social welfare is still higher.

We can look at the impact of uncertainty in this context. If demand is variable and revealed after investment, this may prompt the entering firm to forgo co-investing and to request access when this mode of regulation is possible. In other words, the presence of uncertainty may restore the optimality of a pure co-investment system whereas a mixed system with co-investment and access would be optimal without uncertainty.

CONCLUSION

New generation networks are increasingly in developed economies. It is therefore important for the different players in the sector (firms, regulators) to put in place a regulatory framework conducive to the development of these networks. Cooperation among the actors likely to invest in these networks is an option that must be seriously considered. And national regulators, such as the European Commission (see the draft revision of the regulatory framework), are well aware of this. But the fear that this upstream cooperation might spread downstream puts a damper on the benefits society can expect from this type of cooperation agreement.

This tension between the desire to provide incentive for investment and the fear of diminishing *ex post* competition is a constant feature of the economic literature. The form taken by the various *ex ante* cooperation agreements to encourage investment is therefore very important. And the work presented in this report has clearly shown the consequences associated with the choice of different forms of cooperation. In particular, co-investment agreements in which firms initially jointly finance the network and share user rights are a good compromise solution to generate a good level of investment (more than one solution with a single investor and an access rate) and a reasonable level of *ex post* competition (more intense in joint-venture cases).

An important and difficult question concerns which incentives to give investing firms, and equally, the rights to be granted to firms that do not invest initially. We must avoid a situation where firms, which to begin with have the choice between investing and offering access to their network or not investing and requesting access to third-party networks, all choose the second option. Often, and this is the approach taken by the academic literature, one of the firms is the natural leader in the market and will invest regardless of the others' choices. While this approach has been relevant in the past, it may be reductive for new technologies, and the question arises of which incentives might prevent a war of attrition in which each firm expects the other to invest. For firms that do not invest *ex ante*, for example because they are not initially on the market, a too lenient system would also excessively discourage *ex ante* investment. But it is complicated to freeze the market by prohibiting entry for new firms. It is therefore important that the regulator tries to make late arrivals 'pay' for their decision not to invest (and therefore take risks) upstream, either by including a risk premium in the access rate or the co-investment agreements, or by temporarily allowing actors who have invested the freedom to determine the conditions under which they grant access to third parties.

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