# Should platforms be allowed to charge ad valorem fees?

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**Abstract**

Many platforms that facilitate transactions between buyers and sellers charge ad valorem fees in which fees depend on the transaction price set by sellers. Given these platforms do not incur significant costs that vary with transaction prices, their use of ad valorem fees has been questioned. In this paper, using a model that connects ad valorem fees to third-degree price discrimination, we evaluate the welfare consequences of banning such fees. We find the use of ad valorem fees generally increases welfare, including for calibrated versions of the model based on data from Amazon's marketplace and Visa's signature debit cards.

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# 1 Introduction

Ad valorem platform fees which depend positively on transaction prices are widely used in practice. Well-known examples include online marketplaces (such as Amazon and eBay), payment card platforms (such as Visa, MasterCard and American Express), and hotel booking platforms (such as Booking.com and Expedia). In these cases platforms typically charge sellers percentage fees, as well as sometimes small fixed per-transaction fees. Platform costs, which are largely fixed or dependent on the number (rather than the value) of transactions cannot explain the levels of ad valorem fees set by these platforms. This has led to criticisms of the ad valorem fee structure, given it is not cost reflective. In this paper, we explore

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whether such ad valorem fees harm welfare, and so whether there may be a case for banning them.

Concerns over the use of ad valorem fees have been raised in the context of payment card platforms. Merchants and policymakers point out that debit and prepaid card transactions do not provide credit or float and bear very small fraud risk; therefore, they do not warrant a percentage-based fee structure. For instance, Summers (2012) criticizes that "*Payment schemes' owners and infrastructure operators also have monopoly power that can be used to set prices far above their production cost. There is abundant evidence of clearing and settlement pricing that is based not on production cost but on methods designed to extract very high returns for use of the infrastructure. Perhaps the most prominent example is ad valorem pricing for payment methods that essentially involve giving bank account holders direct access to their deposits and that do not entail bank credit, as in the case of debit cards*". The Canadian Senate Committee on Banking, Trade and Commerce (June 2009) made the following ruling: "*The Committee believes that there is little rationale for percentage-based interchange, merchant discount and switch fees on debit cards, since this payment method involves a relatively simple and nearly instantaneous transfer of funds. There is no obvious credit risk and no interest-free period to fund in these transfers.…The Committee believes that debit card transactions are inherently less risky and costly than credit card transactions; consequently, they do not warrant a percentage-based fee structure, whether at the level of interchange fees or switch fees.*"

To address this issue we make use of the model we developed in Wang and Wright (2017) in which a profit maximizing platform designs its fee structure to take into account heterogeneity in demand across the many products sold over its platform. The key idea captured by the model is that when a market involves many different goods that vary widely in their costs and values that may not be directly observable, then ad valorem fees and taxes represent an efficient form of price discrimination because the value of a transaction is plausibly proportional to the cost of the good traded. The model implies that the profit maximizing fee structure is affine (consisting of a percentage fee plus a fixed per-transaction component) if and only if the demand faced by sellers belongs to the generalized Pareto class that features constant curvature of inverse demand (which includes linear demand, constant-elasticity, and exponential demand as special cases). This matches the fee structure used by many platforms, as shown in Table 1 below.[1] According to the model, the fixed per-transaction component is present only because the platform incurs a marginal cost for

[1] Table 1 reports fees that Amazon and Visa charge to sellers for each transaction on the platform. Note that Visa fees shown in Table 1 are unregulated signature debit card interchange fees for the U.S. market. These fees, set by Visa, are paid by merchants to card issuers through merchant acquirers.

processing each transaction; otherwise a simple percentage fee would be profit maximizing. In Wang and Wright (2017) we used the model to show that ad valorem fees should also be used by an authority that wants to regulate a platform's fees while allowing for the recovery of a certain amount of revenue (e.g., to cover the platform's fixed costs). In contrast, in this paper we investigate a different issue: What would happen if a policymaker banned a platform's use of any fee that depended on the value of transactions (i.e., ad valorem fees) but left the level of the platform's fees unregulated. For policymakers who want platform fees to be determined on the basis of costs but are concerned about directly regulating fee levels, this seems to be a natural approach to consider. However, we show that the welfare results are not at all obvious, and are related to the long-standing debate on the welfare effects of third-degree price discrimination.

Table 1. Platform fee schedules

| Amazon | | | | Visa | | | |
|---|---|---|---|---|---|---|---|
| DVD | 15% | + | \$1.35 | Gas Station | 0.80% | + | \$0.15 |
| Book | 15% | + | \$1.35 | Retail Store | 0.80% | + | \$0.15 |
| Video Game | 15% | + | \$1.35 | Restaurant | 1.19% | + | \$0.10 |
| Game Console | 8% | + | \$1.35 | Small Ticket | 1.50% | + | \$0.04 |

To address this question, we first show that the conditions for welfare to increase as a result of banning the use of ad valorem fees turn out to be the same as those which determine whether banning a monopolist from using third-degree price discrimination improves welfare, in which each good traded is treated as a separate observable market over which the monopolist can price. This allows us to draw on the substantial literature on monopolistic third-degree price discrimination (e.g., see Aguirre *et al.*, 2010, for a recent analysis). In the setting usually adopted for price discrimination studies, in which there are only two markets, we find welfare is generally higher when platforms are allowed to use ad valorem fees given our demand class. Specifically, welfare is higher whenever demand is exponential or log-convex within the generalized Pareto class, and also when demand is log-concave within this class provided the two goods are sufficiently dispersed in terms of costs and values.

The intuition for the above results is as follows. For two goods that have very different costs/values, a monopoly platform that can only set a uniform fee will set the fee very close to the monopoly fee for the high-value good, almost eliminating the sale of the low-value good. This is what happens with exponential and log-convex demand. For log-concave demand there is a choke price, so the uniform fee will be set at the monopoly fee level for the high-value good with the low-value good not being traded at all. In these cases, allowing the platform to price discriminate has little (if any) negative effect on the high-value good but expands output a lot for the low-value good, meaning price discrimination increases welfare.

For two goods that are moderately dispersed in costs/values, a similar intuition applies but the extent to which it holds depends on the log-convexity of demand. We show for such cases, that welfare is still higher under price discrimination when demand is exponential or log-convex, but this need not be the case when demand is log-concave. This reflects that the more log-convex is demand, the closer the uniform fee gets to the monopoly fee for the high-value good. Finally, when the two goods are close in costs/values, we link our result to Proposition 5 of Aguirre *et al.* (2010). They show when demands in two markets are sufficiently close, price discrimination increases welfare when demand is log-convex and decreases welfare when demand is log-concave.

We show these results can be extended to a setting with a continuum of goods, for which the costs and values are drawn from a uniform distribution. In real-world settings, however, platforms handle the trade of many different goods, and the distribution of prices and sales of these goods will typically be highly skewed. Analytical results in such cases are not possible. We therefore use information on the actual distribution of prices and sales measures for two different platforms (Amazon's and Visa's), as well as their fee structures, to calibrate our model. We find, in most cases, welfare would be harmed if ad valorem fees were banned. Our results therefore imply policymakers should be cautious about banning the use of ad valorem fees.

Shy and Wang (2011) also look at the welfare effects of a platform shifting from a fixed per-transaction fee to an ad valorem fee. They consider a setting with a monopoly platform and imperfectly competitive sellers that sell a homogenous good, and demand takes a constant-elasticity form. They find welfare is higher when the platform can use an ad valorem fee, but their result relies on the property that ad valorem fees help mitigate the double marginalization problem. Thus, their work complements ours, which assumes away any double marginalization problem by focusing on the case in which sellers are identical price competitors. In a similar vein, several studies (e.g., Foros *et al.*, 2014; Gaudin and White, 2014a; and Johnson, 2017) have explored the advantages of so-called agency model used by mass retailers such as Amazon, where the retailer lets suppliers (i.e., sellers) set final prices and receive a share of the revenue, which is equivalent to using a percentage fee. Like Shy and Wang (2011), they also show that the revenue-sharing used in the agency model has the advantage of mitigating double marginalization, but they differ by focusing on how the agency model affects retail prices compared with the traditional wholesale pricing model.

Our theory can also be used to justify the adoption of ad valorem taxes rather than unit (or specific) taxes in settings in which governments seek to maximize tax revenue (the so-called Leviathan hypothesis; see Brennan and Buchanan, 1977, 1978).[2] In this case, the tax-revenue maximizing government is identical to a revenue-maximizing platform. Our results imply that an ad valorem tax regime welfare dominates a unit tax regime. Gaudin and White (2014b) obtain a similar result but in a very different setting, in which double marginalization rather than price discrimination is the key driving force.

Finally, our paper also contributes to the extensive literature on the welfare effects of monopolistic third-degree price discrimination (e.g., Schmalensee, 1981; Varian, 1985; Schwartz, 1990; Layson, 1994; Aguirre, 2006, 2008; Cowan, 2007, 2016; Aguirre et al., 2010; and Chen and Schwartz, 2015). Aguirre *et al.* (2010) is particularly relevant. They focus on the case in which there are two markets that are always served and consider a general demand specification. Among the cases for which they obtain strong results is the case in which the demand function in each market has constant curvature of inverse demand and demands are sufficiently close across the two markets. We study a special case of their specification in which all markets have the same constant curvature of inverse demand and in which inverse demand only varies by a multiplicative term across each market. On the other hand, we generalize their result by allowing for larger differences in inverse demand across the two markets. Our results also extend the findings of Malueg and Schwartz (1994), who consider a continuum of markets each having a linear demand, with inverse demand varying with a multiplicative term that is uniformly distributed. Moreover, in contrast to most studies in the existing literature, we go beyond purely theoretical discussions by calibrating our model to the data from Amazon's marketplace and Visa's signature debit cards. This allows us to provide quantitative evaluations of the welfare effects of price discrimination at those platforms based on the actual, highly skewed, distributions of goods traded on these platforms.

The rest of the paper proceeds as follows. Section 2 sets out the model. Section 3 provides some analytical results while Section 4 provides results based on a calibrated model of the Visa platform and the Amazon platform. Finally, Section 5 provides some brief concluding remarks.

## 2 The model

We consider an environment where multiple goods are traded over a platform. For each good traded, a unit mass of buyers want to purchase one unit of the good. There are

[2]This is distinct from the large tax literature comparing the welfare effects of using ad valorem taxes versus specific taxes to raise a given level of tax revenue, which is also what we focused on in Wang and Wright (2017).

multiple identical sellers of each good who engage in Bertrand competition. Different goods sold on the platform are indexed by $c$, which can be thought of as a scale parameter, so that different goods can be thought of as having similar demands except that they come in different scales. In particular, the per-unit cost of good $c$ to sellers (which is known to all buyers and sellers of the good) is normalized to $c$ and the value of the good to a buyer drawing the benefit parameter $b \geq 0$ is $c(1+b)$, so the scale parameter increases the cost and the buyer's valuation proportionally.[3] We denote the lowest and highest values of $c$ as $c_L$ and $c_H$ respectively, with $c_H > c_L > 0$. We assume $1+b$ is distributed according to some smooth (i.e., twice continuously differentiable) and strictly increasing distribution function $F$ on $\left[1, 1+\overline{b}\right]$, where $\overline{b} > 0$. (We do not require that $\overline{b}$ is finite.) Only buyers know their own $b$, while $F$ is public information.

This setup captures the idea that for a specific market category that can be identified by the platform, the main difference across the goods traded is their scale (i.e., some goods are worth a little and some a lot). For example, the main reason external hard drives vary in price from around \$10 to well over \$1,000 is due to differences in costs and values, and not primarily due to differences in demand elasticity or the shape of demand. Therefore, cost and value come hand in hand to measure the scale of the trade. Another more general interpretation, as shown in Wang and Wright (2017), for this specification is that such a platform reduces trading frictions, and as a result, the value of buyers of using the platform (so that they can avoid the loss of using a less efficient trade intermediary) is proportional to the cost or price of the goods traded.[4] In this case, higher cost goods involve higher gains from trade via the platform.

The number of transactions $Q_c$ for a good $c$ is the measure of buyers who obtain non-negative surplus from buying the good, $\Pr\left(c(1+b) - p_c \geq 0\right)$. Therefore, the demand function for good $c$ is

$$Q_c(p_c) \equiv Q\left(\frac{p_c}{c}\right) \equiv 1 - F\left(\frac{p_c}{c}\right). \tag{1}$$

The corresponding inverse demand function for good $c$ is $p_c(Q_c) = cF^{-1}(1 - Q_c)$, which is proportional to $c$. Note this specification assumes demand is independent across goods.

Given this setup, in Wang and Wright (2017) we show that the profit-maximizing platform

[3]The assumption $b \geq 0$ is just a normalization. We do not have to consider buyers drawing benefits with $b < 0$, given their valuation for a good would be less than its cost, so no such trades would take place.

[4]These interpretations are consistent with empirical findings. The assumption that buyers' values for a good can be scaled by $c$ is indeed a key empirical finding of Einav et al. (2015) who study quasi-experimental observations from a large number of auctions of different goods on eBay. Wang and Wolman (2016) analyze payment patterns for two billion retail transactions, and they find that the dollar amount of transaction is the key to explain consumers' choice between using payment cards and cash.

fee is affine if and only if $F$ takes on the generalized Pareto distribution

$$F(x) = 1 - (1 + \lambda(\sigma - 1)(x - 1))^{\frac{1}{1-\sigma}}. \tag{2}$$

Here $\lambda > 0$ is the scale parameter and $\sigma < 2$ is the shape parameter. Note that the generalized Pareto distribution implies the corresponding demand functions for sellers on the platform are defined by the class of demands with constant curvature of inverse demand

$$Q_c(p_c) = 1 - F\left(\frac{p_c}{c}\right) = \left(1 + \frac{\lambda(\sigma - 1)(p_c - c)}{c}\right)^{\frac{1}{1-\sigma}}, \tag{3}$$

where $p_c$ is the price of good $c$ on the platform and $Q_c(p_c)$ is the measure of units of good $c$ sold by sellers on the platform at that price.[5] The constant $\sigma$ is the curvature of inverse demand, defined as the elasticity of the slope of the inverse demand with respect to quantity. When $\sigma < 1$, the support of $F$ is $[1, 1 + 1/\lambda(1 - \sigma)]$ and it has increasing hazard. Accordingly, the implied demand functions $Q_c(p_c)$ are log-concave and include the linear demand function ($\sigma = 0$) as a special case. Alternatively, when $1 < \sigma < 2$, the support of $F$ is $[1, \infty)$ and it has decreasing hazard. The implied demand functions are log-convex and include the constant elasticity demand function ($\sigma = 1 + 1/\lambda$) as a special case. When $\sigma = 1$, $F$ captures the left-truncated exponential distribution $F(x) = 1 - e^{-\lambda(x-1)}$ on the support $[1, \infty)$, with a constant hazard rate $\lambda$. This implies the exponential (or log-linear) demand $Q_c(p_c) = e^{-\frac{\lambda(p_c - c)}{c}}$.

Taking as given that demand belongs to the generalized Pareto class, we allow $c$ to take on potentially many different values in $[c_L, c_H]$, with the set of all such values being denoted $C$. The distribution of $c$ on $C$ is denoted $G$. We allow for the possibility $c$ takes only a finite number of values in $C$, or that it is continuously distributed. We let $g_c$ capture the probability (or density in case $G$ is continuous) corresponding to the realization $c$.

The platform incurs a cost of $d \geq 0$ per transaction. The platform can potentially charge fees to buyers, sellers, or both. Given that identical sellers compete for buyers, any fee charged to sellers will be passed through to buyers. The final price faced by buyers will reflect any fees, and the buyer treats these the same whether she faces them directly or through sellers. Due to this standard result on the irrelevance of the incidence of taxes across the two sides, we can assume without loss of generality that only the seller side is charged.

If it charges sellers the fee schedule $T(p_c)$, the platform's profit is $\Pi_c = (T(p_c) - d)\, Q_c(p_c)$

[5] This class of demands has been considered by Bulow and Pfleiderer (1983), Aguirre *et al.* (2010), Bulow and Klemperer (2012), and Weyl and Fabinger (2013), among others.

for good $c$. Note given Bertrand competition between sellers, the price $p_c$ for good $c$ solves

$$p_c = c + T(p_c). \tag{4}$$

The platform's problem is to choose $T(p_c)$ to maximize

$$\Pi = \sum_{c \in C} g_c \Pi_c. \tag{5}$$

In Wang and Wright (2017), we show that under these assumptions, the optimal fee schedule is affine, given by

$$T(p_c) = \frac{\lambda d}{1 + \lambda(2 - \sigma)} + \frac{p_c}{1 + \lambda(2 - \sigma)}, \tag{6}$$

which maximizes (5). Note the platform's optimal fee schedule has a fixed per-transaction component only if there is a positive cost to the platform of handling each transaction (i.e., $d > 0$). Given $\lambda > 0$ and $\sigma < 2$, the fee schedule is increasing (higher prices imply higher fees are paid) but with a slope less than unity (this implies (4) has a unique solution for any given $c > 0$). The result in (6) also implies the platform can maximize its profit without knowing the distribution $G$ of goods that are traded on its platform.

# 3 Banning ad valorem fees: analytical results

In this section, we consider whether banning the use of ad valorem fees (i.e., any fees that depend on transaction prices) would harm welfare in an otherwise unregulated environment. Without any restrictions on its pricing, the platform chooses a fee schedule to maximize (5), which results in the affine fee schedule (6). This can be thought as a form of second-degree price discrimination given that sellers are free to set their prices and the fee that applies to them will be determined by the fee schedule. If instead the platform cannot condition on transaction prices in any way, it must choose a single fixed per-transaction fee $T$ across all goods. In this case, it will choose $T$ to maximize

$$\Pi = \sum_{c \in C} g_c (T - d) Q_c(p_c), \tag{7}$$

where from (3) and (4), $Q_c(p_c) = 1 - F\left(\frac{p_c}{c}\right) = 1 - F\left(1 + \frac{T}{c}\right)$. Our problem of interest is thus what happens to total welfare in going from the platform's optimal fee schedule (6), which maximizes (5), to the single fee $\widehat{T}$, which maximizes (7). In other words, is banning ad valorem fees desirable?

We will solve this problem by instead solving a dual problem, which amounts to the welfare effects of banning third-degree price discrimination. We first note that given Bertrand competition between sellers, a seller with cost $c$ facing the fee schedule in (6) will not want to set a price different from (4). (Since the fee schedule has a slope less than one, a lower price will imply a loss). This implies a one-to-one mapping between $c$ and $T(p_c)$, so there is an equivalence between solving for the optimal $T_c$ for each observed good $c$ and solving for the optimal fee schedule (6). Specifically, the solution in (6) is equivalent to the platform charging its profit-maximizing per-transaction fee for each different good $c$, which would be possible if the platform could identify each good $c$ and set its profit-maximizing fee fee for each good accordingly. Thus, the second-degree price discrimination problem faced by the platform can be effectively converted into a third-degree price discrimination problem.

We now explain how the platform's third-degree price discrimination problem can be interpreted as a standard monopoly third-degree price-discrimination problem as studied in the existing literature. Consider a standard monopolist firm that sells in distinct and identifiable markets, each indexed by $c$. It sets $T_c$ for each market $c$ to maximize profit

$$\Pi_c = (T_c - d)\, Q_c(T_c)\,. \tag{8}$$

In our context, $Q_c(T_c)$ can be interpreted as the demand function that the platform faces for its intermediary service, $T_c$ is the relevant price in each market, and $c$ is a parameter which shifts demand across different markets. The expression of $Q_c(T_c) = 1 - F\left(1 + \frac{T_c}{c}\right)$ is given by

$$Q_c(T_c) = \left(1 + \frac{\lambda(\sigma - 1)\, T_c}{c}\right)^{\frac{1}{1-\sigma}}, \tag{9}$$

which also belongs to the generalized Pareto class. The corresponding optimal price is

$$T_c^* = \frac{\lambda d + c}{\lambda(2 - \sigma)}, \tag{10}$$

which is equivalent to the fee implied by the optimal fee schedule (6). We will then consider a ban on third-degree price discrimination across these markets, so the monopolist has to choose a uniform price $T$ across all markets to maximize its profit

$$\sum_{c \in C} g_c (T - d) Q_c(T).$$

Given our demand specification, the resulting $T$ (denoted $\widehat{T}$) is between $T_{c_L}^*$ and $T_{c_H}^*$, the lowest and highest optimal discriminatory prices.[6] We have thus established the following duality result.

**Proposition 1** ***(Duality):*** *The welfare effect of banning a platform from using an ad valorem fee is identical to the welfare effect of banning third-degree price discrimination in the dual problem in which a monopolist can observe the demand of each different market c as given by (9) and charge different (optimal) prices accordingly.*

Given Bertrand competition in each market, this duality result shows that the platform's second-degree price discrimination problem is equivalent to a third-degree one, which allows us to draw on the existing literature on the welfare effects of monopolistic third-degree price discrimination. The results we will obtain on price discrimination across markets then directly apply to the welfare effects of allowing a platform to use ad valorem fees.

In this section, to derive analytical results, we primarily focus on the standard setting in the price discrimination literature in which there are two markets $c_L$ and $c_H$, with $c_H > c_L$, and $g_c = 1$ for each market, corresponding to two different goods that are traded on the platform. Aguirre *et al.* (2010) focus on the case in which the monopolist sells in two distinct markets, and will continue to sell in both markets even with uniform pricing. They provide general conditions to sign the effect on output of price discrimination under non-linear demand. When the curvature of inverse demand function $\sigma$ is common across the two markets, as it is in our case, a sufficient condition for total output to increase is that $\sigma$ is positive and constant for each market. This implies that in our setting with generalized Pareto demand, price discrimination will always expand output (i.e., the number of transactions on the platform) provided $\sigma > 0$ (so demand is more convex than linear demand). However, generally, even if output expands, welfare may be higher or lower depending on the extent of the output expansion relative to the misallocation of consumption under price discrimination.

Define $k \equiv c_H/c_L > 1$ as the measure of dispersion of the two demand levels, where recall in our demand specification, a higher $c$ shifts up inverse demand. We establish a new result on the welfare effects of third-degree price discrimination.

**Proposition 2** ***(Welfare effects with two markets)****: Assume that demand is given by (9) and the monopolist has zero marginal costs (i.e., $d = 0$). If there are two markets with demand characterized by $c_L$ and $c_H$, then banning price discrimination across the two*

[6]Given $\sigma < 2$, it can be shown that $d\Pi_c/dT < 0$ if $T > T_c^*$ and $d\Pi_c/dT > 0$ if $T < T_c^*$, so $\Pi_c$ is single-peaked. In this case, given that $T_c^*$ is increasing in $c$, $\widehat{T}$ would never be below $T_{c_L}^*$ (above $T_{c_H}^*$) since a higher $T$ (lower $T$) can increase profits (see Nahata, Ostaszewski and Sahoo, 1990).

*markets lowers welfare if demand is exponential ($\sigma = 1$) or log-convex ($1 < \sigma < 2$), and will also lower welfare if demand is log-concave ($\sigma < 1$) provided $k \equiv c_H/c_L$ is sufficiently large.*

From the duality result in Proposition 1, Proposition 2 implies that when demand is given by (9), then whenever $\sigma \geq 1$, or $\sigma < 1$ (but with large enough $k$), banning a monopolist platform from using ad valorem fees will lower welfare. The proof of Proposition 2 is lengthy and given in an Online Appendix. Here we provide an intuitive discussion.

Note that with $d = 0$, the monopoly fee charged in market $c$ is $T_c^* = \frac{c}{\lambda(2-\sigma)}$ implying $\frac{T_{c_H}^*}{T_{c_L}^*} = k$. On the other hand, the uniform fee $\widehat{T}$ maximizes

$$T\left[\left(1 + \frac{\lambda(\sigma - 1)T}{c_L}\right)^{\frac{1}{1-\sigma}} + \left(1 + \frac{\lambda(\sigma - 1)T}{c_H}\right)^{\frac{1}{1-\sigma}}\right]. \tag{11}$$

The main idea behind Proposition 2 is that for two markets that are dispersed in demand, price discrimination tends to improve welfare when the ratio $\frac{\widehat{T}}{T_{c_H}^*}$ is sufficiently close to 1 (which means the uniform fee is close to the discriminatory fee in the high-demand market). This implies that the negative welfare effect of price discrimination, which happens because price discrimination leads to a higher fee in the high-demand market, is relatively small, while there is a strong positive output effect from the much lower fee that arises under price discrimination in the low-demand market.

To illustrate this result, we start by noting that when $k = 1$, the ratio $\frac{\widehat{T}}{T_{c_H}^*} = 1$. As $k$ increases above 1, as long as both markets are served, $\frac{\widehat{T}}{T_{c_H}^*}$ decreases in $k$ and reaches a minimum when $\widehat{T} = 2T_{c_L}^*$. Then $\frac{\widehat{T}}{T_{c_H}^*}$ increases in $k$ and converges back to 1 as $k \to \infty$. (For log-concave demands, because there is a choke price, $\frac{\widehat{T}}{T_{c_H}^*}$ jumps to 1 as soon as $k$ exceeds some critical level so that the low-demand market is shut off). These patterns, which can be fully characterized by the first and second-order conditions for maximizing (11), are shown in Figure 1.

For the case in which two markets are not much dispersed in demand (i.e., $k$ is close to 1), we can link to the findings of Proposition 5 in Aguirre *et al.* (2010). Interpreting their Proposition 5 using our specification implies a sufficient condition for welfare to be higher with price discrimination is that $\sigma > 1$ and $\eta_H\left(\widehat{T}\right)\sigma \geq 1$, where $\eta_H\left(\widehat{T}\right)$ is the price elasticity of the high demand measured at the uniform price. Focusing on the case that $\sigma > 1$, the condition $\eta_H\left(\widehat{T}\right)\sigma \geq 1$ holds iff $\frac{\lambda\widehat{T}}{c_H} \geq 1$, or equivalently $\frac{\widehat{T}}{T_{c_H}^*} \geq 2 - \sigma$. Because $\widehat{T} > T_{c_L}^* = \frac{T_{c_H}^*}{k}$, a sufficient condition for $\frac{\widehat{T}}{T_{c_H}^*} \geq 2 - \sigma$ is that $1 < k \leq \frac{1}{2-\sigma}$. This implies that price discrimination always increases welfare regardless of how log-convex demand is

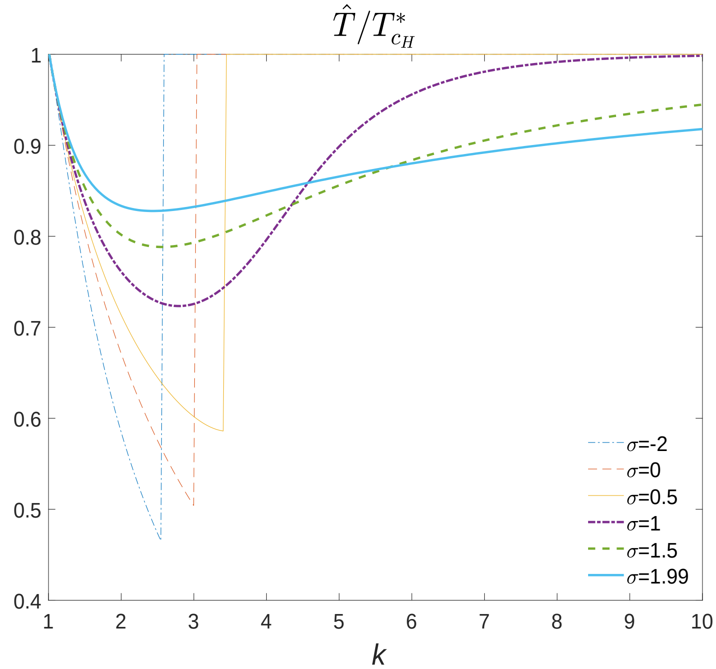


Figure 1: The ratio of uniform to high-demand price

provided the demand is sufficiently close across the two markets (i.e. $1 < k \le \frac{1}{2-\sigma}$).[7]

In Proposition 2 we extend the sufficient condition for price discrimination to be welfare improving from Aguirre et al. (2010) to the full range of $k > 1$, including cases where demands in the two markets are moderately dispersed. To provide further insight, recall as $k$ becomes large enough, the fee ratio $\frac{\widehat{T}}{T^*_{c_H}}$ converges (or jumps) to 1 regardless of $\sigma$. This property implies that when $\sigma < 1$, so demand is log-concave, the monopolist will not serve the low-demand market under uniform pricing, so price discrimination always increases welfare by opening up sales for the low-demand market without any misallocation effect. When demand is exponential or log-convex the effect is similar even though it does not rely on the low-demand market not being served. Because the fee ratio $\frac{\widehat{T}}{T^*_{c_H}}$ is very close to 1 when $k$ is large, there is little misallocation effect of price discrimination, while there is a strong positive output effect through the low-demand market.

Moreover, note from Figure 1 that when $k$ is in the intermediate range, the fee ratio $\frac{\widehat{T}}{T^*_{c_H}}$ still depends on $\sigma$, with a higher $\sigma$ implying the fee ratio is closer to 1, which implies the negative misallocation effect of price discrimination is more likely being dominated by the positive output effect. In fact, for $\sigma \ge 1$, the output effect always dominates so the welfare

[7]Similarly, applying Proposition 5 of Aguirre *et al.* (2010) to our setting implies that for $\sigma < 1$, price discrimination lowers welfare (when both markets are served under uniform pricing) regardless of how log-concave demand is provided demand is sufficiently close across the two markets (i.e., $1 < k \le 2 - \sigma$).

effect is positive.[8]

In the Online Appendix, we extend these results in two different dimensions. First, we consider what happens in case $d > 0$, so the platform faces some positive (albeit small) marginal cost. The results presented in the Online Appendix suggest price discrimination still increases welfare whenever $\sigma \geq 1$ and/or $k$ is sufficiently large, and as we show there, the underlying logic based on the fee ratio $\frac{\widehat{T}}{T^*_{c_H}}$ being close enough to 1 in these cases still hold.

Second, we consider what happens when there is a continuum of markets with $c$ drawn from the uniform distribution on $[c_L, c_H]$ so that the platform's profit becomes

$$\left(\frac{1}{c_H - c_L}\right) \int_{c_L}^{c_H} [(T_c - d)Q_c(T_c)]dc,$$

where $c_L > 0$, $c_H = kc_L$, with $k \equiv c_H/c_L$ and $k > 1$. We establish that welfare is always higher under price discrimination whenever demand is log-concave provided there is enough dispersion in $c$ when $d = 0$. In particular, we show there is a cutoff level of $c$ equal to $xc_L$ (where $1 < x < k$) such that all markets below the cutoff will be shut down by the monopolist, provided that the dispersion in $c$ is large enough (i.e., $k > k_0$). We show that the threshold $k_0$ depends only on $\sigma$, and the cutoff value $x$ is a constant fraction of $k$ provided $k > k_0$. Thus, we generalize the result of Malueg and Schwartz (1994), who did a similar exercise with linear demand. Finally, we provide numerical results for the case with exponential or log-convex demand, which suggest similar to our case with two markets, welfare is always higher under price discrimination regardless of the level of $k$ and $d$.

# 4 Banning ad valorem fees: calibrated model

In practice, platforms deal with thousands of different goods rather than just two, and moreover, $c$ will not be uniformly distributed across these goods. For example, there are typically many more transactions using Visa debit cards in the \$10-\$50 range than the \$60-\$100 range. The same is true for goods traded on Amazon's marketplace, where the sales distribution is highly skewed. The welfare effects of price discrimination in such settings are largely unexplored in the literature. In this section, we wish to work out the welfare effects of banning ad valorem fees (i.e., banning price discrimination in the equivalent setting where different $c$ captures distinct markets with observably different demand) using realistic sales distributions. The data we use are from Visa signature debit card transactions and DVD

[8] On the other hand, Aguirre *et al.* (2010) show that for $\sigma \leqslant 0$, the output effect is never positive when both markets are served, so the welfare effect must be negative.

listings on Amazon's marketplace. In both cases, the platforms have adopted affine fee schedules charged to sellers, as shown in Table 1.

## 4.1 Methodology

First, we illustrate how our theoretical model can be calibrated to real world data.[9] Rather than assume there is a unit mass of buyers for each good, we allow for the possibility that for each good there can be a different number of potential buyers so that even goods with the same $c$ can sell different amounts.

The number of transactions for a distinct good $i$ with cost $c$ is $Q_{i,c} = n_{i,c}Q_c$ and the platform makes a profit $\Pi_{i,c} = n_{i,c}\Pi_c$, where $Q_c$ and $\Pi_c$ are the quantity and profit expressions from Section 2 based on a unit mass of potential buyers, and $n_{i,c}$ is the number of potential buyers for good $i$ with cost $c$. We denote the number of distinct goods with cost $c$ as $n_c$. A platform's total profit is therefore

$$\Pi = \sum_{c \in C} \sum_{i=1}^{n_c} n_{i,c}\Pi_c. \tag{12}$$

Given (12), all our previous analysis holds except that we need to change the mass $g_c$ to $\sum_{i=1}^{n_c} n_{i,c}$. This follows because, as shown in Wang and Wright (2017), the optimal platform fee does not depend on $g_c$. Accordingly, an affine fee schedule (such as those in Table 1) can be rationalized by the platform facing generalized Pareto demands, and the profit maximizing platform fee is still given by (6).

Given an observed platform fee schedule $T(p_c) = a_0 + a_1 p_c$, (6) implies that we can uniquely identify the values of $\lambda$ and $d$ for a given value of $\sigma$. Our welfare comparisons will then consider all the possible values of $\sigma$.[10] Note that

$$\frac{\lambda d}{1 + \lambda(2 - \sigma)} = a_0, \quad \frac{1}{1 + \lambda(2 - \sigma)} = a_1,$$

so $\lambda = (1/a_1 - 1)/(2 - \sigma)$ and $d = a_0/\lambda + a_0(2 - \sigma)$. Given the value of $\lambda$, and the observed price $p_c$ and quantity $Q_{i,c}$ for each good traded on the platform, we can then identify the

[9] In our calibration exercises we observe just one fee schedule. Assuming no randomness on the demand side, each parameter of our model (as well as the distribution of goods) is exactly identified.

[10] Alternatively, we could pin down $d$ and $\sigma$ for a given value of $\lambda$, and then conduct welfare comparisons based on different values of $\lambda$. However, given that $\sigma$ determines the shape of demand functions, deriving welfare results based on different values of $\sigma$ is more informative. It allows us to compare our results with those in the literature that typically assume specific demand functions (e.g., linear demand).

number of potential buyers $n_{i,c}$ for each good. Substituting $T(p_c) = a_0 + a_1 p_c$ into

$$Q_{i,c} = n_{i,c} \left(1 + \frac{\lambda(\sigma - 1) T_c}{c}\right)^{\frac{1}{1-\sigma}},$$

we derive

$$n_{i,c} = \frac{Q_{i,c}}{\left[1 + \frac{\lambda(\sigma-1)(a_0+a_1 p_c)}{(1-a_1)p_c - a_0}\right]^{\frac{1}{1-\sigma}}}. \tag{13}$$

With $n_{i,c}$ determined, we can use the weight $\sum_{i=1}^{n_c} n_{i,c}$ in place of $g_c$ when calculating profit and welfare. Our theory also allows us to identify the lower bound of $\sigma$ from the data. Recall when $\sigma < 1$, the generalized Pareto demand has finite support on $[1, 1 + \frac{1}{\lambda(1-\sigma)}]$. This means that if we observe any good with positive sales, its price has to satisfy $\frac{p(c)}{c} < 1 + \frac{1}{\lambda(1-\sigma)}$. Since $p(c) = c + T^*(p_c)$, this requires that $\frac{T^*(p_c)}{c} < \frac{1}{\lambda(1-\sigma)}$. Substituting in that $T^*(p_c) = a_0 + a_1 p_c$, $c = (1 - a_1)p_c - a_0$ and the expression for $\lambda$ from above, the equivalent inequality can be written as $\sigma > 1 + a_1 - \frac{a_1(1-a_1)p_c}{a_0}$. Thus, the minimum price we observe in the data pins down the minimum value of $\sigma$ that our model permits.

## 4.2 Visa debit cards

We use data from the Diary of Consumer Payment Choice (DCPC), conducted in October 2012 by the Boston, Richmond, and San Francisco Federal Reserve Banks to calibrate the model. The DCPC collects consumer payments data on the dollar value of purchases, the payment instrument used, and the category of expense. A national representative sample of 2,468 U.S. respondents were selected, who each recorded all their payments over a three-day period. Since respondents were spread over the entire month of October 2012, this sampling methodology provides reasonable probability estimates of all consumers. For transactions made with payment cards, respondents were asked to report the dollar amount, the exact card type and the card network's brand name.

Based on the DCPC data, we identify 1,048 Visa signature debit card transactions in four distinct market categories, namely retail, restaurant, gas station, and small ticket, to form our empirical transaction distributions. For each market category, we use the interchange fee schedule published by Visa (shown in Table 1) to infer its platform pricing. Given merchant acquirers are highly competitive in the U.S. market, the interchange fee schedules posted by Visa mirror very closely the actual fee schedules passed onto sellers.

Figure 2 plots the raw density distribution of transaction prices in each market category. The distributions are quite skewed. Based on the raw transaction distributions and the fee schedules, we then numerically calculate percentage welfare gains under the observed affine fee schedule compared with the counterfactual optimal uniform per-transaction fee for each possible value of $\sigma$ assuming the underlying demand takes the generalized Pareto form. The results are presented in Figure 3.

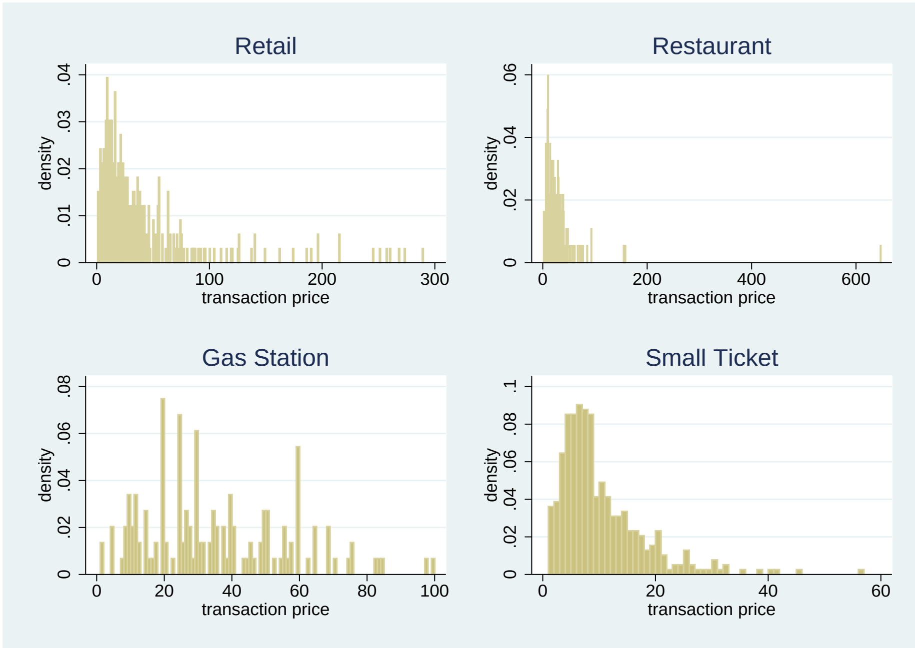


Figure 2: Visa Signature Debit Card Transaction Distributions

Figure 3 shows that in three out of the four markets, welfare is consistently higher when ad valorem fees are allowed for any possible value of $\sigma$.[11] The only exception is for the Restaurant market for lower values of $\sigma$. However, this result is driven by a single outlier which has an unusually large transaction price, as can be seen from Figure 2. If that outlier is removed from the sample, welfare would also be consistently higher in the Restaurant market when ad valorem fees are allowed.

Note that the percentage welfare gain (or loss) from allowing ad valorem fees is calculated by assuming that the platform only incurs a marginal cost $d$. Obviously, the percentage change in welfare would be even higher if a positive level of fixed cost is taken into account. Moreover, the absolute level of welfare change is likely to be substantial given the size of the payment card industry. In 2011, debit cards were used in 49 billion transactions for a total value of \$1.8 trillion in the U.S. market, in which 60 percent were signature debit card

[11]Note that the implied value of $d$ from our calibrated model varies from zero in the limit as $\sigma$ tends to its highest allowed value (i.e., 2) up to 16 cents as $\sigma$ tends to its lowest allowed value as determined by the lowest observed price. This is consistent with the Federal Reserve's study based on comprehensive cost surveys of debit card issuers, as mandated by the Durbin Amendment to the Dodd-Frank Act. According to the study, most issuers incur a marginal cost no more than 21 cents per transaction (See Federal Reserve Board, 2011).

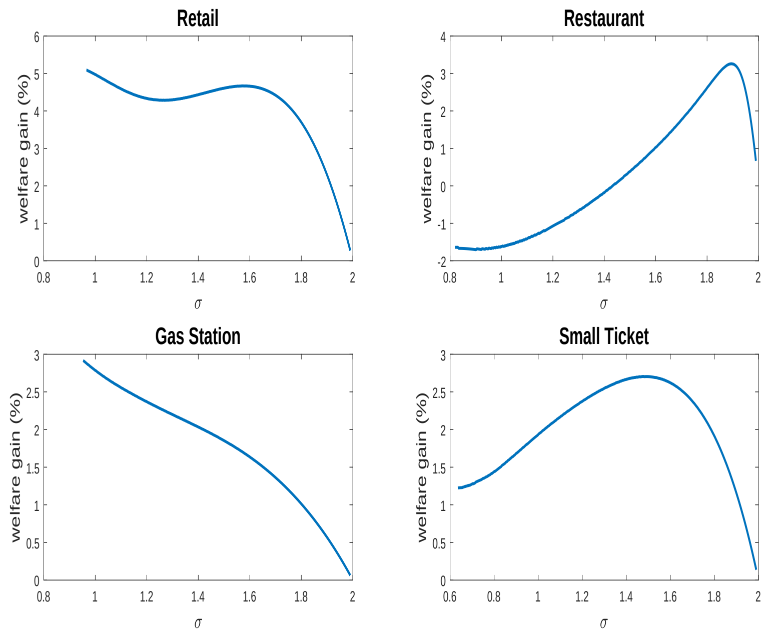


Figure 3: Visa Signature Debit Cards: Welfare Gain from Ad valorem Fees

transactions, with Visa's share of these being about 75 percent.

In the Online Appendix, we decompose the change in welfare from allowing ad valorem fees into changes in platform profit and consumer surplus. The findings show that the platform's profit gain from using ad valorem fees is always positive but decreases in $\sigma$. In contrast, the gain of consumer surplus increases in $\sigma$ and it tends to be negative when $\sigma$ is low but turns positive when $\sigma$ is high. For a low value of $\sigma$, the positive profit gain dominates the negative change of consumer surplus, so the total welfare gain tends to be positive; while for a high value of $\sigma$, the positive change of consumer surplus reinforces the welfare gain from higher profits. These findings suggest that while policymakers should be cautious about banning ad-valorem fees for efficiency reasons, the grounds for considering such a ban are stronger if consumer surplus is the main criterion.

## 4.3 Amazon marketplace

We also calibrate our model using data from Amazon's marketplace. We focus on DVDs given that it is a well defined market category for which we can be sure all the goods identified are subject to the same fee schedule, and also since we can collect consistent sales ranks for this category. Using a web robot, we collected data on every DVD that was listed under "Movies & TV" on Amazon's marketplace in January 2014. We selected "New" under "Condition" and de-selected the "Out of Stock" option, and ended up with a total of 295,171 distinct items. The data collected include the title, unique ASIN number identifying the DVD, the price, and sales rank of each DVD.[12] Given shipping fees are often not included in the listed price, we also separately collected data on only those items where the listed price included free shipping, resulting in a sample with 191,280 distinct items. Since some DVDs are listed with extreme prices, we restrict our sample to DVDs selling for under \$1,000, which includes around 99% of the items collected. For robustness, we also tried alternative price limits, including \$500 and \$2,000, and the results are very similar.[13]

Given we do not directly observe the sales of each DVD, we use a power law to infer it from the sales rank, so $Q_{i,c} = aR_{i,c}^{-\phi}$, where $Q_{i,c}$ is the estimated sales of an item and $R_{i,c}$ is the corresponding sales rank.[14] The parameter $a$ does not affect our results, so we normalize it by setting $a = 1$. We try different values for the parameter $\phi$, including $\phi = 0$ (where sales rank is assumed to be irrelevant), $\phi = 1$ (Zipf's law) and $\phi = 1.7$ (which is the number suggested by Smith and Telang (2009) in an experimental study on DVD sales on Amazon, although it implies very little weight is placed on items with sales ranks below the top ten).

Figure 4 plots the density of items listed at each price which corresponds to the sales distribution under the assumption that $\phi = 0$. The distributions are highly skewed with a majority of items listed at prices below \$50. With $\phi = 1$ or $\phi = 1.7$, the distributions become even more skewed.

Based on each of the sales distributions and the fee schedule from Table 1, we numerically calculate percentage welfare gains under the observed affine fee schedule compared with the counterfactual optimal uniform per-transaction fee for each possible value of $\sigma$ assuming the underlying demand takes the generalized Pareto form. The results are presented in Figure 5, which shows that once sales ranks are taken into account, welfare is consistently higher under an affine fee schedule than under a uniform per-transaction fee.[15]

[12] The price is taken as the price posted at Amazon's marketplace for the DVD. It is the price a buyer will face when they add the item to their cart and go to the checkout – i.e., the "buy-box" price.

[13] A concern with extreme DVD prices is that the prices listed are unlikely to reflect the prices at which transactions actually take place. For instance, some sellers post extreme prices as placeholders to avoid a temporary delisting when they are out of stock or away for vacation. Others may be errors in the seller's entry of its prices.

[14] Power law distributions are widely used to describe rank data, with the well-known "Zipf's law" being a special case. See Chevalier and Goolsbee (2003) for detailed discussions as well as an application to online sales data.

[15] In the Amazon case, the implied value of $d$ from our calibrated model varies from zero up to \$1.65 as $\sigma$ varies from its highest possible value to its lowest. We again decompose the welfare change into changes in profit and consumer surplus in the Online Appendix, with the pattern of results being very similar to those found for Visa debit cards.

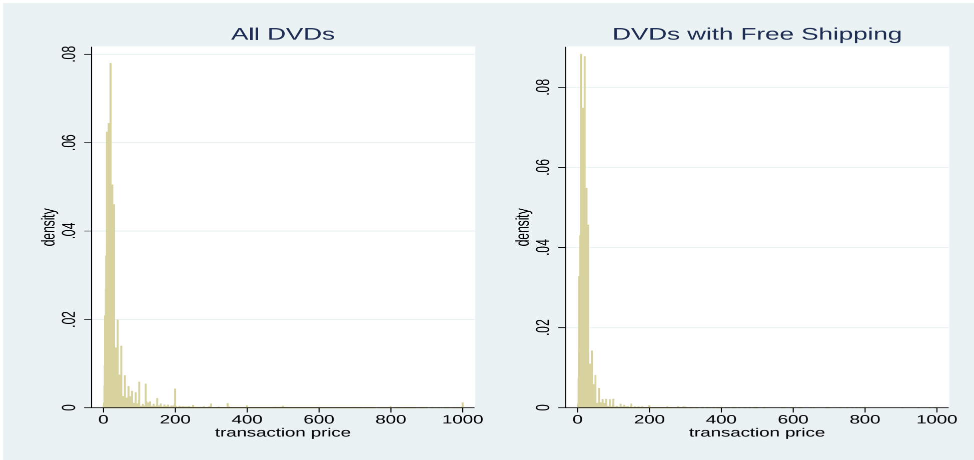


Figure 4: DVD Sales Distribution

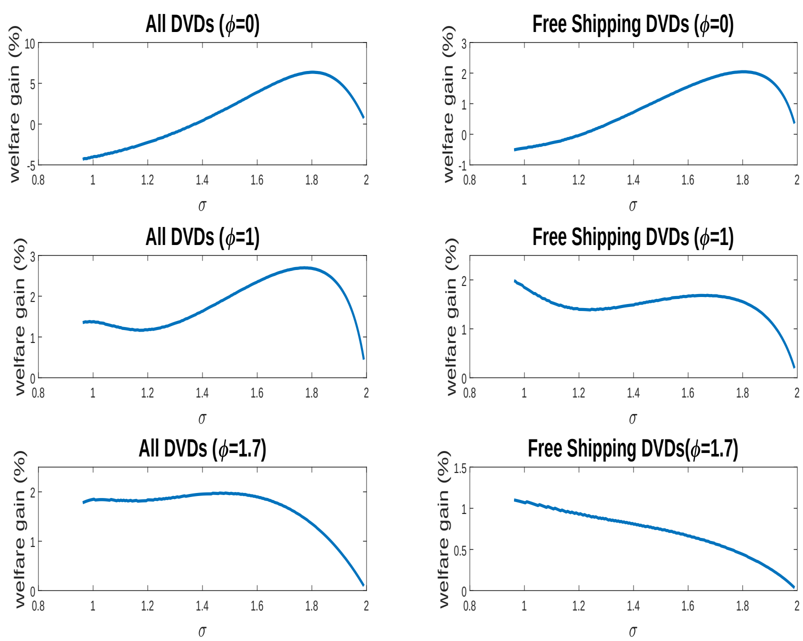


Figure 5: DVDs: Welfare Gain from Ad valorem Fees

# 5 Concluding remarks

Many platforms that facilitate transactions between buyers and sellers charge ad valorem fees in which fees depend on the transaction price set by sellers. Given these platforms do not incur significant costs that vary with transaction prices, their use of ad valorem fees has raised controversies about the efficiency of this practice. For policymakers who would want to align platform fees with costs but are concerned about directly regulating fee levels, it seems natural to consider regulating fee structures, such as banning platforms from using ad valorem fees. However, we have shown that such regulation tends to have negative welfare outcomes, including when we calibrate our model to data on sales of DVDs on Amazon's marketplace and data for Visa signature debit card transactions. Therefore, caution should be taken when policymakers consider this option. A similar result would also apply to a government that wanted to maximize tax revenue—welfare would be higher when it does so using an ad valorem tax. The key feature that drives these results is that when a market involves many different goods that vary widely in their costs and values, ad valorem fees and taxes represent an efficient form of price discrimination. In comparison, uniform fees or taxes could adversely affect low-cost low-value goods so that the total welfare is reduced.

There are several avenues for future research. In reality, there could be some substitution on the demand side across the different goods within the same market category (e.g. DVDs), whereas for tractability we treated goods of different scale within a market category to be independent. It would be interesting to study how such substitution changes the merits of ad valorem fees. In a platform context, it would also be interesting to explore whether allowing for cross-group network effects changes the case for ad valorem fees. Finally, it would be interesting to try to redo our analysis in a setting with imperfect competition between sellers, which would potentially provide another reason to prefer ad valorem fees, so as to help to mitigate double marginalization.

# References


Aguirre, Iñaki (2006) "Monopolistic Price Discrimination and Output Effect under Conditions of Constant Elasticity Demand." *Economics Bulletin*, 4(23), 1–6.

Aguirre, Iñaki (2008) "Output and Misallocation Effects in Monopolistic Third-Degree Price Discrimination." *Economics Bulletin*, 4(11), 1–11.

Aguirre, Iñaki, Simon Cowan and John Vickers (2010) "Monopoly Price Discrimination and Demand Curvature." *American Economic Review*, 100, 1601–1615.

Brennan, G., and J. M. Buchanan (1977) "Towards a Tax Constitution for Leviathan." *Journal of Public Economics*, 8(3), 255–273.

Brennan, G., and J. M. Buchanan (1978) "Tax Instruments as Constraints on the Disposition of Public Revenues." *Journal of Public Economics*, 9(3), 301–318.

Bulow, Jeremy and Paul Pfleiderer (1983) "A Note on the Effect of Cost Changes on Prices." *Journal of Political Economy*, 91, 182–185.

Bulow, Jeremy and Paul Klemperer (2012) "Regulated Prices, Rent Seeking, and Consumer Surplus." *Journal of Political Economy*, 120, 160–186.

Chen, Yongmin and Marius Schwartz (2015) "Differential Pricing When Costs Differ: A Welfare Analysis." *RAND Journal of Economics*, 46(2), 442–460.

Chevalier, Judith and Austan Goolsbee (2003) "Measuring Prices and Price Competition Online: Amazon.Com and Barnesandnoble.Com." *Quantitative Marketing and Economics*, 1(2), 203–222.

Cowan, Simon (2007) "The Welfare Effects of Third-Degree Price Discrimination with Nonlinear Demand Functions." *RAND Journal of Economics*, 38(2), 419–28.

Cowan, Simon (2016) "Welfare-Increasing Third-Degree Price Discrimination," *RAND Journal of Economics*, 47(2), 326–340.

Einav, Liran, Theresa Kuchler, Jonathan Levin, and Neel Sundaresan (2015) "Assessing Sale Strategies in Online Markets using Matched Listings." *American Economic Journal: Microeconomics*, 7, 215-247.

Federal Reserve Board (2011) *Regulation II (Debit Card Interchange Fees and Routing) Final Rule,* June 29, www.federalreserve.gov/newsevents/press/bcreg/20110629a.htm.

Foros, Øystein, Hans Jarle Kind and Greg Shaffer (2014) "Turning the Page on Business Formats for Digital Platforms: Does Apple's Agency Model Soften Competition?" Working Paper.

Gaudin, Germain and Alexander White (2014a) "On the Antitrust Economics of the Electronic Books Industry." Working Paper.

Gaudin, Germain and Alexander White (2014b) "Unit vs. Ad valorem Taxes under Revenue Maximization." Working Paper.

Johnson, Justin (2017) "The Agency Model and MFN Clauses." *Review of Economic Studies*, 84(3), 1151–1185.

Layson, Stephen (1994) "Market Opening under Third-Degree Price Discrimination." *Journal of Industrial Economics*, 42(3), 335–40.

Malueg, David and Marius Schwartz (1994) "Parallel Imports, Demand Dispersion, and International Price Discrimination." *Journal of International Economics*, 37, 167–195.

Nahata, Babu, Krzysztof Ostaszewski, and Prasanna K. Sahoo (1990) "Direction of Price Changes in Third-Degree Price Discrimination." *American Economic Review*, 80(5), 1254–58.

Schmalensee, Richard (1981) "Output and Welfare Implications of Monopolistic Third-Degree Price Discrimination." *American Economic Review*, 71(1), 242–47.

Schwartz, Marius (1990) "Third-Degree Price Discrimination and Output: Generalizing a Welfare Result." *American Economic Review*, 80(5), 1259–62.

Shy, Oz and Zhu Wang (2011) "Why Do Payment Card Networks Charge Proportional Fees?" *American Economic Review*, 101, 1575–1590.

Smith, Michael and Rahul Telang (2009) "Competing with Free: The Impact of Movie Broadcasts on DVD Sales and Internet Piracy." *MIS Quarterly*, 33, 321–338.

Standing Senate Committee on Banking, Trade, and Commerce. *Transparency, Balance and Choice: Canada's Credit Card and Debit Card Systems*, Canada, 2009.

Summers, Bruce (2012) "Facilitating Consumer Payment Innovation through Changes in Clearing and Settlement." *Consumer Payment Innovation in the Connected Age*, Conference Proceedings, Federal Reserve Bank of Kansas City.

Varian, Hal (1985) "Price Discrimination and Social Welfare." *American Economic Review*, 75(4), 870–75.

Wang, Zhu and Alexander Wolman (2016) "Payment Choice and Currency Use: Insights from Two Billion Retail Transactions." *Journal of Monetary Economics*, 84, 94–115.

Wang, Zhu and Julian Wright (2017) "Ad Valorem Platform Fees, Indirect Taxes, and Efficient Price Discrimination." *RAND Journal of Economics*, 48(2), 467–484.

Weyl, Glen and Michal Fabinger (2013) "Pass-through as An Economic Tool: Principle of Incidence under Imperfect Competition." *Journal of Political Economy*, 121, 528–583.