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# THE AGENCY AND WHOLESALE MODELS WHEN A PLATFORM CAN CHARGE ENTRY FEES


## Abstract

We study the agency and wholesale models of intermediation in a bilateral monopoly where a platform can charge sellers an entry fee. With full-profit-extracting entry fees, the agency model eliminates double marginalization and yields lower prices and higher platform profits than the wholesale model, while the seller earns zero profit under both models. With partial rent extraction, the agency model yields lower prices than the wholesale model when demand satisfies Marshall's Second Law, or when the platform can extract a sufficiently large share of the seller's profit, regardless of demand. To disentangle the mechanisms at play in this comparison, we also study the agency model with per-unit commissions. We show that shifting price-setting power from the platform to the seller lowers prices, while changing the commission instrument from per-unit to ad valorem usually further reduces prices. Finally, when the platform is uncertain about the seller's dead-weight loss from paying the entry fee, entry may fail. We characterize when the platform optimally sets a zero entry fee, extend the price comparison, and provide conditions under which the agency model delivers both lower prices and higher entry than the wholesale model. We also show that per-unit commissions never dominate ad valorem commissions simultaneously in terms of price and entry, whereas the reverse can occur.



JEL Classification: D21, L42, L86

Keywords: N/A



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# The Agency and Wholesale Models When a Platform Can Charge Entry Fees*

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**Abstract**

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# 1 Introduction

Entry fees are common in many industries where platforms act as intermediaries for consumers. These fees serve different purposes and can take different forms, depending on the industry and the business model. For example, Amazon charges professional sellers a monthly fee of $39.99 for placing their products on the platform, along with a commission that varies by product category and ranges from 6% to 45% of the total transaction value, including shipping costs. Another example is Etsy, which charges a fee per product listing, regardless of whether the product ends up being sold.[1] The magnitude of entry fees varies significantly across platforms. Some platforms impose substantial entry fees on sellers; for example, Alibaba charges up to $1,833 per month to maintain an online store. In contrast, other platforms, such as Facebook Marketplace, do not charge any entry fee at all. Entry fees are also common in traditional retail. For example, supermarket chains impose various fees on manufacturers, such as slotting fees and pay-to-stay fees, to be paid upfront for access to their shelf space. A survey conducted by the Federal Trade Commission (FTC, 2003) reports that retailers impose slotting allowances for 50% to 90% of new grocery product introductions (see also Klein and Wright, 2007; Bonnet et al., 2013; Bonnet and Dubois, 2015). While these fees vary from country to country, they represent a significant portion of the retailers' profits (see, for instance, Hristakeva, 2022), leading some experts to argue that "[s]upermarkets today are as much about selling shelves to food companies as they are about selling food to customers"(Rivlin, 2016).

In this paper, we study and compare two intermediation models widely used in online markets, namely the agency and the wholesale models, in terms of final consumer prices, entry probability and agents' profits. In the wholesale model, the platform first sets the entry fee, after which the seller decides whether to enter and then sets its wholesale price. Finally, the platform acts as the retailer and sets the final consumer price. The wholesale model has been Amazon's core business model for many years and continues to be so for many product categories. Other examples of platforms using the wholesale model include traditional retail chains such as Walmart for groceries and Barnes and Noble for books. In the agency model, the platform first sets an entry fee and an *ad valorem* commission rate; the seller decides to enter, and then sets the final consumer price. Many platforms, including Booking, Uber and the Apple App Store, or marketplaces such as AbeBooks in the book market employ the agency model. A key challenge in comparing these two canonical models is that they differ along two dimensions: the *timing* of price-setting (who chooses the final consumer price) and the *commission instrument* (a per-unit

[1] Similarly, app stores charge developers a fee to list their mobile applications, and commissions on app and in-app purchases. LinkedIn charges recruiters $1,680 annually for its 'Recruiter Lite' service. Doctolib, an intermediary connecting patients and doctors in France, charges general practitioners a monthly fee between €135 and €274, plus a 1% commission on teleconsultations. OpenTable charges restaurants a monthly fee ranging from $149 to $499 depending on the contract, plus a 2% commission. Artsy, an online marketplace, charges galleries a monthly fee of $425 and a 10% commission.

wedge under wholesale versus an ad valorem rate under agency). To disentangle these forces, we also analyze an agency model with *per-unit* commissions, which preserves the agency timing but replaces the ad valorem commission with a fixed fee per transaction, thereby isolating what is specific to price-setting power from ad valorem commissions. In practice, an increasing number of platforms use a mix of models (for instance, Amazon), which makes it important to understand how they compare.

Using a bilateral monopoly setting where the seller must commercialize its product using the intermediation services of a platform, we compare the wholesale and agency models (and, within the agency model, both ad valorem and per-unit commissions) in three distinct settings. As a benchmark, we first consider the case where the platform can charge full-profit-extracting entry fees. In such a case, we show that the agency model results in a final consumer price equal to the price that maximizes industry profit, thereby eliminating the double-marginalization problem altogether. Importantly, this benchmark is not driven by the ad valorem nature of commissions: the same industry-profit-maximizing price is implemented under per-unit commissions as well, because the platform can choose the commission to induce the desired seller price and then use the entry fee to extract the whole industry profit. The wholesale model, by contrast, fails to eliminate double marginalization and hence results in prices that are excessive from the viewpoint of industry profit maximization. With full-profit-extracting entry fees, the seller makes no profit in either intermediation model. As a result, both the platform and the consumers prefer the agency model to the wholesale model, irrespective of the commission instrument and the shape of demand, while the seller is indifferent. This result is in stark contrast with Johnson (2017), who compares the two intermediation models in a bilateral monopoly setting without entry fees.

After studying the performance of the two intermediation models when the platform can charge full-profit-extracting entry fees, in line with Calzolari et al. (2020), we turn to a more realistic setting in which the seller can afford to pay only a part of its profit to enter. This may occur because the entry payment generates dead-weight losses for the seller, for instance due to financial costs associated with paying the entry fee upfront. This variant of the model collapses to that in Johnson (2017) in the limit case where the seller's willingness to pay for entry is zero. We show that, no matter the demand function, the agency model leads to lower prices provided that the platform extracts a sufficiently large fraction of the seller's profit. In the special case where demand satisfies Marshall's Second Law (i.e., elasticity increasing in price; henceforth, Marshall demands), the agency model leads to lower prices irrespective of how much surplus it can extract from the seller (including nothing at all, like in Johnson, 2017).[2] The platform prefers the agency model and so do consumers. However, the seller gets higher gross profit under the wholesale model when the amount of rents extracted by the platform via entry

[2]This implies that one can dispense with assumptions on demand stronger than just Marshall's Second Law of demand (in contrast to Johnson, 2017; Proposition 3). The reason for this is that our proof is somewhat different and this allows us to derive a weaker sufficient condition.

fees is sufficiently low.

To explain what drives the price decrease when moving from wholesale to agency under Marshall demands, we decompose the change into two effects. First, we hold the commission instrument fixed (per-unit commissions) and shift final price-setting power from the platform to the seller by comparing the wholesale model to the agency model with per-unit commissions. We show that the resulting price in the agency model with per-unit commissions is below the price in the wholesale model regardless of the extent to which the platform can extract the seller's rents, thereby accounting for a first part of the price reduction that occurs when moving from wholesale to agency. Next, we hold the agency timing fixed and change the commission scheme from per-unit to ad valorem. We show that ad valorem commissions typically further reduce the price relative to per-unit commissions, although this ranking can reverse when the platform can extract a sufficiently large share of the seller rents and upstream costs are low. A similar pattern often arises under non-Marshall demands: shifting price-setting power reduces prices, while changing the commission instrument increases them.

We finally turn to an extension of the model where the platform is uncertain about the seller's willingness to pay for entry because it does not observe the dead-weight loss the seller incurs when paying the entry fee. While in the case without uncertainty the platform always chooses its entry fee so as to leave the seller indifferent between entering and not entering, in this setting the platform picks its entry fee so as to resolve the following trade-off: a higher entry fee increases the probability that the seller refuses to enter, while it increases the platform's payoff in case of entry. *A priori*, thus, it is not clear that a platform will employ entry fees at all. A key implication is that rent extraction via entry fees may become interior, and hence the equilibrium entry probability need not be equal to one. We show that the platform's choice of entry fee can conveniently be reformulated as a choice of the fraction of the seller's profit it wants to extract, and we carry out this analysis under wholesale, agency with ad valorem commissions, and agency with per-unit commissions.

For each of the intermediation models, we establish a condition under which this trade-off makes it optimal for the platform to charge no entry fee. This condition is quite intuitive and implies that the platform will refrain from using entry fees when the probability mass at zero willingness to pay for entry (or equivalently, at very high dead-weight losses) is sufficiently large. In that case, charging an entry fee would deter entry too often, so the platform optimally sets a zero entry fee and relies solely on variable revenue instruments (wholesale price or commissions). This result then adds to the literature by providing a possible rationale for why some platforms, irrespective of the intermediation model they use, charge entry fees while others do not, or why some platforms use entry fees for some, but not all, product categories.

Uncertainty about the seller's dead-weight loss need not overturn the price comparison between wholesale and the agency model with ad valorem commissions. When entry fees are strictly positive in both models, the final price under ad valorem commissions continues to be lower than under the wholesale model for all demands that satisfy Marshall's Second Law. Moreover, the same price ranking extends to demands that do not satisfy Marshall's Second Law whenever the distribution of dead-weight losses places sufficient weight on low values, so that the platform optimally chooses a sufficiently high entry fee under ad valorem commissions.

To rank consumer surplus levels across intermediation models, it is no longer sufficient to compare final consumer prices because the seller's entry probability is also relevant. Motivated by this observation, we provide conditions under which the agency model with ad valorem commissions dominates the wholesale model on *two* accounts: it yields both a lower final price and a higher entry probability. In particular, under Marshall demands, if the platform's margin is sufficiently large, the seller enters with higher probability under the agency model with ad valorem commissions than under the wholesale model; combined with the lower final consumer price, this implies higher consumer surplus and higher total welfare under agency.

Finally, we also compare the two agency models and show that the agency model with per-unit commissions never dominates the agency model with ad valorem commissions simultaneously in terms of final prices and entry probability. By contrast, there are settings for which ad valorem commissions induce both a lower price and a higher entry probability than per-unit commissions.

**Related literature**

We contribute to the literature that compares the wholesale and agency models. This literature, to the best of our knowledge, has so far not allowed for entry fees. Johnson (2017) compares these two intermediation models in a bilateral monopoly setting. As is known from the taxation literature, he reports that the retail price is lower in the agency model than in the wholesale model if Marshall's Second Law of demand holds (Bishop, 1968); consequently, consumer surplus and total welfare are higher under agency. Gaudin and White (2014a) report a similar result. Because the agency model with per-unit commissions is similar to the wholesale model, Gaudin and White (2014b), Gaudin and White (2021) and Llobet and Padilla (2016) contain distinct versions of this result.[3] De Los Santos et al. (2024) show that this price ranking may be reversed if the platform and the seller are allowed to bargain over the terms of trade and the bargaining power of the platform is sufficiently large.

[3]This result has been generalized in various competitive settings. In Section 2 of Johnson (2017), the author extends the result to a setting in which there is imperfect competition at both layers of the supply chain using a conduct-parameter approach. Gu and Huang (2024) generalize this result to a setting in which there is a platform and a set of sellers selling homogeneous products and competing in quantities. They also have a section with two competing platforms in which sellers multi-home; however, they assume that sellers' quantities on different platforms are independent of each other. Johnson (2020) studies the agency and wholesale intermediation models in a model where two retail platforms compete over two periods in the presence of consumer lock-in. He shows that, relative to the wholesale model, the agency model can lead to higher prices in the first period but lower prices in the second period. See also Hu et al. (2022) who consider the impact of competition between producers and cross-brand pass-through.

Our paper generalizes these results to settings where platforms can charge sellers for entry. Specifically, we allow for full-profit-extracting and partial-profit-extracting entry fees.[4] Our contribution is to show that the final consumer price under the agency model is always lower than under the wholesale model provided that the platform can extract sufficient surplus from the seller via entry fees. We also show that when the platform can charge full-profit-extracting entry fees, the agency model is efficient, while the wholesale model is not. We extend our results to a setting with uncertainty about the seller's willingness to pay and characterize when the platform optimally chooses to charge a positive entry fee. When entry is uncertain, comparing prices is no longer sufficient to rank the two intermediation models in terms of consumer surplus; the seller's probability of entry must also be taken into account. We show that the agency model can dominate on both dimensions, whereas the wholesale model cannot.

Johnson (2017) also shows conditions on demand under which a shift from the wholesale model to the agency model may result in a conflict of interest, with the platform benefiting at the expense of the seller. We show that the platform prefers the agency model under weaker conditions than those in Johnson (2017), even if entry fees are not charged, and establish that a conflict of interest arises when rent-extraction via entry fees is not too large.

Hagiu and Wright (2015) study the choice of a monopoly intermediary to adopt the agency model or the wholesale model. They show that this choice depends on whether the intermediary or the sellers have better information to conduct marketing activities. Loertscher and Niedermayer (2020) show that a monopoly intermediary may adopt the agency model to prevent the emergence of a competing platform. Foros et al. (2017) study the endogenous choice of the wholesale or agency model under platform competition. They show that agency is never adopted in equilibrium when it is pro-competitive. In contrast, Abhishek et al. (2016) show that competing platforms adopt the agency model when their online channel diverts sales from their traditional (brick-and-mortar) channels. Finally, Wang and Wright (2017) provide a rationale for the prevalence of ad valorem platform fees (instead of per-unit) that is different from the downstream pricing-incentive channel and the platform's ability to extract rents via entry fees we discuss. They argue that in markets with many goods that differ widely in costs and values that may not be directly observable (so that fees cannot be conditioned on each good's characteristics), ad valorem fees act as an efficient price-discrimination device. We complement this literature by analyzing the platform's preferred intermediation model when it can charge entry fees.

[4]In a similar spirit, Calzolari et al. (2020) develop a model of exclusive dealing where the upstream firms cannot efficiently extract the full profit of the downstream firms through fixed fees.

**Structure of the paper**

The rest of the paper is organized as follows. In Section 2, we set up the model of bilateral monopoly. In Section 3, we compare the wholesale and agency models for the case in which the platform can charge full-profit-extracting entry fees. In Section 4, we consider the case where the platform can only extract a fraction of the seller's profit. In Section 5, we introduce an agency model with per-unit commissions to disentangle the effects of shifting final price-setting power from the platform to the seller from those of changing the commission instrument (per-unit versus ad valorem). In Section 6, we consider the case where the platform faces uncertainty about the seller's willingness to pay for entry. We conclude in Section 7. An appendix contains the proofs of the propositions.

# 2 The model

We study a bilateral monopoly market where a seller ($S$) produces a good and sells it to final consumers via an intermediary, which we call platform ($P$). We assume that the platform has a marginal cost equal to $c_p \geq 0$; the marginal cost of the seller is $c_s > 0$.[5] The demand for the seller's product is denoted by $Q(p)$, where $p$ is the price of the good. We assume that $Q'(p) < 0$ and that the demand intercept is high enough to make trade profitable at equilibrium prices. As in Johnson (2017), it is useful to define the function:

$$\lambda(p) \equiv -\frac{Q(p)}{Q'(p)} > 0,$$

where $\lambda(p)$ is a measure of the price sensitivity of demand.[6] We assume $\lambda(p)$ and $\lambda(p)(2-\lambda'(p))$ have slopes less than 1, which ensures that second-order conditions (SOCs) are satisfied. The curvature of demand, $\sigma(p) \equiv \frac{Q(p)Q''(p)}{(Q'(p))^2}$, is related to $\lambda(p)$ via $\sigma(p) = \lambda'(p) + 1$. Marshall's Second Law of demand, which states that the elasticity increases with price, is equivalent to the condition $\lambda(p) - p\lambda'(p) \geq 0$. From now on, we refer to demands that satisfy this condition over the relevant range of prices as Marshall demands, and to those that fail to satisfy it as non-Marshall demands. An alternative characterization is in terms of the curvature and the elasticity of demand; the law holds if and only if $1 - \sigma(p) + \varepsilon(p)^{-1} \geq 0$. Notably, all concave demand functions satisfy Marshall's Second Law of demand.

[5] If $c_s = 0$, the final price set by the seller in the agency model is not affected by the commission chosen by the platform. See Kind and Koethenbuerger (2018) for a discussion in the context of taxation of printed and digital books.

[6] Note that $\lambda(p) = \frac{p}{\varepsilon(p)}$, where $\varepsilon(p) \equiv \frac{-pQ'(p)}{Q(p)}$ is the price elasticity of demand. $\lambda(p)$ can also be interpreted as the negative of the inverse of the slope of log-demand. When demand stems from a unit mass of consumers with random valuations following the distribution $F(p)$ and density $f(p)$, $\lambda(p)$ is equal to the inverse hazard rate of the random valuations (*i.e.*, the Mills ratio): $\lambda(p) = \frac{1-F(p)}{f(p)}$. Hence, $\lambda'(p) < 0$ is equivalent to log-concavity of demand, $\lambda'(p) > 0$ to log-convexity, and $\lambda'(p) = 0$ to log-linearity.

Differently from Johnson (2017), we allow the platform to charge the seller a positive entry fee, which we denote $F$. However, following Calzolari et al. (2020), we assume that extracting rents through entry fees potentially creates dead-weight losses, which implies that the amount that the platform can charge for entry may be limited.[7] To keep the model as realistic as possible, we assume that a seller is not able to enter the market if the entry fee is larger than a share $\beta$ of its expected profits.[8] We assume that $\beta$ is distributed according to the cdf $G$ with support $[0, \bar{\beta}]$, with $0 < \bar{\beta} \leq 1$. Without loss of generality, we normalize $\bar{\beta} = 1$. Let $g$ be the density of $G$ and define the inverse hazard rate by $\mu(\beta) \equiv \frac{1-G(\beta)}{g(\beta)}$. We assume that the density $g$ is finite and, for the second-order conditions (SOC) to hold, increasing. This implies that $\mu(\beta)$ is decreasing.[9]

The case where the platform cannot charge an entry fee is studied in Johnson (2017), and it arises here when $G$ is degenerate at $\beta = 0$. Our formulation is more general and captures the following alternative cases, which we analyze in turn in the rest of the paper:

- **Full-profit-extracting entry fees.** The benchmark case in which the platform can charge entry fees that extract the full profit of the seller arises when $G$ is degenerate at $\beta = 1$. We present the analysis with full-profit-extracting entry fees in Section 3.

- **Partial-profit-extracting entry fees.** Because full-profit-extracting entry fees are arguably impractical (see above), we next examine in Section 4 the case where $G$ is degenerate at $\beta \in [0, 1)$, which implies that the platform can extract only a fraction $\beta$ of the seller's profit.

- **Partial-profit-extracting entry fees with dead-weight loss uncertainty.** To model the idea that the platform may be uncertain about the seller's willingness to pay for entry, we let $G$ be a proper distribution. Interestingly, in this case we shall show that there are conditions, which depend on the primitives of the model, under which the platform abstains from charging entry fees. We place this analysis in Section 6.

We study (and compare in terms of final consumer prices, entry probability and profits) two business models that are widely used in practice. First, we consider the *wholesale model*, in which the intermediary platform first sets the entry fee to be paid by the seller, who then sets a wholesale price before the platform chooses the price at which it sells the good to final consumers. We then analyze the *agency model*, in which the platform first sets the entry fee and the ad valorem commission it charges to the seller, and then the seller picks the price

[7] See also Gaudin and White (2021), where the platform has limited ability to charge consumers for access.

[8] In line with Calzolari et al. (2020), the idea is that if the platform charges an entry fee $F$, it costs $(1+\kappa)F$ to the seller, where $\kappa \geq 0$ represents a dead-weight loss. Thus, if the seller's profit is $\pi^S$, the seller enters if and only if $\beta\pi^S \geq F$, with $\beta \equiv 1/(1+\kappa) \leq 1$. More generally, $\beta$ represents the maximum share of the seller's variable profit that the platform can extract through the entry fee.

[9] We ignore the possibility that the platform pays the seller for participating, because negative entry fees are strictly dominated: an entry fee equal to zero is sufficient to induce the entry of the seller.

at which it sells the good to final consumers. These two modes of intermediation have been compared by Johnson (2017) for the case in which entry fees are not allowed. They differ not only in the instruments used to extract profits from the seller (wholesale price versus ad valorem commissions), but also in which agent sets the final consumer price (the platform versus the seller). In Section 5, we disentangle the effects of changing the order of moves from those of modifying the profit-shifting instrument. To do this, we analyze an agency model in which commissions are per-unit, rather than ad valorem.

Before delving into the analysis of the two intermediation models, it is useful for later use to consider the benchmark case in which the platform and the seller are vertically integrated and choose the final price to maximize the joint industry profit. Suppose the market is controlled by a monopolist bearing the costs $c_p + c_s$ per unit of output. In such a setting, the monopolist would maximize its profit $\pi^m(p) = (p - c_p - c_s)Q(p)$. Because the SOC $1 - \lambda'(p) > 0$ holds,[10] the price $p^m$ that maximizes the joint profit of the industry is the solution to the first-order condition (FOC):

$$p - c_p - c_s - \lambda(p) = 0. \tag{1}$$

At this price, the monopolist makes a profit equal to $\pi^m(p^m) = \lambda(p^m)Q(p^m)$.

# 3 Full-profit-extracting entry fees

In this section, we study the case in which the platform can charge a full-profit-extracting entry fee to the seller. This case, which arises when the distribution of $G$ is degenerate at 1, can be regarded as the benchmark case of entry fees.

## 3.1 The wholesale model

We start by analyzing the wholesale model. In the wholesale model, the platform first chooses its entry fee, $F \geq 0$, and then the seller decides whether to enter or not. If the seller enters, in the second stage it chooses the wholesale price, $w$. In the last stage, the platform chooses the final consumer price, $p$.

To solve for an equilibrium, we proceed backwards. Because the entry fee is sunk when the seller and the platform decide on the wholesale and final prices, the latter are not affected by the level of the entry fee. Hence, the determination of the seller's and the platform's prices follows from Johnson (2017), which we reproduce here for completeness. Consider the platform's choice of final consumer price $p$. This choice must maximize the platform's profits:

$$\pi_P(p) = (p - w - c_p)Q(p).$$

[10] The SOC is $2Q'(p) + Q''(p)(p - c_p - c_s) < 0$, which simplifies to $2Q'(p) - Q''(p)Q(p)/Q'(p) < 0$ after using the FOC (1). Dividing by $Q'(p)$ and noting that $1 + \lambda'(p) = Q''(p)Q(p)/(Q'(p))^2$ gives the condition $1 - \lambda'(p) > 0$.

The FOC is $Q(p) + (p - w - c_p)Q'(p) = 0$, which can be rewritten as:

$$\lambda(p) - (p - w - c_p) = 0. \tag{2}$$

Because the SOC $1 - \lambda'(p) > 0$ holds, the payoff $\pi^P(p)$ has a unique stationary point, $p(w)$, which is a maximum and increases in $w$.[11] In equilibrium, the platform makes a positive profit since its margin $p - c_p - w$ equals $\lambda(p)$ and $\lambda(p) > 0$.

We now move backwards to the seller's choice of wholesale price $w$. Because the entry fee is sunk once the seller has entered, the seller, anticipating the final price $p(w)$ chosen by the platform, sets the wholesale price to maximize his variable profits:

$$\pi_S(w) = (w - c_s)Q(p(w)).$$

As $p(w)$ is monotone, this problem is equivalent to optimizing the seller's profits in the final consumer price $p$ that it wishes to induce via its choice of wholesale price $w$:

$$\pi_S(p) = (p - c_p - c_s - \lambda(p))Q(p),$$

where we have used the FOC of the platform (2) to rewrite the problem. The FOC is

$$(1 - \lambda'(p))Q(p) + (p - c_p - c_s - \lambda(p))Q'(p) = 0. \tag{3}$$

Dividing by $Q'(p)$, this condition can be rewritten as:

$$p - c_p - c_s = \lambda(p)(2 - \lambda'(p)), \tag{4}$$

which implicitly characterizes the equilibrium final price, $p^*$, and the total industry margin. Because $\lambda(p)(2 - \lambda'(p))$ has a slope less than 1, the payoff $\pi_S(p)$ has a unique stationary point that is a maximum.[12] Note that the equilibrium price $p^*$ is higher than the price set by the vertically-integrated monopolist, given by (1), due to double marginalization.

In equilibrium, the sharing of profits between the platform and the seller depends only on the shape of demand. From (2), the platform's margin is $\lambda(p)$, and from (4), the seller's margin can be written as:

$$w^* - c_s = \lambda(p^*)(1 - \lambda'(p^*)).$$

As a result, the ratio of the platform's margin to the seller's margin is $\frac{1}{1-\lambda'(p^*)}$. Hence, the seller's margin is equal to the platform's margin for log-linear demands, higher for log-concave demands, and lower for log-convex demands.

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[11] The SOC is $2Q'(p) + Q''(p)(p - w - c_p) < 0$, which simplifies to $2Q'(p) - Q''(p)Q(p)/Q'(p) < 0$ after using the FOC (2). Dividing by $Q'(p)$ and proceeding as in footnote 10 gives the condition $1 - \lambda'(p) > 0$. It follows that $p'(w) = (1 - \lambda'(p(w)))^{-1} > 0$.

[12] The SOC is $-\lambda''(p)Q(p) + 2(1 - \lambda'(p))Q'(p) + (p - c_p - c_s - \lambda(p))Q''(p) < 0$. After using the FOC (2), this can be rewritten as $-\lambda''(p)Q(p) + 2(1 - \lambda'(p))Q'(p) - \frac{(1-\lambda'(p))Q(p)}{Q'(p)}Q''(p) < 0$. Dividing by $-Q'(p)$ and noting that $1 + \lambda'(p) = Q''(p)Q(p)/(Q'(p))^2$ gives the condition $-\lambda(p)\lambda''(p) - (1 - \lambda'(p))^2 < 0$. This is the same as requiring $\lambda(p)(2 - \lambda'(p))$ to have a slope strictly less than 1.

Finally, in the first stage, the platform sets an entry fee $F \geq 0$ to maximize its profit. Because the platform profit, $(p^* - w^* - c_p)Q(p^*) + F$, is monotone increasing in $F$, it is clear that $F$ should extract the full profit of the seller. Hence:

$$F^* = \lambda(p^*)(1 - \lambda'(p^*))Q(p^*).$$

The next lemma summarizes our findings:

**Lemma 1** *In the wholesale model, when $G$ is degenerate at 1 and hence the platform can extract the full profit of the seller, the final price $p^*$ charged to consumers solves the equation $p - c_p - c_s = \lambda(p)(2 - \lambda'(p))$, while the wholesale price is $w^* = p^* - c_p - \lambda(p^*)$. The entry fee equals $F^* = \lambda(p^*)(1 - \lambda'(p^*))Q(p^*)$. The seller obtains zero profits, i.e., $\pi_S^* = 0$, while the platform makes profits equal to $\pi_P^* = \lambda(p^*)(2 - \lambda'(p^*))Q(p^*)$.*

## 3.2 The agency model

We now turn to the agency model with revenue-sharing contracts and full-profit-extracting entry fees. In this model, the platform first chooses the entry fee $F \geq 0$ and the commission $t \in [0, 1)$ that the seller must pay to the platform on sales revenue. Then, if the seller enters, it chooses the final consumer price $p$.

To solve the game, we proceed backwards again. Because $F$ is sunk when the seller decides on the final consumer price, its choice of price is the same as in Johnson (2017). That is, the seller will charge a price $p$ to maximize:

$$\pi_S(p) = (p(1 - t) - c_s)Q(p).$$

The FOC is

$$(1 - t)Q(p) + (p(1 - t) - c_s)\, Q'(p) = 0.$$

After dividing by $Q'(p)$, this FOC can be rewritten as:

$$p(1 - t) - c_s = (1 - t)\lambda(p). \tag{5}$$

Because $1 - \lambda'(p) > 0$, the payoff $\pi_S(p)$ has a unique stationary point, which is a maximum and generates a positive demand as long as $t$ is not too large.[13] Let us denote by $p(t)$ the seller's profit-maximizing price and note that $p(t)$ increases in $t$:

$$p'(t) = \frac{p(t) - \lambda(p(t))}{(1 - t)(1 - \lambda'(p(t))} \geq 0.$$

Inspection of (5) further reveals that $p(t)$ satisfies $p(t) > c_s + \lambda(p(t))$ for all $t \in (0, 1)$ and $p(0) = c_s + \lambda(p(0))$.

[13]The SOC requires $2Q'(p) + \left(p - \frac{c_s}{1-t}\right) Q''(p) < 0$, which can be rewritten as $-2 + \left(p - \frac{c_s}{1-t}\right) \frac{1+\lambda'(p)}{\lambda(p)} = -1 + \lambda'(p) < 0$, where we have used the FOC (5) in the last equality.

We now move backwards to the choice of commission $t \in [0, 1)$ and entry fee $F \geq 0$ by the platform. Anticipating how the seller will price, the problem of the platform is to solve:

$$\max_{t,F} \left\{ \pi_P(t, F) = (tp(t) - c_p) \, Q\,(p(t)) + F \right\},$$
$$\text{subject to}$$
$$F \leq (p(t)(1-t) - c_s) \, Q(p(t)),$$

where $p(t)$ is the solution to (5). Since the platform can raise the entry fee until the constraint binds, for a given $t$, the profit-maximizing choice of entry fee is $F^a(t) = (p(t)(1-t) - c_s) \, Q(p(t))$. Substituting $F^a(t)$ for $F$ in the objective function and simplifying, the platform's problem becomes

$$\max_t \, (p(t) - c_p - c_s) \, Q(p(t)),$$

or equivalently,

$$\max_p \, (p - c_p - c_s) \, Q(p).$$

This expression is equal to the profit a vertically integrated firm would make. Denoting by $p^a$ the final consumer price, we thus have $p^a = p^m$. Using (5), it follows that the entry fee is $F^a = (1 - t^a)\lambda(p^a)Q(p^a)$ and the commission is $t^a = \frac{c_p}{c_p + c_s}$, with $t^a \in [0, 1)$ as $c_p \geq 0$ and $c_s > 0$.

In conclusion, when the platform is certain that the dead-weight loss of entry fees is zero, it can extract the full profit of the seller and implement an efficient outcome from the industry point of view by setting a commission equal to $t^a = \frac{c_p}{c_p + c_s}$. With this commission, the effective marginal cost of the seller becomes $c_p + c_s$, so the seller ends up producing the industry profit-maximizing output.

**Lemma 2** *In the agency model, when $G$ is degenerate at 1 and hence the platform can extract the full profit of the seller, the final consumer price $p^a$ equals the price $p^m$ that maximizes industry profits, which solves the equation $p - c_s - c_p - \lambda(p) = 0$. The platform's optimal entry fee equals $F^a = (1 - t^a)\lambda(p^a)Q(p^a)$, while its optimal commission is $t^a = \frac{c_p}{c_p + c_s}$. The seller obtains zero profits, i.e., $\pi^a_S = 0$, while the platform gets a profit equal to the monopoly profit $\pi^a_P = \pi^m(p^m)$.*

A comparison between the two modes of intermediation yields the following sharp result in favor of the agency model:

**Proposition 1** *Assume $G$ is degenerate at 1 so that the platform can use a full-profit-extracting entry fee. Then, $p^* > p^a = p^m$, and the platform prefers the agency model to the wholesale model, while the seller is indifferent. Consumer surplus is also higher in the agency model. Consequently, a shift from the wholesale model to the agency model results in a Pareto improvement.*

Proposition 1 stands in sharp contrast to the result presented in, e.g., Bishop (1968), Gaudin and White (2014a), Johnson (2017), and Llobet and Padilla (2016), where entry fees are excluded.

While the ability to extract the full profit of the seller eliminates the double-marginalization problem in the agency model, this is not the case in the wholesale model because the entry fee is sunk when the firms make their pricing decisions and the platform cannot commit to a marginal cost markup policy.[14] This makes the agency model better for both the platform and consumers, regardless of the nature of demand. By contrast, when entry fees are excluded, both models exhibit a double-marginalization problem, and the price ranking depends on the convexity of demand. Specifically, the agency model leads to higher prices than the wholesale model if and only if the demand function satisfies Marshall's Second Law. Johnson (2017) also shows that the platform prefers the agency model to the wholesale model when demand is log-concave, log-linear or constant elasticity (see his Proposition 3). With full-profit extraction via entry fees, the platform always prefers the agency model.[15]

Proposition 1 shows that with full-profit-extracting entry fees, the agency model is efficient while the wholesale model is not. This result is fundamentally linked to the timing of pricing decisions and does not depend on the nature of the wholesale price and the commission. In the agency model, the platform simultaneously sets the entry fee and the commission rate in the first stage and uses this two-part tariff to induce the seller to produce the industry profit-maximizing output and capture the full industry profit. By contrast, because the entry fee is sunk when the agents make their pricing decisions, the wholesale model gives rise to double marginalization.

To see that the efficiency of the agency model does not depend on the ad valorem nature of the commission, suppose that in the agency model the platform used a per-unit instead of an ad valorem commission. Then, in the second stage, the seller would maximize its profit $(p - t - c_s)Q(p)$ by setting a price $p$ satisfying the FOC $p - t - c_s - \lambda(p) = 0$. In the first stage, for a given $t$, the profit-maximizing entry fee set by the platform would be $F(t) = (p(t) - t - c_s)Q(p(t))$. As a result, the platform would choose its per-unit commission to maximize the profit $\pi_P = (t - c_p)Q(p(t)) + F = (p(t) - c_s - c_p)Q(p(t))$. This would again result in the efficient equilibrium price $p^m$. This equivalence between ad valorem and per-unit commissions when the platform can charge full-profit-extracting entry fees stands in contrast to earlier results in the literature, which show that, in the absence of entry fees, ad valorem commissions are preferred to per-unit commissions, and by implication, to the wholesale model to which the latter is equivalent (see, e.g., Bishop, 1968, Shy and Wang, 2011, Gaudin and White, 2014b, and Johnson, 2017). We note in the next section that with entry fees, the agency model with per-unit commissions is no longer equivalent to the wholesale model.

Likewise, the inefficiency of the wholesale model does not depend on the per-unit nature of the wholesale price. To see this, suppose that in the wholesale model the seller used an ad

[14] If the platform could credibly commit *ex-ante* to a marginal cost markup policy $p = w + c_p$, then the seller would choose a wholesale price that maximizes the joint profit, and the two business models would be equivalent.

[15] A byproduct of the analysis in the next section on partial-profit extraction is to show that demand satisfying Marshall's Second Law of demand is a weaker sufficient condition than that in Johnson (2017) for the platform to prefer the agency model over the wholesale model when entry fees are restricted to be zero.

valorem commission $\tau$ instead of a per-unit price $w$. Then, in Stage 3, the platform would maximize its profit $\pi_P = (p(1-\tau) - c_p)Q(p)$ by setting a final price $p(\tau)$ satisfying the FOC $p - \frac{c_p}{1-\tau} - \lambda(p) = 0$. In Stage 2, the seller would set its commission $\tau$ to maximize its profit $\pi_S = (\tau p(\tau) - c_s)Q(p(\tau))$. It is easy to see that maximizing this profit in $\tau$ is equivalent to maximizing $\pi_S = \left(p - c_p - c_s - \frac{\lambda c_p}{p-\lambda}\right) Q(p)$ in $p$. Because this profit function clearly differs from the joint profit $(p - c_p - c_s)\, Q(p)$, it is obvious that the final price would not be equal to $p^m$. Again, because the entry fee is sunk when the agents set the terms of trade, double marginalization arises in the wholesale model and the equilibrium final price does not maximize industry profits.

The key distinction among the models is hence the timing of pricing decisions. In the wholesale model, full-profit-extracting entry fees affect only the division of profits, not the final prices or consumer surplus. In contrast, in the agency model, entry fees influence both the profits distribution and the final prices.

# 4 Partial-profit-extracting entry fees

In the previous section, we have studied the case in which the platform can use a full-profit-extracting entry fee. In reality, however, extracting rents by means of fixed fees may create dead-weight losses and so sellers may only be able to allocate a fraction of their profits to cover entry costs (see Calzolari et al., 2020). Accordingly, in this section we assume that $G$ is degenerate at some $\beta \in [0, 1)$, which represents the share of profit a seller can afford to pay for entry. Naturally, the case where $G$ is degenerate at $\beta = 0$ is equivalent to Johnson (2017).

## 4.1 The wholesale model

We start by analyzing the wholesale model. The wholesale and final prices are the same as in the previous section, where the platform uses full-profit-extracting entry fees (and as in Johnson, 2017), because the entry fee becomes sunk once the seller has entered. Moving directly to the first stage and noting that the payoff of the platform is monotone increasing in $F$, the platform will set an entry fee exactly equal to the seller's willingness to pay for entry, i.e.,

$$F^* = \beta\lambda(p^*)(1 - \lambda'(p^*))Q(p^*).$$

As a result:

**Lemma 3** *In the wholesale model, when $G$ is degenerate at $\beta \in [0, 1)$ and so the platform can only extract part of the seller's profit, the final price $p^*$ charged to consumers solves the equation $p - c_p - c_s = \lambda(p)(2 - \lambda'(p))$, while the wholesale price is given by $w^* = p^* - c_p - \lambda(p^*)$.*

*The entry fee equals* $F^* = \beta\lambda(p^*)(1-\lambda'(p^*)Q(p^*)$. *The seller obtains a gross profit*[16] *equal to* $\pi_S^* = (1-\beta)\lambda(p^*)(1-\lambda'(p^*))Q(p^*)$, *while the platform's profit equals* $\pi_P^* = \lambda(p^*)Q(p^*)[1+\beta(1-\lambda'(p^*)]$.

In the wholesale model, neither the final price $p^*$ nor the wholesale price $w^*$ depends on $\beta$. This is because when the seller sets the final consumer price, the entry fee is sunk.

## 4.2 The agency model

In the agency model, the final consumer price that the seller charges is chosen to maximize the same profit as in the previous section, so the FOC (5) continues to give the final consumer price as a function of the commission $t$.

Moving backwards, the platform chooses its entry fee $F \geq 0$ and commission $t \in [0,1)$ to solve the problem:

$$\max_{t,F} \left\{\pi_P(t,F) = (tp(t)-c_p)Q(p(t)) + F\right\},$$
subject to
$$\beta(1-t)\lambda(p(t))Q(p(t)) \geq F.$$

Because the objective function of the platform increases in $F$, the constraint will bind and the platform's program thus boils down to:

$$\max_t [tp(t) - c_p + \beta(1-t)\lambda(p(t))]Q(p(t)). \tag{6}$$

As argued above, $p(t)$ is monotone increasing. Therefore, as in Johnson (2017), we can reformulate the problem of the platform as choosing $p$ instead of $t$. Once $p$ is determined, the commission is pinned down from (5): $t = 1 - \frac{c_s}{p-\lambda(p)}$. Hence, replacing $t$ by $1 - c_s/(p-\lambda(p))$ in problem (6), we can rewrite the platform's problem as:

$$\pi_P(p) = \left[\left(1 - \frac{c_s}{p-\lambda(p)}\right)p - c_p + \beta\frac{c_s}{p-\lambda(p)}\lambda(p)\right]Q(p),$$

or, adding and subtracting $c_s$, as:

$$\pi_P(p) = \left(p - c_p - c_s - c_s(1-\beta)\frac{\lambda(p)}{p-\lambda(p)}\right)Q(p). \tag{7}$$

Note that except when $\beta = 1$, the platform does not internalize the entire industry profit.

The price $p^a$ that maximizes the platform's profit must then satisfy the FOC for profit maximization:[17]

$$p - c_p - c_s - \lambda(p) - c_s(1-\beta)\frac{p\lambda(p)(1-\lambda'(p))}{(p-\lambda(p))^2} = 0. \tag{8}$$

Note that $p^a$ depends on $\beta$.

As a result:

[16] By gross profit we mean the profit net of the entry fee but gross of dead-weight losses.
[17] See the appendix for the SOC.

**Lemma 4** *In the agency model, when $G$ is degenerate at $\beta \in [0,1)$ and hence the platform can only extract part of the profit of the seller, the final consumer price $p^a$ solves the equation*

$$p - c_p - c_s - \lambda(p) - c_s(1-\beta)\frac{p\lambda(p)(1-\lambda'(p))}{(p-\lambda(p))^2} = 0.$$

*The platform's optimal entry fee equals $F^a = \beta(1-t^a)\lambda(p^a)Q(p^a)$, while its optimal commission is $t^a = 1 - \frac{c_s}{p^a - \lambda(p^a)}$. The seller gets a gross profit $\pi_S^a = (1-\beta)\frac{c_s}{p^a-\lambda(p^a)}\lambda(p^a)Q(p^a)$, while the platform receives profits equal to $\pi_P^a = \left(1 + \frac{(1-\beta)c_s[\lambda(p^a) - p^a\lambda'(p^a)]}{(p^a-\lambda(p^a))^2}\right)\lambda(p^a)Q(p^a)$.*

In the agency model, when $G$ is degenerate at $\beta \in [0,1)$, the platform can no longer capture the whole industry profit through the entry fee. Consequently, it increases its commission at the detriment of the joint profit, which gives rise to the usual double marginalization inefficiency. This inefficiency worsens as the share of the profit captured by the platform becomes lower; as a result, the equilibrium price $p^a$ decreases in $\beta$.[18] (For notational convenience, we shall continue to write $p^a$ instead of $p^a(\beta)$ in what follows.)

The comparison between the two business models yields the following result.

**Proposition 2** *Assume $G$ is degenerate at $\beta \in [0,1)$ so that the platform can only extract part of the profit of the seller with its entry fee. Then:*

1. *Both the final consumer price under the wholesale model, $p^*$, and under the agency model, $p^a$, are higher than the price that maximizes the joint profit, $p^m$.*

2. *The final price under the agency model is lower than under the wholesale model, i.e., $p^a < p^*$, if and only if $\beta > \hat{\beta} \equiv \max\left\{0, 1 - \frac{(p^*-\lambda(p^*))^2}{c_s p^*}\right\}$. As a result, $p^a < p^*$:*
   - *for any demand if $\beta$ is sufficiently large,*
   - *for any demand function that satisfies Marshall's Second Law, regardless of $\beta$.*

3. *The platform prefers the agency model*
   - *for any demand function that satisfies Marshall's Second Law,*
   - *for any demand function that fails to satisfy Marshall's Second Law provided that $c_p$ is sufficiently large.*

   *Moreover, if $\beta - \frac{\lambda(p^a) - p^a\lambda'(p^a)}{p^a(1-\lambda'(p^a))} < 0$, then the seller obtains higher gross profits under the wholesale model (which never occurs for non-Marshall demands).*

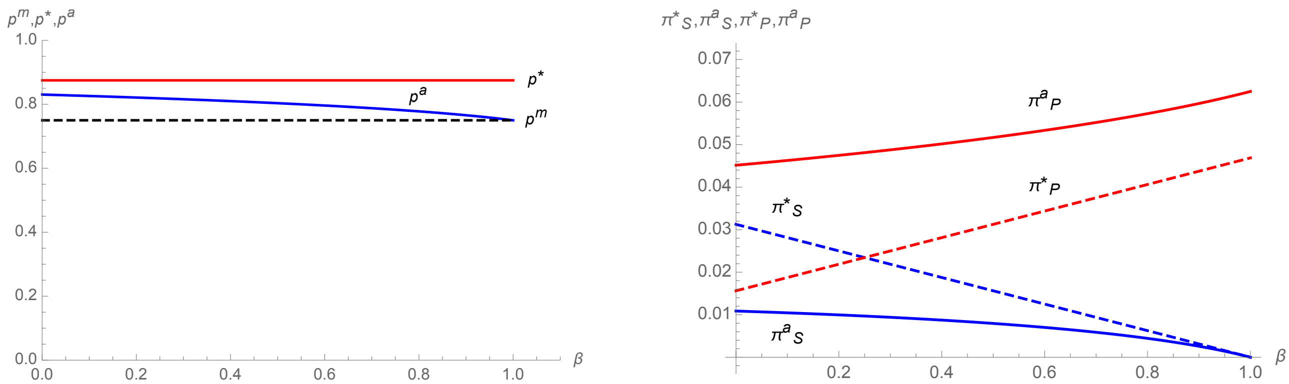
[18] Assuming the SOC holds, applying the implicit function theorem in the FOC (8) immediately shows that $\partial p^a/\partial\beta < 0$.

Proposition 2 shows that consumers always benefit from a shift from the wholesale model to the agency model, provided the demand function satisfies Marshall's Second Law. This result generalizes a well-known finding in the literature: in the absence of entry fees, ad valorem commissions are less distortionary than per-unit commissions (or equivalently, than the wholesale model), under the same demand condition (cf. Bishop, 1968; Shy and Wang, 2011; Gaudin and White, 2014b and Johnson, 2017). By contrast, when the demand function does not satisfy Marshall's Second Law, the price ranking depends on the extent to which the platform can extract the seller's profit. This can be explained as follows. In the absence of rent extraction via entry fees, the aforementioned literature shows that the price under the agency model is higher than under the wholesale model for such non-Marshall demands. With full rent extraction, as shown in Proposition 1, the price under the agency model equals the monopoly price and is lower than the price under the wholesale model. Since the agency price decreases as rent extraction increases, while the price in the wholesale model remains constant, it follows that there exists a threshold level of rent extraction below which the agency price exceeds the price in the wholesale model, and above which the reverse holds.

Further, Proposition 2 provides strong support for the idea that platforms prefer the agency model over the wholesale model. For Marshall demands, this preference holds regardless of the extent of rent extraction. Moreover, even for non-Marshall demands, the agency model is preferred as long as rent extraction is sufficiently high. The intuition is as follows. For a given price, total industry profits are the same across intermediation models. However, when $\beta$ is sufficiently large, the price under the agency model is lower than the price induced by the wholesale model, implying that the corresponding quantity sold, and thus industry profits, is higher under the agency model. Since the platform captures most of these profits through rent extraction, its payoff is also higher under the agency model. The seller, however, need not share this preference: when demand satisfies Marshall's Second Law, a shift from the wholesale to the agency model can be detrimental to the seller when its willingness to pay for entry is sufficiently low, creating a conflict of interest between the platform and the seller.

It is worth emphasizing that Proposition 2 includes the case $\beta = 0$, which encompasses the results in Johnson (2017). This implies that our analysis avoids relying on stronger assumptions about demand beyond Marshall's Second Law, unlike Johnson's Proposition 3. The key reason for this difference lies in our distinct proof technique, which yields a weaker sufficient condition for the platform's preference. In Section 6, we substantially generalize this result by showing that the platform continues to prefer the agency model even when it faces uncertainty about the seller's willingness to pay for entry and therefore cannot condition the entry fee on the seller's dead-weight loss; in that case, rent extraction is determined endogenously by an interior optimum rather than being set to make the seller just indifferent about entering the market.

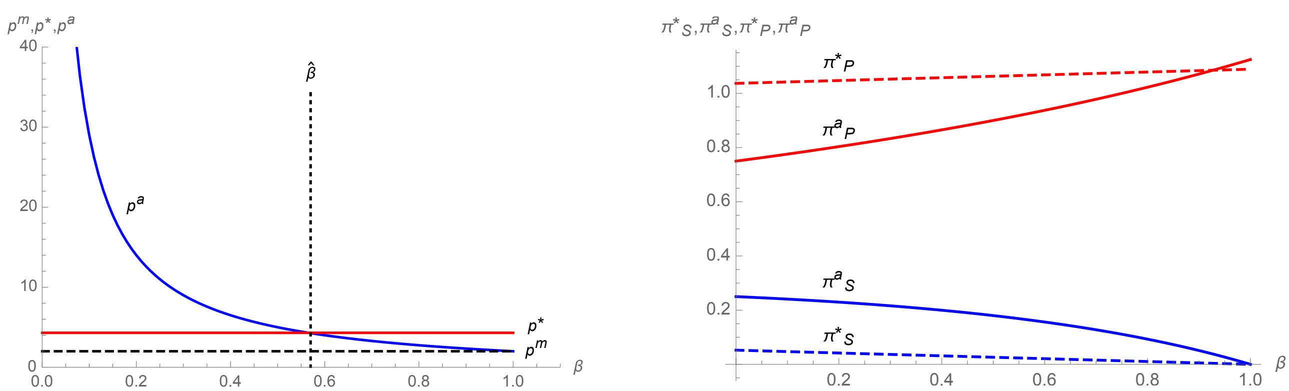
We illustrate Proposition 2 with Figures 1 and 2. To construct these figures, we set marginal costs equal to $c_p = c_s = 1/4$.




(a) Equilibrium prices (b) Equilibrium profits

Figure 1: Linear demand $Q(p) = 1 - p$.

In Figure 1, we plot the equilibrium prices and profits for the linear demand function $Q(p) = 1 - p$, which satisfies Marshall's Second Law. Panel (a) shows the equilibrium prices under the wholesale and agency models, along with the price that maximizes joint profits as a function of $\beta$. As Proposition 2 states, the price under agency is always lower than under wholesale. Moreover, it decreases in $\beta$ and converges to the monopoly price when rent extraction is complete ($\beta = 1$). In panel (b), we plot the equilibrium profits. As the graph shows, there is a conflict of interest because the platform prefers the agency model, while the seller gets a higher gross profit under the wholesale model, irrespective of the extent to which the platform can extract the seller's surplus.




(a) Equilibrium prices (b) Equilibrium profits

Figure 2: Non-Marshall demand: $Q(p) = \frac{1}{p} + \frac{1}{p^2}$.

In Figure 2, we perform the same exercise for the demand function $Q(p) = \frac{1}{p} + \frac{1}{p^2}$, which does not satisfy Marshall's Second Law. Panel (a) shows the equilibrium prices under the wholesale and agency models, along with the price that maximizes joint profits. Consistent with Proposition 2, the price is lower under agency than under wholesale if $\beta$ is sufficiently high;

otherwise, the wholesale model is better for consumers. This example thus illustrates a case where, without entry fees, the final consumer price is lower under the wholesale model; however, with entry fees, the price ranking may reverse. Panel (b) shows the equilibrium profits. There is still a conflict of interest, but for this non-typical demand its nature is quite different. The seller obtains a higher gross profit under the agency model, while the platform prefers the wholesale model, unless rent extraction is very high because in that case the final price in the agency model converges to the monopoly price and the double marginalization problem vanishes.

# 5 Disentangling the effects: the agency model with per-unit commissions

In the previous section, we have compared the wholesale model with the agency model. As noted above, shifting from wholesale to agency entails two key changes: first, a change in the order of moves, which transfers final price-setting power from the platform to the seller; and second, a change in the commission structure, from per-unit fees to ad valorem commissions. To isolate the effects of these two factors, this section examines the agency model with per-unit commissions. Comparing the wholesale model with the agency model with per-unit commissions isolates the impact of the change in the order of moves, whereas comparing the agency model with per-unit commissions to the agency model with ad valorem commissions identifies the effect of the change in the commission instrument.

## 5.1 The agency model with per-unit commissions

In the agency model with per-unit commissions, the platform first chooses its entry fee, $F \geq 0$, and its per-unit commission, $\tau > 0$. Then, the seller decides whether to enter or not, and sets the final consumer price, $p$.

To solve for an equilibrium, we proceed backwards. Since the entry fee is sunk, the final consumer price that the seller would charge follows from maximizing its profits:

$$\pi_S(p) = (p - \tau - c_s)Q(p).$$

The FOC is

$$Q(p) + (p - \tau - c_s)Q'(p) = 0.$$

After dividing by $Q'(p)$, the FOC can be rewritten as:

$$p - \tau - c_s = \lambda(p). \tag{9}$$

Because the SOC $1 - \lambda'(p) > 0$ holds, the payoff $\pi^S(p)$ has a unique stationary point, $p(\tau)$, which is a maximum and increases in $\tau$:[19]

$$p'(\tau) = \frac{1}{1 - \lambda'(p)} > 0.$$

Moving backwards, the problem of the platform is to solve:

$$\max_{\tau, F} \{\pi_P(\tau, F) = (\tau - c_p)Q(p(\tau)) + F\}$$
subject to
$$\beta(p(\tau) - \tau - c_s)Q(p(\tau)) \geq F.$$

As the objective function increases in $F$, the seller's participation constraint must be binding. Substituting the constraint into the objective function gives the problem:

$$\max_{\tau} \{(\tau - c_p)Q(p(\tau)) + \beta(p(\tau) - \tau - c_s)Q(p(\tau))\}. \tag{10}$$

Rewriting this problem in terms of choosing the final consumer price $p$ rather than $\tau$, and using (9), gives:

$$\max_{p} \{[p - c_p - c_s - (1 - \beta)\lambda(p)]Q(p)\}. \tag{11}$$

The FOC is

$$(1 - (1 - \beta)\lambda'(p))Q(p) + [p - c_p - c_s - (1 - \beta)\lambda(p)]Q'(p) = 0.$$

Dividing by $Q'(p)$, the price $p^u$ that maximizes the platform's payoff when it uses per-unit commissions must satisfy the FOC:

$$p - c_p - c_s - \lambda(p) - (1 - \beta)\lambda(p)(1 - \lambda'(p)) = 0. \tag{12}$$

The SOC holds if $1 - \lambda'(p) > 0$.[20] Note also that $p^u$ depends on $\beta$; as before, we suppress this dependence in the notation and write $p^u$ instead of $p^u(\beta)$ for brevity. As a result:

**Lemma 5** *In the agency model with per-unit commissions, when $G$ is degenerate at $\beta \in [0, 1)$ and so the platform can only extract part of the seller's profit, the final price $p^u$ charged to consumers solves the equation $p - c_p - c_s - \lambda(p) - (1 - \beta)\lambda(p)(1 - \lambda'(p)) = 0$. The platform's optimal entry fee equals $F^u = \beta\lambda(p^u)Q(p^u)$, and its optimal per-unit commission fee is $\tau^u = c_p + (1 - \beta)\lambda(p^u)(1 - \lambda'(p^u))$. The seller obtains a profit equal to $\pi_S^u = (1 - \beta)\lambda(p^u)Q(p^u)$, while the platform gets a profit equal to $\pi_P^u = (1 - (1 - \beta)\lambda'(p^u))\lambda(p^u)Q(p^u)$.*

[19] The SOC is $2Q'(p) + (p - \tau - c_s)Q''(p) < 0$, which simplifies to $2Q'(p) - Q(p)Q''(p)/Q'(p) < 0$ after using the FOC (9). Dividing by $Q'(p)$ and noting that $1 + \lambda'(p) = Q''(p)Q(p)/(Q'(p))^2$ gives the condition $1 - \lambda'(p) > 0$.

[20] The SOC is $2(1 - (1 - \beta)\lambda'(p))Q'(p) + [p - c_s - c_p - (1 - \beta)\lambda(p)]Q''(p) < 0$, which simplifies to $(1 - (1 - \beta)\lambda'(p))\,[2Q'(p) - Q(p)Q''(p)/Q'(p)] < 0$ after using the FOC (12). Following footnote 19, this holds if $1 - \lambda'(p) > 0$.

In the agency model with per-unit commissions, the final consumer price $p^u$ is also decreasing in $\beta$. The intuition is the same as in the case of ad valorem commissions. When $G$ is degenerate at $\beta \in [0, 1)$, the platform can no longer capture the whole industry profit through the entry fee. Consequently, it increases its per-unit commission at the detriment of the joint profit, which gives rise to the usual double marginalization inefficiency. This inefficiency worsens as the share of the profit captured by the platform falls; as a result, the equilibrium price decreases in $\beta$.

## 5.2 Effect of a shift in price-setting power

We are now ready to isolate the impact of shifting final price-setting power from the platform to the seller by comparing the wholesale model to the agency model with per-unit commissions. Recall that, in the absence of entry fees, these two models are equivalent in terms of the induced prices (see, e.g., Johnson, 2017; Gaudin and White, 2014b, 2021; Llobet and Padilla, 2016).[21] However, once the platform can charge (partial) entry fees, the price equivalence generally breaks down. In the agency model with per-unit fees, the platform moves first and therefore internalizes part of the follower's operating profit through the entry-fee channel.

**Proposition 3** *Assume $G$ is degenerate at $\beta \in [0, 1)$, so that the platform can only extract a part of the profit of the seller. Then:*

1. *The final consumer price in the agency model with per-unit commissions $p^u$ is higher than the price $p^m$ that maximizes joint profit, and lower (or equal, when $\beta = 0$) than the price in the wholesale model $p^*$.*

2. *If the demand function is log-concave, the platform prefers the agency model with per-unit commissions while the seller gets higher gross profits under the wholesale model. Conversely, if the demand function is log-convex, the platform prefers the wholesale model, whereas the seller obtains higher gross profits under the agency model with per-unit commissions.*

When $\beta = 0$, the wholesale model and the agency model with per-unit commissions are equivalent in terms of the induced final price, except that the roles of the two agents are reversed: in the wholesale model, the seller is the first mover, whereas in the agency model, it is the platform. In both models, the first mover sets a per-unit price, and the second mover determines the final consumer price. Because the two marginal costs enter symmetrically in the first mover's objective, the platform's maximization problem in the agency model with per-unit commissions is identical to the seller's problem in the wholesale model:

$$\max_p \, [p - c_p - c_s - \lambda(p)]Q(p).$$

[21] Chen et al. (2025) extend this neutrality result to a multi-product platform, but show that it no longer holds under platform competition.

Hence, for $\beta = 0$ the equilibrium prices coincide in the two models. The only difference lies in the distribution of profits: the identity of the first mover determines who captures the first-mover rents under linear contracts, so that the seller's profit in the wholesale model corresponds to the platform's profit in the agency model with per-unit commissions, and vice versa.

As $\beta$ increases, the agency model with per-unit commissions begins to diverge from the wholesale model. The reason is that the platform, as first mover in the agency model, starts to internalize the externality that its commission imposes on the second mover, the seller, since it can appropriate part of the latter's operating profit through the entry fee. Consequently, the equilibrium price $p^u$ decreases with $\beta$: as the platform captures a larger share of the joint profit, its objective becomes more closely aligned with joint profit maximization, and the induced final price moves toward $p^m$.

Although the move order is (essentially) neutral for the final price when $\beta = 0$, it is not neutral for payoffs. Part (2) of Proposition 3 formalizes this by showing that the profit ranking across the wholesale model and the agency model with per-unit fees hinges on demand curvature: under log-concavity the platform prefers the agency model while the seller gets higher gross profits under the wholesale model; these preferences reverse under log-convexity. This move-order preference result is already present in Johnson (2017) for the benchmark without entry fees ($\beta = 0$). Our contribution is to generalize it to all $\beta$.

## 5.3 Effect of a change in commission instrument

To isolate the effect of the change in the commission instrument, we now compare the agency model with per-unit commissions to the agency model with ad valorem commissions.

**Proposition 4** *Assume $G$ is degenerate at $\beta \in [0, 1)$, so that the platform can only extract part of the profit of the seller. Then:*

1. *The final price with ad valorem commissions is lower than the final price with per-unit commissions, i.e., $p^a < p^u$, if and only if*

$$\beta - \frac{c_p p^u + \lambda(p^u)[\lambda(p^u) - p^u \lambda'(p^u))]}{p^u \lambda(p^u)(1 - \lambda'(p^u))} < 0, \tag{13}$$

*or equivalently,*

$$\frac{c_s p^u}{(p^u - \lambda(p^u))^2} < 1. \tag{14}$$

*As a result:*

- *if $c_p > 0$ and $c_s \to 0$, then $p^a < p^u$ $\forall \beta$.*
- *if $c_p = 0$ and the demand function fails to satisfy Marshall's Second Law, then $p^a > p^u$ $\forall \beta$.*

- *if $c_p = 0$, the demand function satisfies Marshall's Second Law, and the curvature of demand is increasing, i.e. $\lambda''(p) \geq 0$, then $\exists \bar{\beta} \in (0,1)$ such that $p^a < p^u$ $\forall \beta < \bar{\beta}$ (and $p^a \geq p^u$ otherwise).*
- *If the demand function satisfies Marshall's Second Law and $p^m > (c_p + c_s)^2/c_s$, then $p^a < p^u$ in a neighborhood of $\beta = 0$ and $\exists \tilde{\beta} \in (0,1)$ such that $p^a > p^u$ $\forall \beta > \tilde{\beta}$.*

2. *The platform always prefers ad valorem commissions. The seller gets higher gross profits with per-unit commissions if $p^u < p^a$.*

If condition (14) of Proposition 4 is satisfied, the agency model with ad valorem commissions induces a lower price than the agency model with per-unit commissions. To understand this condition, note that the difference between the platform's objectives under ad valorem and per-unit commissions can be written as

$$\pi_P^a(p) = \pi_P^u(p) + (1-\beta)\, t(p)\lambda(p)Q(p),$$

with $\pi_P^u(p) = \big(p - c_p - c_s - \lambda(p)\big)Q(p) + \beta\, \lambda(p)Q(p)$. The term $\Omega(p) \equiv (1-\beta)t(p)\lambda(p)Q(p)$ thus represents the platform's additional profit under ad valorem commissions, that is, the extra share $(1-\beta)t(p)$ that it can extract from the seller's operating profit $\lambda(p)Q(p)$. As $\beta$ increases, the platform's objectives under ad valorem and per-unit commissions get closer to one another, and in the limit $\beta = 1$ they coincide. Differentiating the additional profit $\Omega(p)$ with respect to $p$ yields:

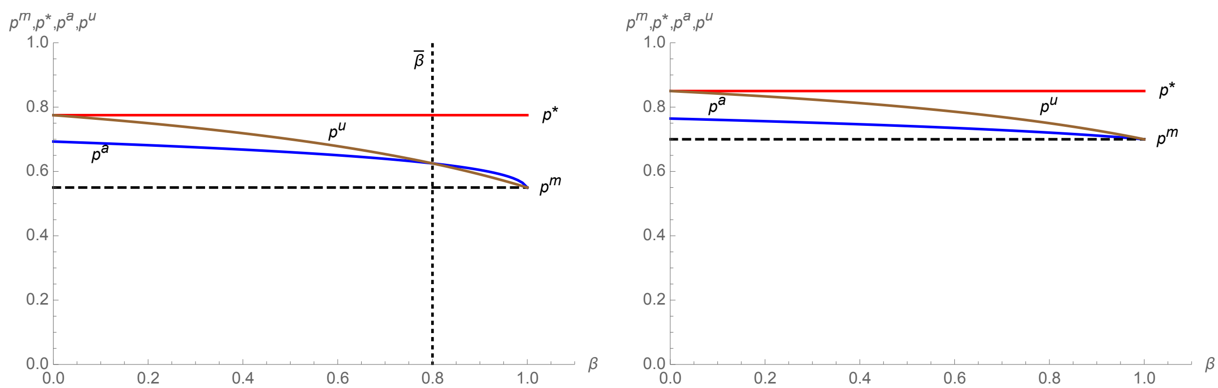
$$\Omega'(p) = \underbrace{(1-\beta)t'(p)\lambda(p)Q(p)}_{>0} + \underbrace{(1-\beta)t(p)\frac{d}{dp}\big(\lambda(p)Q(p)\big)}_{<0} = (1-\beta)Q(p)(1-\lambda'(p))\left[\frac{c_s p}{(p-\lambda(p))^2} - 1\right].$$

The first term of $\Omega'(p)$ is positive, because a higher price implies a higher commission and, therefore, a larger share of the seller's operating profit extracted by the platform (*share effect*). The second term is negative because a higher consumer price reduces the seller's operating profit $\lambda(p)Q(p)$ (*base effect*). If condition (14) holds at $p^u$, the base effect outweighs the share effect, implying $\Omega'(p^u) < 0$. This means that, evaluated at $p^u$, the marginal gain from increasing the price is lower under ad valorem commissions than under per-unit commissions. Since marginal profits are decreasing (by the SOCs), the ad valorem optimal price must lie to the left of $p^u$, which yields $p^a < p^u$. Conversely, if condition (14) does not hold, then $p^a > p^u$.

Let us now explain why, for Marshall demands, we tend to have $p^a < p^u$ when $\beta$ is low, but we may have $p^a > p^u$ when $\beta$ is high. In the benchmark case where $\beta = 0$, we have $p^a < p^u$ for Marshall demands, while $p^a = p^u$ when $\beta = 1$. Moreover, as mentioned above, both $p^a$ and $p^u$ decrease in $\beta$. However, $p^u$ tends to decrease faster with $\beta$ than $p^a$, which implies that we may have $p^a > p^u$ for some $\beta \in (0,1)$. This happens when for a given $\beta$, we have $\Omega'(p^u) > 0$, that is, when the share effect dominates the base effect at the optimal per-unit price.

The intuition is as follows. As $\beta$ increases, the platform internalizes more of the seller's operating profit, which lowers commissions and thus lowers consumer final prices under both instruments. However, the rate at which commissions go down depends on the type of commission and the marginal costs of the agents. Under per-unit commissions, the platform internalizes the seller's operating profit at the rate $\beta$. Under ad valorem commissions, it internalizes it at the rate $\beta + t(1-\beta)$, so the incremental internalization from raising $\beta$ is $1-t$ rather than 1 (abstracting from the induced response of $t$). Thus, for a given $t$, the induced final consumer price falls more rapidly with per-unit than with ad valorem commissions. This force pushes toward $p^u$ falling faster than $p^a$, which can eventually generate cases where $p^u < p^a$ for some $\beta$, even though $p^a < p^u$ when $\beta = 0$.[22] For example, Proposition 4 shows that when $c_p = 0$, Marshall's Second Law holds, and $\lambda''(p) \geq 0$, we have $p^u < p^a$ beyond some threshold $\overline{\beta}$.

Figures 3 and 4 provide an illustration of these observations. In Figure 3, we plot the final consumer prices under ad valorem and per-unit commissions, along with the monopoly and the wholesale final consumer prices, for a linear demand (which satisfies Marshall's Second Law). In Figure 3(a), we set $c_p = 0$ and observe that for low levels of rent extraction $\beta$, the ad valorem price is lower than the per-unit price. However, when $\beta$ becomes sufficiently large, the price ranking flips. In Figure 3(b), we choose a larger value for $c_p$ and observe that $p^u > p^a$ for all $\beta < 1$.



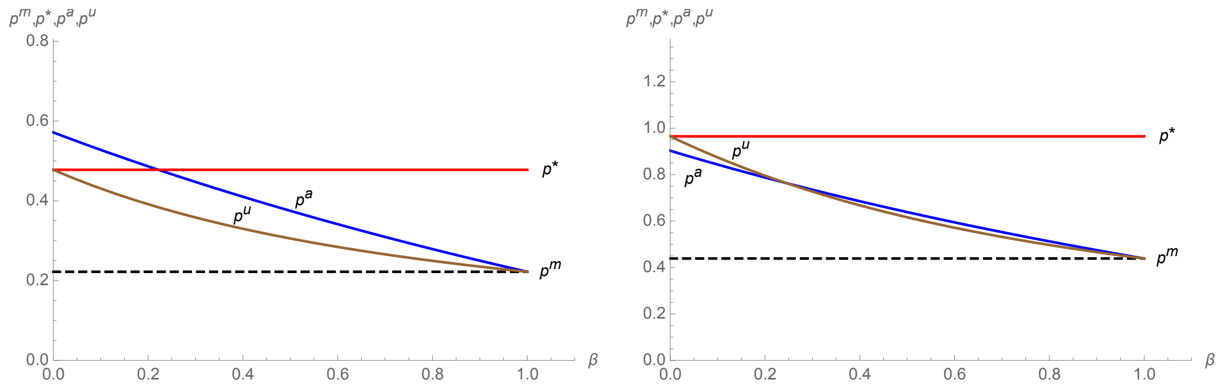

(a) Prices with $c_p = 0$, $c_s = 0.1$ (b) Prices with $c_p = 0.3$, $c_s = 0.1$

Figure 3: Marshall demand $Q(p) = 1 - p$.

In Figure 4, we plot the same prices for a demand function that does not satisfy Marshall's Second Law. In Figure 4(a), we observe that when $c_p = 0$ (or is small enough), the price with ad valorem commissions is always above the price implied by per-unit commissions. In Figure 4(b), $c_p > 0$ is chosen so that (13) holds at $\beta = 0$. In that case, we have the same situation as with Marshall demands, i.e., the per-unit price is higher than the ad valorem price. Because the

[22] This effect is mitigated by the fact that the ad valorem commission $t$ decreases with $\beta$, and hence, the internalization rate under ad valorem commissions, $1-t$, increases with $\beta$.

per-unit price decreases faster than the ad valorem price, the price ranking eventually flips. If we choose a higher $c_p$, the ad valorem price is always lower than the per-unit price, exactly as in Figure 3(b).




(a) Prices with $c_p = 0$, $c_s = 0.1$ (b) Prices with $c_p = 0.08$, $c_s = 0.1$

Figure 4: Non-Marshall demand $Q(p) = 1/p + 1/p^2$.

Regarding profits, the intuition is clear. The platform always (weakly) prefers ad valorem commissions because, for a given consumer price, it internalizes a larger share of the seller's operating profit than under per-unit commissions (i.e., $\beta + t(1 - \beta)$ rather than $\beta$). Hence, even if the platform were to (suboptimally) set an ad valorem commission that replicates the per-unit induced price, it would already earn a higher profit than under per-unit commissions. Optimizing $t$ reinforces this advantage. Consequently, the platform's profit under ad valorem commissions strictly dominates that under per-unit commissions.

By contrast, for a given price $p$, the seller obtains higher gross profits with per-unit than with ad valorem commissions because less rent-extraction occurs. Because the seller's gross profits decrease in $p$, it is clear that the seller's gross profits are higher with per-unit commissions if the per-unit price is lower than the ad valorem price. This occurs, for example, when $c_p = 0$, demand satisfies Marshall's Second Law and $\beta$ is sufficiently large; or when $c_p = 0$ and demand does not satisfy Marshall's Second Law.

# 6 Dead-weight loss uncertainty

In the most general version of our model, $G$ is a proper distribution function. The interpretation is that the platform is uncertain about the dead-weight loss incurred by the seller when paying for entry. Alternatively, $G$ may capture heterogeneity across many independent sellers who share similar demand conditions but differ in their willingness to pay for entry. In what follows, we adopt the former interpretation and extend our results accordingly.

While in the case without uncertainty the platform always chooses its entry fee so as to leave the seller indifferent between entering and not entering the market and hence entry always occurs in equilibrium, this is no longer true in the presence of uncertainty. Instead, the platform picks its entry fee to solve the following trade-off: a higher entry fee increases the probability that the seller refuses to enter, while it increases the platform's payoff in case of entry. As a result, the amount of rent extraction via entry fees becomes interior, and hence the probability of entry need not be equal to 1 in equilibrium. As we will see, this more general model delivers a rationale for why platforms sometimes do not charge entry fees at all.

## 6.1 The wholesale model

We start with the wholesale model. As already mentioned, in the wholesale model the continuation equilibrium prices and profits are independent of the entry fee $F$, which is sunk. As a result, the wholesale price $w^*$ and the final consumer price $p^*$ continue to be the solution to the FOCs (2) and (4), respectively.

Moving to the first stage, the platform sets an entry fee $F \geq 0$ to maximize the probability that the seller enters times the payoff in case of entry:

$$\max_F \{\pi_P(F) = \Pr[\beta\lambda(p^*)(1-\lambda'(p^*))Q(p^*) \geq F](\lambda(p^*)Q(p^*) + F)\},$$

which is equivalent to:

$$\max_F \left[1 - G\left(\frac{F}{\lambda(p^*)(1-\lambda'(p^*))Q(p^*)}\right)\right](\lambda(p^*)Q(p^*) + F).$$

It is useful to reformulate the problem of the platform as maximizing over the share of the seller's profit it wants to extract, $y$, rather than maximizing with respect to $F$. In this case, we have

$$y = \frac{F}{\lambda(p^*)(1-\lambda'(p^*))Q(p^*)}.$$

The platform's problem can then be reformulated as:

$$\max_y (1 - G(y)) [\lambda(p^*)Q(p^*) + y(1-\lambda'(p^*))\lambda(p^*)Q(p^*)]. \tag{15}$$

The FOC wrt $y$ is:[23]

$$-g(y)[\lambda(p^*)Q(p^*) + y(1-\lambda'(p^*))\lambda(p^*)Q(p^*)] + [1 - G(y)](1-\lambda'(p^*))\lambda(p^*)Q(p^*) = 0,$$

Rearranging, we obtain that the equilibrium share $y^*$ of the seller's profit extracted by the platform via its entry fee is the solution in $y$ to the equation:

$$\mu(y) = y + \frac{1}{1-\lambda'(p^*)} \tag{16}$$

if it exists. Otherwise, $y^* = 0$. Hence, we have the following result:

[23] The SOC is satisfied if $-2g(y)(1-\lambda'(p^*)) - g'(y)[1 + y(1-\lambda'(p^*))] \leq 0$, which holds because $g' \geq 0$.

**Proposition 5** *In the wholesale model with dead-weight loss uncertainty, the final price $p^*$ charged to consumers solves the equation $p - c_p - c_s = \lambda(p)(2 - \lambda'(p))$, while the wholesale price is $w^* = p^* - c_p - \lambda(p^*)$. The platform charges an entry fee $F^* > 0$ if and only if $g(0) < 1 - \lambda'(p^*)$, in which case $F^*$ is equal to a share $y^*$ of the seller's profits $\pi^S(p^*)$, where $y^*$ solves the equation $\mu(y) = y + (1 - \lambda'(p^*))^{-1}$. Otherwise, $F^* = 0$.*

Proposition 5 shows that the platform will charge an entry fee if and only if $g(0) < 1 - \lambda'(p^*)$. This condition depends on all the model primitives, but in particular on the properties of $G$. Since the equilibrium price does not depend on $G$, this condition is more likely to be satisfied when the probability a seller cannot afford to pay anything to enter the platform's market because it has a very high dead-weight loss is sufficiently small. Interestingly, for any distribution function with no mass at 0 (i.e., $g(0) = 0$),[24] the platform will charge a strictly positive entry fee. Conversely, if $G$ has positive mass at zero (e.g., when $G$ is uniform), the platform risks deterring the seller from entering the market if it imposes a positive entry fee.[25]

Proposition 5 also shows that the fraction $y^*$ of the seller's profit captured by the platform as entry fee is lower the higher the pass-through from the wholesale price to the final price in equilibrium: $p^{*\prime}(w) = (1 - \lambda'(p^*(w)))^{-1}$. This means that, holding $G$ fixed, measuring pass-through is sufficient to learn about rent extraction: in markets where demand and cost conditions lead to a greater pass-through, the share of profits extracted by the platform will be smaller.

Finally, we observe that the pass-through in equilibrium equals the ratio of the platform's margin to the seller's margin, as demonstrated by Bresnahan and Reiss (1985). Hence, at the equilibrium price, equation (16) can be rewritten as:

$$\mu(y) = y + RM^*(p^*),$$

where

$$RM^*(p) \equiv \frac{\lambda(p)}{p - c_p - c_s - \lambda(p)}$$

is the ratio of profit margins of the platform and the seller.[26]

**Corollary 1** *In the wholesale model with dead-weight loss uncertainty, when $g(0) < 1 - \lambda'(p^*)$ so that the platform finds it optimal to charge a positive entry fee, the fraction $y^*$ of the seller's*

[24] This is the case, for example, if $G$ is the power distribution, i.e., $G(\beta) = \beta^\alpha$, with $\alpha > 1$.

[25] To be sure, when $G$ is uniform, the platform will only use an entry fee if the demand function is sufficiently concave. Note that $\mu(y) = 1 - y$. Using (16), it is straightforward to derive that the equilibrium entry fee extracts a fraction of the seller's profits equal to $y^* = -\lambda'(p^*)/2(1 - \lambda'(p^*))$. As a result:

$$F^* = \begin{cases} -\frac{\lambda(p^*)\lambda'(p^*)Q(p^*)}{2}, & \text{if } \lambda'(p^*) < 0 \\ 0, & \text{otherwise.} \end{cases} \tag{17}$$

Hence, with $G$ uniform, the platform will choose $F^* = 0$ for all log-linear and log-convex demands and $F^* > 0$ for all log-concave demands.

[26] Note that in equilibrium, the margin of the platform is larger than the margin of the seller if and only if $\lambda'(p^*) < 0$: this is necessarily true for log-concave demands, whereas the reverse is true for log-convex demands.

*profit captured by the platform through the entry fee is larger for a demand and cost system that yields a lower pass-through rate or, equivalently, a lower ratio of platform margin over seller margin.*

## 6.2 The agency model

In the agency model, the final consumer price that the seller charges for a given commission continues to be the solution to equation (5). Moving back to stage 1, the platform chooses its commission $t \in [0,1)$ and entry fee $F \geq 0$ to solve:

$$\max_{t,F} \{\pi_P(t,F) = \Pr[\beta(p(t)(1-t) - c_s)Q(p(t)) \geq F]\,[(tp(t) - c_p)Q(p(t)) + F]\},$$

which is equivalent to

$$\max_{t,F} \left\{ \left[1 - G\left(\frac{F}{(p(t)(1-t) - c_s)Q(p(t))}\right)\right] [(tp(t) - c_p)Q(p(t)) + F] \right\}. \tag{18}$$

In this expression, the first factor represents the likelihood of seller entry. The second factor is the payoff the platform receives conditional on the seller entering the market.

As we did before, because $p(t)$ is monotone, we can reformulate the problem of the platform as choosing $p$ instead of $t$. Once $p$ is determined, the commission is given by the relationship $t = 1 - \frac{c_s}{p - \lambda(p)}$. Substituting $t$ by $1 - c_s/(p - \lambda(p))$ in problem (18), we can rewrite the platform's objective function as

$$\max_{p,F} \left\{ \left[1 - G\left(\frac{(p - \lambda(p))F}{c_S \lambda(p) Q(p)}\right)\right] \left[\left(p - c_p - \frac{pc_S}{p - \lambda(p)}\right) Q(p) + F\right] \right\}. \tag{19}$$

In regard to the platform's choice of entry fee, as we have done in the analysis of the wholesale model, it is also useful here to reformulate the problem of the platform as maximizing over the share $y$ of the seller's profit it wants to extract:

$$y = \frac{F}{\frac{c_s \lambda(p) Q(p)}{p - \lambda(p)}}.$$

The platform's problem (19) can then be reformulated as:

$$\max_{p,y} \left\{ (1 - G(y)) \left[\left(p - c_p - \frac{pc_S}{p - \lambda(p)}\right) Q(p) + y \frac{c_s \lambda(p) Q(p)}{p - \lambda(p)}\right] \right\},$$

which we can rewrite as:

$$\max_{p,y} \left\{ (1 - G(y)) \left(p - c_p - c_s - c_s(1-y)\frac{\lambda(p)}{p - \lambda(p)}\right) Q(p) \right\}. \tag{20}$$

Notice that, conditional on the entry of the seller, the platform's payoff is exactly the same as the payoff in (20) but with $y$ replacing $\beta$. Hence, the FOC with respect to price is the same as that in (8) but with $y$ replacing $\beta$:

$$p - c_p - c_s - \lambda(p) - c_s(1-y)\frac{p\lambda(p)(1 - \lambda'(p))}{(p - \lambda(p))^2} = 0. \tag{21}$$

Taking now the FOC of (20) with respect to $y$ gives:

$$-g(y)\left(p-c_p-c_s-c_s(1-y)\frac{\lambda(p)}{p-\lambda(p)}\right)+(1-G(y))\frac{c_s\lambda(p)}{p-\lambda(p)}=0, \tag{22}$$

which can be rewritten as:

$$\mu(y)=y+\frac{p\left(p-c_p-c_s-\lambda(p)\right)}{c_s\lambda(p)}+\frac{c_p}{c_s}. \tag{23}$$

If an interior equilibrium exists, then it is given by the solution to the FOCs (21) and (23) in $p$ and $y$, respectively. We then have the following result:

**Proposition 6** *In the agency model:*

*(A) If* $g(0)<\frac{c_s\lambda(p^a)}{p^a(p^a-c_s-c_p-\lambda(p^a))+c_p\lambda(p^a)}$*, the platform charges a commission* $t^a=1-\frac{c_s}{p^a-\lambda(p^a)}$ *and an entry fee equal to:*

$$F^a=Q(p^a)\left(\frac{c_s\lambda(p^a)}{p^a-\lambda(p^a)}-\frac{(p^a-\lambda(p^a))(p^a-c_p-c_s-\lambda(p^a))}{p^a\left(1-\lambda'(p^a)\right)}\right), \tag{24}$$

*where the final consumer price* $p^a$ *is the solution to:*

$$\mu\left(1-\frac{(p-\lambda(p))^2(p-c_p-c_s-\lambda(p))}{c_sp\lambda(p)\left(1-\lambda'(p)\right)}\right) - \frac{(p-\lambda(p))\left[(p-c_p-c_s)\left(\lambda(p)-p\lambda'(p)\right)+\lambda(p)(p-\lambda(p))\right]}{c_sp\lambda(p)\left(1-\lambda'(p)\right)}=0. \tag{25}$$

*(B) Otherwise,* $F^a=0$ *and the final price* $p^a$*, as in Johnson (2017), is given by the solution to*

$$p-c_p-c_s=\lambda(p)\left[1+\frac{c_sp(1-\lambda'(p))}{(p-\lambda(p))^2}\right]. \tag{26}$$

Proposition 6 demonstrates that, also in the agency model, there are conditions under which the platform will refrain from charging a positive entry fee. In fact, the platform will charge positive entry fees only when the inequality $g(0)<\frac{c_s\lambda(p^a)}{p^a(p^a-c_s-c_p-\lambda(p^a))+c_p\lambda(p^a)}$ holds. This condition is different from the one in the wholesale model, but it is also more likely to hold if the mass of sellers who cannot afford to pay for entry is sufficiently small. The intuition is the same.[27]

Unlike in the wholesale model, in the agency model the fraction $y^a$ of the seller's profit captured by the platform as an entry fee is not directly related to the pass-through of commissions to final consumer prices. However, as in the wholesale model, the ratio of margins of the platform

[27] When $G$ is uniform, the platform will refrain from charging any entry fee if the demand function satisfies Marshall's Second Law. Because log-concave demands are in the class of demands that satisfy Marshall's Second Law of demand, this, combined with the remark about in footnote 25, means that no entry fees will be charged in the agency model, while they will be in the wholesale model. As a consequence, the seller will always enter in the agency model while not always in the wholesale model. For a proof, see the appendix.

and the seller is sufficient to tell whether there is more or less rent extraction. This is because equation (23) can be written as:

$$\mu(y) = y + RM^a(p),$$

where

$$RM^a(p) \equiv \frac{p - c_p - \frac{pc_s}{p-\lambda(p)}}{\frac{c_s\lambda(p)}{p-\lambda(p)}}.$$

Because $RM^a(p)$ is increasing in $p$ and $p^a$ is decreasing in $y$, this implies a substitution relationship between the entry fee and the platform margin.

**Corollary 2** *In the agency model with dead-weight loss uncertainty and ad valorem commissions, when* $g(0) < \frac{c_s\lambda(p^a)}{p^a(p^a - c_s - c_p - \lambda(p^a)) + c_p\lambda(p^a)}$, *the fraction* $y^a$ *of the seller's profit captured by the platform as entry fee is larger for a demand and cost system that yields a lower ratio of platform margin over seller margin.*

## 6.3 Per-unit commissions

In the agency model with per-unit commissions, the final consumer price that the seller charges for a given commission continues to be the solution to equation (9). Moving back to stage 1, the platform chooses its commission $\tau \in [0, 1)$ and entry fee $F \geq 0$ to solve:

$$\max_{\tau,F} \{\pi_P(\tau, F) = \Pr[\beta(p(\tau) - \tau - c_s)Q(p(\tau)) \geq F] [(\tau - c_p)Q(p(\tau)) + F]\}.$$

This can be rewritten as:

$$\max_{\tau,F} \left\{ \left[1 - G\left(\frac{F}{(p(\tau) - \tau - c_s)Q(p(\tau))}\right)\right] [(\tau - c_p)Q(p(\tau)) + F] \right\}. \quad (27)$$

In this expression, the first factor represents the likelihood of seller entry. The second factor is the payoff the platform receives conditional on the seller entering the market.

As we did before, because $p(\tau)$ is monotone, we can reformulate the problem of the platform as choosing $p$ instead of $\tau$. Once $p$ is determined, the commission is given by the relationship $\tau = p - c_s - \lambda(p)$. Substituting $\tau$ in problem (27), we can rewrite the platform's objective function as

$$\max_{p,F} \left\{ \left[1 - G\left(\frac{F}{\lambda(p)Q(p)}\right)\right] [(p - c_s - c_p - \lambda(p))Q(p) + F] \right\}. \quad (28)$$

As before, it is also useful to reformulate the problem of the platform as maximizing over the share $y$ of the seller's profit it wants to extract:

$$y = \frac{F}{\lambda(p)Q(p)}.$$

The platform's problem (28) is then reformulated as:

$$\max_{p,y} \{(1 - G(y)) [(p - c_s - c_p - \lambda(p))\, Q(p) + y\lambda(p)Q(p)]\},$$

which we can rewrite as:

$$\max_{p,y} \{(1 - G(y)) [(p - c_p - c_s - (1-y)\lambda(p)) Q(p)]\}. \tag{29}$$

Notice that, conditional on the entry of the seller, the platform's payoff is exactly the same as the payoff in (11) but with $y$ replacing $\beta$. Hence, the FOC with respect to price is the same as that in (12) but with $y$ replacing $\beta$:

$$p - c_p - c_s - \lambda(p) - (1-y)\lambda(p)(1 - \lambda'(p)) = 0. \tag{30}$$

Taking now the FOC of (29) with respect to $y$ gives:

$$-g(y) [(p - c_p - c_s - (1-y)\lambda(p)) Q(p)] + (1 - G(y)) \lambda(p) Q(p) = 0,$$

which can be rewritten as:

$$\mu(y) = y + \frac{p - c_p - c_s - \lambda(p)}{\lambda(p)}. \tag{31}$$

If an interior equilibrium exists, then it is given by the solution to the FOCs (30) and (31) in $p$ and $y$, respectively. We then have the following result:

**Proposition 7** *In the agency model with per-unit commissions:*

*(A) If $g(0) < \frac{p^u - c_s - c_p - \lambda(p^u)}{\lambda(p^u)}$, the platform charges a commission $\tau = p^u - c_s - \lambda(p^u)$ and an entry fee equal to:*

$$F^u = \lambda(p^u) Q(p^u) \left(1 - \frac{p^u - c_p - c_s - \lambda(p^u)}{\lambda(p^u)(1 - \lambda'(p^u))}\right), \tag{32}$$

*where the final consumer price $p^u$ is the solution to:*

$$\mu\left(1 - \frac{p - c_p - c_s - \lambda(p)}{\lambda(p)(1 - \lambda'(p))}\right) - \frac{\lambda(p) - (p - c_p - c_s)\lambda'(p)}{\lambda(p)(1 - \lambda'(p))} = 0. \tag{33}$$

*(B) Otherwise, $F^u = 0$ and the final price $p^u$ is equal to the price in the wholesale model $p^*$.*

Proposition 7 shows once more that there are conditions under which the platform will refrain from charging a positive entry fee. In fact, the platform will charge positive entry fees only when the inequality $g(0) < \frac{\lambda(p^u)}{p^u - c_s - c_p - \lambda(p^u)}$ holds. This condition is different from the ones derived above but it is also more likely to hold if the mass of sellers who cannot afford to pay for entry is sufficiently small. The intuition is analogous.[28]

[28] When $G$ is uniform and the demand function is log-concave, the platform charges positive entry fees. For a proof, see the appendix. This is in line with the observation in footnote 25 regarding entry fees in the wholesale model. The implication is that when $G$ is uniformly distributed with ad valorem commissions there will be more entry of sellers than with per-unit commissions.

Like in the agency model with ad valorem commissions, the fraction $y$ of the seller's profit captured by the platform as an entry fee is not directly related to the pass-through of commissions to final consumer prices. However, as in the wholesale model, the ratio of margins of the platform and the seller is sufficient to tell whether there is more or less rent extraction. This is because equation (31) can be written as:

$$\mu(y) = y + RM^u(p),$$

where

$$RM^u(p) \equiv \frac{p - c_s - c_p - \lambda(p)}{\lambda(p)}.$$

Because $RM^u(p)$ is increasing in $p$ and $p^u$ is decreasing in $y$, we see again that entry fees and margins are substitutes:

**Corollary 3** *In the agency model with uncertain dead-weight losses and per-unit commissions, when $g(0) < \frac{\lambda(p^u)}{p^u - c_s - c_p - \lambda(p^u)}$, the fraction $y$ of the seller's profit captured by the platform as entry fee is larger for a demand and cost system that yields a lower ratio of platform margin over seller margin.*

## 6.4 Comparison

We have already shown in Proposition 1 that the final consumer price under the wholesale model is higher than the monopoly price, i.e., $p^* > p^m$. We have also shown in Proposition 2 that the final consumer price under the agency model with ad valorem commissions is higher than the monopoly price for any exogenous level of rent-extraction $\beta \in [0, 1)$, i.e., $p^a > p^m$. This implies that no matter the endogenous level of rent-extraction $y$, it is also the case that $p^a > p^m$. The same holds for the final consumer price with per-unit commissions (see Proposition 3).

We now proceed to compare the equilibrium prices under the wholesale model and the agency model with ad valorem commissions when the level of rent-extraction is interior. For Marshall demands, we can directly apply Proposition 2 and conclude that $p^a < p^*$. This is because Proposition 2 demonstrates that $p^a < p^*$ for any $\beta$, and hence for any endogenous $y^a$. However, for non-Marshall demands, we do not know whether the equilibrium level of rent extraction $y^a$ is below or above the threshold $\hat{\beta}$ defined in Proposition 2. The following result provides the necessary and sufficient condition under which $p^a < p^*$ in this general case.

**Corollary of Proposition 2** *In the model with uncertain dead-weight losses, assume that entry fees are strictly positive in both intermediation settings, wholesale and agency with ad valorem commissions, for which $g(0) = 0$ suffices. Then, the final price under the agency model with ad valorem commissions $p^a$ is lower than under the wholesale model $p^*$ if and only if*

$$y^a > 1 - \frac{(p^* - \lambda(p^*))^2}{c_s p^*}.$$

*As a result, $p^a < p^*$ for any demand function that satisfies Marshall's Second Law.*

To rank consumer surplus across the two intermediation models, this corollary is no longer sufficient because consumer surplus depends not only on how prices compare across models, but also on the seller's entry probability. Our next result compares entry probabilities in the wholesale model and in the agency model with ad valorem commissions when entry fees and commissions are positive.

**Proposition 8** *In the model with uncertain dead-weight losses, assume that entry fees are strictly positive in both models of intermediation, wholesale and agency with ad valorem commissions, for which $g(0) = 0$ suffices. Assume also that the demand function satisfies Marshall's Second Law so that $p^a < p^*$. Then, the seller's entry probability under the agency model is higher than under the wholesale model if:*

$$p^a - c_p - \frac{p^a c_s}{p - \lambda(p^a)} > \lambda(p^a), \tag{34}$$

*or equivalently,*

$$y^a < \frac{\lambda(p^a) - p^a \lambda'(p^a)}{p^a(1 - \lambda'(p^a))}. \tag{35}$$

*As a result, the agency model with ad valorem commissions results in a higher consumer surplus, higher platform profits but lower seller's gross profits. On aggregate, welfare under the agency model with ad valorem commissions is higher than under the wholesale model.*

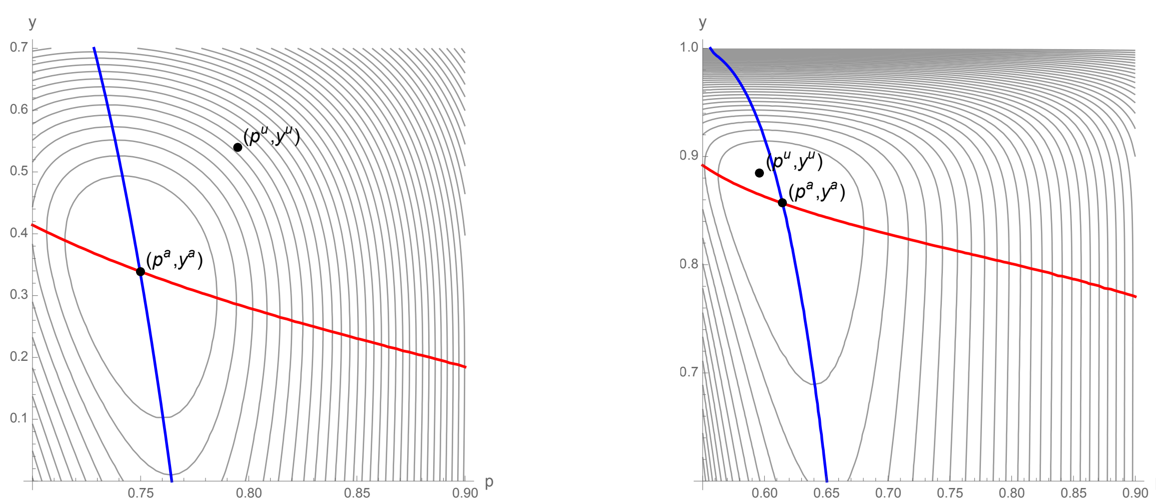
Proposition 8 generalizes Proposition 2 to settings where the platform is uncertain about the seller's willingness to pay for entry. In such a case, the seller's entry probability is no longer equal to one. When demand satisfies Marshall's Second Law and the platform's margin is sufficiently large (i.e., condition (34) in Proposition 8 is met), the seller's entry probability in the agency model with ad valorem commissions exceeds that in the wholesale model. Because we know from Proposition 2 that the equilibrium price is lower in the agency model than in the wholesale model when the demand function satisfies Marshall's Second Law, consumer surplus in the agency model is also higher than in the wholesale model. Moreover, as the total industry profit $\pi^m(p)$ is concave and maximized at $p^m$ with $p^m < p^a < p^*$, industry profit when entry occurs is higher in the agency model as well. Hence, whenever entry fees are strictly positive in both models of intermediation (for which $g(0) = 0$ suffices) and condition (34) holds, total welfare is larger in the agency model than in the wholesale model.

We finish by comparing the agency models with ad valorem and per-unit commissions.

**Proposition 9** *In the model with uncertain dead-weight losses, the agency model with per-unit commissions never dominates the agency model with ad valorem commissions both in terms of* *final consumer prices and entry probability. By contrast, there exist parameters for which the agency model with ad valorem commissions induces a lower price and a higher entry probability than the model with per-unit commissions.*

We illustrate Proposition 9 in Figure 5. In the graphs of this figure, the thin grey curves are level sets of the platform objective in the agency model with ad valorem commissions, which is given in (20), plotted in the $(p, y)$-space. The colored curves are the loci where the FOCs are satisfied. The blue curve corresponds to the FOC with respect to price; the red with respect to the level of rent extraction. The crossing point, as indicated, provides the profits maximizing choice of price and rent extraction level $(p^a, y^a)$. In the graphs we also place the platform's choice of price and level of rent extraction in the agency model with per-unit commissions $(p^u, y^u)$.

In Figure 5(a) we represent a case where the agency model with ad valorem commissions (AV) dominates the per-unit commissions (PU) model both in terms of the final consumer price and the seller entry probability. The demand function is $Q(p) = 1 - p$, satisfying Marshall's Second Law, and the cost parameters are set to $c_p = 0.3$ and $c_s = 0.1$. With these costs, Figure 3(b) above shows that $p^a < p^u$ for any exogenous level of rent extraction lower than 1. This result continues to hold when rent extraction is endogenous, which is not necessarily obvious because the rent-extraction level differs across intermediation modes. Under ad valorem commissions, the optimal choice of price and rent extraction is $(p^a, y^a) \approx (0.75, 0.34)$, while under per-unit commissions it is $(p^u, y^u) \approx (0.79, 0.54)$. The entry probability under ad valorem commissions is 98.7%, while under per-unit commissions it is only 91.5%.




(a) AV dominates PU both in price and entry ($c_p = 0.3, c_s = 0.1, G(\beta) = \beta^4$)

(b) AV dominates PU only in entry ($c_p = 0, c_s = 0.1, G(\beta) = \beta^{30}$)

Figure 5: Equilibrium prices and surplus extraction; $Q(p) = 1 - p$.

In Figure 5(b) we represent a case where the agency model with ad valorem commissions dominates the per-unit commissions model only in terms of the seller entry probability. The demand function is the same, while the cost parameters are set to $c_p = 0$ and $c_s = 0.1$. With these costs, Figure 3(a) above shows that $p^a > p^u$ if the level of exogenous rent extraction is sufficiently high. This continues to be true when rent extraction is endogenous. Under ad valorem commissions, the optimal choice of price and rent extraction is $(p^a, y^a) \approx (0.61, 0.86)$, while under per-unit commissions it is $(p^u, y^u) \approx (0.60, 0.88)$. The entry probability under ad valorem commissions is 99%, while under per-unit commissions it is only 97.4%. In this graph, the distribution function $G$ is highly skewed toward 1, which implies high levels of rent extraction and hence very similar levels of profits and social welfare across the two models.

# 7 Conclusions

In this paper, we have studied the agency and wholesale models of intermediation. Two empirical observations have inspired our model. First, many intermediaries charge entry fees, but, perhaps surprisingly, not all of them do. For example, supermarkets often use slotting fees and some platforms such as Amazon and eBay charge entry fees in addition to commissions. However, other platforms such as Facebook Marketplace, Airbnb or Expedia do not use entry fees in their pricing policies. Second, Amazon's entry fees at levels such as \$39.99 per month for some product categories seem relatively low and hence do not probably extract the full profit of the sellers.

Using a bilateral monopoly market, we have compared the agency and wholesale models of intermediation when platforms can charge entry fees. In the benchmark case where the platform can employ full-profit-extracting entry fees, the agency model results in no double marginalization and hence the final consumer price maximizes industry profit. By contrast, because in the wholesale model entry fees have no bearing on the terms of trade, double marginalization is not eliminated. As a result, the wholesale model is (weakly) inferior for all agents: consumers face higher final prices, the platform makes lower profits and the seller makes no profits in either of the intermediation models. These results are quite strong because they hold no matter the shape of demand and the nature of pricing (per-unit vs. ad valorem wholesale prices and commissions).

As mentioned above, the assumption that the platform can extract the full profit of the seller via entry fees is unrealistic. To rationalize this idea, we have followed Calzolari et al. (2020) and assumed that the seller's profit share that can be extracted via entry fees is limited due to the seller incurring dead-weight losses. We have shown that, for arbitrary demand functions, the agency model leads to lower prices provided the fraction of the seller's profit extracted by the platform is sufficiently large. In the special case where demand satisfies Marshall's Second Law, the platform continues to prefer the agency model no matter how much surplus it can extract from the seller (including nothing at all, as in Johnson (2017)), and so do consumers. However, the seller gets a larger gross profit under the wholesale model provided that rent-extraction via entry fees is sufficiently low. To clarify what drives the price decrease when moving from wholesale to agency, we have also studied the agency model with per-unit commissions. This allows us to decompose the wholesale-to-agency change into two steps. The first is a shift in price-setting power from the platform to the seller while holding the commission instrument fixed (a per-unit commission), which leads to lower prices. The second is a change in the commission instrument from per-unit to ad valorem, which typically further reduces prices, although when rent extraction is high and upstream costs are low the ranking can reverse. A similar pattern arises under non-Marshall demands: shifting price-setting power reduces prices while changing the commission instrument typically increases them.

Finally, we have extended our model to a setting where the platform faces uncertainty about the seller's willingness to pay for entry because it does not observe the dead-weight loss the seller incurs when paying the entry fee. In this setting, the platform trades off a higher fee conditional on entry against a lower probability of entry, so the equilibrium entry fee can be interior and entry need not occur with probability one. An important result has been the characterization of the conditions under which the platform charges a positive entry fee. Charging an entry fee may cause the seller to refuse entry, thereby fully destroying the intermediation surplus. For all models, we have shown that entry fees need not always be used. Each intermediation model admits a threshold condition under which the platform optimally sets no entry fee. Intuitively, when the distribution of dead-weight losses places sufficient mass on very high values, entry fees deter entry too often and the platform relies solely on variable revenue instruments.

We have also compared intermediation models with endogenous rent-extraction on consumer welfare grounds. For this, a ranking of the final consumer prices is not sufficient because the seller's entry probability is also relevant. We have seen that uncertainty about the seller's dead-weight loss need not overturn the price comparison under Marshall demands: when entry fees are strictly positive in both models, the final price under agency continues to be lower than under the wholesale model; the same ranking extends to non-Marshall demands whenever the distribution of dead-weight losses places sufficient weight on low values (so that the platform optimally chooses a sufficiently high rent-extraction share under agency). Regarding the seller's entry probability, a sufficient condition stating that the platform's margin is sufficiently large ensures that entry probability in the agency model is larger than in the wholesale model if the demand function satisfies Marshall's Second Law. In such cases, both in terms of prices and entry probability the agency model performs better for consumers than the wholesale model. Because a lower price leads to greater industry profits, we conclude that the agency model is better for welfare under the conditions that demand satisfies Marshall's Second Law and the platform margin is large enough.

Finally, we have also compared the two agency variants. We have shown that the agency model with per-unit commissions never dominates the agency model with ad valorem commissions simultaneously in terms of final prices and entry probability. By contrast, there exist circumstances for which ad valorem commissions induce both a lower price and a higher entry probability than per-unit commissions.

# Appendix

**Second-order condition for agency model with partial-profit-extracting entry fees.**

The SOC is:

$$\frac{d^2\pi_P(p)}{dp^2} = \left(p - c_p - c_s - \frac{c_s(1-\beta)\lambda(p)}{p-\lambda(p)}\right) Q''(p) + 2\left(1 - c_s(1-\beta)\frac{p\lambda'(p)-\lambda(p)}{(p-\lambda(p))^2}\right) Q'(p)$$
$$- c_s(1-\beta)\frac{p(p-\lambda(p))\lambda''(p) - 2(1-\lambda'(p))(p\lambda'(p)-\lambda(p))}{(p-\lambda(p))^3} Q(p) \leq 0.$$

Using the facts that $Q'' = -Q'\frac{1+\lambda'}{\lambda}$, $Q = -\lambda Q'$ and the FOC (8), we have:

$$p - c_p - c_s - \frac{c_s(1-\beta)\lambda(p)}{p-\lambda(p)} = \frac{-Q(p)}{Q'(p)}\left(1 - c_s(1-\beta)\frac{p\lambda'(p)-\lambda(p)}{(p-\lambda(p))^2}\right).$$

It then follows that the SOC can be rewritten as:

$$\frac{d^2\pi_P(p)}{dp^2} = \left(1 - c_s(1-\beta)\frac{p\lambda'(p)-\lambda(p)}{(p-\lambda(p))^2}\right)(1-\lambda'(p))Q'(p)$$
$$+ c_s(1-\beta)\lambda(p)\left(\frac{p(p-\lambda(p))\lambda''(p) + 2(1-\lambda'(p))(\lambda(p)-p\lambda'(p))}{(p-\lambda(p))^3}\right) Q'(p) \leq 0.$$

For example, a sufficient condition for the SOC to hold is that $\lambda(p) - p\lambda'(p) \geq 0$ (i.e., demand satisfies Marshall's Second Law of demand) and $\lambda''(p) \geq 0$.

**Proof of Proposition 1.**

We have shown in the text that $p^a = p^m$. It remains to be shown that $p^* > p^m$. To do this, we evaluate the first-order derivative of the seller's payoff under wholesale at the monopoly price $p^m$. Using (3), we have:

$$\left.\frac{d\pi_S(p)}{dp}\right|_{p=p^m} = Q(p^m)(1-\lambda'(p^m)) + Q'(p^m)(p^m - c_p - c_s - \lambda(p^m)) = Q(p^m)(1-\lambda'(p^m) > 0,$$

where we have used (1) to simplify. Thus, $p^* > p^m$, because the profit function is concave. ■

**Proof of Proposition 2.**

1. We already know that $p^* > p^m$ (see Proposition 1). It remains to show that $p^a > p^m$. Using (8), under agency, we have:

$$\left.\frac{d\pi_P(p)}{dp}\right|_{p=p^m} = -Q'(p^m)\left[c_s(1-\beta)\frac{p^m\lambda(p^m)(1-\lambda'(p^m))}{(p^m-\lambda(p^m))^2} - (p^m - c_p - c_s - \lambda(p^m))\right]$$
$$= Q(p^m)c_s(1-\beta)\frac{p^m(1-\lambda'(p^m))}{(p^m-\lambda(p^m))^2} > 0,$$

which implies that $p^a > p^m$, assuming that the profit function is concave (see above in the appendix).

2. To show this result, we evaluate the first-order derivative of the payoff in the agency model at the optimal price in the wholesale model, $p^*$. This gives:

$$\left.\frac{d\pi_P(p)}{dp}\right|_{p=p^*} = \left(1 - c_s(1-\beta)\frac{p^*\lambda'(p^*) - \lambda(p^*)}{(p^* - \lambda(p^*))^2}\right) Q(p^*) + \left(p - c_p - c_s - c_s(1-\beta)\frac{\lambda(p^*)}{p^* - \lambda(p^*)}\right) Q'(p^*)$$
$$= -Q'(p^*)\left[\left(1 - c_s(1-\beta)\frac{p^*\lambda'(p^*) - \lambda(p^*)}{(p^* - \lambda(p^*))^2}\right)\lambda(p^*) - \left(\lambda(p^*)(2 - \lambda'(p^*)) - c_s(1-\beta)\frac{\lambda(p^*)}{p^* - \lambda(p^*)}\right)\right]$$
$$= -Q'(p^*)\lambda(p^*)(1 - \lambda'(p^*))\left(\frac{c_s(1-\beta)p^*}{(p^* - \lambda(p^*))^2} - 1\right).$$

The previous expression is negative if and only if

$$\beta > \hat{\beta} \equiv \max\left\{0, 1 - \frac{(p^* - \lambda(p^*))^2}{c_s p^*}\right\},$$

in which case the payoff under the agency model is decreasing at $p^*$, so $p^a < p^*$. Note that $\hat{\beta}$ is strictly less than 1, so for any demand function there always exists a sufficiently large $\beta$ for which $p^a < p^*$.

Moreover, for demands for which the Mills ratio is less than 1, $\hat{\beta} = 0$, so for those demands $p^a < p^*$ no matter $\beta$. For this, we need to show that $1 - \frac{(p^* - \lambda(p^*))^2}{c_s p^*} < 0$, which is equivalent to $c_s p^* < (p^* - \lambda(p^*))^2$. This is always true for demands that satisfy Marshall's Second Law because:

$$\begin{aligned} c_s p^* - (p^* - \lambda(p^*))^2 &= [p^* - c_p - \lambda(p^*)(2 - \lambda'(p^*)]\, p^* - (p^* - \lambda(p^*))^2 \\ &= -p^* c_p - p^*\lambda(p^*)(1 - \lambda'(p^*)) + \lambda(p^*)(p^* - \lambda(p^*)) \\ &< -p^*\lambda(p^*)(1 - \lambda'(p^*)) + \lambda(p^*)(p^* - \lambda(p^*)) \\ &= -\lambda(p^*)\left[\lambda(p^*) - p^*\lambda'(p^*))\right] < 0, \end{aligned}$$

where we have used (4) to replace $c_s$, the first inequality follows from dropping $-p^* c_p$, and the second inequality follows from Marshall's Second Law of demand.

3. We first show that the platform prefers the agency model for any demand that satisfies Marshall's Second Law of demand. To do this, let us suppose that in the agency model, rather than choosing its commission optimally, the platform chooses (sub-optimally) a commission $\tilde{t}$ to induce a final price equal to the price $p^*$ prevailing under the wholesale model:

$$\tilde{t} = \frac{c_p + \lambda(p^*)(1 - \lambda'(p^*))}{p^* - \lambda(p^*)},$$

To obtain $\tilde{t}$, we use expression (4) that gives the final price in the wholesale model $p^*$, which implies that $p^* - c_s - \lambda(p^*) = \lambda(p^*)(1 - \lambda'(p^*)) + c_p$, and equation (5) that defines the final price in the agency model, which can be rewritten as $p - c_s - \lambda(p) = t(p - \lambda(p))$. To implement $p^*$, the platform then sets $\tilde{t}$ so that $\lambda(p^*)(1 - \lambda'(p^*)) + c_p = \tilde{t}(p^* - \lambda(p^*))$. Note also that we have $\tilde{t} < 1$ as $p^* - \lambda(p^*) = c_p + c_s + \lambda(p^*)(1 - \lambda'(p^*)) > c_p + \lambda(p^*)(1 - \lambda'(p^*))$ so that $p^*$ can be implemented by an interior commission.

Given this choice of commission, the entry fee that the platform would set equals $\tilde{F}^a = \beta(1 - \tilde{t})\lambda(p^*)Q(p^*)$. As a result, the platform would obtain a profit equal to:

$$\begin{aligned}\pi_P^a(\tilde{t}, \tilde{F}^a) &= (\tilde{t}p^* - c_p)Q(p^*) + \beta(1 - \tilde{t})\lambda(p^*)Q(p^*) \\ &= [\tilde{t}p^* - c_p + \beta(1 - \tilde{t})\lambda(p^*)]Q(p^*) \\ &= \frac{\lambda(p^*)Q(p^*)}{p^* - \lambda(p^*)}[c_p(1 - \beta) + p^*(1 - \lambda'(p^*)) + \beta(p^* - \lambda(p^*)(2 - \lambda'(p^*))],\end{aligned}$$

where the last equality follows from plugging $\tilde{t}$ and simplifying. We now show that this sub-optimal profit level is greater than the maximal profit the platform would make under the wholesale model, which is equal to $\pi_P^*(p^*, F^*) = \lambda(p^*)Q(p^*)[1 + \beta(1 - \lambda'(p^*))]$ (see Lemma 3). In fact, $\pi_P^a(\tilde{t}, \tilde{F}) > \pi_P^*(p^*, F^*)$ if and only if

$$\frac{1}{p^* - \lambda(p^*)}[c_p(1 - \beta) + p^*(1 - \lambda'(p^*)) + \beta(p^* - \lambda(p^*)(2 - \lambda'(p^*))] > 1 + \beta(1 - \lambda'(p^*))$$

This inequality holds if:

$$c_p(1 - \beta) + p^*(1 - \lambda'(p^*)) + \beta(p^* - \lambda(p^*)(2 - \lambda'(p^*))] > (p^* - \lambda(p^*))[1 + \beta(1 - \lambda'(p^*))],$$

which can be simplified to

$$(1 - \beta)\,[c_p + \lambda(p^*) - p^*\lambda'(p^*)] > 0.$$

This inequality is always true provided that the demand function satisfies Marshall's Second Law. As a result, the platform always prefers the agency model for such class of demands. Note that the inequality can also be satisfied for demands that do not satisfy Marshall's Second Law of demand if $c_p$ is sufficiently high, i.e., $c_p > p^*\lambda'(p^*) - \lambda(p^*)$.

We now show that the seller gets higher gross profits under the wholesale model provided that $\beta$ is sufficiently small. Suppose that in the wholesale model the seller does not choose its wholesale price optimally, but chooses a wholesale price $\tilde{w}$ to induce the platform to charge a final price equal to $p^a$, the price prevailing in the agency model:

$$\tilde{w} = c_s + c_s(1 - \beta)\frac{p^a\lambda(p^a)(1 - \lambda'(p^a))}{(p^a - \lambda(p^a))^2}.$$

To obtain $\tilde{w}$, we use equation (2), which defines the final price in the wholesale model, and implies that $\tilde{w} = p^a - c_p - \lambda(p^a)$, and equation (8) that defines the final price in the agency model. With this choice of wholesale price, the seller's payoff in the wholesale model would be equal to

$$\pi_S^*(p^a) = (1 - \beta)(p^a - c_s - c_p - \lambda(p^a))Q(p^a).$$

While in the agency model, the seller would make a profit equal to

$$\pi_S^a(p^a) = (1-\beta)\frac{c_s\lambda(p^a)}{p^a - \lambda(p^a)}Q(p^a).$$

Comparing these two profits gives:

$$\pi_S^*(p^a) - \pi_S^a(p^a) = (1-\beta)\left(p^a - c_s - c_p - \lambda(p^a) - \frac{c_s\lambda(p^a)}{p^a - \lambda(p^a)}\right)Q(p^a).$$

Hence, $\pi_S^*(p^a) > \pi_S^a(p^a)$ if and only if $p^a - c_s - c_p - \lambda(p^a) - \frac{c_s\lambda(p^a)}{p^a-\lambda(p^a)} > 0$. Using the FOC (8), this requires

$$c_s(1-\beta)\frac{p^a\lambda(p^a)(1-\lambda'(p^a))}{(p^a-\lambda(p^a))^2} - \frac{c_s\lambda(p^a)}{p^a-\lambda(p^a)} > 0.$$

After simplifying, this condition can be written as:

$$\beta < \frac{\lambda(p^a) - p^a\lambda'(p^a)}{p^a(1-\lambda'(p^a))},$$

which is the condition given in the proposition. Note that this condition may only hold for demands satisfying the Marshall's Second Law of demand. If the condition holds, then the seller would prefer the wholesale model to the agency model if $p^a$ was the final consumer price. Because $p^a$ is sub-optimal from the point of view of the seller in the wholesale model, it follows that $\pi_S^*(p^*) > \pi_S^*(p^a) > \pi_S^a(p^a)$. So, the seller reaches a higher profit level under the wholesale model.

■

**Proof of Proposition 3.**

1. First, we show that $p^u > p^m$. To prove this result, we evaluate the derivative of the platform's paypff in the agency model with per-unit commissions at the monopoly price:

$$\left.\frac{d\pi_P(p)}{dp}\right|_{p=p^m} = (1-(1-\beta)\lambda'(p^m))Q(p^m) + [p^m - c_s - c_p - (1-\beta)\lambda(p^m)]Q'(p^m)$$
$$= Q'(p^m)\left[p^m - c_s - c_p - (1-\beta)\lambda(p^m) - (1-(1-\beta)\lambda'(p^m))\lambda(p^m)\right]$$
$$= Q'(p^m)\left[\lambda(p^m) - (1-\beta)\lambda(p^m) - (1-(1-\beta)\lambda'(p^m))\lambda(p^m)\right]$$
$$= Q'(p^m)\lambda(p^m)\left[1 - (1-\beta) - (1-(1-\beta)\lambda'(p^m))\right]$$
$$= -Q'(p^m)\lambda(p^m)(1-\beta)(1-\lambda'(p^m)) > 0,$$

where in the second equality we have used $Q(p^m) = -\lambda(p^m)Q'(p^m)$. Because the payoff $\pi_P(p)$ increases at $p = p^m$, assuming that the profit function is concave, we have $p^u > p^m$ for all $\beta$.

To show that $p^u < p^*$, we proceed similarly and evaluate the platform's profit derivative in the agency model with per-unit commissions at the optimal price $p^*$ in the wholesale model:

$$\begin{aligned}\left.\frac{d\pi_P(p)}{dp}\right|_{p=p^*} &= (1-(1-\beta)\lambda'(p^*))Q(p^*) + [p^* - c_s - c_p - (1-\beta)\lambda(p^*)]Q'(p^*)\\ &= Q'(p^*)\left[p^* - c_s - c_p - (1-\beta)\lambda(p^*) - (1-(1-\beta)\lambda'(p^*))\lambda(p^*)\right]\\ &= Q'(p^*)\left[\lambda(p^*)(2-\lambda'(p^*)) - (1-\beta)\lambda(p^*) - (1-(1-\beta)\lambda'(p^*))\lambda(p^*)\right]\\ &= Q'(p^*)\lambda(p^*)\beta(1-\lambda'(p^*)) < 0.\end{aligned}$$

Because the payoff $\pi_P(p)$ decreases at $p = p^*$, assuming that the profit function is concave, we have $p^u < p^*$ for all $\beta \in (0,1)$ (and equal for $\beta = 0$).

2. The gross profit of the seller in the wholesale model is $\pi_S^* = (1-\beta)(1-\lambda'(p^*))\lambda(p^*)Q(p^*)$, while in the agency model with per-unit commissions is $\pi_S^u = (1-\beta)\lambda(p^u)Q(p^u)$. Because the term $\lambda(p)Q(p)$ is decreasing in $p$ and $p^* > p^u$ for all $\beta$, we have $\lambda(p^*)Q(p^*) > \lambda(p^u)Q(p^u)$. Hence, $\pi_S^* > \pi_S^u$ if $\lambda'(p^*) < 0$, so for all log-concave demands. Because the joint profits in the agency model with per-unit commissions are higher than in the wholesale model, it follows that the platform prefers the latter.

The profit of the platform in the wholesale model is $\pi_P^* = (1+\beta(1-\lambda'(p^*))\lambda(p^*)Q(p^*)$, while in the agency model with per-unit commissions is $\pi_P^u = (1-(1-\beta)\lambda'(p^u))\lambda(p^u)Q(p^u)$. As mentioned above, the term $\lambda(p)Q(p)$ is decreasing in $p$ and because $p^* > p^u$ for all $\beta$, we have $\lambda(p^*)Q(p^*) > \lambda(p^u)Q(p^u)$. Hence, $\pi_P^* > \pi_P^u$ if $\beta(1-\lambda'(p^*)) > -(1-\beta)\lambda'(p^u)$, which holds for all log-convex demand functions. Because the joint gross profits in the agency model with per-unit commissions are higher than in the wholesale model, it follows that the seller prefers the former. ■

**Proof of Proposition 4.**

1. To compare $p^u$ and $p^a$, we evaluate the derivative of the platform's profit in the agency model with ad valorem commissions at $p = p^u$:

$$\begin{aligned}\left.\frac{d\pi_P(p)}{dp}\right|_{p=p^u} &= \left(1 - c_s(1-\beta)\frac{p^u\lambda'(p^u)-\lambda(p^u)}{(p^u-\lambda(p^u))^2}\right)Q(p^u) + \left(p^u - c_p - c_s - c_s(1-\beta)\frac{\lambda(p^u)}{p^u-\lambda(p^u)}\right)Q'(p^u)\\ &= -Q'(p^u)\left[\left(1 - c_s(1-\beta)\frac{p^u\lambda'(p^u)-\lambda(p^u)}{(p^u-\lambda(p^u))^2}\right)\lambda(p^u) - \left(\lambda(p^u) + (1-\beta)\lambda(p^u)(1-\lambda'(p^u)) - c_s(1-\beta)\frac{\lambda(p^*)}{p^*-\lambda(p^*)}\right)\right]\\ &= -Q'(p^u)\left[-c_s(1-\beta)\lambda(p^u)\frac{p^u\lambda'(p^u)-\lambda(p^u)}{(p^u-\lambda(p^u))^2} - (1-\beta)\lambda(p^u)(1-\lambda'(p^u)) + c_s(1-\beta)\frac{\lambda(p^u)}{p^u-\lambda(p^u)}\right]\\ &= -Q'(p^u)(1-\beta)\lambda(p^u)\left[-c_s\frac{p^u\lambda'(p^u)-\lambda(p^u)}{(p^u-\lambda(p^u))^2} - (1-\lambda'(p^u)) + c_s\frac{1}{p^u-\lambda(p^u)}\right]\\ &= -Q'(p^u)(1-\beta)\lambda(p^u)\left[c_s\left(\frac{1}{p^u-\lambda(p^u)} - \frac{p^u\lambda'(p^u)-\lambda(p^u)}{(p^u-\lambda(p^u))^2}\right) - (1-\lambda'(p^u))\right]\\ &= -Q'(p^u)(1-\beta)\lambda(p^u)\left[c_s\frac{p^u(1-\lambda'(p^u))}{(p^u-\lambda(p^u))^2} - (1-\lambda'(p^u))\right]\\ &= -Q'(p^u)(1-\beta)\lambda(p^u)(1-\lambda'(p^u))\left[\frac{c_s p^u}{(p^u-\lambda(p^u))^2} - 1\right].\end{aligned} \tag{36}$$

The derivative (36) is negative, and hence, $p^a < p^u$, if and only if

$$\frac{c_s p^u}{(p^u - \lambda(p^u))^2} < 1. \tag{37}$$

This condition can be also expressed in the following way. Note that the sign of (36) is equal to the sign of $c_s p^u - (p^u - \lambda(p^u))^2$. Using (12) to replace $c_s$ in the expression $c_s p^u - (p^u - \lambda(p^u))^2$, we get:

$$\begin{aligned}
&p^u[p^u - c_p - \lambda(p^u) - (1-\beta)\lambda(p^u)(1-\lambda'(p^u))] - (p^u - \lambda(p^u))^2 \\
&= \lambda(p^u)(p^u - \lambda(p^u)) - c_p p^u - (1-\beta)p^u\lambda(p^u)(1-\lambda'(p^u)) \\
&= \lambda(p^u)(p^u - \lambda(p^u)) - c_p p^u - p^u\lambda(p^u)(1-\lambda'(p^u)) + \beta p^u\lambda(p^u)(1-\lambda'(p^u)) \\
&= \lambda(p^u)p^u - \lambda^2(p^u) - c_p p^u - p^u\lambda(p^u) + p^u\lambda(p^u)\lambda'(p^u)) + \beta p^u\lambda(p^u)(1-\lambda'(p^u)) \\
&= -\lambda^2(p^u) - c_p p^u + p^u\lambda(p^u)\lambda'(p^u)) + \beta p^u\lambda(p^u)(1-\lambda'(p^u)) \\
&= -\lambda(p^u)[\lambda(p^u) - p^u\lambda'(p^u))] - c_p p^u + \beta p^u\lambda(p^u)(1-\lambda'(p^u)).
\end{aligned}$$

The above expression is clearly negative if and only if

$$\beta - \frac{c_p p^u + \lambda(p^u)[\lambda(p^u) - p^u\lambda'(p^u))]}{p^u\lambda(p^u)(1-\lambda'(p^u))} < 0, \tag{38}$$

which is the condition in the proposition.

We now examine sufficient conditions for which the sign of (36) is negative or, equivalently, (38) holds. Consider first the case when $c_s \to 0$. The sign of (36) is equal to the sign of $c_s p^u - (p^u - \lambda(p^u))^2$ and because $p^u - \lambda(p^u) > 0$ for any $c_s$ and $c_p > 0$ (see FOC (12)), we conclude that when $c_s \to 0$ we necessarily have $p^a < p^u$.

Next, for $c_p = 0$ (or $c_p$ sufficiently small), and demand functions that do not satisfy Marshall's Second Law at $p = p^u$ (i.e., $\lambda(p^u) - p^u\lambda'(p^u)) < 0$), inequality (38) is never satisfied. This implies that $p^a > p^u$ for all $\beta$, as stated in the Proposition. Note however that if $c_p$ is sufficiently large, it is possible that with demands that do not satisfy Marshall's Second Law the above expression is negative, in which case $p^a < p^u$.

For $c_p = 0$ (or $c_p$ sufficiently small) and demand functions that satisfy Marshall's Second Law of demand, we make the following observations. First, the term $\frac{\lambda(p^u) - p^u\lambda'(p^u)}{p^u(1-\lambda'(p^u))}$ is strictly between 0 and 1 and decreases in $p^u$ if $\lambda''(p^u) \geq 0$. The later is because

$$\frac{\partial}{\partial p^u}\left(\frac{\lambda(p^u) - p^u\lambda'(p^u)}{p^u\,(1-\lambda'(p^u))}\right) = -\frac{(1-\lambda'(p^u))\,(\lambda(p^u) - p^u\lambda'(p^u)) + p^u(p^u - \lambda(p^u))\lambda''(p^u)}{p^{*2}\,(1-\lambda'(p^u))^2} < 0.$$

Because $p^u$ decreases in $\beta$, we can state that the equation

$$\beta - \frac{\lambda(p^u) - p^u\lambda'(p^u))}{p^u(1-\lambda'(p^u))} = 0$$

has a unique solution in $\beta$. Denoting this unique solution by $\overline{\beta}$, it is clear that (38) holds for any $\beta < \overline{\beta}$, as stated in the Proposition.

Finally, consider the sign of (36) in the neighborhood of $\beta = 1$ where we know $p = p^m = c_s + c_p + \lambda(p^m)$. In that case, the sign of (36) is equal to the sign of $c_s p^m - (p^m - \lambda(p^m))^2 = c_s p^m - (c_p + c_s)^2$. So, if $p^m > (c_p + c_s)^2/cs$, then the price under ad valorem commissions will be higher than the price under per-unit commissions. Because we know that $p^u > p^a$ in a neighborhood of $\beta = 0$, we conclude that the price functions $p^u(\beta)$ and $p^a(\beta)$ must cross at least once.

2. We first show that the platform prefers to use ad valorem commissions for any demand function and any level of rent-extraction. To do this, let us suppose that in the agency model with ad valorem commissions, rather than choosing its commission optimally, the platform chooses (sub-optimally) a commission $\tilde{t}$ so as to induce a final price equal to the price $p^*$ prevailing under the per-unit commissions model:

$$\tilde{t} = \frac{c_p + (1-\beta)\lambda(p^u)(1-\lambda'(p^u))}{p^u - \lambda(p^u)},$$

To obtain $\tilde{t}$, we use expression (12) that gives the final price in the per-unit commissions model $p^*$, which implies that $p^* - c_s - \lambda(p^*) = c_p + (1-\beta)\lambda(p^*)(1-\lambda'(p^*))$, and equation (9) that defines the final price in the agency model, which can be rewritten as $p - c_s - \lambda(p) = t(p - \lambda(p))$. To implement $p^*$, the platform then sets $\tilde{t}$ so that $c_p + (1-\beta)\lambda(p^*)(1-\lambda'(p^*)) = \tilde{t}(p^* - \lambda(p^*))$. Note also that we have $\tilde{t} < 1$ as $p^u - \lambda(p^u) = c_p + c_s + (1-\beta)\lambda(p^u)(1-\lambda'(p^u)) > c_p + (1-\beta)\lambda(p^u)(1-\lambda'(p^u))$ so that $p^u$ can be implemented by an interior commission.

Given this choice of commission, the entry fee that the platform would set equals $\tilde{F}^a = \beta(1-\tilde{t})\lambda(p^u)Q(p^u)$. As a result, the platform would obtain a profit equal to:

$$\begin{aligned}\pi_P^a(\tilde{t}, \tilde{F}^a) &= (\tilde{t}p^u - c_p)Q(p^u) + \beta(1-\tilde{t})\lambda(p^u)Q(p^u) \\ &= [\tilde{t}p^u - c_p + \beta(1-\tilde{t})\lambda(p^u)]Q(p^u) \\ &= \frac{\lambda(p^u)Q(p^u)}{p^u - \lambda(p^u)}[c_p(1-\beta) + (1-\beta)(1-\lambda'(p^u))(p^* - \beta\lambda(p^u)) + \beta(p^u - \lambda(p^u)],\end{aligned}$$

where the last equality follows from plugging $\tilde{t}$ and simplifying. We now show that this sub-optimal profit level is greater than the maximal profit the platform would make under the per-unit commissions model, which is equal to $\pi_U^P(p^u, F^*) = \lambda(p^u)Q(p^u)[1 - (1-\beta)\lambda'(p^u))]$ (see Lemma 5). In fact, $\pi_P^a(\tilde{t}, \tilde{F}) > \pi_U^P(p^u, F^*)$ if and only if

$$\frac{1}{p^u - \lambda(p^u)}[c_p(1-\beta) + (1-\beta)(1-\lambda'(p^u))(p^* - \beta\lambda(p^u)) + \beta(p^u - \lambda(p^u)] > 1 - (1-\beta)\lambda'(p^u)$$

This inequality holds if:

$$c_p(1-\beta) + (1-\beta)(1-\lambda'(p^u))(p^* - \beta\lambda(p^u)) + \beta(p^u - \lambda(p^u)] > (p^u - \lambda(p^u))[1 - (1-\beta)\lambda'(p^u)],$$

which can be simplified to

$$c_p(1-\beta) + (1-\beta)^2\lambda(p^u)(1-\lambda'(p^u)) > 0.$$

This inequality is always true. As a result, the platform always prefers the agency model with ad valorem commissions.

Regarding the seller's gross profits under the two intermediation models, recall that with per-unit commissions the seller makes a gross profit $\pi_U^S = (1-\beta)\lambda(p^u)Q(p^*)$, while with ad valorem commissions its profit is $\pi_S^a = (1-\beta)\frac{c_s}{p^a-\lambda(p^a)}\lambda(p^a)Q(p^a)$. It is straightforward to verify that $\lambda(p)Q(p)$ is decreasing in $p$. Because $c_s < p^a - \lambda(p^a)$, we can directly conclude that $\pi_W^S > \pi_A^S$ when $p^u > p^a$. ■

**Proof of Proposition 5.**

The optimal prices follow from the above analysis. Since the density $g$ is increasing (this is necessary for the SOCs to hold), $\mu$ is a decreasing function, hence equation (16) has a solution whenever $\mu(0) > (1-\lambda'(p^*))^{-1}$ or $g(0) < 1-\lambda'(p^*)$. ■

**Proof of Proposition 6.**

In an interior equilibrium, the FOCs (21) and (23) have to hold simultaneously. Inspection of (21) immediately reveals that it must be the case that $p^a > c_s + \lambda(p^a)$ for otherwise (21) would not hold. This ensures that $t^a \in (0,1)$. Solving the FOC (21) for $y$, we find that:

$$y = 1 - \frac{(p-\lambda(p))^2\,[p-c_p-c_s-\lambda(p)]}{c_s p\lambda(p)(1-\lambda'(p))}. \tag{39}$$

and plugging this expression for $y$ into (23) yields equation (25), whose solution is the equilibrium price $p^a$ in an interior equilibrium. Having obtained $p^a$, we can now obtain $y^a$ using (39). Because $y^a = F^a\frac{p-\lambda(p)}{c_s\lambda(p)Q(p)}$, solving for $F^a$ gives the expression for the equilibrium fixed fee as a function of price given in (24).

To obtain the condition under which $F^a > 0$, we use the FOC (23) and note that, because $\mu$ is a decreasing function, $F^a > 0$ if and only if

$$\mu(0) > \frac{p^a(p^a-c_s-c_p-\lambda(p^a)) + c_p\lambda(p^a))}{c_s\lambda(p^a)},$$

which is equivalent to:

$$g(0) < \frac{c_s\lambda(p^a)}{p^a(p^a-c_s-c_p-\lambda(p^a)) + c_p\lambda(p^a))}. \tag{40}$$

Hence, if (40) holds at the price $p^a$ that solves (25), then $F^a > 0$. However, if (40) does not hold, then the equilibrium is not interior and we have Case (B). In such a case, $F^a = 0$ and the final price follows from setting $y = 0$ in the FOC (21) and solving it for $p$. This gives equation (26), which characterizes the agency price in Johnson (2017). ■

**Proof of Proposition 7.**

In an interior equilibrium, the FOCs (30) and (31) have to hold simultaneously. Solving the FOC (21) for $y$ gives:

$$y = 1 - \frac{p - c_p - c_s - \lambda(p)}{\lambda(p)(1 - \lambda'(p))}. \tag{41}$$

and plugging this expression for $y$ into (31) yields equation (33), whose solution is the equilibrium price $p^u$ in an interior equilibrium. Having obtained $p^u$, we can now obtain $y$ using (41). Because $y = F^u \lambda(p^u) Q(p^u)$, solving for $F^u$ gives the expression for the equilibrium fixed fee as a function of price given in (32).

To obtain the condition under which $F^u > 0$, we use the FOC (31) and note that, because $\mu$ is a decreasing function, $F^u > 0$ if and only if

$$\mu(0) > \frac{p^u - c_s - c_p - \lambda(p^u)}{\lambda(p^u)},$$

which is equivalent to:

$$g(0) < \frac{\lambda(p^u)}{p^u - c_s - c_p - \lambda(p^u)}. \tag{42}$$

Hence, if (42) holds at the price $p^u$ that solves (33), then $F^u > 0$. However, if (42) does not hold, then the equilibrium is not interior and we have Case (B). In such a case, $F^u = 0$ and the final price follows from setting $y = 0$ in the FOC (30) and solving it for $p$. This gives equation (26), which characterizes the agency price in Johnson (2017). ■

**Proof that when demand satisfies Marshall's Second Law and $G$ is uniform, the platform does not charge entry fees in the agency model with ad valorem commissions.**

We show this by contradiction. Suppose a positive entry fee is charged in the agency model, in which case, using (24), it must hold that

$$\frac{c_s \lambda(p^a)}{p^a - \lambda(p^a)} > \frac{(p^a - \lambda(p^a))(p^a - c_p - c_s - \lambda(p^a))}{p^a\,(1 - \lambda'(p^a))}. \tag{43}$$

Since the final price $p^a$ must satisfy (25), using the fact that $\mu(x) = 1 - x$ for the uniform distribution and rearranging implies that the equilibrium price $p^a$ must satisfy:

$$p^a - c_s - c_p = \frac{2\lambda(p^a)(p^a - \lambda(p^a))}{p^a - 2\lambda(p^a) + p^a \lambda'(p^a)}, \tag{44}$$

which, naturally, implies that $p^a - 2\lambda(p^a) + p^a\lambda'(p^a) > 0$. Using (44) in (43) and simplifying gives:

$$\frac{c_s \lambda(p^a)}{p^a - \lambda(p^a)} > \frac{\lambda(p^a)(p^a - \lambda(p^a))}{p^a - 2\lambda(p^a) + p^a \lambda'(p^a)}.$$

This inequality holds whenever:

$$c_s \left[p^a - \lambda(p^a) - (\lambda(p^a) - p^a \lambda'(p^a))\right] > (p^a - \lambda(p^a))^2.$$

Because $c_s < p^a - \lambda(p^a)$, this inequality cannot hold for any demand function that satisfies Marshall's Second Law of demand. ■

**Proof of Proposition 8.**

The seller's entry probability under the wholesale model is given by $1 - G(y^*)$, where $y^*$ is the solution to equation (16). Likewise, the seller's entry probability under the agency model is given by $1 - G(y^a)$, where $y^a$ is given by the solution to equation (23). Hence, to compare the entry probabilities, it suffices to compare $y^*$ and $y^a$.

We first note that the RHS of (23) can be rewritten as

$$y + \frac{p(p - c_s - c_p - \lambda(p)) + c_p\lambda(p)}{c_s\lambda(p)}$$

and, as noted in Proposition 3, this expression increases in $p$.

Likewise, the RHS of (16) can be rewritten as

$$y + \frac{\lambda(p)}{p - c_s - c_p - \lambda(p)},$$

which decreases in $p$ if the demand function satisfies Marshall's Second Law.

Hence, $y^a < y^*$ (and so the seller's entry probability is higher under agency than under wholesale) if and only if:

$$\frac{p^a(p^a - c_s - c_p - \lambda(p^a)) + c_p\lambda(p^a)}{c_s\lambda(p^a)} > \frac{\lambda(p^*)}{p^* - c_s - c_p - \lambda(p^*)}. \tag{45}$$

Because $\frac{\lambda(p^a)}{p^a - c_s - c_p - \lambda(p^a)} > \frac{\lambda(p^*)}{p^* - c_s - c_p - \lambda(p^*)}$, for (45) to hold, it suffices that:

$$\frac{p^a(p^a - c_s - c_p - \lambda(p^a)) + c_p\lambda(p^a)}{c_s\lambda(p^a)} > \frac{\lambda(p^a)}{p^a - c_s - c_p - \lambda(p^a)}.$$

Or:

$$p^a(p^a - c_s - c_p - \lambda(p^a))^2 + c_p\lambda(p^a)(p^a - c_s - c_p - \lambda(p^a)) - c_s\lambda(p^a)^2 > 0,$$

which can be rewritten as:

$$(p^a - c_s - c_p)\left[(p^a - \lambda(p^a))^2 - c_p(p^a - \lambda(p^a)) - c_s p^a\right] > 0.$$

Hence, the condition we need is simply:

$$(p^a - \lambda(p^a))^2 - c_p(p^a - \lambda(p^a)) - c_s p^a > 0,$$

which can be rewritten as

$$p^a - c_p - \frac{p^a c_s}{p - \lambda(p^a)} > \lambda(p^a), \tag{46}$$

which is the first condition in the proposition. The FOC (21) implies that:

$$p^a - c_p - \lambda(p^a) = c_s + c_s(1-y)\frac{p^a\lambda(p^a)(1-\lambda'(p^a))}{(p^a-\lambda(p^a))^2}.$$

Using this to rewrite condition (46) gives:

$$c_s - \frac{p^a c_s}{p-\lambda(p^a)} + c_s(1-y)\frac{p^a\lambda(p^a)(1-\lambda'(p^a))}{(p^a-\lambda(p^a))^2} = -\frac{\lambda(p^a)c_s}{p^a-\lambda(p^a)} + c_s(1-y)\frac{p^a\lambda(p^a)(1-\lambda'(p^a))}{(p^a-\lambda(p^a))^2} > 0.$$

Multiplying by $(p^a - \lambda(p^a))^2$ and dividing by $\lambda(p^a)c_s$, condition (46) becomes

$$-(p^a - \lambda(p^a)) + (1-y^a)p^a(1-\lambda'(p^a)) > 0,$$

which is equivalent to

$$y^a < \frac{\lambda(p^a) - p^a\lambda'(p^a)}{p^a(1-\lambda'(p^a))},$$

which is the second condition in the proposition.

Because $p^a < p^*$ and $y^a < y^*$, consumer surplus is higher under the agency model. Moreover, from Proposition 2 it follows that, conditional on seller's entry, platform's profits are higher and seller's gross profits lower. On aggregate, because $p^a < p^*$, welfare is higher conditional on seller's entry. The proof is now complete. ■

**Proof of Proposition 9.**

To prove this result, we first observe that the FOC (21) defines implicitly a decreasing relationship $p_1(y)$. Likewise, the FOC (22) defines implicitly a decreasing relationship $p_2(y)$. The optimal $(p^a, y^a)$ is then given by the crossing point between $p_1(y)$ and $p_2(y)$.

Now, we evaluate the FOCs of the problem with ad valorem commissions (21) and (22) at the optimal solution with per-unit commissions. This gives:

$$\left.\frac{\partial \Pi^a}{\partial p}\right|_{p=p^u;y=y^u} = -Q'(p^u)(1-y^u)\lambda(p^u)(1-\lambda'(p^u))\left(\frac{c_s p^u}{(p^u-\lambda(p^u))^2} - 1\right)$$
$$\left.\frac{\partial \Pi^a}{\partial y}\right|_{p=p^u;y=y^u} = Q(p^u)\lambda(p^u)\left[g(y^u)(1-y^u) + (1-G(y^u)\right]\left(\frac{c_s}{p^u-\lambda(p^u)} - 1\right)$$

As discussed in the proof of Proposition 4, the first derivative may be positive or negative, depending on parameters, while the second derivative is clearly negative.

For the optima to satisfy $p^u < p^a$ and $y^u < y^a$, both these derivatives must be positive, which is impossible because the second one is negative. This implies that the agency model with per-unit commissions never dominates the agency model with ad valorem commissions both in terms of price and entry probability. By contrast, for the optima to satisfy $p^a < p^u$ and $y^a < y^u$ both derivatives must be negative. This is certainly possible for the case in which demand satisfies Marshall's Second Law and the implied share of the seller's profit extracted by the entry fee in the per-unit commissions model is small, as per Proposition 4. In such a case, it is possible that the agency model with ad valorem commissions dominates the agency model with per-unit commissions on both price and entry probability. Finally, when the implied share of the seller's profit extracted by the entry fee $y^u$ is large, the first derivative will be positive, in which case the agency model with ad valorem commissions will only dominate the agency model with ad valorem commissions in terms of entry probability. ■

**Proof that when $G$ is uniform, the platform charges entry fees in the agency model with per-unit commissions.**

For $F^u > 0$, we must have:

$$\lambda(p^u)\,(1-\lambda'(p^u)) > p^u - c_p - c_s - \lambda(p^u). \tag{47}$$

Since $p^u$ must satisfy (33), using $\mu(x) = 1 - x$, it must be the case that:

$$\frac{p^u - c_p - c_s - \lambda(p^u)}{\lambda(p^u)\,(1-\lambda'(p^u))} - \frac{\lambda(p^u) - (p^u - c_p - c_s)\,\lambda'(p^u)}{\lambda(p^u)\,(1-\lambda'(p^u))} = 0.$$

Simplifying gives the relation:

$$p^u - c_p - c_s - \lambda(p^u) = \lambda(p^u) - (p^u - c_p - c_s)\,\lambda'(p^u)$$

Substituting this into the inequality (47) gives:

$$\lambda(p^u)\,(1-\lambda'(p^u)) > \lambda(p^u) - (p^u - c_p - c_s)\,\lambda'(p^u),$$

which can be simplified to:

$$\lambda'(p^u)\,(p^u - c_p - c_s - \lambda(p^u)) > 0.$$

For log-concave demands this inequality is true because $\lambda'(p) < 0$ for all $p$ and, since $p^u > p^m$, $p^u - c_p - c_s - \lambda(p^u) < 0$. ■

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