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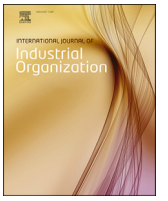

Complex pricing and consumer-side attention ☆

Christian Fischer-Thöne [a,*], Alexander Rasch [b,1], Tobias Wenzel [b,1]

[a] University of Bayreuth, Germany
[b] Düsseldorf Institute for Competition Economics (DICE), Germany

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ABSTRACT

This paper analyzes a market in which two horizontally differentiated firms compete by setting menus of two-part tariffs, and some consumers are not informed about the linear per-unit price component. We consider two regulatory interventions that limit firms' ability to price discriminate: (i) diminishing the range of contracts by reducing the number of two-part tariffs offered (which prohibits inter-group price discrimination); and (ii) reducing tariff complexity by abolishing linear fees (which prohibits inter-group and intra-group price discrimination). We characterize the effects of these interventions on firm profits and consumer welfare, and we identify conditions for the optimal regulatory policy. Our results provide insights for the evaluation of policy interventions.

1. Introduction

Advances in information technology and its applications allow firms to gain more information about their consumers, speeding up the trend toward more targeted offers and personalized pricing strategies. At the same time, however, consumers appear to find it increasingly difficult to compare all relevant information to make their purchase decisions. This is true despite the presence of services such as price-comparison websites on the internet. For example, some contract details are less salient than others, and consumers do not equally consider all price components. As a result, complex pricing practices (multi-part tariffs) have attracted the attention of regulatory authorities and consumer protection agencies. Regulatory interventions aim to ensure that consumers do not get lost in the wide array of offers (see our motivating examples below).

We build a duopoly model in which firms compete for consumers in a differentiated product market. Each consumer has a downward-sloping demand function, and firms can potentially offer a menu of two-part tariffs. Motivated by the examples below and building on the behavioral industrial organization literature (for example, Gabaix and Laibson, 2006; Armstrong and Vickers, 2012; Heidhues and Kőszegi, 2018), we incorporate the aspect of consumer information in our model. When firms set two-part tariffs, a share of consumers is uninformed in the sense that they are only aware of the fixed-price component. As a consequence, these consumers neglect the linear price when they decide from which firm to buy. At a later consumption stage, however, these consumers have also learned about the linear price, and thus they choose the consumption quantity accordingly. By contrast, informed consumers are fully aware of the firms' tariffs at all stages of the game.

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* Corresponding author. Address: University of Bayreuth, Department of Economics, Universitätsstraße 30, 95447 Bayreuth, Germany.
E-mail addresses: fischerthoene@uni-bayreuth.de (C. Fischer-Thöne), rasch@dice.hhu.de (A. Rasch), wenzel@dice.hhu.de (T. Wenzel).
[1] Address: Düsseldorf Institute for Competition Economics (DICE), University of Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany.

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Within this setting, we analyze different (potentially) complex pricing schemes. In our base version, firms offer a menu of two-part tariffs. These screening tariffs are designed so that informed and uninformed consumers self-select into different contracts. Informed consumers choose a contract with a high fixed fee and a low linear price; by contrast, uninformed consumers are attracted by a contract that offers a low fixed fee but features a high linear fee. All contracts are inefficient because the linear price exceeds marginal cost, leading to welfare losses. Furthermore, informed consumers are better off than uninformed consumers.

In the competition-policy debate, regulators and consumer protection agencies typically seek to increase the comparability of different offers through two approaches: education and simplification. When consumers learn to find out about contract pitfalls, they may make more educated purchase decisions. The same is true when firms are obliged to reduce the complexity of their pricing structures. Both policies can potentially result in a higher share of informed consumers. We analyze two policy interventions that restrict firms' choice of pricing schemes: (i) reducing the range of contracts, so that firms compete by offering single two-part tariffs; and (ii) abolishing linear fees, so that firms compete by offering fixed-fee contracts (as in the roaming regulation; see below).

The first intervention, which prohibits inter-group price discrimination, is interesting in itself because it can be viewed as an extension to the prominent framework developed in Gabaix and Laibson (2006). Note that this type of regulatory intervention is often discussed as a way to help consumers make better choices. For instance, Grubb (2015a) mentions the simplification of the choice environment as a concrete measure to reduce complexity, such that consumers find it easier to compare prices.[2] In contrast to some existing papers and the literature that followed (Gabaix and Laibson, 2006; Heidhues and Kőszegi, 2018), consumers do not consider add-on prices at the contracting stage, but optimally account for them in a subsequent consumption stage.[3] We characterize the single equilibrium two-part tariff and find that it depends on the shares of the two consumer types. Interestingly, whereas the linear price is strictly decreasing with the share of informed consumers, there exists a non-monotonic relationship between the share of informed consumers and both the fixed-price component and profits. This is different from previous results with linear or fixed fees only (see the related literature below). In those cases, when a larger share of consumers becomes informed about the prices set by the firms, competition always increases, resulting in lower fixed fees and lower profits. By contrast, our results suggest that the extent of possible waterbed effects crucially depends on the share of informed consumers; it is only significant in situations with many informed consumers.

The finding that a change in the share of informed consumers has ambiguous effects on profits under two-part tariffs is due to the relative strength of two opposing effects. On the one hand, a greater share of informed consumers implies a decrease in linear prices, leading firms to focus more on the fixed fee to earn profits. This effect tends to increase the fixed fee with a higher share of informed consumers. On the other hand, informed consumers are more sensitive than uninformed consumers to changes in the fixed fee. This competition effect puts downward pressure on fixed fees. However, this effect becomes weaker as the share of informed consumers increases. As a result, we find a U-shaped relationship, so that fixed fees and profits first decrease and then increase in the share of informed consumers. Related to this, there is also a non-monotonic relationship between the share of informed consumers and consumer surplus under these tariffs, but in the opposite direction. For low and intermediate shares of informed consumers, simplifying the pricing structure increases consumer surplus. However, consumer surplus can decrease if a larger number of consumers is informed.

Consistent with the idea that regulation removes the opportunity to earn large profits from uninformed consumers, firm profit falls, and overall consumer surplus rises. Yet, there can be opposing effects on different consumer types. Whereas uninformed consumers always benefit from regulation, informed consumers can be worse off.

The second intervention prohibits linear fees and thus prohibits inter- and intra-group price discrimination. The resulting single contract does not depend on the shares of the consumer types. We find that, compared to the base case with screening contracts, consumers and firms are typically affected in opposite directions. When firms set fixed prices only, in models with only informed consumers, this necessarily increases firm profits and hurts consumers (Gössl and Rasch, 2020). In our model with uninformed consumers, this may no longer hold; thus, firms may lose, and consumers may benefit if the share of uninformed consumers is sufficiently large. Interestingly, however, uninformed consumers always benefit from the intervention, whereas informed consumers always lose out. Thus, the overall effects on firm profits and consumer welfare are driven by the group composition. Furthermore, banning price discrimination can hurt firms because it lowers their opportunities to exploit uninformed consumers.

Depending on the parametrization of the model, both interventions can be the optimal choice of a consumer-oriented regulator. The regulation toward a single two-part tariff is the better intervention for a large share of informed consumers. By contrast, a regime with fixed fees only provides a larger surplus to consumers if the share of informed consumers is relatively low. If a regulator – apart from choosing the pricing regime – can influence consumer awareness (that is, via disclosure), a consumer-oriented regulator would opt for a single two-part tariff while promoting an intermediate share of uninformed consumers.

We extend our basic framework in three directions and show that our main results are (largely) robust to these extensions.

Motivating examples

Roaming fees in telecommunications markets offer a prominent example of the kind of market that is addressed here and one in which regulators have taken action. An interesting aspect in this market is that consumers appear to be unaware of the contract details

[2] As the analysis makes clear and in contrast to what one might at first expect to occur, such an intervention does not necessarily reduce total welfare.

[3] Note that in Gabaix and Laibson (2006) and related contributions, the interpretation is often that consumers have failed to take a costly protective action ex ante. As a consequence, consumers are later on unable to avoid the purchase of the add-on product.

with regard to roaming. As Oxera points out, "[t]he problem with international roaming is due in part to its status as an add-on service to the basic functionality of communication services."[4] As is known from the literature on add-on pricing (see below), add-on services and products are frequently not considered by (inattentive) consumers at the time of purchase; hence, add-ons are inconsequential for the purchase decision. As Oxera also argues, the add-on characteristic of roaming is due to the fact that "[c]onsumers typically purchase roaming within a bundle that also contains domestic calls, texts and data usage. However, there is generally little awareness of roaming charges [...]" (p. 1). The European Parliamentary Research Service finds that "in the retail roaming market, customers usually choose their operators on the basis of domestic offers instead of roaming services."[5] Furthermore, roaming services do not appear to feature prominently when operators advertise their plans. Fig. 1 provides two current examples for mobile plans with two of the largest operators in the United States, where full roaming details are only mentioned if prospective users seek additional information.[6]

One may argue that previously inattentive consumers learn over time, such that the share of behavioral consumers falls, and that consumer switching disciplines firms to cut down on roaming charges. As shown by García-Mariñoso and Suárez (2019), however, there appears to be less switching between mobile services than one might think. In particular, bundle complexity (mobile and fixed services) reduces the amount of switching. Furthermore, inattentive consumers appear to be inert because they are much less likely to change their service provider.[7] In a similar vein, Lunn (2013) stresses two important issues from a consumer perspective in the market for telecommunications services: low levels of switching between providers and a failure to select optimum tariffs.[8] On a related note, Grubb and Osborne (2015) find in their empirical study of cellular-service demand that consumers are inattentive to past usage. This suggests that learning does not play a prominent role in this market, which is why we also abstract from learning in our setup.

In the market for mobile services, the simplification of tariff structures was prominently featured in the European Commission's goal to reduce and abolish roaming tariffs in 2017 (roam-like-at-home [RLAH] regulation). What is important, though, is that before roaming charges were abolished, mobile phone operators had to send their consumers an alert with pricing information when they started roaming. Hence, even though consumers were not informed about all relevant charges when they signed their mobile phone contract, contract details actually became known before use.

The issue of roaming charges has regained relevance in the UK because mobile phone operators have indicated that they will levy such fees again as a consequence of the UK's 2016 "Brexit" decision to withdraw from the European Union (EU).[9] Moreover, in 2022, the European Commission announced that roaming was to be free of charge for another 10 years.[10] The policy of putting an end to roaming charges, however, is not only discussed (and implemented) in the European Union, but also in many other parts of the world. Only recently, in May 2024, Argentina approved the Agreement for the Elimination of International Roaming Charges to Mercosur End Users. Argentina, Brazil, Paraguay, and Uruguay had signed the Agreement in 2019.[11] In 2021, six Balkan countries eliminated roaming charges for calls and text messages for all mobile phone users across the region to foster regional integration.[12] A first step toward the elimination of roaming charges was taken by CARICOM in 2022 when roaming charges were reduced by a significant amount (up to 70%) within the Caribbean Community.[13] In Africa there are also various regional initiatives have eliminated roaming fees or indicated a commitment to do so.[14] The Eurasian Economic Union States aim to adopt roaming tariff regulations by the end of 2024 to ensure that their citizens will be able to use communication under domestic tariffs in any member country.[15]

It is crucial to understand the effects of interventions that limit firms' ability to set prices (such as by abolishing roaming fees) and their ability to price discriminate between consumers (such as by restricting the number of contracts). In the case of the abolition of roaming charges, economists worry about potential drawbacks via waterbed effects, such that lower roaming charges might lead to higher subscription prices (see, for example, Duso, 2017; Sutherland, 2010). It is true that roaming is not the main source of revenues for mobile operators, but it is still an important, multi-billion dollar business throughout the world. Indeed, from a global perspective, the roaming tariff market is far from negligible despite all regulatory efforts: it was valued at USD 74.25 billion in 2023, and it is expected to reach USD 113.22 billion in 2032.[16] Prior to the initial regulation in the EU in 2014, Deloitte pointed out that roaming

[4] Oxera, Agenda, October 2014: "A Connected Continent? Eliminating excessive roaming charges in the EU" (p. 1).

[5] European Parliamentary Research Service, May 2021: "Improving roaming on public mobile telecommunications networks" (p. 5).

[6] Consumer unawareness in the United States and possibly a lack of informing consumers on the firms' side are also reflected by the fact that the Federal Communications Commission (FCC) has its own consumer roaming guide on what to do and where to find rates (see https://www.fcc.gov/international-roaming).

[7] We make use of this finding in our alternative model setup in Section 7.3. On a general note, Bornstein (2021) points out that the marketing literature attributes consumer inertia to inattention among other factors. In his survey on consumer behavior, Grubb (2015b) summarizes that "[c]onsumers demonstrate substantial inertia."

[8] As the author points out with regard to switching, "the majority of consumers of fixed-line, mobile and internet services do not even consider switching provider over a twelve-month period" (p. 174).

[9] See, for example, https://www.bbc.com/news/business-45064268.

[10] See, for example, https://www.spiegel.de/netzwelt/web/roaming-bleibt-in-der-eu-zehn-jahre-kostenlos-a-e5bd3ff4-5da9-451b-aa7f-993afc999da5.

[11] See, for example, https://www.lexology.com/library/detail.aspx?g=3d388b01-e0d8-43e9-a2e2-db349d24e50f.

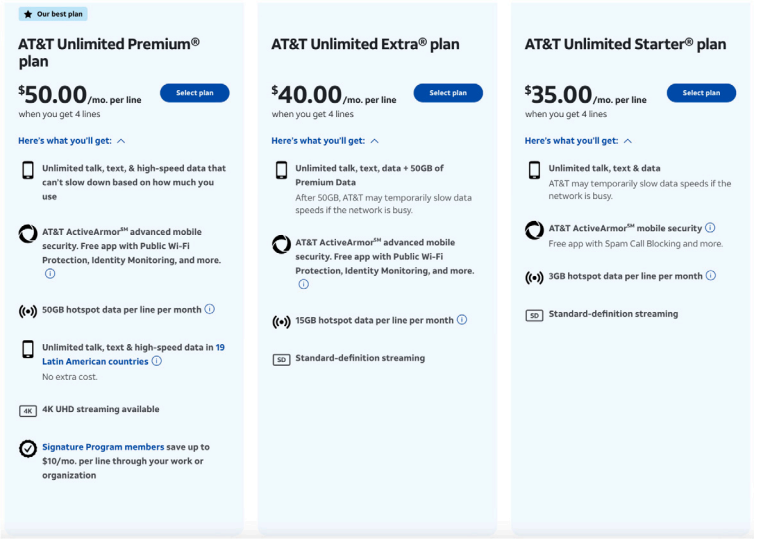
[12] See, for example, https://www.rferl.org/a/balkans-integration-roaming-eu/31336583.html.

[13] See, for example, https://ctu.int/historic-signing-of-declaration-on-reduction-of-roaming-charges-to-significantly-benefit-caricom-citizens/.

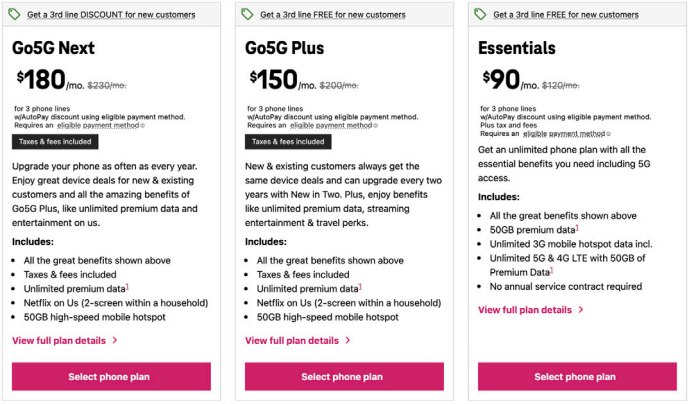
[14] See, for example, https://mg.co.za/africa/2023-06-21-four-sadc-countries-scrap-cell-phone-roaming-charges/.

[15] See, for example, https://eec.eaeunion.org/en/news/pravila-tarifikatsii-v-rouminge-na-territorii-eaes-primut-do-kontsa-2024-goda-/.

[16] See https://straitsresearch.com/report/roaming-tariff-market.



(a) AT&T (`https://www.att.com/plans/wireless/`).



(b) T-Mobile (`https://www.t-mobile.com/cell-phone-plans?INTNAV=tNav:Plans:Magenta`).

Fig. 1. Examples for phone plans advertised in the United States.

was "a significant revenue source also for German mobile operators" and that "[a]pproximately 5 to 6% of the operators' previous revenues are at great risk."[17] Oxera presents similar numbers: revenue generated by roaming within the EU accounted for an average of 4.2% of total mobile operator revenues across the EU in 2009. The fact that European regulators focus on roaming can be seen as evidence that this aspect is very relevant when it comes to consumer protection. Due to the importance of this revenue stream for mobile operators, they were not expected to easily give up on revenues from roaming. For example, Oxera concluded that "some attempt to protect revenue cannot be ruled out" (p. 4).[18]

Note that the insights from our study are not limited to the market for roaming services. Indeed, pricing patterns in which some price components feature more prominently than others are widespread in many industries.[19] Examples include some of the most important sectors of the economy, such as financial services, insurance, and tourism. At the same time, these pricing strategies have attracted the suspicion of regulators and consumer protection agencies around the world. As recently as 2022, in the United States, the Biden-Harris administration has announced its intention to take general action against "junk fees" in all kinds of industries to save households billions of dollars each year.[20] A prominent, concrete example comes from the banking sector's unauthorized

[17] Deloitte, 2014: "What is the next roaming strategy for EU operators? New rules. New game." (p. 2).

[18] There are a couple of contributions investigating the previous regulation on wholesale and retail roaming fees from 2007 (see, for instance, Ambjørnsen et al., 2011). Moreover, Genakos and Valletti (2011, 2012) empirically identify waterbed effects in mobile telecommunication markets when interconnection charges are reduced.

[19] These pricing techniques come in various names and forms, such as contingent prices (e.g., Armstrong and Vickers, 2012), drip pricing (e.g., Rasch et al., 2020), add-on pricing (e.g., Gabaix and Laibson, 2006), and hidden costs/fees.

[20] See, for example, https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/11/biden-harris-administration-announces-broad-new-actions-to-protect-consumers-from-billions-in-junk-fees/, https://www.ftc.gov/news-events/news/press-

(unarranged) overdraft fees in the United Kingdom (UK). As documented in a market study by the Office of Fair Trading (2008) for the UK, a substantial number of consumers was not aware of fees charged for insufficient funds. By contrast, consumers are familiar with the fees to open or maintain current accounts. In the UK, the dominant model for current accounts is the so-called "free-if-in-credit" model, which means that consumers are not charged fixed fees or fees on standard transactions as long as their account balance remains positive.[21] In 2018 overdraft fees came under scrutiny by the Financial Conduct Authority (FCA). According to the FCA, banks made GBP 2.4 billion a year from overdrafts paid by 14 million people, leading the FCA to ban excessive fees for this service.[22]

Related literature

Our paper is related to two strands of literature. First, we contribute to the literature on behavioral industrial organization and add-on pricing. Second, we contribute to the literature on competitive price discrimination (particularly two-part tariffs) in differentiated product markets.

We add to the growing literature on behavioral industrial organization that studies market outcomes in the presence of behaviorally biased consumers.[23] Within this literature, our paper is related to studies on add-on pricing involving consumers who do not take into account the prices of additional products or services (such as fees hotels charge for parking and minibar contents, and fees airlines charge for checked bags) when making a purchase decision (for example, Gabaix and Laibson, 2006; Armstrong and Vickers, 2012; Grubb, 2015a; Heidhues et al., 2017). We extend this literature in three ways.[24] First, this literature typically considers a binary purchase decision of the add-on item, whereas in our setting, individual add-on demand depends on the price.[25] Second, in our model, consumers are only unaware of one (linear) price component at the contract stage (when deciding where to buy), but they are completely informed when making quantity choices about the add-on product. This is consistent with the idea that, at some point, consumers become fully informed about the contract details and can adjust their consumption behavior. Third, our setting allows us to explore different pricing scenarios (with intra- and inter-group price discrimination) and to analyze the welfare effects on market participants.

There is also an older literature on consumer-side market transparency assuming that an exogenously given share of consumers is uninformed about prices and selects randomly among competing firms.[26] By contrast, consumers in our model can observe some, but not all price elements. The focus of these papers is different, however. For example, these contributions analyze firms' ability to maintain collusion when the share of informed consumers changes (Schultz, 2005, 2017; Rasch and Herre, 2013), and they investigate the scope of market entry when the degree of consumer information varies (Schultz, 2009; Gu and Wenzel, 2011).

We also contribute to the literature on competitive price discrimination in differentiated product markets (e.g., Armstrong and Vickers, 2001). Surveys are provided by Armstrong (2006) and Stole (2007). As in Yin (2004) and Gössl and Rasch (2020), we compare different pricing scenarios (two-part tariffs, only fixed prices). In contrast to the previous literature, we study a setting in which consumers are only partially informed about relevant price components. This makes it possible to study the effect of banning only inter-group price discrimination (firms can offer only a single two-part tariff) and situations in which both inter- and intra-group price discrimination are banned (firms can only offer a tariff with a fixed price, but there is no linear-price component).

We also add to the literature that has investigated price discrimination with behaviorally biased consumers. For instance, Eliaz and Spiegler (2006) showed how a monopolist can screen consumers who differ in their degree of naiveté. Heidhues and Kőszegi (2010) analyzed a credit-card market in which consumers differ in their beliefs about time-consistent behavior. Related to add-on pricing, Heidhues et al. (2017) considered a setting in which firms screen consumers by offering an inferior product (with a high add-on price) to naive consumers and a superior product to sophisticated consumers. Herweg and Mierendorff (2013) studied a setting in which consumers are loss averse; the authors derived conditions under which firms offer a flat-rate tariff (that is, a contract with a linear price of zero). Heidhues and Kőszegi (2017) studied the effects of third-degree price discrimination if firms have information about consumer naiveté. We contribute to this literature by studying the welfare effects of banning price discrimination between informed and uninformed consumers in the presence of two-part tariffs.

Our results are in line with the findings of some recent empirical papers evaluating the effects of the EU's RLAH regulation (Canzian et al., 2021; Munoz-Acevedo and Grzybowski, 2023; Quinn et al., 2022). This literature finds that the regulation decreases the mobile operators' revenues and increases consumer surplus. Importantly, this literature also concludes that the regulation does not increase domestic prices (the fixed fees in our setting), which can be explained in our framework with uninformed consumers.

releases/2023/10/ftc-proposes-rule-ban-junk-fees, and https://www.consumerfinance.gov/about-us/newsroom/cfpb-issues-guidance-to-halt-large-banks-from-charging-illegal-junk-fees-for-basic-customer-service/.

[21] Note that in times when consumers receive little to no interest on their positive balances, the lack of interest effectively serves as an implicit payment to the banks, which can reinvest these balances at market rates.

[22] See, for example, https://www.theguardian.com/money/2018/dec/18/banks-fees-unarranged-overdrafts-fca. Note that, as in the case of roaming, some observers warned of waterbed effects.

[23] For a survey, see, for instance, Grubb (2015b) and Heidhues and Kőszegi (2018). This literature shows that policy interventions can sometimes have unexpected equilibrium effects and lead to worse outcomes for consumers. See, for instance, Spiegler (2015) or Grubb (2015a).

[24] In the above-mentioned contributions as well as in our article, add-on products are priced excessively. By contrast, there are also studies that point out in which circumstances add-on products may be subsidized (Gomes and Tirole, 2018; Bourguignon et al., 2019). For instance, Gomes and Tirole (2018) show that firms' concerns about consumers opting not to buy at all (that is, missed sales) can lead firms to reduce add-on prices.

[25] An exception is Grubb (2009), which considers the case in which consumers may overestimate the precision of their future consumption.

[26] See, for instance, (Varian, 1980) for a setting with homogeneous products and Schultz (2005) for a model with differentiated products.

The paper proceeds as follows. Section 2 presents the model setup. Section 3 derives the equilibrium for the case in which firms can offer multiple two-part contracts to consumers. Sections 4 and 5 analyze the outcomes when, due to policy interventions, firms are restricted in the type of contracts they can offer (either a single two-part contract or fixed-fee contracts). Section 6 compares the implications for firm profits, consumer surplus, and social welfare. In Section 7, we discuss two extensions. Section 8 concludes.

2. The model

We consider a model of horizontal product differentiation with two symmetric firms located at opposite ends of a unit line (Hotelling, 1929). Fixed and marginal costs are normalized to zero. Depending on the pricing scenario considered, firm i ($i \in \{1,2\}$) can offer a two-part contract with a fixed price f_i and a linear price p_i that must be paid for every unit purchased.

A unit mass of consumers is uniformly distributed along the unit line. There are two types of consumers, informed and uninformed. The share of informed consumers is ϕ, and the share of uninformed consumers is $1-\phi$. These shares are the same for all locations $x \in [0,1]$ on the unit line. The two groups differ in their information status j about the firms' pricing policy. We denote informed consumers by $j = r$; uninformed consumers are denoted by $j = n$. Firms cannot distinguish between the different consumer types. That is, firms cannot use third-degree price discrimination.

We allow the quantity demanded by an individual consumer to depend on the price. A consumer who is located at x and purchases quantity $q \in [0,1]$ receives the following utility when buying from firm i:

$$u_i(x;q;f_i,p_i) = q - \frac{q^2}{2} - q\left(p_i + \tau|L_i - x|\right) - f_i, \tag{1}$$

where τ is the transport-cost parameter. L_i denotes the location of firm i, where $L_1 = 0$ and $L_2 = 1$.[27]

This formulation follows the approach in Yin (2004). We use a shipping model in which consumers incur (linear) transport costs per unit consumed.[28] This implies that mismatch costs occur for each unit purchased; $q\tau|L_i - x|$ represents the total disutility suffered by a consumer with preferred product characteristics x when consuming a product that is not ideal (that is, not located at x, but at L_i).

Consumer decision-making proceeds in two stages. In a first step (the contracting stage), consumers decide where to buy. In a second step (the consumption stage), consumers decide about the quantity to be consumed at the chosen firm. At the consumption stage, a consumer chooses quantity q to maximize utility from consumption (equation (1)). This implies that the demand of a consumer located at x who buys at firm i takes the following linear form:

$$q_i(x;p_i) = 1 - p_i - \tau|L_i - x|. \tag{2}$$

At the contracting stage, the two consumer groups differ in the extent to which they take into account price information when deciding between the firms' contracts. An informed consumer ($j = r$) takes into account any price component charged by the two firms. By contrast, an uninformed consumer ($j = n$) is aware of the fixed fees charged by the firms, but neglects the linear prices, and expects both firms to set a linear price of zero when selecting a firm.[29] Hence, a consumer of type j (at location x) expects to consume the following quantities:

$$q_i^j(x;p_i) = 1 - \mathbb{1}_r p_i - \tau|L_i - x|, \tag{3}$$

where the indicator function is given as

$$\mathbb{1}_r(j) = \begin{cases} 1 & \text{if } j = r, \\ 0 & \text{if } j = n. \end{cases}$$

Note that for an informed consumer ($j = r$), the expected and actual consumed quantities coincide; that is, expressions (2) and (3) are identical. By contrast, for an uninformed consumer, expected demand and actual demand diverge. Indeed, by neglecting the linear-price element, an uninformed consumer expects to consume a higher quantity than is optimally chosen later.

Given expected demand levels, a consumer with information status j who is located at x and expects to purchase $q_i^j(x;p_i)$ anticipates the following utility when choosing firm i at the contracting stage:

[27] Note that we could add a fixed value for basic services (for example, for domestic calls and internet services in the example of mobile phone roaming prices). For reasons of tractability, we normalize the valuation for such services to zero.

[28] Our linear demand specification is a simplified version of that in Section 3.2 of Yin (2004) that is also used in Gössl and Rasch (2020). The shipping model allows us to derive tractable results, and it fits to the market we have in mind. An alternative approach to introducing elastic demand in the linear city is to consider a setting in which the transport costs are incurred independently of the consumption volume. This approach is taken, for instance, in Armstrong and Vickers (2001) in the context of price discrimination and in Gu and Wenzel (2009) in the context of firm entry. We discuss an alternative setup with location-independent demand in Section 7.3.

[29] We acknowledge that the assumption that uninformed consumers completely ignore the linear fee is quite strong. The results of our analysis, however, do not depend on the assumption that uninformed consumers expect both firms to have zero marginal prices. What is important for our results is that uninformed consumers are not responsive to or underestimate linear fees at the contracting stage. Therefore, in Section 7.2, we generalize the consumer bias and consider a version of our model in which consumers underestimate (but do not completely ignore) the linear fee.

$$u_i^j(x;q;f_i,p_i) = q_i^j(x;p_i) - \frac{(q_i^j(x;p_i))^2}{2} - q_i^j(x;p_i)\left(\mathbb{1}_r p_i + \tau|L_i - x|\right) - f_i.$$

Again, expected and actual utility levels coincide for an informed consumer, but an uninformed consumer expects a higher utility level from choosing a supplier. It should be noted that, in this respect, our setup differs from existing models. In our setting, there is only a distortion in contract choice, but behavior is optimal in the consumption stage (once contracts have been chosen). This is different from existing contributions. For instance, in Gabaix and Laibson (2006), a share of consumers may consume an overpriced add-on product even if there is a cheaper outside opportunity available. Similarly, in Heidhues et al. (2017), a consumer may purchase a product even if the price exceeds the valuation. By contrast, in our approach, all consumers eventually learn about all price components, and their actual purchase decisions are optimal ex post.

Throughout the paper, we focus on situations in which the market is fully covered (that is, each consumer buys from either firm 1 or firm 2), and firms find it profitable to serve both types of consumers. This imposes restrictions on the admissible range of transport costs. On the one hand, transport costs must not be too large because otherwise some of the consumers prefer not to buy from any firm. On the other hand, when transport costs are very low, the optimal strategy for firms may be to cater only to either uninformed or informed consumers. The corresponding restrictions are summarized in Assumption 1 (and derived in the Appendix)[30]:

Assumption 1. *Transport costs are such that*

$$0 \leq \underline{\tau}(\phi) \leq \tau \leq \bar{\tau} = \frac{4\left(23 - 2\sqrt{73}\right)}{79}.$$

The timing of events is as follows:

Stage 1 (Pricing stage) Both firms simultaneously set their prices. Depending on the regime, firms can charge (i) a menu of two-part tariffs, (ii) a single two-part tariff, or (iii) only a fixed fee.

Stage 2 (Contracting stage) Consumers observe firms' pricing decisions and decide which contract to choose. Informed consumers consider all price elements, whereas uninformed consumers ignore linear price elements.

Stage 3 (Consumption stage) Uninformed consumers learn the linear price, and all consumers choose their consumption level. Firm profits and consumer surplus materialize.

Next, we solve for the subgame-perfect equilibria of the various pricing scenarios.

3. Competition with screening contracts

We start by considering the case in which firms can offer two different two-part contracts aimed at screening informed and uninformed consumers.

In the final stage (the consumption stage), all consumers are fully aware of the pricing details of the chosen contract. As a result, the actual demand of every consumer is given by expression (2). However, when deciding from which firm to buy in the second stage, the uninformed agents are unaware of the linear component leading to a type-dependent location for the indifferent consumer. For consumer type j, the location of the indifferent consumer, $\tilde{x}^j$, is uniquely determined by:

$$u_1^j\left(\tilde{x}^j;q_1^j;p_1,f_1\right) = u_2^j\left(\tilde{x}^j;q_2^j;p_2,f_2\right). \tag{4}$$

Hence, the indifferent consumer of type j is located at

$$\tilde{x}^j = \frac{1}{2} - \frac{\mathbb{1}_r\left(p_1 - p_2\right)}{2\tau} - \frac{f_1 - f_2}{\tau(2 - \mathbb{1}_r\left(p_1 + p_2\right) - \tau)}. \tag{5}$$

Note from equation (5) that informed and uninformed consumers differ in their responsiveness to changes in the fixed component f_i: Demand by informed consumers is more sensitive than demand by uninformed consumers to changes in the fixed fee. Moreover, this responsiveness of informed consumers also increases with the linear price. This is because informed consumers anticipate that their benefit from usage is low for relatively high linear prices. In this case, even small differences in the fixed fees translate into relatively large differences in utility from the two firms, increasing informed consumers' sensitivity to changes in the fixed fee.

Firms set their prices anticipating the type-dependent indifference levels and the fact that both types of consumers choose the same quantity after having learned p_i. Assume that $\tilde{x}^j \in [0,1]$. Then, firm i's maximization problem is given by

$$\max_{(p_{i,n},f_{i,n}),(p_{i,r},f_{i,r})} \pi_i((p_{i,n},f_{i,n}),(p_{i,r},f_{i,r})) =$$

[30] Both upper and lower bounds are binding in the case in which firms offer a single two-part tariff. The lower bound is written in terms of the transport-cost parameter τ. Of course, it could also be given in terms of the share of informed consumers ϕ. Note further that we do not give the exact expression for the lower bound due to non-tractability. The expression will be provided by the authors upon request.

$$\phi\left(p_{i,r}\int_{\min\{L_i,\tilde{x}^r\}}^{\max\{L_i,\tilde{x}^r\}}(1-p_{i,r}-\tau|L_i-x|)dx+f_{i,r}\left(\max\left\{L_i,\tilde{x}^r\right\}-\min\left\{L_i,\tilde{x}^r\right\}\right)\right)$$
$$+(1-\phi)\left(p_{i,n}\int_{\min\{L_i,\tilde{x}^n\}}^{\max\{L_i,\tilde{x}^n\}}(1-p_{i,n}-\tau|L_i-x|)dx+f_{i,n}\left(\max\left\{L_i,\tilde{x}^n\right\}-\min\left\{L_i,\tilde{x}^n\right\}\right)\right)$$

subject to consumers choosing the intended contract:

$$u_i^r(x;q;f_{i,r},p_{i,r})\geq u_i^r(x;q;f_{i,n},p_{i,n}),$$
$$u_i^n(x;q;f_{i,n},p_{i,n})\geq u_i^n(x;q;f_{i,r},p_{i,r}).$$

The maximization problem allows firms to offer possibly different contracts to informed consumers $(p_{i,r},f_{i,r})$ and to uninformed consumers $(p_{i,n},f_{i,n})$. Because consumer types are not observable, firms have to ensure that each type chooses the intended contract. Proposition 1 describes the equilibrium contracts offered to the two consumer types (where we drop subscript i and use subscript S to denote equilibrium outcomes under screening contracts).

Proposition 1. *When firms can offer multiple two-part tariffs, firms will design different contracts for informed and uninformed consumers. The contract designed for an informed consumer is*

$$f_{S,r}^*(\tau)=\frac{3\tau(4-3\tau)}{16}\quad\text{and}\quad p_{S,r}^*(\tau)=\frac{\tau}{4}.$$

The contract designed for an uninformed consumer is

$$f_{S,n}^*(\tau)=-\frac{16-80\tau+35\tau^2}{64}\quad\text{and}\quad p_{S,n}^*(\tau)=\frac{4-\tau}{8}.$$

In equilibrium each firm earns profits of

$$\pi_S^*(\phi,\tau)=\frac{\tau(4(9-\phi)-\tau(17+5\phi))}{64}.$$

Consumer welfare and social welfare amount to

$$\Lambda_S^*(\phi,\tau)=2\left(\phi\int_0^{\frac{1}{2}}u\left(x;q_1^r;p_{S,r}^*(\tau),f_{S,r}^*(\tau)\right)dx+(1-\phi)\int_0^{\frac{1}{2}}u\left(x;q_1^n;p_{S,n}^*(\tau),f_{S,n}^*(\tau)\right)dx\right)$$

and

$$\Psi_S^*(\phi,\tau)=\Lambda_S^*(\phi,\tau)+2\pi_S^*(\phi,\tau).$$

Firms segment the market by offering different contracts to informed and uninformed consumers. The contract for the uninformed consumers has a lower fixed component and a higher linear-price component than the contract for informed consumers. This price structure is attractive for uninformed consumers because they ignore the linear price and only consider the fixed-price element. By contrast, informed consumers are willing to pay a higher fixed fee to benefit from a lower linear price (and, hence, a higher consumption quantity).[31]

We note that the contracts offered to both types of consumers are inefficient because the linear prices exceed the marginal costs (normalized to zero). Given the higher linear price for uninformed consumers (and, hence, the larger distortion), it is clear that social welfare strictly increases as the share of uninformed consumers decreases.

It is interesting to look at the effect of the transport costs on equilibrium prices. While for informed consumers, both price elements increase as transport costs increase, this is not the case for uninformed consumers. Here, the fixed price increases, but the linear component decreases. The reason is that with a higher transport cost, firms' revenues from linear sales are decreasing, which means that firms have a lower incentive to attract uninformed consumers via a low-priced, fixed component.

The pricing structure for uninformed consumers is reminiscent of that of other models (see, for example, Gabaix and Laibson, 2006; Armstrong and Vickers, 2012). We note that the firms may charge a negative fixed fee (offer a subsidy) to uninformed consumers if transport costs are sufficiently small (that is, $\tau<8/7-4\sqrt{65}/35\approx 0.2215$). In such cases, firms find it worthwhile to attract uninformed consumers via a give-away (negative fixed fee) and recoup the losses with a high linear price.

[31] The contract for informed consumers corresponds to the benchmark cases (with only informed consumers) as analyzed in Yin (2004) and Gössl and Rasch (2020). We note that the same equilibrium contracts would emerge if firms could observe consumers' type and engage in third-degree price discrimination. Furthermore, these contracts are also chosen when firms can decide whether to offer a single tariff or a menu of two tariffs. We further note that the incentive constraints for both types are not binding.

4. Reducing the range of contracts: competition in single two-part tariffs

We now analyze the effects of a regulatory intervention that reduces the range of contracts, so that firms can only offer one single (two-part) contract. As a result of this policy, firms can only exercise intra-group price discrimination.[32] Nevertheless, as we will show below, the presence of both consumer types shapes the design of the equilibrium contract.

Equilibrium behavior

Firm i's maximization problem is given as

$$\max_{p_i,f_i} \pi_i(p_i,f_i;p_j,f_j) = \phi\left(p_i \int_{\min\{L_i,\tilde{x}^r\}}^{\max\{L_i,\tilde{x}^r\}} (1-p_i-\tau|L_i-x|)dx + f_i\left(\max\left\{L_i,\tilde{x}^r\right\}-\min\left\{L_i,\tilde{x}^r\right\}\right)\right) + (1-\phi)\left(p_i \int_{\min\{L_i,\tilde{x}^n\}}^{\max\{L_i,\tilde{x}^n\}} (1-p_i-\tau|L_i-x|)dx + f_i\left(\max\left\{L_i,\tilde{x}^n\right\}-\min\left\{L_i,\tilde{x}^n\right\}\right)\right),$$

where $\tilde{x}^r$ and $\tilde{x}^n$ are defined as in equation (5). Solving the maximization problem and defining

$$A := \sqrt{\tau^2\left(-23\phi^2+18\phi+9\right)+8\tau\left(10\phi^2-9\phi-3\right)-64\phi^2+64\phi+16}$$

gives the following equilibrium result (where we drop subscript i and use subscript T to denote equilibrium outcomes under single two-part tariffs):

Proposition 2. *When each firm sets a single two-part tariff, the symmetric equilibrium tariffs depend on the share ϕ of informed consumers and are given by*

$$p_T^*(\phi,\tau) = \frac{12-\tau(5-3\phi)-A-8\phi}{16(1-\phi)}$$

and

$$f_T^*(\phi,\tau) = \frac{(A+\tau(5\phi-3)-8\phi+4)}{256(1-\phi)^2(A-3\tau(\phi+1)+8\phi+4)}\left(A^2+2A(-3\tau\phi+\tau+8\phi-4) - 143\tau^2+(8-3\tau)^2\phi^2+2(\tau(61\tau-108)-32)\phi+312\tau-48\right).$$

The equilibrium profit for each firm is

$$\pi_T^*(\phi,\tau) = \frac{\tau\left(\phi(A+13\tau-12)-8(A+3\tau-4)+(8-3\tau)\phi^2\right)}{128(\phi-1)\phi}.$$

Given symmetric equilibrium prices, consumer surplus is calculated as[33]

$$\Lambda_T^*(\phi,\tau) = 2\int_0^{\frac{1}{2}} u\left(x;q;p_T^*(\phi,\tau),f_T^*(\phi,\tau)\right)dx,$$

and social welfare is

$$\Psi_T^*(\phi,\tau) = \Lambda_T^*(\phi,\tau)+2\pi_T^*(\phi,\tau).$$

Note that in this scenario in which firms have to offer the same contract to all consumers, the share of uninformed consumers has no direct effect on total consumer surplus. It has, however, an indirect effect via firms' pricing decisions. This is different in existing approaches. For example, in Gabaix and Laibson (2006), the consumer types also make different decisions in equilibrium, whereas in our model, both types consume the same quantity in equilibrium. In our setting, the existence of the two groups only has an indirect effect via influencing the firms' pricing strategies (which then affect both consumer types in the same way).

[32] There is an alternative motivation for studying a single two-part tariff, beyond its role as a possible policy intervention. For example, offering multiple contracts may act an eye opener for uninformed consumers, as was suggested by a reviewer of this article. An uninformed consumer may be induced by the presence of multiple contracts to think more carefully about the contracts, and, as a result, this may make it harder for firms to separate the consumer segments.

[33] We do not present formal expressions here, due to readability; instead, we illustrate our findings below. Details are available from the authors upon request.

Impact of consumer types

The following proposition describes the effects of an increase of the share of informed consumers on equilibrium contracts:

Proposition 3. *An increase in the share of informed consumers has the following effects on firms' equilibrium pricing strategies:*

(i) It holds that $\partial p_T^*/\partial\phi < 0$.
(ii) There exists a $\phi_{f_T^*}(\tau)$ *such that* $\partial f_T^*/\partial\phi < 0$ *for* $\phi < \phi_{f_T^*}(\tau)$, *and* $\partial f_T^*/\partial\phi > 0$ *for* $\phi > \phi_{f_T^*}(\tau)$.

Part (i) of the proposition shows that the linear-price component decreases in the share of the informed consumers. By contrast, part (ii) shows that there is a non-monotonic effect on the fixed fee. Clearly, the more consumers are informed about the linear price at the contracting stage, the lower the price that firms must set.

The non-monotonic effect of ϕ on the fixed fee component is due to two opposing effects: a direct effect and an indirect effect. The direct effect is a composition effect. The indirect effect works via the decrease of the linear-price component as the share of informed consumers increases. The effects can be seen in the first-order condition of firm profits with respect to the fixed fee at the symmetric equilibrium:

$$\frac{\partial \Pi_1}{\partial f_1} = \frac{1}{2} + \underbrace{\left(\phi\frac{\partial \tilde{x}^r}{\partial f_1} + (1-\phi)\frac{\partial \tilde{x}^n}{\partial f_1}\right)}_{\text{Direct effect: composition effect}}(f_1 + \underbrace{p_T^*(\phi)(1-p_T^*-\tau x)}_{\text{Indirect effect: decreases with } \phi}) = 0.$$

The indirect effect follows from the decrease of the linear-price component. With lower linear prices, informed consumers become less sensitive toward changes in the fixed fee. Hence, as the linear price decreases with more informed consumers, firms have greater incentives to increase the fixed fee. This effect is similar in spirit to an increase in the transport-cost parameter in a standard model. Because the linear price decreases with more informed consumers, consumption quantities increase (and, hence, consumption becomes more efficient). While consumers benefit from this effect, firm profits originating from the linear-price component decrease. The lower profit reduces the intensity of competition among firms for new consumers via lower fixed fees; this allows them to charge higher fixed fees. This effect is similar to the cross-subsidization effects in the add-on literature (see, for example, Gabaix and Laibson, 2006).

The direct effect is a composition effect. As noted earlier (see equation (5)), informed consumers are more sensitive than uninformed consumers to changes in the fixed fee. Hence, as the share of informed consumers increases, market demand becomes more elastic with regard to the fixed fee, forcing firms to reduce this fee. However, the effect becomes weaker as ϕ further increases. The effect can best be understood by looking at the cross-derivative of the marginal informed consumer (equation (5)) with respect to both price components:

$$\frac{\partial \tilde{x}^r}{\partial f_1 \partial p} = -\frac{2}{\tau(2-2p-\tau)^2} < 0.$$

Due to the two opposing effects, the overall effect of a larger number of informed consumers is U shaped. As part (ii) of Proposition 3 shows, the fixed fee first decreases for low values of the share of informed consumers and then increases for high values of the share of informed consumers (see also Fig. 2).

An alternative way to demonstrate this non-monotonicity is by considering a regulation that lowers the linear-price component directly (instead of indirectly via a larger number of informed consumers). In a version of our model in which firms set the linear fee at a regulated level of $\bar{p}$, and firms compete on the fixed fee, we can show the following result:

Corollary 1. *Suppose that firms compete by offering a single two-part tariff and a regulator fixes the linear price at* $\bar{p}$. *Then, decreasing* $\bar{p}$ *leads to lower (higher) fixed fees for sufficiently high (low) values of* $\bar{p}$.

This corollary relates our findings to the discussion of waterbed or see-saw effects, according to which the regulation of one price component may lead to the increase of other price components (see, for example, Genakos and Valletti, 2011, 2012).[34] Our analysis brings a more nuanced picture forward and suggests that the extent of such waterbed effects depends on consumer awareness. The corollary suggests that adverse waterbed effects of regulation are non-monotonic. Starting from high levels of $\bar{p}$, a reduction in the linear fee also leads to a lower fixed fee. By contrast, if $\bar{p}$ is already at a low level, a further decrease of the linear fee may lead to a waterbed effect and, hence, a higher fixed fee.

The next proposition explores the welfare and profit implications:

Proposition 4. *An increase in the share of informed consumers has the following effects on welfare and firm profits:*

[34] For instance, Genakos and Valletti (2011) find that a decrease of the interconnection charge in mobile telecommunication markets leads to an increase of subscription prices.

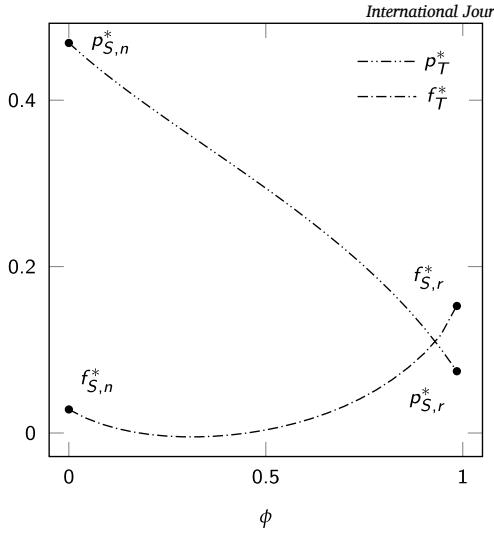


Fig. 2. Impact of a policy that bans multiple two-part tariffs on prices ($\tau = 1/4$).

(i) *It holds that* $\partial\Psi^*_T/\partial\phi > 0$.
(ii) *There exists a* $\phi_{\pi^*_T}(\tau)$, *such that* $\partial\pi^*_T/\partial\phi < 0$ *for* $\phi < \phi_{\pi^*_T}(\tau)$, *and* $\partial\pi^*_T/\partial\phi > 0$ *for* $\phi > \phi_{\pi^*_T}(\tau)$.
(iii) *There exists a* $\phi_{\Lambda^*_T}(\tau)$, *such that* $\partial\Lambda^*_T/\partial\phi > 0$ *for* $\phi < \phi_{\Lambda^*_T}(\tau)$, *and* $\partial\Lambda^*_T/\partial\phi < 0$ *for* $\phi > \phi_{\Lambda^*_T}(\tau)$.

Because the only inefficiency in the market arises from a linear price that is set above the marginal cost of zero, we can immediately conclude that social welfare increases as the share of informed consumers increases due to lower linear prices.

Interestingly, as opposed to existing findings, the effects on firm profits and consumer surplus are non-monotonic. The U-shaped effect on firm profits follows the logic on firms' pricing strategies outlined in Proposition 3. When many consumers are initially uninformed, informing some of them leads to lower linear prices and lower fixed fees. As a consequence, profits decrease. The picture changes when few consumers are initially uninformed. In this case, the linear price decreases, but the increase in the fixed price compensates for this negative effect, so that overall profits increase. In addition, we point out that profits are highest when all consumers are uninformed about linear prices; that is, $\pi^*_T(1,\tau) < \pi^*_T(0,\tau)$.

With regard to consumer surplus, note that the previous literature suggests that consumers are mainly affected by the fixed fee (Gössl and Rasch, 2020). Because the fixed fee first decreases and then increases as the share of informed consumers increases, this translates into similar effects on consumers surplus. Indeed, consumer surplus first increases and then decreases for (very) high levels of informed consumers.

This last aspect has also implications for the optimal level of marker information from the consumers' point of view. From the observation that consumer surplus decreases in the share of informed consumers when many consumers are already well informed (see part (iii) of Proposition 4) and the fact that

$$\Lambda^*_T(0,\tau) = \frac{144 - 7\tau(72 - 31\tau)}{384} < \frac{67\tau^2}{69} - \frac{5\tau}{4} + \frac{1}{2} = \Lambda^*_T(1,\tau),$$

we can state the following result:

Corollary 2. *Total consumer welfare attains a maximum for an intermediate share of informed consumers that is given by* $\phi_{\Lambda^*_T}(\tau)$.

Implications of the policy intervention

Prices can be compared in Fig. 2. The figure provides a comparison of prices under the screening contracts and the prices under a single two-part tariff. With regard to the linear price, the figure shows that, due to the intervention, the linear price will decrease for uninformed consumers, but it will increase for informed consumers. More interestingly, because the fixed fee is U shaped in the number of informed consumers (see our previous discussion), this price component can decrease for both consumer segments.

Our next finding relates to firm profits:

Proposition 5. *A reduction of the permissible number of two-part tariffs results in lower profits for firms; that is,* $\pi^*_T < \pi^*_S$.

The proposition shows that firm profits necessarily decrease when firms can no longer target uninformed consumers via a separate contract. Hence, losing the ability to price discriminate hurts firms.

Define the following critical level of the number of informed consumers

$$\phi_{\Lambda^*_{ST,r}}(\tau) = \frac{256 + 3232\tau^2 - 4000\tau^3 + 1101\tau^4 - (-4+3\tau)(-4+7\tau)^2\sqrt{16+8\tau+161\tau^2}}{2(256 - 256\tau + 2720\tau^2 - 3856\tau^3 + 1389\tau^4)}.$$

The following proposition evaluates the welfare effects of the intervention:

Proposition 6.

(i) Informed consumers are made better (worse) off by the reduction of the permissible number of two-part tariffs when their share is small (large); that is, $\Lambda^*_{T,r} > (<)\Lambda^*_{S,r}$ *for* $\phi < (>)\phi_{\Lambda^*_{ST,r}}$.
(ii) Uninformed consumers always benefit from the reduction; that is, $\Lambda^*_{T,n} > \Lambda^*_{S,n}$.
(iii) Consumers as a whole always benefit from the reduction; that is, $\Lambda^*_T > \Lambda^*_S$.
(iv) Requiring a reduction of the permissible number of two-part tariffs always increases social welfare; that is, $\Psi^*_T > \Psi^*_S$.

The findings on firm profits and consumer welfare follow from the intuition that this intervention removes the ability of firms to earn relatively large amounts from targeting uninformed consumers via a separate contract. As a result, the market becomes more competitive, so that firm profits fall, and consumer surplus can rise. Interestingly, however, whereas uninformed consumers always benefit, the effect is ambiguous for informed consumers.

5. Abolishing linear fees: competition in fixed-fee contracts

In this section, we consider the case in which firms are restricted to fixed-fee pricing and cannot make use of the linear-price component.[35] This intervention corresponds to the EU ban of roaming charges in mobile telecommunications, and rules out any form of price discrimination.

Equilibrium behavior

Because consumer information does not matter in this scenario, our model simplifies to the analysis in Gössl and Rasch (2020). From expression (2) it follows that the local demand of a consumer at firm i is $q_i(x) = 1 - \tau|L_i - x|$. Because there is no linear price, the actual demand level coincides with the expected demand for both consumer types at the contracting stage. Hence, the indifferent consumer $\tilde{x}$ in both segments is given by:

$$u_1(\tilde{x}; q_1; f_1) = u_2(\tilde{x}; q_2; f_2) \Leftrightarrow \tilde{x} = \frac{1}{2} - \frac{f_1 - f_2}{\tau(2-\tau)}.$$

Firms now simultaneously maximize:

$$\max_{f_i} \pi_{i,F}(f_i; f_j) = f_i \left(\max\left\{L_i, \tilde{x}\right\} - \min\left\{L_i, \tilde{x}\right\}\right).$$

The following proposition describes equilibrium firm behavior and the market outcome (where we drop subscript i and use subscript F to denote equilibrium outcomes under fixed fees only):

Proposition 7. *When firms compete using fixed fees, both firms set the same contract to both consumer types. The equilibrium fixed fee is*

$$f^*_F = \tau - \frac{\tau^2}{2},$$

and firms earn

$$\pi^*_F = \frac{\tau}{2} - \frac{\tau^2}{4}.$$

Consumer surplus is given by

$$\Lambda^*_F(\tau) = \frac{13\tau^2}{24} - \frac{5\tau}{4} + \frac{1}{2},$$

and social welfare amounts to

$$\Psi^*_F(\tau) = \frac{\tau^2}{24} - \frac{\tau}{4} + \frac{1}{2}.$$

[35] Note that we have normalized marginal costs to zero. Hence, this policy could be regarded as requiring firms to price the linear component at cost. In Section 7.1, we consider positive production costs and discuss the effects of policy interventions that limit the linear fees at cost or ban the linear fee entirely (which amounts to below-cost pricing).

Implication of the policy intervention

We can now compare the outcome of this intervention with the market outcome when firms offer screening contracts to consumers (as described in Proposition 1). Define the following critical levels of consumer types:

$$\phi_{\pi^*_{SF}}(\tau) = \frac{4-\tau}{4+5\tau}$$

and

$$\phi_{\Lambda^*_{SF}}(\tau) = \frac{16+8\tau-3\tau^2}{16+8\tau+17\tau^2},$$

where $\phi_{\pi^*_{SF}} < \phi_{\Lambda^*_{SF}}$ for each τ.

The following two propositions describe the effects of the intervention on firms and consumers. The findings are also illustrated in the right panel of Fig. 3.

Proposition 8. *Abolishing the linear price results in lower (higher) profits for firms as long as the share of informed consumers is sufficiently low (high), that is,* $\pi^*_F < (>)\pi^*_S$ *for* $\phi < (>)\phi_{\pi^*_{SF}}(\tau)$.

Proposition 8 says that, depending on the number of informed consumers, firms can lose or benefit from the intervention. Indeed, this brings a more nuanced picture to the literature. The existing literature shows that in markets with full consumer information, reducing the number of price elements over which firms compete is beneficial for firm profits (Yin, 2004). By contrast, in our setting with informed and uninformed consumers, if the share of uninformed consumers is sufficiently large, profits fall due to the intervention. Hence, our model with imperfect consumer information is in line with mobile telecommunications firms' opposition to the European Commission's ban of roaming charges. It is also in line with some UK operators reintroducing roaming fees following the UK's exit from the EU.

The next proposition explores the consumer-welfare effects of the intervention:

Proposition 9.

(i) Informed consumers never benefit from the abolishment of the linear price component; that is, $\Lambda^*_{S,r} > \Lambda^*_{F,r}$.
(ii) Uninformed consumers always benefit from the abolishment of the linear price component; that is, $\Lambda^*_{S,n} < \Lambda^*_{F,n}$.
(iii) Consumers as a whole benefit from (are worse off after) the abolishment as long as the share of informed consumers is sufficiently small (large); that is, $\Lambda^*_S < (>)\Lambda^*_F$ *for* $\phi < (>)\phi_{\Lambda^*_{SF}}$.

The main message behind Proposition 9 is that, while overall consumer welfare can go up or down, the effects on the two consumer groups are clear-cut. Uninformed consumers benefit from the intervention, and informed consumers lose out. Thus, the effects on overall consumer welfare largely depend on the distribution of types. With a large number of informed consumers ($\phi > \phi_{\pi^*_{SF}}(\tau)$), the effect is negative; for $\phi < \phi_{\pi^*_{SF}}(\tau)$, the effect is positive. Here, we also complement existing findings by showing that consumer information crucially matters to determine whether a reduction of pricing instruments hurts or benefits consumers.

The left panel of Fig. 3 provides the intuition of these findings. While both consumer groups benefit from the reduction of the linear fee, all consumers are also negatively affected via higher fixed fees (waterbed effect). Note that this waterbed effect, however, is stronger for uninformed consumers compared to informed consumers. Nevertheless, we find that uninformed consumers overall can benefit from the regulation because the decrease of the linear fee dominates. By contrast, informed consumers never benefit because, as can be seen in the figure, the reduction of the linear fee is relatively small compared to the increase of the fixed fee.

Finally, note that the intervention results in higher social welfare due to efficient consumption.

6. Comparing policy interventions

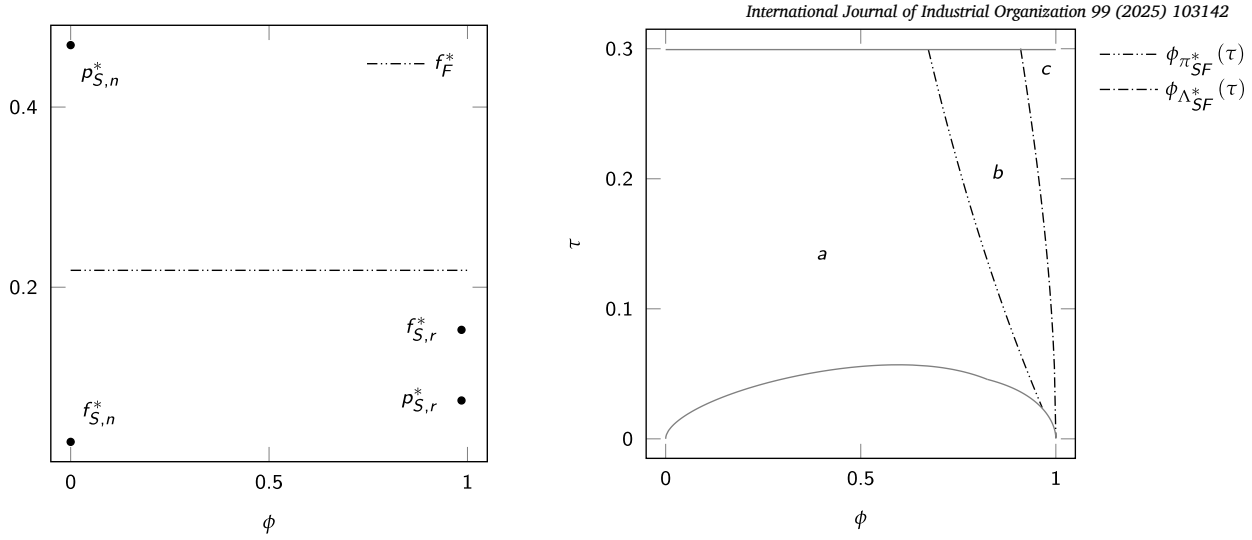
In this section, we compare the two interventions and identify the conditions in which one or the other is the better solution for a regulator to implement. We also discuss the effects of a further scenario in which a regulator – apart from affecting the price scheme – might also affect consumer awareness of the linear-price component via, for instance, disclosure requirements.

Comparison of total consumer surplus and firm profits

We start by comparing preferences of firms and consumers as an aggregate group:

Proposition 10. *Comparing the two scenarios of a policy intervention reveals that*

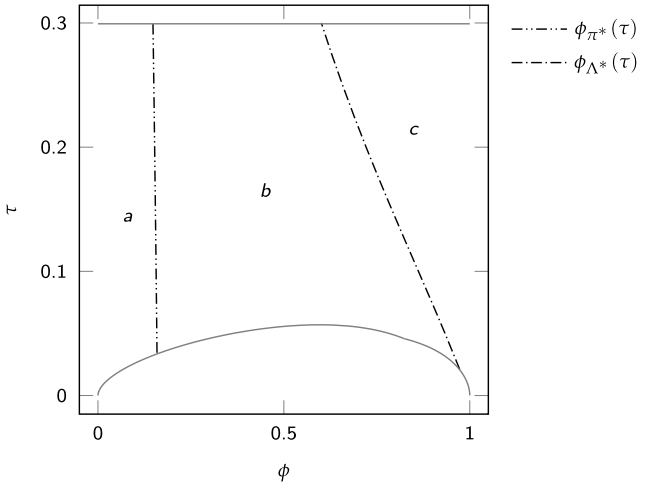
(i) there exists a $\phi_{\pi^*}(\tau)$ *such that* $\pi^*_F(\tau) < \pi^*_T(\phi,\tau)$ *for* $\phi < \phi_{\pi^*}(\tau)$, *and* $\pi^*_T(\phi,\tau) < \pi^*_F(\tau)$ *for* $\phi > \phi_{\pi^*}(\tau)$;
(ii) there exists a $\phi_{\Lambda^*}(\tau)$ *such that* $\Lambda^*_T(\phi,\tau) < \Lambda^*_F(\tau)$ *for* $\phi < \phi_{\Lambda^*}(\tau)$, *and* $\Lambda^*_F(\tau) < \Lambda^*_T(\phi,\tau)$ *for* $\phi > \phi_{\Lambda^*}(\tau)$; *and*



(a) Impact on prices ($\tau = 1/4$). (b) Impact on profits and consumer surplus.

Note: The area between the solid gray line and the solid gray curve in the right panel represents those combinations of the share of informed consumers and transport costs considered in the analysis. For combinations in section *a*, firms and consumers as a whole lose out due to the ban, whereas both parties benefit from the ban in section *c*. In section *b*, firms benefit, but consumers are worse off.

Fig. 3. Impact of a policy that bans linear prices.



Note: The area between the solid gray line and the solid gray curve represents those combinations of the number of informed consumers and transport costs considered in the analysis. For combinations in section *a*, firms prefer two-part tariffs, whereas the regulator with a consumer standard prefers fixed fees. In section *b*, firms and the regulator favor fixed fees. Firms prefer fixed fees, and the regulator favors two-part tariffs in section *c*.

Fig. 4. Optimal policy intervention for consumers.

(iii) it holds that $\Psi^*_T(\phi, \tau) < \Psi^*_F(\tau)$.

Fig. 4 illustrates the findings of the proposition (parts (i) and (ii)). The intuition behind these results can be related to our findings in Proposition 4. Consumers as a whole are better off when linear prices are abolished, as long as the share of informed consumers is sufficiently low.[36] This is illustrated by the areas *a* and *b* in Fig. 4. In this case, it is true that fixed fees would be lower under a single two-part tariff; however, firms can exploit the fact that many consumers are not aware of the linear prices charged. As a result, a policy that bans this linear component maximizes total consumer surplus.

[36] While in our model, the effect of this policy intervention on consumer surplus crucially depends on the share of uninformed consumers in the population, this does not hold true for related models of add-on pricing. As stated in Ellison (2005), "[...] such a policy would make all consumers better off. High types gain because they pay lower prices. Low types are better off despite paying more because they get a higher quality good."

Table 1
Optimal regimes.

		$\tau \lesssim 0.0798$		
	$0 \leq \phi < \phi_{\pi^*_{SF}}$	$\phi_{\pi^*_{SF}} \leq \phi < \phi_{\Lambda^*_{FT}}$	$\phi_{\Lambda^*_{FT}} \leq \phi < \phi_{\Lambda^*_{ST,\tau}}$	$\phi_{\Lambda^*_{ST,\tau}} \leq \phi \leq 1$
Firms	Screening	Fixed fees	Fixed fees	Fixed fees
Consumer surplus	Fixed fees	Fixed fees	Single TPT	Single TPT
Informed consumers	Screening	Screening	Screening	Single TPT
Uninformed consumers	Fixed fees	Fixed fees	Single TPT	Single TPT
Total welfare	Fixed fees	Fixed fees	Fixed fees	Fixed fees
		$\tau \gtrsim 0.0798$		
	$\phi < \phi_{\Lambda^*_{FT}}$	$\phi_{\Lambda^*_{FT}} \leq \phi < \phi_{\pi^*_{SF}}$	$\phi_{\pi^*_{SF}} \leq \phi < \phi_{\Lambda^*_{ST,\tau}}$	$\phi_{\Lambda^*_{ST,\tau}} \leq \phi \leq 1$
Firms	Screening	Screening	Fixed fees	Fixed fees
Consumer surplus	Fixed fees	Single TPT	Single TPT	Single TPT
Informed consumers	Screening	Screening	Screening	Single TPT
Uninformed consumers	Fixed fees	Single TPT	Single TPT	Single TPT
Total welfare	Fixed fees	Fixed fees	Fixed fees	Fixed fees

Note: We use the acronym TPT to indicate a two-part tariffs.

In the opposite case in which a larger number of consumers is informed, the optimal policy intervention would require firms to offer only a single two-part tariff (illustrated by area c in Fig. 4). Because a larger number of consumers is informed, the negative effect of a high fixed fee when the linear fee is banned dominates, so that consumers are better off with a (single) two-part tariff.

These findings for consumer welfare have important implications for firms. Firms' and consumers' preferences are generally not aligned. We can conclude that, despite the fact that more pricing instruments tend to result in more intense competition, firms benefit from being able to exploit uninformed consumers when their share is large. In this situation, abolishing the linear fee boosts competition in fixed fees to an extent such that profits decrease.

Interestingly, however, there is also an intermediate region of ϕ for which both firms and consumers benefit from the abolishment of the linear price (area b in Fig. 4). Compared to the case with no or only very few informed consumers, the linear price is lower, and, hence, social welfare is higher. In this intermediate range, firms cannot appropriate all of this gain but only parts of it due to competition. As a result, consumers also get a share of the gain.

Due to the positive linear price under two-part tariffs, social welfare is always higher in the fixed-fee scenario.

Differential effects on informed and uninformed consumers

The results of a comparison of both consumer groups' preferred pricing regimes (including no intervention whatsoever) are presented in Table 1. In addition to showing the effect on the two consumer types, the table, drawing on Proposition 10, shows the preferred pricing regimes for consumers as a whole and for firms. While the preferences of consumers (as a whole) and uninformed consumers are aligned, these can differ for informed consumers, particularly in markets with a large share of uninformed consumers. The comparison shows that for markets with a sufficiently large number of uninformed consumers, informed consumers prefer no intervention at all (that is, their surplus is maximized with screening contracts), whereas uninformed consumers prefer an intervention (typically, fixed fees only).

Interestingly, in contrast to uninformed consumers, informed consumers never prefer the ban of linear fees because this makes it possible for firms to appropriate a large share of their surplus via a high fixed fee (Yin, 2004). By contrast, such fixed-fee-only contracts can be optimal for uninformed consumers because uninformed consumers cannot be exploited via unexpected high linear prices.

7. Discussion and extensions

This section considers the robustness of our results by exploring three extensions: (i) positive production costs, (ii) general consumer bias, and (ii) location-independent demand.

7.1. Positive marginal cost

Firms face positive, but small (constant) marginal costs $c > 0$.[37] We provide a comparison of the benchmark with screening contracts and a regulation that limits firms' ability to set linear fees. With positive costs, there are now two policy options that a regulator might consider. First, the regulator may impose a policy that bans all linear fees. Because production is costly, this implies that firms would offer the product below cost. An alternative to this policy is a cost-based regulation that sets the linear price equal to the marginal cost.

[37] The derivations are relegated to the Appendix.

We first discuss the effects of an intervention that bans the linear fee in the presence of a production cost, and we then compare it to the baseline scenario with screening contracts. We focus on this comparison due to its simplicity and its implementation in practice (see, for example, the EU roaming regulation). With regard to the effects on consumers and firms, we find that the results from our main analysis are largely robust. The policy intervention is beneficial to consumers if the share of informed consumers is sufficiently small; the intervention hurts them otherwise. For firms' profits, the opposite pattern occurs. However, with positive marginal costs, the scope for consumers to benefit decreases, whereas the scope for firms to benefit increases. The reason for this more adverse effect on consumers is that competition between firms is further weakened. When the linear fee is below cost, firms have less incentive to attract additional consumers – leading to a higher fixed fee, which hurts consumers, but tends to benefit firms.

On the downside, this policy may lead to overconsumption and, hence, might have negative effects on social welfare. However, we point out that such effects appear rather small because they have to be weighted against the problem of underconsumption in the case in which no intervention is undertaken. (Note that, with screening contracts, linear prices are inefficiently high.) This is particularly true for cases in which consumer information is poor. Only when the initial share of informed consumers is very high, the overall effect on welfare is negative. These results are line with empirical evidence. In their study, Canzian et al. (2021) point out that abolishing roaming fees in Europe resulted in welfare gains despite the distortion from a possible overconsumption at zero surcharges.

With regard to a cost-based regulation (in which the regulator sets the linear fee equal to marginal cost), we find that such a regulation leads to higher social welfare compared to entirely banning the linear fee. This is intuitive because banning linear fees (that is, a regulated price of zero) would lead to overconsumption. What is perhaps more surprising is that consumer welfare is also higher when the linear fee is equal to the cost. Consumers prefer the cost-based regulation because below-cost pricing leads to disproportionately high fixed fees. Marginal prices below cost weaken competitive pressure because firms have fewer incentives to compete for new consumers. However, even though firms can charge high fixed fees, they nevertheless also prefer a cost-based regulation due to the problem of overconsumption that negatively affects their profits. Hence, from the perspective of consumers, firms, and overall welfare, a cost-based regulation is preferable, and, hence, entirely banning the linear fee may be too costly for society when costs are significant.

7.2. Generalization of consumer bias

We consider a version of the model in which consumers underestimate the linear price, but do not completely ignore it. The model variant extends the validity of our predictions to a more general class of consumer bias, where – in the spirit of Martimort and Stole (2020) – consumers have difficulty discerning the relevant margin from an offered, nonlinear schedule.

For this extension of the model, we assume that, at the contracting stage, any contract $(p_{i,j}, f_{i,j})$, $i \in \{1,2\}$, $j \in \{r,n\}$, is evaluated as $(\alpha p_{i,j}, f_{i,j})$, $\alpha \in [0,1)$ by an uninformed consumer. Hence, the parameter α measures the degree of the consumer bias – that is, the extent to which the consumer underestimates the linear fee with smaller values measuring a larger bias. Note that, in contrast to our main analysis, uninformed consumers are now responsive to changes in the linear fee, though to a smaller extent than informed consumers. When $\alpha = 0$, the version of the model coincides with our main analysis. We focus our discussion on small deviations from this benchmark; that is, when α is positive, but small.[38]

With regard to equilibrium pricing with screening contracts, we find that firms are still able to separate uninformed and informed consumers; quite intuitively, however, the contract offered to uninformed consumers becomes increasingly similar to that offered to informed consumers as the extent of the bias becomes smaller. This decreases the profitability of these contracts, and, at the same time, increases the surplus to uninformed consumers. The observations on pricing have two implications that warrant consideration when analyzing the effects of a regulation that requires firms to charge fixed fees only. First, it is more likely that firms will be negatively affected by the market intervention when the bias becomes larger. Second, as the extent of the bias increases, it becomes more likely that uninformed consumers and consumers as a whole will benefit from the market intervention.

In a nutshell, when we weaken our assumption on the extent to which uninformed consumers ignore the linear-price component, we find that our main results are robust. We find that an intervention is more desirable (from a consumer perspective) when the awareness of consumers is small and the extent of the bias is large.

7.3. Alternative specification with location-independent demand

In this part of our analysis, we depart from the assumption of location-dependent demand, report the results from this exercise, and point out the similarities with regard to market outcomes in the two setups. We find minor differences in the results, but the overall message from the analysis in the main part remains valid. The formal analysis is relegated to the supplementary material (Section C).

The model used in this extension broadly follows the one in the main part. There are two distinct differences: First, as mentioned above, we give up the assumption of an individual demand that depends on consumers' preferences. Instead, we assume that consumers' (elastic) demand is the same along the line and only depends on the (perceived) price. Second, we allow uninformed consumers to face weakly higher transport costs. Note that there is widespread evidence that uninformed or inattentive consumers

[38] The derivations of the following results can be found in the supplementary material, Section A.

are less likely to switch providers. For example, in their empirical study of the Spanish market for mobile services, García-Mariñoso and Suárez (2019, p. 426) find that "inattentive consumers (...) were much less likely to switch."[39]

In the Appendix, we provide a detailed analysis of the firms' pricing strategies and the welfare outcomes in each of the three pricing scenarios considered. Here, we summarize the main effects of the intervention that bans the linear fee. This intervention leads to (weakly) lower firm profits and higher total consumer surplus. These findings are slightly stronger in this modification compared to the specification in the main text. There, firm profits and consumer welfare only increase if the share of uninformed consumers is sufficiently large. We note, however, that the profit and consumer-surplus implications of the alternative specification are in line with the empirical literature, as summarized in the Introduction, which shows that firms are hurt and consumer surplus increases with the roaming regulation (see, for example, Canzian et al., 2021).

The alternative specification makes similar predictions with regard to differential effects on the consumer types. As in the main part, implementing the regulation is always surplus increasing for uninformed consumers, whereas informed consumers never benefit.

8. Conclusions

Our analysis suggests that, given the small share of consumers who are fully informed, the model can explain the divergence of interests in the political decision-making process over the use of roaming fees for mobile phones. The European Commission promoted measures to abolish roaming fees. Telecommunications firms opposed these measures. Our model predicts that mobile telecommunications operators' opposition to this kind of policy intervention suggests that only (very) few consumers were fully informed about all pricing components. Indeed, such circumstances warrant a regulatory intervention. This is because in such circumstances the difference between the consumer surplus that would accrue under a two-part-tariff option and under a fixed-fee option is most pronounced.

The welfare results of our model in a market with boundedly rational consumers not only provide a rationale for regulating the European telecommunications markets; moreover, they also allow one to surmise that a large fraction of consumers are severely challenged by the complex pricing schemes that are standard with many products. Consequently, following its consumer standard, it is consistent with our theory that the European Commission continues to make a noticeable effort to support consumers in making economically sound decisions.

Let us conclude by discussing some dynamic implications of our analysis. As pointed out in the Introduction, learning about firms' pricing strategies has not appeared to play an essential role in telecommunications markets (Grubb and Osborne, 2015). We emphasize again that the effects identified in the model rely on consumer awareness at the contracting stage and not at the consumption stage, when consumers may be better informed. Dynamic aspects, however, may be relevant due to changing market parameters, including those in sectors other than telecommunications. For mobile telephone communications, one might argue that consumers' attention to roaming services and charges may increase automatically because of the sharp increase that has taken place in the use of data services. Consumers may be more willing to reduce calls than they are to reduce (or temporarily forgo) the use of their social media accounts, messenger services, or other services that require data roaming. At the same time, some consumers will most likely stay uninformed even in a dynamic context. For the resulting intermediate to high level of informed consumers (at the contracting stage), banning roaming fees would still be beneficial for consumers, but the optimal regulatory policy, by contrast, is to demand a single two-part tariff (see Table 1).

A similar argument holds when we consider the optimal policy decision that would arise if a regulator can determine both the pricing instruments that firms can use and the extent to which linear fees are salient. To affect price salience, the regulator could require firms to disclose and advertise the linear-price component. In our setting, such a disclosure requirement can be interpreted as an increase in the share of informed consumers (and a corresponding decrease in the share of uninformed consumers).

This observation is in line with regulatory efforts other than price interventions. As a matter of fact, education and disclosure requirements are further pillars of market intervention in the EU. For example, in its most recent efforts to reduce pricing complexity, the European Commission has put into effect the Markets in Financial Instruments Directive (MIFID II). Applying from January 2018, this legislative framework aims to strengthen investor protection in Europe and to educate consumers about the often-complex pricing structures of financial products. The regulation requires that, before consumers can buy or sell stocks or funds, banks must provide them with standardized information about the costs of transacting and holding these stocks.

CRediT authorship contribution statement

Christian Fischer-Thöne: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Alexander Rasch:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Tobias Wenzel:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

[39] Note that in our setup, consumer inertia (modeled as higher transport costs) and inattention (modeled as a lack of attention paid to the linear-price component) are assumed to be two independent traits that simultaneously occur in one of the two consumer groups. This appears to be in line with empirical findings (see, for example, Heiss et al., 2021 who analyze health plan choices under Medicare Part D in the United States).

Appendix A. Derivation of Assumption 1

In this appendix, we derive the thresholds for transport costs that ensure the existence of the pure-strategy equilibria characterized for all three scenarios discussed in the main text. The bounds on transport costs are necessary in two cases; in the case of the upper bound this is due to our requirement of full market coverage, and in the case of the lower bound this is needed to rule out deviations of firms to serve only one consumer group. We find that, in both cases, the constraints implied by the case with a single two-part tariff are binding.

Market coverage condition: competition with screening contracts

The market is covered when both consumer groups derive non-negative utility from consumption. In the symmetric equilibrium, the consumer with the lowest utility is located at $x = \frac{1}{2}$. It must hold that

$$u_1^r\left(\frac{1}{2}, q^r, f_{S,r}^*, p_{S,r}^*\right) = u_2^r\left(\tfrac{1}{2}, q^r, f_{S,r}^*, p_{S,r}^*\right) \geq 0 \quad \Leftrightarrow \quad \tau \leq \frac{4}{9} \equiv \bar{\tau}^r,$$

$$u_1^n\left(\frac{1}{2}, q^r, f_{S,n}^*, p_{S,n}^*\right) = u_2^n\left(\tfrac{1}{2}, q^r, f_{S,n}^*, p_{S,n}^*\right) \geq 0 \quad \Leftrightarrow \quad \tau \leq \frac{4(27-4\sqrt{19})}{85} \equiv \bar{\tau}^n.$$

Note that $\bar{\tau}^r < \bar{\tau}^n$.

Market coverage condition: competition in single two-part tariffs

In this case, the market is covered whenever

$$u_1^r\left(\frac{1}{2}, q^r, f_T^*, p_T^*\right) = u_2^r\left(\frac{1}{2}, q^r, f_T^*, p_T^*\right) \geq 0$$
$$- \frac{(A+\tau(5\phi-3)-8\phi+4)\left(\tau\left(A(5-7\phi)-8\left(5\phi^2+32\phi-39\right)\right)+4\left(4(A-2)\phi-3(A+4)+16\phi^2\right)+\tau^2\left(5\phi^2+134\phi-143\right)\right)}{256(\phi-1)^2(A-3\tau(\phi+1)+8\phi+4)}$$
$$\geq 0. \tag{A.1}$$

The point where condition (A.1) binds with equality implicitly determines $\bar{\tau}(\phi)$. Graphical inspection shows that $\min \bar{\tau}(\phi) = \bar{\tau}(\phi = 0) = 4/79(23 - 2\sqrt{73}) \equiv \bar{\tau}$. Note that $\bar{\tau} < \bar{\tau}^r$.

Market coverage condition: competition in fixed-fee contracts

In this case the market is covered whenever:

$$u_1^r\left(\frac{1}{2}, q^r, f_F^*, 0\right) = u_2^r\left(\frac{1}{2}, q^r, f_F^*, 0\right) \geq 0 \quad \Leftrightarrow \tau \leq \frac{2}{5} \equiv \bar{\tau}^f$$

Noting that $\bar{\tau}^f > \bar{\tau}$ we can conclude that for all $\tau \leq \bar{\tau}$ the market is covered in all our scenarios.

Firm non-deviation condition

Note that, in the single two-part tariff scenario, firms may be able to deviate profitably and serve only one of the consumer groups. In the screening case, however, such a deviation is never incentive compatible for firms because offering two different contracts is costless and therefore profit maximizing. Moreover, in the fixed-fees-only case, a deviation to one of the two groups of consumers is impossible because, in such a scenario, the information statuses of the two groups coincide.

In the following, we derive a lower bound on transport costs which ensures that serving both types of consumers is indeed optimal. If transport costs are too low, a firm can deviate by serving exclusively either informed or uninformed consumers. Upon deviating to serve only the uninformed consumers, firm 1 faces the following maximization problem:

$$\max_{p_1, f_1} \pi_1^{D,n}(p_1, f_1; p_T^*, f_T^*) = (1-\phi)\left(p_1 \int_0^{\hat{x}_T^n} (1 - p_1 - \tau x)dx + f_1 \hat{x}_T^n\right),$$

where $\hat{x}_T^n = \frac{1}{2} - \frac{f_1 - f_T^*}{\tau(2-\tau)}$ denotes the indifferent uninformed consumer. Correspondingly, when deviating to serve only informed consumers, the firm faces the following maximization problem:

$$\max_{p_1, f_1} \pi_1^{D,r}(p_1, f_1; p_T^*, f_T^*) = \phi\left(p_1 \int_0^{\hat{x}_T^r} (1 - p_1 - \tau x)dx + f_1 \hat{x}_T^r\right),$$

where $\hat{x}_T^r = \frac{1}{2} - \frac{p_1 - p_T^*}{2\tau} - \frac{f_1 - f_T^*}{\tau(2 - p_1 - p_T^* - \tau)}$.

We denote the prices under a deviation to consumer type $j \in \{n, r\}$ by $\{p_{D,j}^*, f_{D,j}^*\}$ and the corresponding payoffs of the firm by $\pi_1^{D,j}(p_{D,j}^*, f_{D,j}^*; p_T^*, f_T^*)$. Whenever deviating, the firm will choose to deviate to serve that group of consumers that promises higher profits. We thus denote the firm's deviation payoffs as $\pi_1^D \equiv \max\{\pi_1^{D,n} \pi_1^{D,r}\}$. Because we study the fully symmetric equilibrium, we can drop the firm index in the following without any loss of generality, and we can treat firms equally.

Because numerical simulations show that the deviating firm obtains zero profits from the group of consumers that is not targeted by the deviation, deviating by serving only one group of consumers will not be profitable for a firm if and only if $\pi^D \leq \pi_T^*$ holds.

This condition can be reinterpreted as a lower bound on the transport-cost parameter, $\underline{\tau}(\phi)$. Hence, for all $\tau \geq \underline{\tau}(\phi)$, the deviation of a firm to serve only one group of consumers is ruled out.

Appendix B. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.ijindorg.2025.103142.

Data availability

No data was used for the research described in the article.

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