Two-way interconnection, competition and investment incentives: A survey of the economic literature

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Abstract—**This paper surveys the broad literature of two-way interconnection. In particular, it discusses how different assumptions concerning retail pricing strategies, demand structures, network externalities and asymmetries in the market affect the impact of termination charges on competition and investment incentives. The main contribution of this paper is that it points out the cases that have not been fully studied yet or the related literature provides mixed results.**

Keywords—competition; interconnection; termination charges; two-way access

I. INTRODUCTION

The deregulation of most telecommunications markets has challenged the need for regulatory intervention. In the case of one-way access, an unregulated incumbent may charge a too high access price in order to foreclose the access seekers (entrants) from the retail market. Therefore, the regulatory intervention in the access market is necessary for establishing competition, especially at the earlier stages of deregulation. On the contrary, in the case of two-way access, the operators have a mutual incentive to interconnect their networks in order to serve calls originated on their networks and terminated on competing networks. Therefore, although each operator is a monopolist over its subscribers' access lines, regulators are still concerned about the need to regulate termination charges (or access prices or interconnection charges).

Indeed, the economic literature on two-way interconnection provides ambiguous results concerning the impact of negotiated termination charges on the competition outcome in an unregulated access market. The seminal papers of this literature are those of Laffont, Rey and Tirole [1] and Armstrong [2], here-after A-LRT. These papers show that interconnection charges between two unregulated competing networks can be used to facilitate collusive outcomes. In particular, A-LRT show that under linear retail tariffs high interconnection charges reduce each network's incentives to lower retail price in order to increase market share.

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The reason is that if either network decreases its retail price, its subscribers will make more calls which triggers a net outflow of calls. Therefore, with termination charges above marginal cost, the incentive to decrease retail prices is reduced and the retail competition is softened. This implies that networks find it profitable to collude over the access charge in an unregulated market.

On the contrary, two-part tariffs (i.e. introducing a fixed charge into the linear retail pricing formula), which is a particular pricing scheme of non-linear pricing, make the two networks indifferent over the termination charges (profit neutrality) [1]. The basic intuition of this result stems from the fact that the fixed fee provides the networks with an additional instrument to build their market shares. Therefore, when the termination charge is increased, firms will increase call prices but, at the same time, they will reduce the fixed component to keep market shares. This implies that collusion over termination charges is unsustainable since each network sets the usage access fee at its perceived marginal cost (in order to avoid an access deficit) and uses the fixed fee to build market share.

It is thus obvious that the results are significantly sensitive to the assumption about the structure of the retail tariffs. However, since the benchmark A-LRT model is not only based on the assumption of linear retail prices, but also on many other assumptions, the robustness of the collusive and the profit-neutrality outcomes should be explored when relaxing the underlying assumptions. In particular, the A-LRT framework assumes that: (i) the network operators set linear retail prices, (ii) there are two symmetric unregulated networks which compete in a standard Hotelling framework (hence, full consumer participation is also assumed), (iii) the termination charges are uniform (i.e per-minute and usage-based) and reciprocal (i.e. symmetric networks charge as much for terminating a call originated on the rival network as they pay for terminating a call on the rival network), (iv) the demand for calls is homogeneous (i.e. all consumers have the same demand for calls), (v) the retail pricing is non-discriminatory (i.e. network operators charge their subscribers the same retail price either if a call originated on a network will be terminated on the same network ("on-net call") or on a competing network ("off-net call"), (vi) only callers receive utility from a call

TABLE I. CLASSIFICATION OF THE REVIEWD PAPERS ACCORDING TO THEIR UNDERLYING ASSUMPTIONS

		SYMMETRIC OPERATORS (MATURE MARKET)		ASYMMETRIC OPERATORS (EARLY STAGES OF DEREGULATION PROCESS)	
		LINEAR TARIFFS	**TWO-PART TARIFFS**	**LINEAR TARIFFS**	**TWO-PART TARIFFS**
BENCHMARK ASSUMPTIONS (iii)-(vii)		[1], [2], *[33]*, *[34]*, *[35]*	[1], *[35]*, **[37]**	[5]	[6], [7], *[35]*, **[37]**, **[39]**
TERMINATION-BASED DISCRIMINATION	**ONLY CALLERS PAY**	[15]	[14], [15], [16], [17]		[18], [19], **[38]**
	CALLERS& RECEIVERS DERIVE UTILITY BUT ONLY CALLERS PAY	[20]	[21]	[22]	[22]
	BOTH DERIVE UTILITY- BOTH PAY	[23], [24], [25], [26], [30]	[23], [24], [25], [26], [27], [30]		[28]
CONSUMER HETEROGENEITY			[8], [9], [10], [11], [12], *[35]*		[13]
NETWORK EXTERNALITIES (PARTIAL PARTICIPATION)			[8], [31], [32]		

(caller-pays principle) and (vii) there is a balanced calling pattern (i.e. the percentage of on-net calls is equal to the fraction of consumers subscribing to this network, which implies that for equal marginal prices, flows in and out of a network are balanced even if market shares are not).

This paper reviews the existing publications that extend the common A-LRT framework by relaxing some of the above benchmark assumptions. A first aim of this paper is to update previous reviews of the literature on two-way interconnection ([3], [4]) since these articles are published in 2002 and 2003, respectively, and as a result they only review the early publications. However, the main goal of this paper is to point out the cases that have not been studied yet or the related literature provides mixed results. Thus, each paper is classified according to its underlying assumptions. Table 1 classifies all the articles reviewed by this paper according to the way they depart from the benchmark A-LRT framework. Since the seminal papers derive the impact of termination charges on competition under linear and two-part tariffs in a symmetric environment, there are two ways to extend this framework. The first way is to study the robustness of the derived results when allowing for termination-based discrimination (i.e. price discrimination between on-net and off-net calls), consumer heterogeneity or network externalities (i.e. non-full consumer participation) in a symmetric environment. The second way is to examine whether the seminal results or the extended ones are robust in an asymmetric environment.

A much more significant extension is to study the impact of *regulated* termination charges on competition outcomes or to introduce an endogenous **investment** in quality. Each of these two assumptions can be combined with all the other assumptions that extend the A-LRT framework and hence each combination should be investigated separately. However, rather than presenting two more tables, we have italicized the papers that assume regulated termination charges and we have bolded the papers that introduce investment incentives.

From table I it can be concluded that the impact of termination charges on competition has been adequately studied in the cases where two either symmetric or asymmetric network operators charge two-part (discriminatory) retail prices. In addition, although there are several papers that study the impact of consumer heterogeneity and network externalities on the collusive and profit-neutrality outcomes with two-part tariffs, the related literature does not provide any result when asymmetries and/or linear tariffs are taken into account. Most significantly, the literature has not studied the impact of alternative regulatory settings that departs from the standard termination charges when relaxing the benchmark assumptions. Last, although regulators aim at not only promoting

competition but also at encouraging investments, the relationship between termination charges, competition and investments has not been fully investigated. In particular, the related literature has studied this relationship only with two-part tariffs and only for one deviation from the benchmark assumptions (termination-based discrimination when only callers receive utility from calls).

Therefore, table I can be used as a motivation for future research on the fields that the related literature provides few or no results. Section II reviews the existing publications that extend the common A-LRT framework and examine the robustness of the collusive and the profit-neutrality outcomes when departure from the benchmark assumptions. It is obvious that future research is also needed when the related literature provides mixed results. The last section concludes the main results of the literature of two-way interconnection.

II. Literature Review

This section reviews the literature that studies the robustness of the collusive and the profit-neutrality outcomes when the benchmark assumptions of the A-LRT framework are relaxed.

A. Asymmetric market structure

A first significant extension of the A-LRT framework is to allow for asymmetry between the two networks. This case better corresponds to the earlier stages of the deregulation process of the telecommunications market where the incumbent has several advantages over the (potential) entrants in terms of cost and demand. Allowing for unequal-sized networks by providing for brand loyalty, shows that the ability to use interconnection charges to facilitate collusion is retained with asymmetry [5]. However, the profit-neutrality outcome vanishes when asymmetric networks charge two-part tariffs [6]. In particular, the incumbent prefers the reciprocal access charge to be set at the marginal cost of providing the local loop, whereas the entrant prefers to have below (above) cost access charges when it faces a net outflow (inflow) of calls. If the two networks cannot agree on the level of interconnection charges, the regulator should require that the incumbent and entrant interconnect at some reciprocal price, but leave the incumbent free to set this price. The reason is that cost-based interconnection charges achieve the welfare maximizing outcome without any need for the regulator to determine costs or prices. If networks set non-reciprocal interconnection prices, then each firm prefer to unilaterally increase their charge for local call interconnection. In this case, non-reciprocal interconnection agreements allow the incumbent to use its greater bargaining power to charge more for incoming calls than it pays for outgoing calls. This can act as a barrier to entry for competitors to the extent it is not justified by cost differentials.

Therefore, when asymmetries call for non-reciprocal interconnection charges, the primary aim of access regulation should be the promotion of competition. According to [7], an access regulation scheme that provides the incumbent with cost-based termination charges and gives a positive access markup to the entrant has two positive effects on competition: a potential entrant is more likely to enter and, given entry, competition is more intense. Hence, this type of wholesale price regulation is effective in protecting consumers and encouraging entry at the same time. However, it also leads to a loss in total surplus which arises from a distorted per-minute price by the incumbent. It should be noted that this policy recommendation holds under both linear prices and two-part tariffs.

B. Consumers heterogeneity

It is shown that the profit-neutrality outcome still holds when customers are heterogeneous and networks engage in non-linear retail pricing [1] [8]. This result suggests that the optimal regulatory policy is to recommend networks set their access charge equal to the marginal termination cost [9]. Provided competing networks are symmetric, the firms have no strict incentive not to follow the recommendation. Then, with access charges being equal to costs the equilibrium tariff is a simple cost-based two-part tariff, resulting in efficient call-allocations for all types of consumers. On the contrary, when the A-LRT framework is modified in order to capture the fact that there might be a time frame after the deviation period where the cartel firms can react by changing the retail tariff but not by adjusting the termination charge, then termination fees can support collusion in the retail market even under two-part tariffs [10]. The reason is that with heterogeneous consumers, the optimum deviation strategy is usually to try to attract the high valuation customers since they are the ones with the highest profits. This strategy is made less attractive by setting termination fees above cost, since a deviator with a pool of high users will have more outgoing than incoming calls. Therefore, termination fees above marginal cost reduce the deviation profits and stabilize the collusion. The same outcome is reached when assuming that with high access prices (and so high retail prices) low demand users would not necessarily want to participate [11]. In particular, if there is a call imbalance between the two sectors, firms can set an access charge so that high demand customers generate an access revenue deficit. The effect of this is to limit competition for high demand customers and increase competition for light users.

From the above analysis, it can be deduced that introducing consumer heterogeneity in the A-LRT model with non-linear tariffs yields different results depending on the underlying assumptions. This analysis becomes much more complex if we take into account that customer heterogeneity in outgoing volume demand is not only correlated with differences in incoming call volume, but also with differences in how customers perceive competing networks. In particular, different customer types are likely to perceive the substitutability of the networks differently as they have different switching costs, different brand loyalty or a differentiated access to publicity and information about the networks. When networks are seen as better substitutes by the heavy (light) users than by the light (heavy) users, networks obtain higher profits by agreeing on an access charge below (above) marginal cost [12]. Therefore, the

[1] In this section, we use the general term "non-linear pricing" because the networks also price-discriminate among the different types of customers.

standard neutrality of two-way access prices found in the earlier literature no longer holds.

The only paper that discusses the impact of termination charges on competition between two asymmetric networks when subscribers are heterogeneous in their demand for calls is [13]. It shows that an increase in the incumbent's (entrants') termination charge leads the entrants to increase (decrease) their prices to all subscriber groups. An equal increase in both termination charges leads the entrants to lower their prices to low-volume users and raise their prices to high-volume users. Hence, the difference between termination charges affects the average intensity of competition, while an increase in the average termination charge affects the relative intensity of competition for the high and low volume subscribers. Concerning the optimal regulatory policy, it is shown that a reciprocal termination charge is optimal as long as the incumbent is regulated so that it just breaks even. This reciprocal charge is above the incumbent's cost of access whenever its retail tariff involves subsidizing low volume users.

C. Termination-based price discrimination

The most important extension of the A-LRT model is to allow the networks to price-discriminate according to whether a call originated on one network is terminated on the same network (on-net) or on a rival network (off-net). The reason is that such a pricing strategy is widely used in the typical two-way markets, such as mobile communications and internet services. The related literature is mainly focuses on two-part tariffs since the pricing structures are non-linear in these markets.[2] Therefore, under price-discrimination and two-part tariffs, networks would like to agree on a reciprocal termination charge below marginal cost in order to relax downstream competition [14]. In such cases, off-net calls are cheaper than on-net calls and hence networks compete less aggressively for market share. This result corrects the argument that termination charges are negotiated to equal the marginal cost of terminating a call provided by [15]. The conclusion of [14] that networks are interested in setting the access charges below cost to soften competition is not altered when generalizing to the multi-firm case [16]. However, when allowing for networks to choose competitively non-reciprocal access prices, it is shown that optimal access charges exceed the cost of termination [17].

There are two papers that study the impact of termination charges on competition between two asymmetric networks when they can set different two-part tariffs for on-net and off-net calls. The first paper assumes a reciprocal access price and shows that departing from cost-based access pricing allows the incumbent to foreclose the market in a profitable way [18]. This result depends on the impact of switching costs on consumers' ability to switch between networks. If the incumbent benefits from customer inertia, then it has an incentive to insist in the highest possible access markup even in the absence of actual switching costs. If instead the entrant benefits from customer activism, then foreclosure is profitable only when switching costs are large enough. The second paper shows that granting an access markup to the entrant reduces the probability of foreclosure and hence intensifies competition [19]. Therefore, non-reciprocal access prices that favor the entrant increase the entrant's profits and consumer surplus but decrease social welfare. The reason for their positive effect on entrant's profits and consumer surplus is that an increase in the access price paid by an operator is passed on to consumers through an increase of the per-minute price of off-net calls (which obviously benefits the entrant). On the contrary the reason for their negative impact on total surplus is that the off-net price of the strong operator is distorted above the socially efficient level and the market share of the strong operator is distorted further below the socially efficient level.

All the above studies assume that only the caller benefits from a call and not the receiver. The following three papers allow both callers and receivers to receive utility from a call (namely call externalities). In such cases consumers care about being called and hence networks set higher off-net prices in order to make the rival network less attractive. This implies that access charges below marginal cost can be used as a collusion device [20]. It is also shown that the welfare maximizing access charge is below the one that maximizes industry profits. Under two-part tariffs both the collusive and the welfare maximizing access charges also fall below marginal cost [21]. Therefore, call externalities do not alter the main result of termination-based price discrimination provided by [14]. In the case of asymmetric networks, the structure of retail pricing (i.e. linear or two-part tariffs) does not affect the incumbent's incentives to set higher off-net prices. This implies a higher off-net/on-net differential which leads the entrant to incur a permanent access when the reciprocal access charge is above marginal cost. In addition, the incumbent can adopt an anti-competitive, predatory-pricing strategy aimed at foreclosing the entrant. Predatory behavior would be accompanied by even larger on-net/off-net differentials even if access charges are set at cost [22]. Therefore, the presence of call externalities can lead the incumbent to foreclose the entrant, whereas in the absence of call externalities the incumbent can foreclose the entrant when the former benefits from customer inertia [18].

Another set of papers not only allow for call externalities and termination-based price discrimination but also assume that both callers and receivers share the cost of a call (i.e. networks charge both callers and receivers). This literature analyzes the effects of termination charges on retail prices when networks can set four separate per minute usage rates: an off-net origination rate, an off-net termination rate, an on-net origination rate and an on-net termination rate. The literature has produced two differing results concerning the effect of access charges on usage retail rates. The first result is widely known as "the off-net cost pricing principle (ONCPP)", which argues that all on-net and off-net usage rates will equal the marginal cost of providing service plus (minus) access charges paid (received) [23], [24]. The second result concludes that on-net rates depend only on (efficiently allocating) the on-net costs of service, while off-net rates depend both on the costs of providing the service and the access rate [25]. It is shown in

[2] In fact, this retail pricing scheme can been seen as a three-part tariff since it consists of a fixed fee and two usage fees for the on-net and the off-net traffic, respectively. However, the related literature calls this pricing scheme as two-part tariffs.

[26] that these different results depend on different assumptions regarding: (i) how usage rates affect consumer usage, (ii) whether subscribers to a telephone network both originate and receive calls, and (iii) whether some customers only originate calls while others only receive calls. Specifically, when customer usage does not depend on usage rates, and some customers originate all of the calls in which they engage while other customers receive all of the calls in which they engage, then the ONCPP will tend to describe the equilibrium. On the other hand, when the number of minutes of calling in which a customer engages depends on usage rates and customers tend to originate about the same number of minutes as they receive, then on-net rates tend to reflect only the cost of providing on-net service.

The literature studying the impact of termination charges on retail prices when both callers and receivers pay for the utility they derive is based on the assumption that there is a fixed volume of transactions for each receiver-caller match and all calls deliver the same gross surplus to a given end user. Thus, the distinction between linear and non-linear tariffs is irrelevant. However, a much more general determination of the ONCPP shows that when volume is variable, the marginal cost perceived by each network is affected by the externalities on the rival network's subscribers, and this leads networks to charge prices equal to off-net costs while, when volume is fixed, there are no such externalities [27].

A significant problem emerges when the receiver of a call benefits by as much as, or more than, the sender. In this case, both networks set off-net call charges so high as to eliminate off-net calling altogether. Even when the reciprocal termination charge is set equal to marginal cost, equilibrium off-net call charges still exceed the efficient level and a connectivity breakdown emerges [27]. This result also holds when allow for asymmetric networks [28]. However, the probability of a connectivity breakdown is reduced when calls made and received are complements in the information exchange [29].

Another problem concerns the necessity of reciprocal access prices for the existence of equilibrium [24]. In addition, symmetric access charges ensure the robustness of the ONCPP in an industry with any number of competing networks. Allowing for asymmetric but reciprocal access pricing in the presence of an arbitrary number of network operators shows that if the reciprocal access charge of a pair of networks departs away from a given symmetric access charge, then the two networks are driven out of one side of the market [30].

D. Partial consumer participation

Another significant deviation from the basic A-LRT framework is to relax the "full consumer participation principle" of the Hotelling model. Therefore, the demand for calls is elastic, some customers choose not to subscribe and the industry exhibits network externalities. This implies that networks should take into account the market expansion effects, as well as, the business stealing effects of their pricing strategies.

In particular, symmetric network operators may increase their profits by agreeing on an access charge below the marginal cost of access when they charge the callers with two-part tariffs [8]. This result removes the idea that the collusion concern should be associated with high access charges and confirm the results of [14]. Therefore, one may conclude that allowing for either partial participation or network-based price discrimination results in a reciprocal below cost access charge which vanish the profit-neutrality outcome of [1].

However, as it is shown in [31] a fixed participation rate makes the networks indifferent over the level of the access charge. On the contrary, an endogenous participation rate is crucial for the non-neutrality of the access charge. In particular, the profit maximizing access charge is also below marginal cost. As in the full participation case, the access charge can be used to manipulate equilibrium per-minute prices and rentals. Below cost termination charges make additional consumer less attractive (i.e. softens competition), but competition in rentals is even more fierce because there are new customers outside the market to be competed for, as well as, existing customers. It can be thus deduced that whether the profit-neutrality outcome still holds under partial participation depends on the endogeneity of the participation rate.

A very significant finding is provided by combining partial participation and network-based price discrimination. As it has been already mentioned in [8] and [14], higher than cost-based access charges induce stronger competition when networks can price-discriminate or there exist network externalities, respectively, and hence networks prefer below cost access charges. However, when both price discrimination and network externalities are present, network operators have an incentive to set the access charge above marginal costs of termination in order to increase joint market coverage and thereby exploiting network effects [32]. This strategy is in line with the maximization of social welfare and can hardly be called "collusion". In fact, the welfare maximizing level of access charges is also above marginal costs of termination and may be higher or lower than the negotiated access charge.

E. Regulation of the access price

So far we have mainly focused on two unregulated networks which agree on a reciprocal termination charge. Now, we study the optimal regulatory policy that reduces the networks' incentives to collude over a reciprocal termination charge. Recall that in a symmetric equilibrium with linear tariffs access charge may be used as a collusive device if high access charges inflate retail prices [1]-[2]. Therefore, an efficient access pricing rule must not inflate retail prices. It is shown that the Generalized Efficient Component Pricing Rule (GECPR)[3] exhibits such a property, and induces a highly pro-competitive outcome for a wide range of parameters. The GECPR dominates the Efficient Component Pricing Rule (ECPR), marginal cost pricing, and any non-negative fixed access charges in terms of efficiency [33].

Another regulatory alternative is to deviate from per-minute (usage) termination charges in order to prevent collusive outcomes and market foreclosure that harm consumers.

[3] The GECPR resembles the ECPR in that it also determines access charges based on the incumbent's opportunity cost. But the GECPR measures the opportunity cost in terms of the entrants' retail price instead of the incumbent's retail price.

Specifically, in the case of partially collusive retail market, non-linear access prices that are cost-based, negatively sloped and based on per-consumer usage result in the social optimal outcome [34]. This result holds under the benchmark assumptions of the A-LRT model. However, as it is shown in [35], an access price which is a linear function of both marginal costs and (average) retail prices set by both networks, can lead to the most efficient outcome under different assumptions concerning retail pricing, consumer heterogeneity and asymmetries in the market. In particular:

(i) With linear retail prices, there is a unique rule that implements the Ramsey price outcome as an equilibrium, independently of the underlying demand conditions, as long as there exists at least a mild degree of substitutability between networks' services. Therefore, even if the regulator does not have any information about the demand structure, it can provide the social optimal outcome by increasing the competition level. The reason is that contrary to the results of [1] and [2], such an access pricing scheme promotes competition in retail prices since each network decreases its access payments by decreasing its retail price.

(ii) With two-part tariffs, there exists a class of rules under which firms choose the variable price equal to the true marginal cost. Therefore, the regulator can choose among these rules to pursue additional objectives, such as increasing consumer surplus or promoting socially optimal investment, while achieving the efficient outcome. The profit-neutrality outcome of [1] does not hold because a higher magnitude of the impact of the average retail prices on the access price intensifies competition in fixed fees. It should be noted that the marginal cost pricing result holds even for asymmetric networks.

(iii) Contrary to [8] and [9] which show that efficiency is achieved by making the case with interconnection identical to the case without interconnection (i.e. setting the access price equal to the marginal cost), an access price which is a linear function of both marginal costs and (average) retail prices can achieve efficiency (under a class of access pricing rules) in the presence of interconnection and consumer heterogeneity.

F. Investment incentives

It is obvious that the primary goal of regulators is to promote effective competition in order to achieve static efficiency. Indeed, the question of the impact of two-way interconnection on static efficiency had been adequately investigated from the advent of the seminal works on 1998 until 2003, when it was first stated that there had not been developed any analysis of the linkage between access pricing and investment incentives [36]. The necessity of studying such linkage stems from the fact that the aim of regulators is not only to promote effective competition among network operators, which leads to lower prices and higher consumer surplus, but also to encourage efficient and timely investments by all networks, which leads to innovation and economic growth. However, the regulators' two-fold goal is related to the common trade-off between static and dynamic efficiencies.

In a two-way interconnection framework, the benchmark model of A-LRT is extended in order to allow networks to make quality-enhancing investments. An obvious reason for undertaking such costly investments is that they increase the consumers' willingness to pay and hence networks' profits. However, the related literature also studies whether such investments can be used as an instrument of "tacit collusion".

A starting point for answering such question is to keep in mind that quality-upgrading investments can reflect an endogenous asymmetry. The reason is that when competing networks choose different levels of investment, they face different demand and cost structures. Therefore, contrary to the results provided by an exogenous asymmetry under two-part tariffs [6], the networks have an incentive to agree to termination charges above the respective marginal cost since this strategy softens the competition over investments [37]. Therefore, in this case, the collusive outcome stems from diminishing each other's incentives to invest rather than raising each other's cost. It is obvious that this result is detrimental to social welfare and hence freely negotiated interconnection charges do not achieve the welfare maximizing outcome. This result is in stark contrast with the result obtained without quality-upgrading investments as provides by [6]. Since the above collusive outcome also holds in a symmetric equilibrium, the profit-neutrality outcome of two-part tariffs does not hold when quality-upgrading investments are taken into account.

A further extension is to examine whether termination-based price discrimination affects the under-investment result when termination charges have an impact on networks' investment incentives. It is found that when quality is regarded as exogenous factor, the results of [14] still hold even in an asymmetric environment. This implies that networks prefer to agree on a reciprocal termination charge below marginal cost in order to relax downstream competition. However, when quality-upgrading investments are endogenized, networks increase their profits by agreeing on above-cost reciprocal termination charges that diminish investment incentives [38]. Therefore, the under-investment result found in [37] is robust under termination-based price discrimination.

The aforementioned papers that study the impact of termination charges on networks' investment incentives explicitly assume that a quality-upgrading investment increases the consumers' willingness to pay, but does not alter their calling patterns. Allowing for a quality-sensitive traffic does not affect the main conclusion of this literature that private and social preferences always diverge once investments are endogenized [39].

III. CONCLUSIONS

This paper provided a review of the economic[4] literature of two-way interconnection. The existing publications are mainly based on the seminal works of this literature which found that: (i) under linear retail pricing firms use above-cost reciprocal interconnection charges as an effective tool to soften competition in the retail market (collusive outcome), and (ii)

[4] We intentionally neglected technical aspects of interconnection (such as differences between circuit and packet switching technologies) since we aimed at discussing the impact of access charges on retail competition from an economic perspective.

under two-part tariffs interconnection charges have no effect on network operators' profits and hence collusion over termination charges is unsustainable (profit-neutrality outcome).

However, both results are based on particular assumptions concerning retail pricing strategies, asymmetries in the market, demand structures and network externalities. The literature that followed the advent of the seminal works mainly focused on exploring the robustness of the two main results when relaxing these benchmark assumptions.

It was found that the collusive outcome seems to be robust in asymmetric markets, as well as, under call externalities. However, in the latter case call externalities make the firms use below-cost reciprocal interconnection charges as an effective tool to soften competition in the retail market. Concerning the profit-neutrality outcome, it was concluded that this outcome still holds under consumer heterogeneity but it vanishes either in asymmetric markets or under termination-based discriminatory pricing.

In many cases, the collusive outcome can be achieved even with two-part tariffs. The detrimental effect of a collusive outcome on competition can be exacerbated when asymmetries in the market call for non-reciprocal access prices. In such cases the incumbents can use their greater bargaining power to foreclose the entrants from the retail market. Although the need for regulation is imperative in both cases, the related literature has not adequately investigated the impact of termination charges on competition. In addition, there are only few papers proposing different regulatory settings that prevent network operators from using the termination charges as an effective tool for collusion.

Most importantly, network operators can also agree on termination charges above marginal cost in order to soften competition over investments. This collusive behavior makes operators to under-invest which leads to both static and dynamic inefficiencies. Since private and social preferences always diverge once investments are endogenized, regulators should intervene in the access market in order to promote competition and encourage investments. Although this is a very interesting and challenging result, the relationship between access regulation, competition and investment incentives has been investigated in very few ways.

It is thus obvious that this paper not only reviewed the existing literature of two-way interconnection, but also pointed out the fields that the future research should focus in order to deal with the currently open issues. These fields include the investigation of the robustness of the two seminal results in cases where: (i) the existing literature provides few or no results (see table I), (ii) the existing literature provides mixed results, and (iii) the regulatory intervention is imperative in order to deal with anti-competitive practices and encourage efficient investments.

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