The Disruptive Effect of Open Platforms on Markets for Wireless Services

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Abstract

Application-based discrimination is common in telecommunications. Wireless carriers charge consumers more per byte of traffic for SMS text messages than they do for wireless surfing or voice calls. Such discrimination is possible because carriers and handset manufacturers have the ability to tag and meter each application. While tagging and metering are possible in the case of proprietary platforms such as iPhone, they are not in the case of open platforms like Android. Android is open source with open application programming interfaces, and anyone can develop applications for it. Because the carriers have little control over applications, Android is inherently disruptive of discriminatory pricing across applications. Users and neutrality advocates support Android, believing that a disruption of discrimination can increase consumer surplus. We show why their belief does not always hold. Similarly, firms are expected to prefer discriminatory pricing. We show that this expectation is also not true under certain circumstances.

Keywords: Nonlinear Pricing, Quasi-bundling, Wireless Services, Open Platforms, Net Neutrality

1. Introduction

In the 18th century, navigation tolls varied from one cargo type to another, e.g., the toll for a ton of sand was not the same as the toll for a ton of timber [13]. Similar discrimination that is based on the traffic type is currently prevalent in telecommunications. Cable companies in the US do not price the broadband internet traffic the same way they price the cable TV traffic [13]. Wireless carriers in the US also practice such discrimination. Table 1 shows the typical rates that they charge for different applications. As is evident from the right-most column of the table, consumers are currently paying different prices for different applications.

Carriers can practice application-based discrimination because they have the ability to tag and meter each application. Tagging and metering are possible in the case of proprietary platforms. But they are not in the case of open platforms. For open platforms such as Android, anyone can develop and distribute new applications that offer different functions. Carriers supporting Android neither have the ability to restrict these applications nor do they have the ability to tag them for the purpose of metering them separately. They can however still meter the traffic consumption and charge a tariff that depends on traffic alone.

Many in the US, including many supporters of net-neutrality, welcome Android. They believe that open platforms like Android benefit consumers by disrupting the practice of discrimination. According to them, discrimination of any form based on the source, destination or traffic type only enriches carriers at the expense of consumers [16]. Claims Mossberg [11], a popular Wall Street Journal columnist, “We need a wireless mobile device ecosystem that mirrors
Table 1. Average per unit prices charged by a national carrier in the US in April, 2008

<table>
<thead>
<tr>
<th>Application</th>
<th>Price</th>
<th>Approx. traffic</th>
<th>Effective Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice Call</td>
<td>$0.1/minute</td>
<td>100KB/minute</td>
<td>$1/MB</td>
</tr>
<tr>
<td>Text Message</td>
<td>$0.2/message</td>
<td>100B/messgage</td>
<td>$2,000/MB</td>
</tr>
<tr>
<td>Image</td>
<td>$0.25/image</td>
<td>100KB/image</td>
<td>$2.5/MB</td>
</tr>
<tr>
<td>Wireless Surfing</td>
<td>$1.99/MB</td>
<td>-</td>
<td>$1.99/MB</td>
</tr>
</tbody>
</table>

the PC/Internet ecosystem, one where consumer’s purchase of the network capacity is separate from the purchase of the hardware and the software they use on that network.” Despite the popularity of this view against discrimination, the literature on pricing and economics of information has not critically examined the merits and demerits of the application-based discrimination prevalent in the US. Our intention is to fill this void in the literature.

To understand how the disruption of discriminatory pricing impacts carriers, consumers, and the society as a whole, we compare two different pricing regimes. One regime involves pricing different applications differently — we name this discriminatory regime application pricing. In the other regime, the carrier simply prices the traffic consumed — we call this second regime traffic pricing.

Open platforms also have an impact on innovation, particularly with regard to the development of new applications. The freedom to develop applications spurs development of new applications for them. We do not analyze the innovation issue in this paper. Our focus is on the first order impact of the disruption of discriminatory pricing.

We model a monopolist’s tariff design problem assuming it faces a heterogeneous market with two consumer types. We carry out the comparison of the two pricing regimes assuming that each regime employs nonlinear pricing [12, 6, 9, 14, 15]. Nonlinear pricing is highly relevant to wireless services. The most commonly used wireless tariff looks as follows: “we charge you $p$ dollars per month for up to $n$ units of usage, and usage over $n$ units are billed at $r$ dollars per unit.” Such “Fixed Up To” or “FUT” pricing have three components: a fixed fee of $p$ dollars, a free call time allowance of $n$ units, and an over-limit rate of $r$ dollars per unit. Masuda and Whang [10] show that, when the number of consumer types is finite and the monthly usage of a consumer type is deterministic, no consumer in the equilibrium goes over limit. Though there is empirical evidence suggesting that some users go over limit [8], we assume away that possibility here for the sake of tractability.

Traffic pricing is similar to selling a bundle consisting of all applications. However, in the case of bundling [1, 2, 3], the seller chooses the bundle composition. In the case of traffic pricing, each consumer chooses his or her own bundle composition. Traffic pricing is therefore best described as quasi-bundling or customized bundling [4, 7]. We examine a two-stage model of quasi-bundling: in the first stage, consumers make the decision to buy traffic, and in the second, they make the decision to allocate the purchased traffic between different applications. This model, while parsimonious, is suitable for a fine-grained analysis of producer, consumer, and social surpluses under different forms of consumer heterogeneity.

We find that the prevalent view favoring open platforms holds in certain circumstances, but it does not in many others. For example, discrimination expectedly leads to a lower consumer surplus in markets characterized by a few high-income consumers and a large number of low-income consumers. However, discrimination surprisingly leads to a higher consumer surplus when the fraction of high-income consumers becomes moderate to large. We also find that discrimination can be pareto-optimal, i.e., it can benefit the producer and consumers alike. Intriguingly, we find that the common wisdom, that discrimination always increases profits, holds when consumer types are uniformly ordered, but it does not otherwise.
2. Model

When a carrier employs application pricing, it announces a separate nonlinear pricing schedule for each application. We use the term plan to refer to an item on a schedule. If a carrier offers a plan \((p_A, n_A)\) for an application, say \(A\), it means that a consumer can purchase \(n_A\) units of that application for \(p_A\) dollars. When the carrier uses traffic pricing, it uses one nonlinear pricing schedule to price the traffic consumption — it offers plans of type \((p, t)\), which means that a consumer can purchase \(t\) bytes of traffic for \(p\) dollars. After the decision to purchase, each consumer makes the decision to allocate the purchased traffic to different applications based on his or her own preferences for those applications. Taking the traffic of each application as given, we can normalize the units for application pricing to be the same as that of traffic. For example, we can express the plan \((p_A, n_A)\) discussed above also as \((p_A, t_A)\), where \(t_A = n_A \tau_A\), and \(\tau_A\) is the average traffic generated per unit of application \(A\). Such normalization to a common unit makes it easier for us to compare the two pricing regimes. Assume that consumer types have the same preference ordering. Alternatively, if consumer type \(i\)’s reservation price for application \(j\) is \(v_{ji}(t)\), \(i \in \{1, 2\}\), then, for any \(j \in \{A, B\}, v_{j2}(t) > v_{j1}(t)\ \forall t > 0\). Heterogeneity may be a result of a difference in tastes or a difference in incomes. When the income factor dominates the taste factor, we expect uniform ordering. For example, if type 2 has a significantly higher income, its willingness to pay is going to be higher for every application.

This setting with two consumer types, a high type and a low type, resembles a vertically differentiated market. But it is in fact different. In a vertically differentiated market, a seller offers two competing goods — a high-quality good and a low-quality good — with each consumer deciding between the two according to his or her preference for quality. In our case, a consumer may buy both applications.

We now state our assumptions. Following recommendations of prior empirical research [5], we assume a square-root form for the reservation prices.

\[ v_{A1}(t) = 2\alpha_A \sqrt{t}, \quad v_{B1}(t) = 2\alpha_B \sqrt{t} \]
\[ v_{A2}(t) = 2\alpha_A \theta_A \sqrt{t}, \quad v_{B2}(t) = 2\alpha_B \theta_B \sqrt{t} \]
\(\alpha_A, \alpha_B, \theta_A\) and \(\theta_B\) are all positive.

Assumption 2. The carrier’s marginal cost is \(c\) dollars per byte of traffic.
Table 2. Application Pricing Solution for application \( j \) when \( \theta_j > 1 \)

<table>
<thead>
<tr>
<th>Case</th>
<th>Solution ( (t_{ji}) )</th>
<th>Producer Surplus ( (\pi_j) )</th>
<th>Consumer Surplus ( (\gamma_j) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-degree Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0 &lt; f &lt; 1 )</td>
<td>( t_{j1}^B = \left( \frac{f}{\theta_j} \right)^2 ), ( t_{j2}^B = \left( \frac{\theta_j}{\theta_j} \right)^2 )</td>
<td>((1-f)v_{j1}(t_{j1}^B) + \frac{f}{1+f}v_{j2}(t_{j2}^B) - cf\left(1-f\right)t_{j2}^B )</td>
<td>0</td>
</tr>
<tr>
<td>Second-degree Discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0 &lt; f &lt; \frac{1}{\theta_j} )</td>
<td>( t_{j1}^B = \left( \frac{f_1 - f_0}{\theta_j} \right)^2 ), ( t_{j2}^B = \left( \frac{\theta_j}{\theta_j} \right)^2 )</td>
<td>((1-f)v_{j1}(t_{j1}^B) + \frac{f}{1+f}v_{j2}(t_{j2}^B) - cf\left(1-f\right)t_{j2}^B )</td>
<td>( f(v_{j2}(t_{j2}^B) - v_{j1}(t_{j1}^B)) )</td>
</tr>
<tr>
<td>( \frac{1}{\theta_j} \leq f &lt; 1 )</td>
<td>( t_{j1}^B = 0, t_{j2}^B = \left( \frac{\alpha_j}{\theta_j} \right)^2 )</td>
<td>( f(v_{j2}(t_{j2}^B) - c(t_{j2}^B)) )</td>
<td>0</td>
</tr>
</tbody>
</table>

Following the literature on bundling [2], we also assume that the total willingness to pay for the two applications is the willingness to pay for \( A \) plus the willingness to pay for \( B \). We do so in order to separate out the effects of synergy. We use a constant marginal cost in order to separate out the issues related to scale-economy. We also normalize the fixed cost to zero because we consider it sunk and not relevant to the pricing decision.

Note that \( \theta_j > 1 \) signifies that consumer type 2 is the high type for application \( j \), and \( \theta_j < 1 \) signifies that consumer type 1 is the high type. When the reservation prices are uniformly ordered, we can assume, without loss of generality, that consumer type 2 is the high type for both applications, i.e., we can assume that both \( \theta_A > 1 \) and \( \theta_B > 1 \). Without loss of generality, we also assume \( \theta_B \geq \theta_A \).

2.1.1. Application Pricing: Under application pricing, the carrier offers the schedule \((p_{A1}, t_{A1}), (p_{A2}, t_{A2})\) for application A, and the schedule \((p_{B1}, t_{B1}), (p_{B2}, t_{B2})\) for application B. When each consumer type self-selects, as we know from the theory of second-degree discrimination [12], optimal policies for the seller occur when the low type consumer is indifferent between purchasing and not, and the high type consumer is indifferent between purchasing the plan aimed at the low type consumer and its own plan.

The IR constraints for the low type (type 1) are:

\[ v_{j1}(t_{j1}) \geq p_{j1}, \quad j \in \{A, B\} \]  \hspace{1cm} (1)

The IC constraints for the high type (type 2) are:

\[ v_{j2}(t_{j2}) - p_{j2} \geq v_{j2}(t_{j1}) - p_{j1}, \quad j \in \{A, B\} \]  \hspace{1cm} (2)

When equations 1 and 2 are equalities, we can express the carrier’s problem as follows.

\[
\max_{t_{A1}, t_{B1}, t_{A2}, t_{B2} \geq 0} \left( v_{A1}(t_{A1}) + v_{B1}(t_{B1}) + f(v_{A2}(t_{A2}) - v_{A2}(t_{A1})) + f(v_{B2}(t_{B2}) - v_{B2}(t_{B1})) - c(1-f)(t_{A1} + t_{B1}) - cf(t_{A2} + t_{B2}) \right)
\]

The problem is separable, i.e., we may solve this problem separately for \( A \) and \( B \). We summarize the closed form solution in table 2. In the table we denote the profit from application \( j \) by \( \pi_j \) and the corresponding consumer surplus that the monopolist cedes to the high type (i.e., type 2) by \( \gamma_j \). The surplus equals zero when the low type is not served. The separable nature implies that the total producer surplus under application pricing equals \( \pi_A + \pi_B \), and that the total consumer surplus equals \( \gamma_A + \gamma_B \).

2.1.2. Traffic Pricing: Under traffic pricing, the carrier offers two plans, \((p_1, t_1)\) and \((p_2, t_2)\), to the two types of consumers who self-select. After making the decision to purchase, each consumer type chooses its own bundle composition. Consumer type \( i \)'s problem is:

\[
\max_{t_{Ai}, t_{Bi} \geq 0, t_{AI} + t_{Bi} \leq t} v_{Ai}(t_{Ai}) + v_{Bi}(t_{Bi})
\]

We traverse the timeline backwards, i.e., we first solve the consumers’ problems and then...
solve the carrier’s profit maximization problem. Let the solution to the consumer type $i$’s problem be $(t^*_i(t), t^*_i(t))$. This solution satisfies:

$$v'_B(t^*_B(t_i)) = v'_A(t^*_A(t_i)) \quad (3)$$

To solve the carrier’s problem, using assumption 1 and equation 3, we derive the reservation prices for traffic. We denote consumer type 1’s reservation price for traffic by $v_1(t)$ and type 2’s by $v_2(t)$.

$$v_1(t) = 2\alpha \sqrt{t}, \quad v_2(t) = 2\alpha \theta \sqrt{t} \quad (4)$$

where:

$$\alpha = \sqrt{\alpha_A^2 + \alpha_B^2}, \quad \theta = \sqrt{\frac{\alpha_A^2 \theta_A^2 + \alpha_B^2 \theta_B^2}{\alpha_A^2 + \alpha_B^2}} \quad (5)$$

The traffic pricing problem is therefore structurally identical to the problem of pricing an application. Additionally, $\theta_B \geq \theta_A > 1$ implies that $\theta > 1$; therefore, type 2 is also the high type in the case of traffic pricing. The solution to the traffic pricing problem is thus what one gets by dropping the subscript $j$ from table 2. In the following discussion, we assume away the degenerate case of $\theta_A = \theta_B$ and focus on the interesting case of $\theta_B > \theta_A$.

2.1.3. A Comparison of the Two Regimes: Refer to figure 2 for a comparison of the two pricing regimes. Depending on the value of $f$, the fraction of type 2, we break the problem down into four regions numbered U1 through U4. In region U4 consumer type 1 is shut out under both pricing regimes. However, significant differences between the two pricing regimes exist in regions U1 to U3. The differences are more pronounced in regions U2 and U3, where type 1 is served differently under different pricing regimes even though type 2 is always served both applications. We now define the following.

$$f^A = \left(\frac{\theta_A + \frac{\alpha(\theta - \theta_A)}{\alpha - \alpha_A(\frac{\theta_A - 1}{\alpha(\theta - 1)})}}{\frac{1}{\theta_B}} \right)^{-1}$$

Because $\theta_B > \theta > \theta_A$, the definition above implies that $\frac{1}{\theta_B} < f^A < \frac{1}{\theta}$. Theorem 1. When consumer types are uniformly ordered as described above, the following holds:

(a) Application pricing always results in a strictly higher producer surplus in regions U1, U2 and U3.
(b) Application pricing always produces a strictly higher consumer surplus everywhere in region U3; therefore, it is also pareto-optimal in U3.
(c) Traffic pricing produces a strictly higher consumer surplus everywhere in region U1 and in parts of region U2, but application pricing still leads to a strictly higher consumer surplus in the part of region U2 where $f > f^A$; i.e., application pricing is always pareto-optimal in the part of U2 where $f > f^A$.
(d) In U4 the two pricing regimes are equivalent: they lead to the same producer surplus and a zero consumer surplus.
Figure 3 depicts how the three surpluses vary with the fraction of type 2, and it illustrates the counterintuitive theoretical results. It is important to note that the example is representative in the sense that the shapes of the different curves shown in the figure do not depend on the parameter values assumed. In region U3, traffic pricing shuts out the low type consumer, driving the consumer surplus to zero; but application pricing still allows the low type consumer to use one of the two applications, producing a strictly positive consumer surplus. More intriguingly, in parts of region U2, where both consumer types are served both applications under traffic pricing, application pricing produces a higher consumer surplus despite restricting the low type consumer to only one application. The figure also demonstrates that, wherever application pricing leads to a higher consumer surplus, it does so while also leading to a higher producer surplus. This pareto-optimality of application pricing implies that open platforms may even lead to a lower social welfare. Only in U1, which is characterized by a few high-income consumers and a large number of low-income consumers, disrupting discrimination works as expected, i.e., it leads to a higher consumer surplus and a lower producer surplus.

We now explain the intuition behind these apparently counter-intuitive results. Traffic pricing favorably affects the consumer surplus in U1 and in parts of U2 because it lets all consumers freely allocate the purchased traffic between the two applications. However, in U3 and in parts of U2, traffic pricing significantly reduces the carrier’s incentive to serve the low type consumers. Because the carrier is not able to restrict the low type to one application in these regions, serving the low type requires ceding too large a “information rent” (i.e., surplus) to the high type. On the other hand, discrimination allows the carrier to restrict application B only to the high type, creating opportunities to control the information rent. So, when discrimination is not an option, the carrier severely under-serves the low type in those regions, reducing everyone’s welfare. The prevalent view supporting open platforms is therefore not applicable in situations in which discrimination is essential in restricting certain applications to the high type only.
2.2. Non-uniform Ordering of Consumer types

We now deal the other scenario, which is non-uniform ordering of consumer types, i.e., one consumer type is the high type for application A while the other is the high type for application B. Let us assume that type 1 is the high type for application A, i.e., \( \theta_A < 1 \), and that type 2 is the high type for application B, i.e., \( \theta_B > 1 \). Non-uniform ordering occurs when consumers’ preferences depend more on their idiosyncratic tastes for different applications and less on their incomes.

It is important to note that this setting is different from that of a horizontally differentiated market, in which a seller offers two competing goods with each consumer opting for the one that minimizes his or her “fit cost.” In our case, a consumer may buy both applications.

The application pricing problem is still identical to the problem discussed in the previous section except that the roles of the two consumer types have now interchanged for application A. In the case of traffic pricing, however, either the high type for A or the high type for B can be the high type depending on the relative sizes of \( \alpha_A \) and \( \alpha_B \). Without loss of generality, we are going to assume that the high type for application B is the high type in the case of traffic pricing, i.e., \( \theta > 1 \).

Because \( \theta_A < 1 < \theta_B \), we have \( \frac{1}{\theta_B} < \frac{1}{\theta} \). The implication is that we need to examine three possible scenarios, which we name case X, case Y and case Z. The figures 4, 5 and 6 show how the two pricing regimes compare in these three scenarios. For each scenario, we consider four cases. For case X, we name them X1, X2, X3 and X4. We name the regions for cases Y and Z in a similar fashion.

**Theorem 2.** When consumer types are non-uniformly ordered as described above, in regions where one consumer type is not served at all under traffic pricing, i.e., in regions X4, Y4, Z3 and Z4, application pricing is pareto-optimal. Specifically, the following holds:

(a) In regions X4, Y4, Z3 and Z4, application pricing produces a strictly higher producer surplus.

(b) Application pricing also results in a strictly higher consumer surplus in regions X4, Y4 and Z4; therefore, it is strictly pareto-optimal in these three regions.

(c) Both pricing regimes lead to a zero consumer surplus in region Z3. Therefore, application pricing is weakly pareto-optimal in this region.

Theorem 2 extends the counter-intuitive findings described in the context of uniform ordering to the case of non-uniform or inverse ordering. Figure 7 shows a representative example of case X. As is evident from it, discrimination is superior in X4 from both the consumers’ viewpoint and the carrier’s viewpoint. The intuition is still the same as what we described earlier. While using discrimination, the carrier selectively serves the two consumer types; for example, in X4, it restricts application B to type 2 consumers only. However, when discrimination is not possible, the carrier has to choose between serving type 1 consumers both applications in X4 and serving them none. Serving both requires ceding too large a surplus to type 2 consumers. The carrier therefore shuts out type 1 in X4, forgoing all profits from that market segment and also reducing the surplus of the other segment.

So far we have focused on the surprising ability of discrimination to lead to a higher consumer surplus. But equally interesting is the ability of open platforms to lead to a higher profit for the carrier. To explain the circumstances under which the carrier benefits from open platforms, we define the following notations:

\[
\begin{align*}
\theta^k &= \alpha_A^2 + \alpha_B^2 \theta_B + \frac{1}{2} (\alpha_A \theta_A)^2 \\
\theta^{x1} &= \frac{1}{1 - \theta_B} - \frac{\alpha_A^2 + \alpha_B^2}{\theta_A} \times \\
&\sqrt{\frac{\alpha_A^2 (\theta_A - (1 - \theta_B) \theta_B^2) + \theta_A \alpha_B^2 (1 - (1 - \theta_A) \theta_B)^2}{(\alpha_A^2 + \alpha_B^2)^2}} \\
\theta^{x2} &= \theta_B - (\theta_B - 1) \times \\
&\sqrt{\frac{\alpha_A^2 (\theta_B - 1 - \theta_B^2) + \alpha_A^2 (1 - (1 - \theta_A) \theta_B)^2}{(\theta_B - 1)(\alpha_A^2 + \alpha_B^2)}}
\end{align*}
\]
By definition, $\theta^k > 1$. We can also show that $\theta^k > \theta^x_1 > \theta^x_2 > 1$ holds for case Z, and, that $\theta^k > \theta^y_1 > \theta^y_2 > 1$ holds for case Y. Additionally, for case X, $\theta^k > \theta^x_1 > \theta^x_2 > 1$.

**Theorem 3.** When consumer types are non-uniformly ordered as described above, if $\theta \geq \theta^k$, application pricing expectedly produces a higher profit at all values of $f$. However, if $\theta < \theta^k$, either application pricing or traffic pricing may produce a higher profit. Additionally, the following holds:

(a) For case X, if $\theta < \theta^x_1$, traffic pricing results in a strictly higher profit everywhere in region $X1$. And, if $\theta < \theta^x_2$, traffic pricing results in a strictly higher profit everywhere in region $X1$ as well as everywhere in region $X2$. 

$$
\theta^{y_1} = \theta_B - (\theta_B - 1)\sqrt{\frac{\alpha_A^2(\theta_B - 1 - \theta^2_A)}{\theta^2_B - 1)(\alpha_A^2 + \alpha_B^2)}}
$$

$$
\theta^{y_2} = \frac{1}{1 - \theta_A} - \frac{\theta_A}{1 - \theta_A} \sqrt{\frac{\alpha_A^2(\theta_A - (1 - \theta_A)\theta^2_A)}{(\alpha_A^2 + \alpha_B^2)\theta_A}}
$$

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(b) For case Y, if \( \theta < \theta^y_1 \), traffic pricing results in a strictly higher profit everywhere in region \( Y_1 \). And, if \( \theta < \theta^y_2 \), traffic pricing results in a strictly higher profit everywhere in region \( Y_1 \) as well as everywhere in region \( Y_2 \).

(c) For case Z, if \( \theta < \theta^z_1 \), traffic pricing results in a strictly higher profit everywhere in region \( Z_1 \).

Consider the producer surplus plot again in the example shown in figure 7. For this example, \( \theta^y = 1.4341 \), \( \theta^z_1 = 1.4 \), \( \theta^z_2 = 1.30258 \) and \( \theta = 1.2411 \). Because \( \theta < \theta^z_2 \) in our example, in both \( X_1 \) and \( X_2 \), traffic pricing leads to a higher profit. The plot further shows that traffic pricing performs better even in parts of \( X_3 \). The reason behind this surprising phenomenon is that traffic pricing acts like an effective quasi-bundle in these regions. As is indicated by theorem 3, this effectiveness is particularly visible when \( \theta \) is small, i.e., it is close to unity or, alternatively, the reservation prices for traffic of the two consumer types are very similar. A small \( \theta \) implies a strong inverse relationship between the preferences of the two consumer types. Prior research shows that such strong inverse relationships increase the effectiveness of bundling [14]. Theorem 3 extends the same insights to the case of quasi-bundling. Also, theorems 1 and 3 collectively prove that a necessary condition for quasi-bundling to be effective from a producer’s viewpoint is that the primary source of consumer heterogeneity be taste and not income, and a necessary condition for it to be highly effective is that the reservation price for traffic be similar across different segments.

Figure 7 also shows that, at moderate values of \( f \), e.g., in \( X_2 \), traffic pricing is pareto-optimal. This superiority of traffic pricing occurs despite the fact that application pricing is pareto-optimal in \( X_4 \). Therefore, depending on the sizes of different market segments and their relative preferences, either regime can lead to a higher social surplus.

3. Conclusion

Open platforms prevent carriers from practicing application-based discrimination, and they are expected to increase consumer welfare. However, we show that, when consumers differ mainly in their incomes, the benefits are realized only in situations that involve a few high-
income consumers and a large number of low-income consumers. In situations that involve a larger fraction of high-income consumers, the carrier, unable to prevent the low-income segment from using certain applications, starts under-serving it severely. Forgoing the low-income consumers partly or fully leads to a lower surplus for both the carrier and consumers. The same phenomenon occurs even when consumers differ mainly in their tastes for different applications. The lesson therefore is that discrimination allows a producer greater flexibility with regards to how it serves different market segments and that the flexibility in some cases makes both the producer and consumers better off.

Another insight that emerges from our study is that the common wisdom that discrimination is always good for the producer holds only when consumer types are uniformly ordered. It does not hold otherwise. The reason is that an inverse ordering of consumer types makes traffic pricing work like a quasi-bundle. We show that quasi-bundling is particularly effective from a producer’s viewpoint when different market segments have similar willingness to pay for traffic.

In conclusion, the major contribution of this paper is that it shows that application-based discrimination is pareto-optimal in many instances. Further, it shows that disrupting such discrimination may not always lead to a lower profit for carriers. All these findings are unexpected, and they form a critical foundation for further research in this area. Future research is essential to address many of the issues not addressed in this paper, including those related to competitive settings and more complex forms of tariff.

References


