Agency Pricing and Bargaining: Evidence from the E-Book Market*

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Abstract

This paper examines the pricing implications of two types of vertical contracts under bargaining: wholesale contracts, where downstream firms set retail prices after negotiating wholesale prices, and agency contracts, where upstream firms set retail prices after negotiating sales royalties. We show that agency contracts can lead to higher or lower retail prices than wholesale contracts depending on the distribution of bargaining power. We propose a methodology to structurally estimate a model with either contract form under Nash-in-Nash bargaining. We apply our model to the e-book industry, which transitioned from wholesale to agency contracts after the expiration of a ban on agency contracting imposed in the antitrust settlement between U.S. Department of Justice and the major publishers. Using a unique dataset of e-book prices, we show that the transition to agency contracting increased Amazon prices substantially but had little effect on Barnes & Noble prices. We find that the assumption of Nash-in-Nash bargaining explains the data better than an assumption of take-it-or-leave-it input contracts. Counterfactual simulations indicate that reinstitution of most favored nation clauses, which were banned for five years in the 2012 settlement, would raise the prices of non-fiction books by nearly nine percent.

Keywords: e-books, agency agreements, vertical restraints, bargaining, most favored nation clause
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1 Introduction

In many retail markets, the distribution arrangement involves suppliers charging retailers wholesale prices and retailers setting final prices to consumers (the "wholesale" model). The wholesale model has been extensively-studied in the literature and forms the foundation for much of the economics of vertical contracting, particularly that which informs antitrust policy.[1] Another distribution arrangement that has received much less attention involves agency relationships where suppliers pay retailers sales royalties to distribute products at prices determined by suppliers (the "agency" model).[2] Agency arrangements are used in some conventional markets (e.g., newspapers sold at kiosks, insurance sold by independent agents), but they are especially prevalent in online markets.[3]

Agency arrangements raise interesting questions for both price theory and policy. Key questions include how the choice of pricing institution affects prices and profits. In a recent antitrust case, the Department of Justice (DOJ) alleged that Apple and major book publishers engineered a shift from wholesale to agency pricing in the market for e-books, and that this shift, in combination with most-favored nation ("MFN") clauses, raised the prices of e-books. Empirical evidence (De los Santos and Wildenbeest, 2017) confirms the price increase. A natural question is whether the price increase was caused by the shift to the agency model, the MFN clause, or both.

Recent theoretical literature has begun to address this question, but the literature to date has a significant gap: it abstracts from bargaining, which is an important feature of many intermediate markets, including the e-book market. Johnson (2017) compares the wholesale and agency models under the assumption that input terms are established through take-it or leave-it offers by the bargaining entity that is not responsible for setting the downstream price.[4] Under a reasonably weak condition on demand, he finds that the agency model generates lower retail prices than the wholesale model. But suppose that instead of having the non price-setting firm making take-it or leave-it offers, the downstream buyer makes the offers instead. In the wholesale model, the buyer would set the wholesale price equal to upstream marginal cost and thereby eliminate double marginalization. In the agency model, by contrast, the buyer would set the royalty looking ahead

[1]For example, the wholesale model forms the basis for most of the discussion of antitrust treatment of vertical integration and restraints in leading industrial organization textbooks (e.g., Carlton and Perloff (2004)).

[2]Johnson (2017) distinguishes two other pricing arrangements: the "franchise" model, where the suppliers collect sales royalties from retailers that set the retailer price, and the "consignment" model, where suppliers charge a wholesale price and also control retail prices. Our focus in this paper is on the wholesale and agency models.

[3]For example, third-party sellers on Amazon Marketplace (the "upstream" firms) set the retail price for their products, while Amazon (the "downstream" firm) receives a percentage of the revenue. Other examples include eBay Buy It Now and the Apple App Store.

[4]If the entity with all bargaining power also controls retail prices then it can achieve the vertical integrated outcome. Hence, take-it or leave-it offers in this context are assumed to be made by the entity without control of retail prices.

to the impact on the upstream firm's pricing decision, and this would generally lead to a degree of double marginalization.[5] Thus, the comparison between wholesale and agency arrangements is sensitive to the distribution of bargaining power. Yet, the theoretical literature on agency pricing (Gans, 2012; Gaudin and White, 2014; Abhishek, Jerath, and Zhang, 2015; Foros, Kind, and Shaffer, 2017; Condorelli, Galeotti, and Skreta, 2018; Johnson, 2018) abstracts from bargaining. The literature on the wholesale model, in contrast, has focused extensively on bargaining and considers it to be a fundamental economic factor determining outcomes in many situations.[6]

In this paper we examine the relationship between agency contracts and retail prices when intermediate pricing terms are determined through bargaining, and we propose and estimate a structural model that allows examining both arrangements empirically. We begin in Section 2 by extending the bilateral monopoly models of wholesale and agency pricing in Johnson (2017) to allow for bargaining between the supplier and retailer. We show that agency contracts can lead to higher or lower retail prices depending upon the relative bargaining powers of the upstream and downstream firms. When the upstream firm has high bargaining power, the wholesale price is relatively high in the wholesale model but the royalty paid to the retailer is relatively low in the agency model. In the wholesale model, retailers pass the high input price on to consumers in the form of higher retail price. In the agency model, by contrast, low royalties give the supplier a larger share of the retail price and reduce double marginalization, leading to a lower price than in the wholesale case. The opposite is true when the downstream firm has high bargaining power. In this case, a low wholesale price in the wholesale model reduces double marginalization and leads to a low retail price, while a high royalty paid to the retailer in the agency model causes significant double marginalization and a high retail price. In summary, the retail price tends to be lower in either arrangement when the firm with high bargaining power also determines the retail price, as the price-setting firm has an incentive to establish input terms that mitigate double marginalization. This relationship between bargaining power and retail prices in the wholesale and agency models plays an important role in the identification strategy in our empirical model, as we explain in more detail below.

In Section 3 we adapt the theoretical model to make it more amendable to estimation by allowing for multi-product firms and multiple suppliers and retailers. We use a nested logit demand structure to capture the possibility that consumers may be more likely to substitute among com-

[5] A form of double marginalization arises in the agency model unless the upstream firm has zero marginal cost.

[6] Examples include Horn and Wolinsky (1988) [mergers]; Dobson and Waterson (1997) [countevailing power], O'Brien and Shaffer (2005) [mergers], O'Brien (2014) [price discrimination], Crawford, Lee, Whinston, and Yurukoglu (2018) [vertical integration], and Ho and Lee (2019) [hospital and health insurance pricing.]

peting products within the same retailer than across retailers. We also allow for competition among both upstream firms and downstream firms. Following recent literature, we use the "Nash-in-Nash" solution to model bargaining.[7] In this framework each pair of firms reaches an asymmetric Nash bargaining solution while taking the terms negotiated by other pairs as given. We extend this literature, which has focused on wholesale pricing contracts, to allow for agency contracts between upstream and downstream firms. Moreover, when deriving the bargaining equilibrium for both types of vertical contracts, we let firms take into account retail price reactions to input prices.

We apply our model to the e-book industry. This industry is uniquely suited to study the effects of bargaining under wholesale and agency contracts because the industry has experienced various transitions between these vertical contracts since the introduction of the Kindle e-reader in 2007. In Section 4 we describe the changes in contracts between publishers and book retailers in the e-book industry and how these changes affected retail prices. E-books, similar to printed books, were initially sold using the wholesale model. In this period, Amazon pursued a low price strategy for e-books (e.g. \$9.99 for e-books new releases). As De los Santos and Wildenbeest (2017) document, publishers were against this pricing arrangement because they believed that it cannibalized profitable hardcover sales, eroded consumer perceptions of the value of a book, and would eventually lead to lower wholesale prices.[8]

With the introduction of the iPad in 2010, major publishers negotiated agency contracts with Apple to offer e-books for sale in Apple's new iBookstore. The terms of the agency contracts with Apple, particularly the MFN clause that required publishers to match lower retail prices at other retailers, prompted five of the six major publishers (the "Big Six") to compel the adoption of agency contracts on Amazon. The industry adoption of agency contracts and the MFN led to higher prices for e-books. In 2012 the Department of Justice sued Apple and five of the Big Six publishers for conspiring to raise e-book prices. All five publishers that were sued settled the lawsuit and agreed to a two-year ban on publisher-set prices, which effectively meant a return to traditional wholesale

[7]The "Nash-in-Nash" solution concept was first applied in the wholesale model by Horn and Wolinsky (1988) to study mergers and by Davidson (1988) to study multi-unit bargaining in labor markets (neither set of authors used the term "Nash-in-Nash," which appears to have arisen in the folklore). O'Brien (1989, 2014) provides non-cooperative foundations for this solution concept based on an extension of Rubinstein's (1982) bargaining model to environments with upstream monopoly, downstream oligopoly, and linear input pricing. The extension to the case of multiple upstream firms is straightforward. Collard-Wexler, Gowrisankaran, and Lee (2019) provide a non-cooperative foundation for the Nash-in-Nash solution concept for bargaining that is over fixed transfers that do not affect downstream firms' pricing decisions. Our model is different because we allow wholesale prices and sales royalties to affect downstream pricing decisions. Empirical papers that use some variant of the Nash-in-Nash solution to study the wholesale model include Draganska, Klapper, and Villas-Boas (2010), Crawford and Yurukoglu (2012), Grennan (2013), Gowrisankaran, Nevo, and Town (2015), Crawford, Lee, Whinston, and Yurukoglu (2018), Ho and Lee (2019).

[8]Related work by Li (2015) estimates a structural model where consumers choose how many books to buy, their format, and platform. The study finds that about half of e-book sales come from cannibalization of print book sales. Reimers and Waldfogel (2017) find that e-books are priced below *static* profit maximizing levels.

contracts. De los Santos and Wildenbeest (2017) analyze the transition from agency to wholesale contracts following the ban and find that retail prices decreased by 18 percent at Amazon and 8 percent at Barnes & Noble as a result.

The expiration of the two-year ban on agency pricing meant that, by the end of 2014, publishers could again negotiate agency contracts to control retail prices directly. Bargaining between publishers and retailers played an important role in the renegotiation of existing contracts. In Section 4 we describe some aspects of the bargaining dispute between Amazon and Hachette, which included inventory reductions and price increases for Hachette titles. These negotiations took over six months, were extensively covered by the media, and they involved public pressure by some of Hachette's bestselling authors. Despite the lengthy bargaining period, by the end of 2015, all of the major publishers had returned to agency contracts with publisher-set prices. In Section 4 we also investigate the effect on retail prices following this latest shift towards agency contracts. We exploit the variation in the timing of the implementation of the new agency contracts to estimate the change in retail prices resulting from the switch to the new agency arrangements using a difference-in-differences approach. Our findings indicate that, on average, Amazon prices increased 16 percent and Barnes & Noble prices decreased 1.5 percent. The estimates also show substantial heterogeneity in price effects across publishers. These findings are difficult to explain using take-it or leave-it contracting models, but they are consistent with a bargaining model in which publishers have different bargaining weights.[9]

In Section 5 we discuss how to structurally estimate the empirical model developed in Section 3 in light of the industry transitions discussed in Section 4, and we present demand- and supply-side estimates of the model. The extent to which prices change following a shift to agency contracts is related to the relative bargaining power of the firms involved. To fully exploit this mechanism for identification and estimation, we use data from both before and after the latest switch to agency pricing. The estimation consists of two stages. In the first stage we estimate the demand side using price and sales rank data. Because demand estimation does not depend on the type of vertical contract, we combine data from both periods to estimate the demand parameters. In the second stage we estimate the supply side taking the demand-side estimates as given. The nested logit demand structure allows us to account for customer lock-in to a particular e-book reader platform

[9] An important difference between the analysis in this paper and that in De los Santos and Wildenbeest (2017) is that we study transitions between the wholesale and agency model in the absence of an alleged conspiracy, whereas De los Santos and Wildenbeest analyze transitions that resulted from an alleged conspiracy involving Apple and competing publishers. In addition, MFN clauses were not used during the period we study, allowing us to isolate the effect of agency pricing from the effect of the MFN. This is important, as the theoretical results of Johnson (2017) indicate that the MFN would have had a positive effect on prices.

(e.g., Amazon's Kindle device or Barnes & Noble's Nook), which makes consumers more likely to substitute between books within a platform than across platforms.

The objective of the supply-side estimation is to determine the bargaining parameter and agency royalty parameter for each publisher-retailer pair as well as the parameters of the marginal cost equation. Although the supply model varies between wholesale and agency contracts, we assume the bargaining parameters do not change when switching. Specifically, for a given set of agency royalty parameters, we can use the pricing and bargaining first-order conditions in the agency model to solve for the bargaining parameters. We can then use these bargaining parameters, estimated under the agency model, to derive the margins of the upstream firms in the wholesale period. As the margins for the upstream and downstream firms are functions of royalties and wholesale prices, we use them to obtain an estimate of marginal costs. The estimation procedure selects marginal cost parameters and bargaining parameters that maximizes the fit of the upstream marginal cost equation defined by relating the marginal cost estimate obtained in the previous step to marginal cost observables.

The estimates indicate that demand is relatively elastic. The price coefficient for the nested logit specification implies a median own-price elasticity of -2.7. The supply-side estimates suggest that, on average, bargaining power is roughly equally distributed between publishers and retailers. However, there are substantial differences in bargaining parameters between different retailer-publisher pairs. The estimates imply an agency royalty of 30.7 percent on average, which is near the thirty percent royalty that was common during the first agency period.

We compare the fit of the bargaining model to an alternative model with take-it or leave-it offers by the party that does not control retail prices. That is, we estimate a model in which retailers make take-it or leave-it royalty offers to publishers in the agency arrangement, and publishers make take-it or leave-it wholesale price offers to retailers in the wholesale arrangement. We find that the bargaining model gives a better fit to the data than the take-it or leave-it specification.

In Section 6 we discuss the results of a counterfactual analysis where we use the estimates of the bargaining model to simulate the effect of MFN clauses on retail prices. MFN clauses in this context are price-parity restrictions that guarantee that the same title is sold at the same price everywhere, as in the contracts used during the first agency period in the e-book industry. The settlements between the DOJ and publishers banned the use of MFN clauses for a period of five years, as they were considered to have played a crucial role in the alleged conspiracy. The role of MFN has been explored theoretically by Johnson (2017), who finds that it tends to raise retail prices. In line with this theoretical finding, our counterfactual simulations indicate that prices would increase an additional three percent, on average, if MFN clauses were added to the agency contracts, with higher price increases for non-fiction books than for fiction books.

2 Vertical Bargaining Model

In this section we extend the bilateral monopoly models of wholesale and agency pricing in Johnson (2017) to allow for bargaining over input terms. Suppose there are two firms, an upstream firm U and a downstream firm D, that produce and sell a product to consumers at retail price p. Consumer demand is given by a continuously differentiable and strictly decreasing function $Q(p)$. Marginal cost is $c^U > 0$ for the upstream firm and $c^D > 0$ for the downstream firm. We consider two pricing structures, a wholesale arrangement and an agency arrangement. In the wholesale arrangement, firms first agree to a per-unit wholesale price to be paid by the downstream firm to the upstream firm when units of the product are sold, and then the downstream firm sets the retail price. In the agency model, firms first agree to an ad valorem (percent of price) royalty to be paid by the upstream firm to the downstream firm when units are sold, and then the upstream firm sets the retail price.

2.1 Wholesale Pricing

In the wholesale model, upstream and downstream profits are

$$\pi^U = (w - c^U)Q(p) \text{ and } \pi^D = (p - w - c^D)Q(p).$$

Given the wholesale price w, the downstream firm choose a price p to maximize its profits. The first-order condition is

$$p - w - c^D = \phi(p), \tag{1}$$

where

$$\phi(p) = -\frac{Q(p)}{Q'(p)}$$

is a measure of the sensitivity of demand to price. As in Johnson (2017), we assume that $\phi(p)$ and $\phi(p)(2 - \phi'(p))$ have slopes strictly less than 1.[10]

The wholesale price w is determined through asymmetric Nash bargaining (Nash, 1950) between

[10] As is well-known (Bagnoli and Bergstrom, 2005; Weyl and Fabinger, 2013), the sign of $\phi'(p)$ determines whether the demand function is log-concave ($\phi'(p) < 0$), log-convex ($\phi'(p) > 0$), or log-linear ($\phi'(p) = 0$). The assumption $\pi'(p) < 1$ ensures that the pass-through rate is positive. The assumption that $\phi(p)(2 - \phi'(p))$ has slope less than 1 implies a unique solution to the pricing problem in the case where the upstream firm has all the bargaining power.

the upstream and downstream firm. Let $p^*(w)$ solve (1). Assuming zero disagreement payoff, the Nash product is

$$\Omega = (\pi^U)^\lambda (\pi^D)^{1-\lambda},$$

where the profit functions are evaluated at $(w, p^*(w))$ and $\lambda \in [0,1]$ is the a bargaining parameter identified with the upstream firm's bargaining weight. This weight is 0 if the downstream firm has all the bargaining power and 1 if the upstream firm has all the bargaining power (which corresponds to the take-it-or-leave-it case). If $\lambda = 0.5$ then the bargaining power is evenly distributed between the upstream and downstream firms.

The bargaining solution is found by maximizing the Nash product. The first order condition is

$$\lambda \pi^D \pi^{U'} + (1-\lambda)\, \pi^U \pi^{D'} = 0, \tag{2}$$

where primes ordinarily indicate derivatives with respect to w. However, because $p^*(w)$ is monotonically increasing in w, it is possible to use the first order condition (1) to eliminate w from the profit functions and express the Nash product as a function of the retail price p (as Johnson (2017) observed for the take-it or leave-it case). It is then possible (and simpler) to characterize the bargaining solution by maximizing the Nash product with respect to the retail price p. To this end, we substitute equation (1) into the profit functions to express profits in terms of the retail price: $\pi^U = (p - \phi(p) - c^U - c^D)Q(p)$ and $\pi^D = \phi(p)Q(p)$. Substituting these expressions and their derivatives into equation (2) gives

$$\begin{aligned} &\lambda\phi(p)Q(p)\left[(1-\phi'(p))Q(p) + (p - \phi(p) - c^U - c^D)Q'(p)\right] \\ &+ (1-\lambda)\,(p - \phi(p) - c^U - c^D)Q(p)\left[\phi'(p)Q(p) + \phi(p)Q'(p)\right] = 0. \end{aligned} \tag{3}$$

Dividing both sides of equation (3) by $Q'(p)$ and rearranging gives an expression for the markup as a function of $\phi(p)$, $\phi'(p)$, and λ:

$$p - c^U - c^D = \phi(p)\left(\frac{\lambda + 1 - \phi'(p)}{\lambda + (1-\lambda)(1-\phi'(p))}\right). \tag{4}$$

2.2 Agency Pricing

In the agency model, upstream and downstream profits are

$$\pi^U = \left((1-r)p - c^U\right) Q(p) \text{ and } \pi^D = (rp - c^D)Q(p).^{11} \tag{5}$$

Given the royalty r, the upstream firm chooses p to maximize its profits. The first order condition is

$$(1-r)p - c^U = (1-r)\phi(p). \tag{6}$$

We can rewrite the first-order condition for price in equation (6) as

$$r = 1 - \frac{c^U}{p - \phi(p)}. \tag{7}$$

It is again helpful to substitute the first order condition (7) into the profits in (5) to express profits in terms of the retail price. After some algebra, this gives an upstream profit of

$$\pi^U = \frac{c^U}{p - \phi(p)} \phi(p) Q(p). \tag{8}$$

Downstream profit can be written as the difference between joint profit and upstream profit:

$$\begin{aligned} \pi^D &= \left(p - c^U - c^D\right) Q(p) - \pi^U \\ &= \left(p - c^U - c^D\right) Q(p) - \frac{c^U}{p - \phi(p)} \phi(p) Q(p). \end{aligned} \tag{9}$$

The derivative of the upstream profit (8) with respect to p is

$$\pi^{U\prime} = \frac{c^U \left[\phi'(p)Q(p) + \phi(p)Q'(p)\right] (p - \phi(p)) - c^U \phi(p) Q(p)(1 - \phi'(p))}{(p - \phi(p))^2}, \tag{10}$$

and the derivative of the downstream profit (9) is

$$\pi^{D\prime} = Q(p) + (p - c^U - c^D)Q'(p) - \pi^{U\prime}. \tag{11}$$

Substituting the expressions in (8), (9), (10), and (11) into the bargaining first-order condition

[11] For brevity we use π^U and π^D to indicate profits in both regimes and will be clear whenever it might cause confusion.

in (2) gives

$$\lambda\left[\left(p-\phi(p)\frac{c^U}{p-\phi(p)}-c^U-c^D\right)Q(p)\right]\pi^{U\prime}+(1-\lambda)\left(\frac{c^U}{p-\phi(p)}\phi(p)Q(p)\right) \times\left[Q(p)+(p-c^U-c^D)Q'(p)-\pi^{U\prime}\right]=0. \tag{12}$$

Observe that

$$\pi^{U\prime}/Q'(p)=\phi(p)\left[c^U\frac{p(1-\phi'(p))}{(p-\phi(p))^2}\right].$$

Dividing both sides of the bargaining first-order condition (12) by $Q'(p)$ and rearranging expresses the markup in the agency model as a function of $\phi(p)$, $\phi'(p)$, and λ:

$$p-c^U-c^D=\phi(p)\left(\frac{(1-\lambda)(p-\phi(p))^2+c^U p(1-\phi'(p))}{(p-\phi(p))\big(p(1-\lambda\phi'(p))-\phi(p)(1-\lambda)\big)}\right). \tag{13}$$

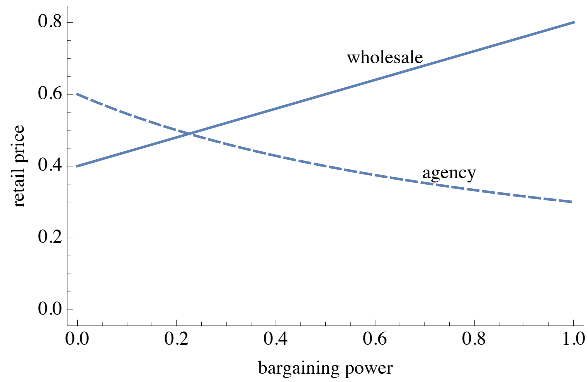
2.3 Comparison of Vertical Contracts

Proposition 1 shows that whether prices are higher or lower under agency in comparison to wholesale pricing depends on the relative bargaining power of the two firms.

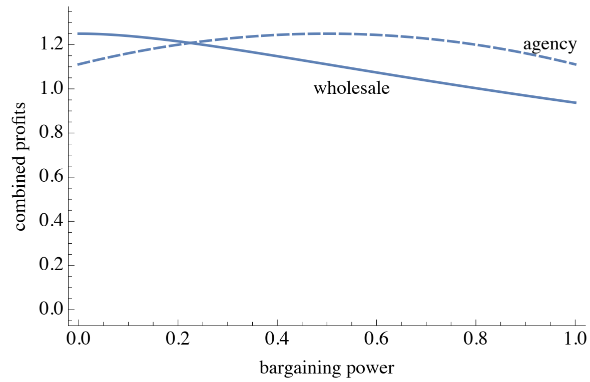
Proposition 1 *There exist critical bargaining parameters $\lambda^* \in (0,1)$ and $\lambda^{**} \in [\lambda^*, 1)$ such that if the upstream firm's bargaining weight exceeds λ^{**}, the equilibrium retail price is higher under wholesale pricing than under agency pricing, and if the upstream firm's bargaining weight is less than λ^*, the opposite is true.*

The proof of Proposition 1 is in Appendix A. To illustrate this proposition, Figure 1 shows optimal retail prices and combined profits when demand has the constant-elasticity form $Q(p)=p^{-1/\kappa}$. In this case, the equilibrium price in the wholesale model is $p^w=(c^U+c^D)(1+\sigma(\lambda-1))/(\kappa-1)^2$, and the equilibrium price in the agency model is $p^a=2(c^U+c^D(1-\kappa))/((1-\kappa)\cdot(1+\kappa(\lambda-1)))$.

In Figure 1(a) we set $\kappa=0.5$ and $c^U=c^D=0.1$ and plot the equilibrium price as a function of the bargaining power parameter λ. Retail prices are increasing in λ in the wholesale model—the more bargaining power the upstream firm has, the higher the negotiated wholesale price, with higher retail prices as a result. On the other hand, retail prices are decreasing in λ in the agency model as a better bargaining position for the upstream firm leads to lower royalties, which in turn reduces the double marginalization problem and leads to lower prices. Figure 1(a) also illustrates that whether retail prices are higher or lower under agency depends on the exact value of the bargaining parameter. In this example prices are higher under agency than under wholesale for



(a) Retail price

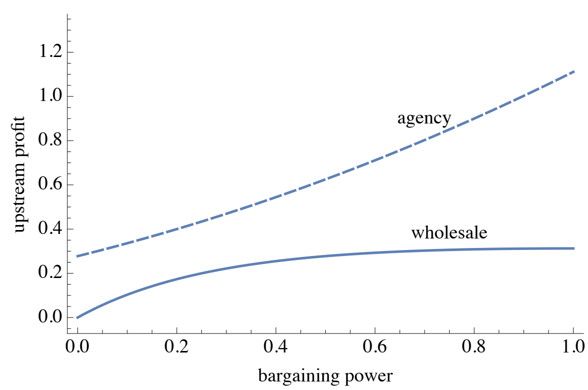


(b) Combined profits

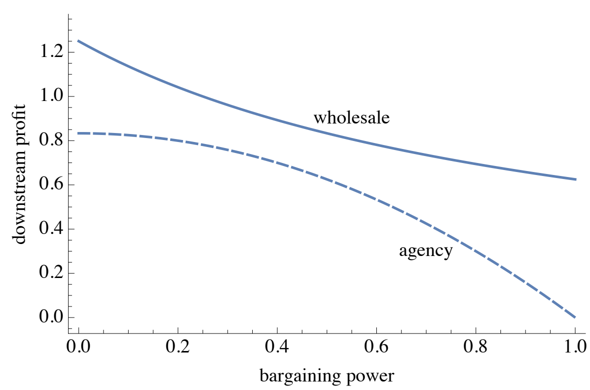
Figure 1: Retail prices and combined profit as a function of bargaining power

bargaining power parameters that are less than 0.23 and lower otherwise. Also note that in the case of take-it-or-leave-it offers, which corresponds to $\lambda = 1$ for the wholesale model and $\lambda = 0$ for the agency model, prices under wholesale are higher than prices under agency.[12]

Figure 1(b) shows the combined profits of the upstream and downstream firm as a function of the bargaining power parameter for each of the two models. For this particular example, the joint firm profits are maximized under the agency model when the firms share equal bargaining power. However, under the wholesale model joint profits are maximized when the downstream firm has all the bargaining power. The latter happens because when the downstream firm has all the bargaining power, it will demand a wholesale price that equals the marginal cost of the upstream firm, which completely eliminates the double marginalization problem and maximizes joint firm profits.



(a) Upstream profits



(b) Downstream profits

Figure 2: Upstream and downstream profits as a function of bargaining power

[12]This result is consistent with the conditions of Lemma 2 of Johnson (2017) for lower retail prices under the agency model compared to the wholesale model.

Figure 2(a) compares the upstream firm's profit under the two types of vertical contracts for the same demand parameters, whereas 2(b) makes the same comparison for the downstream firm. For a given value of the bargaining power parameter, the upstream firm always prefers agency pricing whereas the downstream firm prefers wholesale pricing. The opposite is true when firms use take-it-or-leave-it offers in which the party that does not control retail prices has all bilateral bargaining power, i.e., $\lambda = 1$ under wholesale pricing and $\lambda = 0$ under agency pricing. It follows that with take-it-or-leave-it offers, transitioning to agency means higher profits for the downstream firm and lower profits for the upstream firm (see also Proposition 3 of Johnson, 2017).

3 Empirical Strategy

To make the model amendable for estimation, we extend the model to allow for multiple upstream and downstream firms, as well as multi-product firms. In addition, we model consumer demand using a nested logit discrete choice framework. In this section, we derive the equilibrium conditions of the model.

3.1 Demand

We consider an industry with multiple upstream suppliers where each produces one or more goods and sells a set of these goods non-exclusively through multiple downstream retailers. Upstream producers can sell the same good through different retailers and retailers can sell goods of different suppliers. We define a product as a good-retailer pair. That is, a product is a specific good sold by a specific retailer. This means that product j sold by one retailer may be the same good as product k sold by another retailer. The idea is that different good-retailer pairs (different products) represent different points in product space. The utility consumer i derives from product j is given by

$$u_{ij} = \alpha p_j + x_j'\beta + \xi_j + \bar{\varepsilon}_{ij}, \tag{14}$$

where p_j is the price of product j, x_j and ξ_j are observed and unobserved characteristics of product j, α and β are demand parameters, and $\bar{\varepsilon}_{ij}$ is a consumer-product specific utility shock. We allow for an outside option with utility $u_{i0} = \bar{\varepsilon}_{ij}$. To allow for correlation between utility shocks of related products, we assume the utility shock is distributed as in the nested logit model. Specifically, we assume that each product belongs to a mutually exclusive group $g = 0, \ldots, G$. The utility shock can then be written as

$$\bar{\varepsilon}_{ij} = \zeta_g + (1 - \sigma)\varepsilon_{ij},$$

where ε_{ij} is extreme value distributed, σ is a nesting parameter, and ζ_g is distributed such that $\bar{\varepsilon}_{ij}$ is extreme value distributed as well. Note that when $\sigma = 0$, within-group correlation is zero, and the model is equivalent to a conditional logit model.

Letting $\delta_j = \alpha p_j + x_j'\beta + \xi_j$, the within-group market share of product j is

$$s_{j|g} = \frac{\exp[\delta_j/(1-\sigma)]}{D_g},$$

where $D_g = \sum_{j \in \mathcal{J}_g} \exp[\delta_j/(1-\sigma)]$ and $\mathcal{J}_g$ is the set of products in group g. The probability of buying a product from group g is

$$s_g = \frac{D_g^{(1-\sigma)}}{\sum_g D_g^{(1-\sigma)}}.$$

The market share of product j is then $s_j = s_{j|g} s_g$, or

$$s_j = \frac{\exp[\delta_j/(1-\sigma)]}{D_g^{\sigma}\left[\sum_g D_g^{(1-\sigma)}\right]}.$$

Group 0 represents the outside option; its market share is given by

$$s_0 = \frac{1}{\sum_g D_g^{(1-\sigma)}}.$$

3.2 Wholesale Model

We model wholesale and retail pricing as a two stage game. In stage one, the supplier and retailer of each product j agree to a wholesale contract in which the retailer pays the supplier a wholesale price w_j for product j.[13] All contracts are determined simultaneously in stage one. In stage two, retailers simultaneously choose retail prices given the wholesale terms established in stage one.

Normalizing the size of the market to one, the downstream variable profit from selling product

[13] The actual wholesale contracts that were used for e-books in the period 2012-2014 are typically called agency contracts because the retailer keeps a fraction r_j of the recommended price ρ_j for every product sold and the supplier receives the remainder. However, during this period, the retailer was free to set a discount, which means that these contracts are equivalent to wholesale agreements. To see this, observe that variable profit of the retailer from selling product j is

$$\begin{aligned} \pi_j^D(p) &= \left(r_j\rho_j - (\rho_j - p_j) - c_j^D\right) s_j(p) \\ &= \left(p_j - (1-r_j)\rho_j - c_j^D\right) s_j(p), \end{aligned}$$

where $\rho_j - p_j$ reflects the discount the retailer may set. Note that the term $(1-r_j)\rho_j$ is effectively a per-product wholesale price w_j paid to the supplier, which is the notation we use in this section.

j is given by

$$\pi_j^D(p) = \left(p_j - w_j - c_j^D\right) s_j(p), \tag{15}$$

where p_j is the price of product j, w_j is the wholesale price, and c_j^D is the retailer's marginal cost of product j. The upstream variable profit from selling j is

$$\pi_j^U(p) = \left(w_j - c_j^U\right) s_j(p), \tag{16}$$

where c_j^U is the upstream supplier's marginal cost of product j. The variable joint profit of the supplier and retailer associated with product j is $\pi_j^J = (p_j - c_j^D - c_j^U) s_j(p)$.

Downstream Market

Overall profits of the retailer that sells products in the set Ω^D are given by

$$\pi^D = \sum_{j \in \Omega^D} \left(p_j - w_j - c_j^D\right) s_j(p).$$

We assume a pure-strategy Nash equilibrium in retail prices. The first-order condition for product j is given by

$$s_j + \sum_{k \in \Omega^D} m_k^D \frac{\partial s_k}{\partial p_j} = 0, \tag{17}$$

where $m_k^D = p_k - w_k - c_k^D$ is the downstream margin on product k. The derivative of the market share of product k with respect to price p_j is given by

$$\frac{\partial s_k}{\partial p_j} = \begin{cases} \alpha s_k \left(1 - s_k + \gamma(1 - s_{k|g})\right) & \text{if } k = j; \\ -\alpha s_j (s_k + \gamma s_{k|g}) & \text{if } k \neq j \text{ and in same nest;} \\ -\alpha s_j s_k & \text{if } k \neq j \text{ and not in same nest,} \end{cases} \tag{18}$$

where $\gamma = \sigma/(1-\sigma)$.

Upstream Market

We assume that wholesale prices are the outcome of a bilateral bargaining process between suppliers and retailers, and separate wholesale prices are chosen for each product. Overall profits of an upstream firm that sells products in the set Ω^U are given by

$$\pi^U = \sum_{j \in \Omega^U} m_j^U s_j(p),$$

where $m_j^U = w_j - c_j^U$ is the upstream margin for product j and c_j^U is the upstream firm's marginal cost for product j.

We assume that wholesale prices are determined through simultaneous Nash bargaining ("Nash-in-Nash" bargaining) between the upstream and downstream firm associated with each product. The Nash product for downstream firm d and upstream firm u is

$$NP_{du}(w_{du}; w_{-du}) = \left(\pi^U - d_{du}^U\right)^{\lambda} \left(\pi^D - d_{du}^D\right)^{1-\lambda}, \tag{19}$$

where w_{du} is the vector of wholesale prices of the products associated with the upstream-downstream pair du, w_{-du} is the vector of wholesale prices for products associated with other upstream-downstream pairs, d_{du}^U and d_{du}^D are disagreement payoffs (discussed below), and $\lambda \in [0, 1]$ is the bargaining weight of upstream firm u. Although we do not index λ to keep the notation simple, in our empirical application we allow λ to vary across supplier-retailer pairs. The Nash-in-Nash bargaining solution is the vector of wholesale prices for all products such that w_{du} maximizes NP_{du} for all upstream-downstream pairs du.

We assume disagreement payoffs for each du combination are given by

$$\begin{aligned} d_{du}^U &= \sum_{k \in \Omega^U \setminus \{k \in du\}} m_k^U s_k^{-du}; \\ d_{du}^D &= \sum_{k \in \Omega^D \setminus \{k \in du\}} m_k^D s_k^{-du}. \end{aligned}$$

In these expressions, s_k^{-du} is defined as the market share for product k when products of du are not offered, i.e.,

$$s_k^{-du} = \frac{\exp[\delta_k/(1-\sigma)]}{D_g'^{\sigma} \left[\sum_g D_g'^{(1-\sigma)}\right]}, \tag{20}$$

where $D_g' = \sum_{l \in \mathcal{J}_g \setminus \{l \in du\}} \exp \delta_l/(1-\sigma)$. So the disagreement payoff for the pair du consists of the profits for d from products not supplied by u and profits for u for products sold by other retailers that are not available at retailer d, considering that the demand for products $-du$ may have increased as a result of the products du not being sold.

The bargaining first-order condition is found by setting the derivative of equation (19) with respect to w_{du} equal to zero for all products that belong to the set of products offered by each du combination. Let j be such a product. The first-order condition for product j is

$$\lambda \left(\pi^U - d^U_{du}\right)^{\lambda-1} \left(\pi^D - d^D_{du}\right)^{1-\lambda} \frac{\partial \pi^U}{\partial w_j} + (1-\lambda) \left(\pi^U - d^U_{du}\right)^{\lambda} \left(\pi^D - d^D_{du}\right)^{-\lambda} \frac{\partial \pi^D}{\partial w_j} = 0. \tag{21}$$

Equation (21) can be simplified to

$$\lambda \left(\pi^D - d^D_{du}\right) \frac{\partial \pi^U}{\partial w_j} + (1-\lambda) \left(\pi^U - d^U_{du}\right) \frac{\partial \pi^D}{\partial w_j} = 0. \tag{22}$$

The partial derivatives $\partial\pi^U/\partial w_j$ and $\partial\pi^D/\partial w_j$ are given by

$$\frac{\partial \pi^U}{\partial w_j} = \sum_{k\in\Omega^U} \frac{d\pi^U_k}{dw_j} \quad \text{and} \quad \frac{\partial \pi^D}{\partial w_j} = \sum_{k\in\Omega^D} \frac{d\pi^D_k}{dw_j},$$

where $d\pi^U_k/dw_j$ and $d\pi^D_k/dw_j$ are the *total* derivatives of π^U_k and π^D_k with respect to w_j. These total derivatives include the direct effect of w_j on the profits as well as an indirect effect that comes through changes in equilibrium prices $p^*(w)$ and are derived in Appendix B.[14] Condition (22) together with condition (17) yield the equilibrium wholesale input prices and retail prices.

3.3 Agency Model

In the agency model, retail prices are set by the upstream suppliers, while the retailers obtain a royalty r_j. The variable profit of the retailer from selling product j is

$$\pi^D_j(p) = \left(r_j p_j - c^D_j\right) s_j(p).$$

The upstream variable profit from selling product j is

$$\pi^U_j(p) \quad = \quad \big((1-r_j)p_j - c^U_j\big) s_j(p).$$

The variable joint profit of the supplier and retailer associated with product j is $\pi^J_j = (p_j - c^D_j - c^U_j)s_j(p)$.

[14] An alternative approach, which is used in Draganska, Klapper, and Villas-Boas (2010) and Ho and Lee (2017), assumes retail prices and input prices are simultaneously determined, which allows one to treat retail prices as fixed. In addition to treating the retail prices as fixed, this literature also assumes that the derivative of the disagreement payoff with respect to input prices is zero. While we depart from this literature by letting input prices depend on equilibrium prices, we do keep the assumption that there are no disagreement payoff derivatives with respect to input prices.

Upstream Market

In the agency model, the upstream supplier determines the retail price p_j. Overall profits of the supplier that sells products in the set Ω^U are given by

$$\pi^U = \sum_{j \in \Omega^U} \left((1 - r_j)p_j - c_j^U\right) s_j(p).$$

As in the wholesale model, we assume a pure-strategy Nash equilibrium in retail prices. The first-order condition for product j is

$$(1 - r_j)s_j + \sum_{k \in \Omega^U} m_k^U \frac{\partial s_k}{\partial p_j} = 0, \tag{23}$$

where $m_k^U = (1 - r_j)p_j - c_j^U$ is the upstream margin on product k and the derivative of the market share of product k with respect to p_j is given by equation (18).

Downstream Market

The Nash bargaining solution is a vector of royalties that maximizes the Nash product,

$$NP_{du}(r_{du}; r_{-du}) = \left(\pi^U - d_{du}^U\right)^{\lambda} \left(\pi^D - d_{du}^D\right)^{1-\lambda}$$

for each upstream-downstream pair du, where r_{du} and r_{-du} are vectors of royalties for the pairs du and $-du$, respectively. The bargaining first-order condition for product j is found by setting the derivative of the Nash product with respect to r_j equal to zero, and can be simplified to

$$\lambda \left(\pi^D - d_{du}^D\right) \frac{\partial \pi^U}{\partial r_j} + (1 - \lambda) \left(\pi^U - d_{du}^U\right) \frac{\partial \pi^D}{\partial r_j} = 0. \tag{24}$$

The partial derivatives $\partial \pi^U / \partial r_j$ and $\partial \pi^D / \partial r_j$ are given by

$$\frac{\partial \pi^U}{\partial r_j} = \sum_{k \in \Omega^U} \frac{d\pi_k^U}{dr_j} \quad \text{and} \quad \frac{\partial \pi^D}{\partial r_j} = \sum_{k \in \Omega^D} \frac{d\pi_k^D}{dr_j},$$

where $d\pi_k^U / dr_j$ and $d\pi_k^D / dr_j$ are the *total* derivatives of π_k^U and π_k^D with respect to r_j. These total derivatives include the direct effect of r_j on the profits as well as an indirect effect that comes through changes in equilibrium prices $p^*(r)$ and are derived in Appendix B. Condition (24) together with condition (23) yield the equilibrium agency royalties and retail prices.

4 Vertical Contracts in the E-Book Industry

In this section we apply the empirical model developed in the previous section to the market for e-books. We first provide a description of important changes in the contracts between upstream book publishers and downstream book retailers. We then use a large dataset on retail prices in the period 2014-2015 to show how retail prices changed as a result of the switch from wholesale to agency contracts between publishers and bookstores. This transition to agency occurred after a period of intense bilateral bargaining between retailers and publishers.

4.1 Background

Initially e-books were sold using wholesale contracts. Publishers would set a list price for the e-book and would sell the book to a retailer for roughly half the list price. The retailer then would set a retail price at which to sell the product to the consumers. This vertical contract changed in 2010 with the introduction of the iPad when Apple, together with five of the (then) Big Six publishers, developed the agency model to sell e-books at the iPad's new iBookstore. Publisher's welcomed Apple's entrance to the e-book industry to provide a counterweight to Amazon's dominance and saw it as an opportunity to increase retail prices. Publishers believed that low e-book prices, especially Amazon's pricing of \$9.99 for new releases, cannibalized hardcover sales and eroded consumers' perception of a book's value. As a MFN clause required the publishers to match retail prices at the iBookstore to the lowest price retailer, publishers compelled Amazon to adopt the agency model. The switch from wholesale to agency contracts led to an immediate increase in retail prices.

In 2012 the US Department of Justice sued Apple and the publishers for conspiring to raise the prices of e-books. Three of the publishers settled right away, and the other two followed in early 2013. As part of the settlement agreement the publishers could not set retail prices for a period of two years. Moreover, the most-favored nation clauses that were fundamental for making the switch to the agency model, were banned for a period of five years. De los Santos and Wildenbeest (2017) show that the transition from agency to wholesale contracts following the ban resulted in an 18 percent decrease in retail prices at Amazon and 8 percent at Barnes & Noble. One motivation for the two-year ban by the U.S. district court was to provide a reset of the bilateral bargaining relationship between retailers and publishers.

The first column in Table 1 displays the effective date of the start of the ban on agency contracts observed in the period after the settlement with the DOJ (De los Santos and Wildenbeest, 2017) for each of the now Big Five publishers. Although Random House was not a conspirator defendant in

Table 1: New contract announcement and switch dates

	Start of the agency ban	New agency agreement announcement	Amazon switch to agency
Simon & Schuster	Dec 17, 2012	Oct 20, 2014	Jan 01, 2015
Hachette	Dec 04, 2012	Nov 13, 2014	Apr 09, 2015
Macmillan	Apr 04, 2013	Dec 18, 2014	Jan 05, 2015
Harper Collins	Sep 10, 2012	Apr 13, 2015	Apr 15, 2015
Penguin Random House	Sep 01, 2013	Jun 18, 2015	Sep 01, 2015

Sources: The contract announcement comes from various news reports and Amazon.com. The switch to the new Agency comes from data from Amazon.com collected for this study. The dates of the start of the agency ban, which corresponds to the switch to wholesale model under the terms on settlement comes from De los Santos and Wildenbeest (2017).

the DOJ lawsuits, Random House adopted the terms of the settlement after a merger with Penguin in July 2013. The second column of Table 1 displays the dates when Amazon and each of the publishers announced that a bilateral agreement had been reached. The third column displays the dates when the switch to agency can be identified in the data. The table shows that each publisher announced an agreement with Amazon prior to the end of the two-year ban, but the agreements did not go into effect immediately. The switch to agency varied between January and September of 2015.

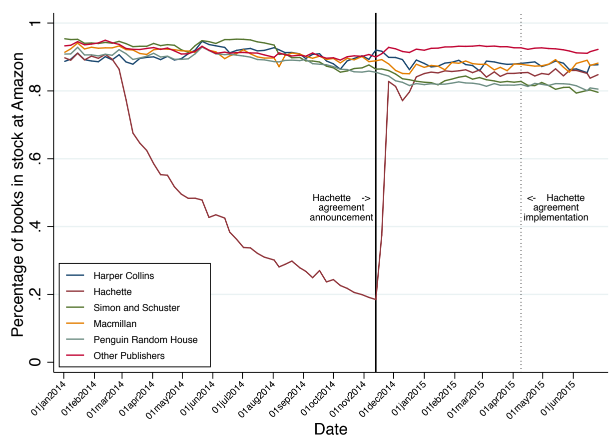


Figure 3: Amazon book inventory decisions by publisher

In the period leading to the expiration of the two-year ban on agency contracts, publishers and retailers engaged in a relatively lengthy period of negotiations over the conditions under which the publishers would regain control of retail prices. The negotiations between Amazon and Hachette became well known publicly as they included various pressure tactics. Amazon reduced the inventory, delayed delivery, increased book prices, and removed the pre-order button of Hachette titles. Hachette started a public campaign to pressure Amazon, which included the involvement of support of some of their bestselling writers. Figure 3 provides some evidence of this by plotting the percentage of books sold at Amazon that were in stock, separated by publisher. The dispute between Amazon and Hachette started in March 2014 when Amazon did not allow customers to pre-order and reduced inventories of newly released Hachette books. The figure shows that the percentage of Hachette books in our sample that were in stock at Amazon declined sharply from levels around 90 percent, similar to other publishers, to less than 20 percent shortly before the agreement announcement in November 2014. After the agreement, the percentage of Hachette books in stock immediately returned to around 80 percent, also similar to other publishers. The figure also show that there was a gradual reduction of the percentage of books in stock for other Big Five publishers starting from the beginning of the year 2014, particularly for Penguin Random House, which was the last publisher to reach an agreement with Amazon.

4.2 The Effect of the Switch to Agency on Retail Prices

In this section we use a large dataset on retail prices for e-books to study the price effects of the switch to agency contracts. Our sample runs between early 2014 and the end of 2015 and consists of daily prices for a large number of e-book titles. All titles are new and former New York Times bestseller books. Books that appear in one the New York Times bestseller lists are added to the sample from the moment of the appearance on the list.[15] For a specific title we observe its retail price as well as sales rank at both Amazon and Barnes & Noble. Moreover, we observe book characteristics such as list price, publisher, number of pages, and ratings and number of reviews at Amazon. We also have data on the printed version of the book, including format, list price, and retail price. Table 2 summarizes the variables.

For the analysis in this section, we use a similar difference-in-differences (DID) approach as in De los Santos and Wildenbeest (2017). But where De los Santos and Wildenbeest study the transition from agency contracts to wholesale contracts that followed the Justice Department's lawsuit against the major publishers and Apple in 2012, we focus on the transition from wholesale to agency that occurred after the two-year ban on agency had expired in the period 2014-2015. An important difference is that during the first period several of the key players in the industry were found to be colluding. Another important difference is that MFN clauses were not used during the second agency period and therefore do not play a role explaining the higher agency prices, as

[15] We modified the collection method for technical reasons in July 21, 2015. Because of this, the number of books we could track was reduced and was restricted to mostly popular books, as defined by the sales rank.

Table 2: Summary statistics

	Harper Collins	Hachette	Simon & Schuster	Macmillan	Penguin Random House	Other publishers
Price e-book						
Amazon	9.05	8.70	10.38	9.08	8.83	8.29
	(3.60)	(2.83)	(3.04)	(2.68)	(2.87)	(4.07)
Barnes & Noble	10.71	9.28	11.54	9.86	10.98	10.42
	(3.79)	(2.76)	(2.77)	(2.63)	(2.72)	(4.08)
Kindle list price	16.95	15.37	16.73	16.44	15.53	16.91
	(7.32)	(8.09)	(6.42)	(7.32)	(6.94)	(7.65)
Book characteristics						
Ratings	4.21	4.18	4.25	4.18	4.21	4.35
	(0.38)	(0.41)	(0.40)	(0.42)	(0.40)	(0.36)
Number of reviews	956.14	1537.35	1187.04	903.21	1395.94	880.05
	(1433.81)	(2043.11)	(1859.16)	(1432.55)	(2668.86)	(2658.83)
Number of years since release	2.26	2.21	2.38	2.29	2.27	2.18
	(2.14)	(1.83)	(2.07)	(2.58)	(2.16)	(2.63)
Print book characteristics						
Sales rank	150269.0	119502.6	114651.2	134988.7	92223.9	207529.8
	(271761.1)	(223733.9)	(206086.7)	(188678.5)	(153229.7)	(476889.3)
Number of pages	407.22	415.05	401.88	393.91	414.86	353.25
	(134.79)	(134.18)	(145.2)	(120.99)	(223.77)	(144.69)
Book weight (oz.)	17.20	17.10	17.15	16.81	17.50	15.51
	(8.43)	(8.53)	(9.13)	(8.17)	(9.48)	(9.95)
List price	22.49	20.49	21.78	22.13	21.25	19.06
	(7.73)	(7.72)	(7.53)	(7.49)	(8.80)	(8.27)
Number of titles	347	361	351	223	1,124	2,945
Number of observations	70,199	84,483	83,870	52,624	280,007	507,618

Notes: The table presents the means of each variable, standard deviation in parentheses.

argued by Johnson (2017).

As shown in Table 1, new contracts were announced between Amazon and the major publishers at different points in time resulting in the staggering of the actual switching dates at Amazon. We exploit this cross-publisher variation in the timing of the switch in a difference-in-differences setup. Specifically, the baseline specification we estimate is

$$\log(price_{jt}) = \gamma \cdot (agency_{jt} \times bigfive_j) + \beta \cdot X_j + \lambda_p + \lambda_w + \varepsilon_{jt}, \tag{25}$$

where $price_{jt}$ is the e-book price of title j at time t, $agency_{jt}$ is an indicator for whether at time t title j was sold using an agency contract, X_j are book characteristics, and λ_p and λ_w are publisher and week fixed effects. The interaction $agency_{jt} \times bigfive_j$ is the difference-in-differences estimator and captures the effect of the switch to the agency model.

Table 3 gives the main results for the difference-in-differences analysis. We estimate equation (25) separately for Amazon and Barnes & Noble. For each retailer, we estimate a specification that

Table 3: Main results difference-in-differences analysis

	Amazon			Barnes & Noble		
	Publisher	Book fixed effects		Publisher	Book fixed effects	
	fixed effects	All	Popular	fixed effects	All	Popular
Difference-in-differences estimator						
Agency × Big Five	0.150***	0.154***	0.343***	-0.015**	-0.022***	0.039
	(0.010)	(0.009)	(0.051)	(0.007)	(0.007)	(0.027)
Other controls						
log(sales rank)	0.003	-0.013***	-0.008	-0.007**	-0.003	0.020**
	(0.003)	(0.003)	(0.013)	(0.003)	(0.002)	(0.009)
Rating on Amazon	-0.032***	-0.012	-0.037	-0.006	-0.012*	-0.012
	(0.009)	(0.010)	(0.032)	(0.026)	(0.007)	(0.024)
Number of reviews on Amazon	-0.000***	-0.000	-0.000	-0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Years since release	-0.008***	0.034	-0.116	-0.000	0.016	0.026
	(0.002)	(0.033)	(0.165)	(0.002)	(0.027)	(0.134)
Kindle list price	0.024***			0.023***		
	(0.001)			(0.001)		
Number of pages in the book	-0.000*			-0.000		
	(0.000)			(0.000)		
Weight of the book (ounces)	0.004***			0.003***		
	(0.001)			(0.001)		
Constant	1.864***	2.192***	2.520***	2.077***	2.364***	2.215***
	(0.061)	(0.084)	(0.419)	(0.103)	(0.074)	(0.356)
R-squared	0.416	0.681	0.798	0.260	0.819	0.740
Number of observations	476,899	476,899	31,892	486,165	486,165	32,446

Notes: Dependent variable is log(*price*). All specifications include week fixed effects. Standard errors (clustered by book) in parentheses. For the third specification for each retailer, the sample is constrained to popular books, defined as those books with Amazon's sales rank lower than 1000. * significant at 10%; ** significant at 5%; *** significant at 1%.

allows for publisher fixed effects and a specification that has book fixed effects. As can be seen from Table 3, the difference-in-differences estimator is very similar across the two specifications. For Amazon, the estimates imply that prices went up by approximately 16 percent as a result of the switch from wholesale to agency; for Barnes & Noble prices went down by approximately 2 percent. We also present for each publisher the effect on popular books, defined as books with a sales rank lower than 1000. Although all the books were relatively popular when they were included in the sample, their popularity decreases over time. Hence, this specification estimates the effect on prices of books that are contemporaneously popular books. The price increase from the switch to agency for popular books at Amazon is more than double than the increase observed for the full sample. The change in prices at Barnes & Noble from the switch is negligible.

Table 4 shows the results for a specification in which we split out the effect by publisher. Consider first Amazon. The results for the baseline specification show that the effect is not the same across publishers: while the effect for Hachette is not significantly different from zero, the estimates for Penguin Random House indicate that prices went up by 32 percent following the

Table 4: Effect of the switch to agency by publisher

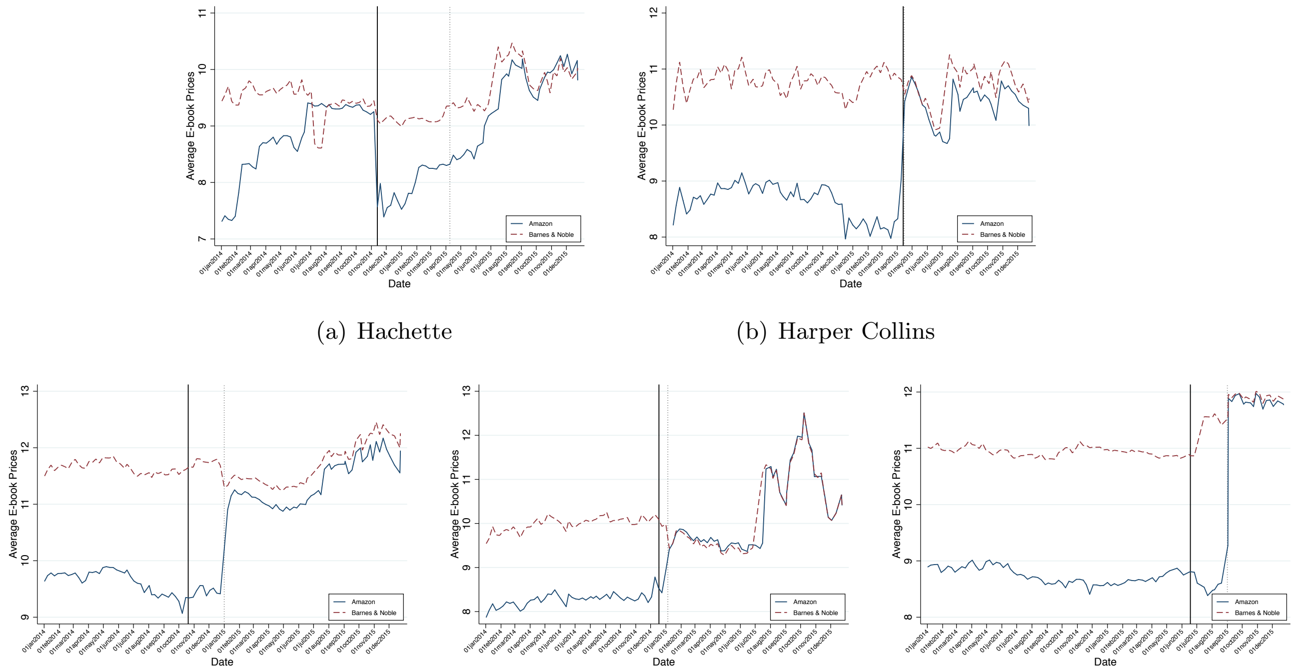
	Amazon			Barnes & Noble		
	Baseline	30-day window	7-day window	Baseline	30-day window	7-day window
Agency × Harper Collins	0.188***	0.287***	0.176***	-0.051***	0.007	-0.034*
	(0.020)	(0.025)	(0.031)	(0.015)	(0.016)	(0.021)
Agency × Hachette	0.017	-0.020***	-0.014*	0.011	0.037***	0.020
	(0.010)	(0.010)	(0.008)	(0.008)	(0.010)	(0.020)
Agency × Simon & Schuster	0.201***	0.142***	0.085***	-0.007	-0.030**	-0.048***
	(0.015)	(0.019)	(0.019)	(0.010)	(0.013)	(0.010)
Agency × Macmillan	0.142***	0.092***	0.063***	-0.084***	-0.043***	-0.061***
	(0.022)	(0.016)	(0.015)	(0.017)	(0.015)	(0.013)
Agency × Penguin Random House	0.279***	0.340***	0.270***	0.049***	0.044***	0.055***
	(0.020)	(0.022)	(0.022)	(0.009)	(0.012)	(0.011)
R-squared	0.424			0.820		
Number of observations	476,924			486,455		

Notes: The table presents difference-in-differences coefficient estimates by publisher. The baseline specification includes switching interaction coefficients for each publisher. As publishers switched at various dates, the windowed coefficients are obtained from separate regressions using observations around the time of the switch of each publisher. All specifications include controls as in the main specification. Dependent variable is log(*price*). Week fixed effects included. Standard errors (clustered by book) in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

switch.[16] The findings for books sold at Barnes & Noble are also mixed. Prices for Macmillan and Harper Collins titles decreased following the switch to agency, while prices for books published by Penguin Random House increased by approximately 5 percent.

A possible explanation for the absence of a price effect for Hachette books sold at Amazon is that Amazon was selling many Hachette books at list price during their contract negotiations in order to put pressure on Hachette. Figure 4 shows the average price changes at Amazon by publisher around the agreement announcement (dashed vertical line) and the date of the switch to agency (solid vertical line). Prior to the dispute Amazon's prices for Hachette books were consistently lower than Barnes & Noble's. During the bargaining period, Amazon increased prices for Hachette books to similar levels to Barnes & Noble, which could have been motivated to hurt sales of Hachette titles during this period. Figure 4(a) shows that after the agreement announcement, but before the actual implementation of agency, Amazon reduced prices for Hachette books to pre-dispute levels. The evolution of prices for the other publishers, which are shown in Figures 4(b)-4(e), do not exhibit similar patterns. For these publishers, the price gap between retail prices at Barnes & Noble and Amazon is stable, and even increased after the announcement, as in the case of Penguin

[16]Note that the estimates for Penguin Random House are based only on popular books (especially when we look at the windowed results), because the aforementioned change in data collection method after July 21st, 2015 (see footnote 15), shifted the mix of titles to mostly popular books. Even though all the other publishers had already switched to agency by that date, Penguin Random House still had to make the switch (on September 1st, 2015). For comparison, Table A2 in Appendix D shows a similar table, but for popular books only.



(a) Hachette (b) Harper Collins

(c) Simon & Schuster (d) Macmillan (e) Penguin Random House

Figure 4: Retail prices at Amazon by publisher

Random House. After the agency agreements were in place, each publisher increased prices to similar levels as Barnes & Noble. Another price pattern that is not captured by the windowed DID regressions above, but is evident from Figures 4(a) to 4(e), is the increase in prices for every publisher at both Amazon and Barnes & Noble after the announcement of the agreement between Amazon and Penguin Random House (as indicated by the dashed black vertical lines), the last Big Five publisher to reach an agreement (on June 18, 2015). These price increases could be interpreted as the publishers' strategic responses to anticipated price increases of Penguin Random House book titles at Amazon, as happened after September 1, 2015.

In Appendix D we show that the above results are robust to different ways of aggregating the data (weekly and monthly), using non-Big Five publishers as an additional control group, and including print-book prices in the analysis. In Appendix D we also discuss the results of a Placebo test in which we replicate the analysis using print-book prices instead of e-book prices. Since printed books remained under the wholesale model throughout the sample period, one would not expect to find any significant results for the DID estimator.

The results from the difference-in-differences analysis point to two important observations. First, the effect of the switch to agency agreements was different for Amazon than for Barnes & Noble. Second, there is heterogeneity in the magnitude of the effect across publishers. These results are consistent with our theoretical and empirical framework discussed in Sections 2 and 3 for a situation in which different retailers and publishers have different relative bargaining power parameters and, therefore, respond differently to a move from wholesale contracts to agency contracts.

5 Estimation of the Bargaining Model

In this section we provide estimates of the bargaining model. We estimate the model in two steps. First, we estimate the demand side parameters. Second, we estimate the marginal cost and bargaining parameters of the supply side model under both wholesale and agency contracts, taking the demand side parameters as given.

5.1 Data

To estimate the structural model, we use a subset of the data discussed in the previous section. For the estimation of the wholesale model, we use four weeks of data from July 2014, which corresponds to a period in which all Big Five publishers were using wholesale agreements. For the estimation of the agency model, we use four weeks of data from September 2015. The last publisher to make the switch to agency was Penguin Random House on September 1st, 2015, which means that all Big Five publishers were using agency contracts by this time. We exclude books sold by the other (smaller) publishers since these books were not sold using agency agreements during the second half of our sample.

As we lack quantity data for each book title, we use the observed sales rank data at both Amazon and Barnes & Noble to infer sales at each of these retailers. Following Chevalier and Goolsbee (2003), we assume that book sales quantities follow a Pareto distribution, i.e., the probability that an observation τ exceeds a level of Sales is

$$\Pr(\tau > \text{Sales}) = \left(\frac{k}{\text{Sales}}\right)^{\theta}, \tag{26}$$

where k and θ are the scale and shape parameters of the Pareto distribution. Since the fraction of books that have more sales than a particular title is (Rank $-$ 1)/(Total number of books), we can write equation (26) as

$$\frac{\text{Rank} - 1}{\text{Total number of books}} = \left(\frac{k}{\text{Sales}}\right)^{\theta}.$$

Solving for Sales gives

$$\text{Sales} = k \cdot \left(\frac{\text{Rank} - 1}{\text{Total number of books}}\right)^{-1/\theta}.$$

Taking logs gives

$$\log(\text{Sales}) = \gamma_0 + \gamma_1 \log(\text{Rank} - 1), \tag{27}$$

where $\gamma_0 = \log(k) + \frac{1}{\theta}(\text{Total number of books})$ and $\gamma_1 = -\frac{1}{\theta}$. Using various sources of sales data, Chevalier and Goolsbee find θ to be in the range 0.9 to 1.3 and use 1.2 as the basic estimate of θ in their analysis. To obtain an estimate of the shape parameter of the Pareto distribution that fits our sales rank data, we use an online sales rank calculator that transforms Kindle sales ranks to Kindle sales data.[17] OLS estimates of equation (27) give us a coefficient θ of 1.19, which is very close to the estimate of 1.2 that Chevalier and Goolsbee (2003) use throughout their paper.[18] We use the fitted sales to transform Kindle sales rank data into quantity data. To obtain Barnes & Noble sales we use the same estimated equation, but shift the intercept to reflect that overall e-book sales at Barnes & Noble are approximately one-quarter of those at Amazon.[19]

Table 5 provides summary statistics of the main variables we use by publisher. Panel A of the table gives summary statistics for the period in which wholesale agreements were used (July 2014) whereas panel B gives summary statistics for the period in which agency agreements were used by the Big Five publishers (September 2015). We aggregate the data into weekly observations. For both periods we use 77 of the most popular titles in our sample which results in a total of 1,146 weekly observations (616 for the wholesale period and 530 for the agency period). The largest Big Five publisher, Penguin Random House, represents most of the observations in our sample. Macmillan is the smallest with 9 titles.

A comparison of the average prices under the two selling regimes indicates that even though average prices were about 10 percent higher at Barnes & Noble than at Amazon during the wholesale period, average prices under agency are very similar across the retailers despite the five-year ban on the use of MFN clauses during this period.

5.2 Demand Estimates

We estimate the demand side of the model using data on market shares, prices, and product characteristics. Let θ denote the parameters of the demand model that need to be estimated. The predicted market share $s_j(\delta(\theta), \theta)$ should match the observed market shares $\hat{s}_j$. Since we are

[17] See https://kindlepreneur.com/amazon-kdp-sales-rank-calculator.

[18] Using 3,720 daily sales rank observations for e-books sold at Amazon as well as sales data obtained using the sales rank calculator, the estimated equation is $\widehat{\log(\text{Sales})} = \underset{(0.015)}{10.572} - \underset{(0.003)}{0.843} \log(\text{Rank} - 1)$, with $R^2 = 0.967$.

[19] Although precise figures are not available, according to their sales data the Digital Book Publisher Vook (rebranded as Pronoun in 2015) estimates Amazon's market share to be 60 percent, while Barnes & Noble's market share is 15 percent. See https://vook.com/static/media/media/Ebook_Marketplaces_and_Royalties_guide.pdf.

Table 5: Summary statistics

	Hachette	Harper Collins	Macmillan	Penguin Random House	Simon & Schuster
	Panel A. Wholesale period				
Price e-book					
Amazon	10.28	9.39	6.18	8.18	10.12
	(2.79)	(3.47)	(3.29)	(3.01)	(3.14)
Barnes & Noble	11.17	10.25	8.79	9.51	11.37
	(2.45)	(3.40)	(3.05)	(2.53)	(2.02)
Weekly sales					
Amazon	10,440	3,815	1,177	5,190	5,841
	(14,599)	(5,657)	(570)	(10,863)	(6,770)
Barnes & Noble	1,664	741	243	1,058	1,422
	(1,335)	(884)	(202)	(2,224)	(1,938)
Book characteristics					
Ratings	4.26	4.35	4.31	4.22	4.12
	(0.35)	(0.27)	(0.16)	(0.44)	(0.53)
Number of reviews	4,077	3,261	2,033	3,142	2,489
	(3,713)	(3,355)	(2,840)	(2,940)	(2,546)
Number of years since release	1.34	3.61	6.35	3.68	0.68
	(2.07)	(6.40)	(10.58)	(6.25)	(0.93)
List price	22.70	19.66	13.16	20.59	23.88
	(7.27)	(6.00)	(6.82)	(7.41)	(6.70)
Number of titles	10	9	6	43	9
Number of observations	80	72	48	344	72
	Panel B. Agency period				
Price e-book					
Amazon	12.68	10.47	10.33	10.93	11.91
	(2.84)	(4.46)	(3.81)	(2.16)	(1.96)
Barnes & Noble	12.62	10.69	9.19	10.59	12.03
	(3.04)	(4.61)	(4.42)	(1.96)	(1.86)
Weekly sales					
Amazon	4,067	1,749	6,034	2,115	1,920
	(6,617)	(4,883)	(7,934)	(1,990)	(2,013)
Barnes & Noble	2,054	481	1,715	772	782
	(3,014)	(464)	(1,837)	(789)	(722)
Book characteristics					
Ratings	4.26	4.17	4.46	4.36	4.41
	(0.27)	(0.35)	(0.28)	(0.30)	(0.22)
Number of reviews	4,608	3,829	4,834	8,626	3,001
	(6,895)	(5,164)	(5,947)	(9,490)	(2,713)
Number of years since release	0.72	4.55	1.05	4.34	9.09
	(0.74)	(7.25)	(0.75)	(5.59)	(23.59)
List price	22.31	18.82	22.50	17.18	21.17
	(7.88)	(9.18)	(5.74)	(5.48)	(7.10)
Number of titles	9	10	3	44	11
Number of observations	71	70	19	290	80

Notes: The table presents the means of each variable, standard deviation in parentheses.

assuming the model has a nested logit structure, we estimate

$$\log(s_j) - \log(s_0) = X_j\beta + \alpha p_j + \sigma \log\big(s_{j|g}\big) + \xi_j.$$

Since both p_j and $\log(s_{j|g})$ are likely to be correlated with ξ_j, we estimate the model using two-stage least squares. Note that the demand side specification does not depend on the type of vertical contract, so we can pool data from both periods.

Table 6 gives the demand-side estimates. In all specifications we estimate both periods together and allow for product-store fixed effects as well as week fixed effects. In specification (1) we do not control for price endogeneity, which means we can estimate the demand side using OLS. Although the price coefficient is highly significant, demand is estimated to be relatively inelastic—the median own-price elasticity is -1.614 and the proportion of products for which demand is estimated to be inelastic is 0.142.

The unobserved characteristic ξ_j in equation (14) captures unobserved quality, which is likely to be correlated with a book's price. Since all our specifications include product-store fixed effects, the product-store-specific variation in unobserved quality that does not vary over time is captured by the product-store dummies. However, the product-store fixed effects will not pick up variation in prices due to differences in unobserved quality over time. For instance, a favorable review in Oprah's Book Club may lead to a sudden increase in demand and retail prices. To deal with any unobserved quality differences over time, we estimate the model by two-stage least squares. The BLP-type instruments that are typically used when estimating demand (see Berry, Levinsohn, and Pakes, 1995) are difficult to apply in this context since e-book attributes do not explain much of the variance in sales and demand. Hausmann-type instruments are not suitable either since there is no regional price variation in this market. However, an instrument that is easily applied in this context is the lagged price (see Villas-Boas and Winer, 1999). This instrument has been used in other markets in which it is difficult to use traditional instruments such as the market for console video games (Nair, 2007; Shiller, 2013). As can be seen in column (2) of Table 6, the estimated price coefficient increases in magnitude when using the lagged price as an instrument for price. The absolute value of the median own-price elasticity increases as a result, with less products facing inelastic demand. Note that we lose about a quarter of the observations to create the lagged prices instrument.

Specification (3) gives demand estimates for the nested logit model estimated by two-stage least squares. Arguably, consumers are more likely to switch within retailer than across retailer because of the platform nature of the e-book market (Kindle versus Nook), and to capture this we assume Amazon and Barnes & Noble are part of different nests. In addition, we assume fiction and non-fiction books are part of different nests. This results in four different nests (Amazon fiction, Amazon non-fiction, Barnes & Noble fiction, and Barnes & Noble non-fiction). As in specification

Table 6: Demand-side estimates

Variable	(1) Logit OLS Coeff.	Std. Err.	(2) Logit 2SLS Coeff.	Std. Err.	(3) Nested logit 2SLS Coeff.	Std. Err.
Price	-0.162	(0.014)***	-0.257	(0.054)***	-0.163	(0.044)***
$\log(s_{j\|g})$	—		—		0.405	(0.141)***
R-squared	0.954					
Median own-price elasticity	-1.614		-2.563		-2.738	
Proportion inelastic demand	0.142		0.029		0.030	
Number of observations	1,146		853		853	

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. All specifications include product-store fixed effects, as well as week fixed effects. Both the logit 2SLS and nested logit 2SLS specifications use the lagged price as an instrument for price, while the nested logit specification also uses the number of within-nest products as an instrument for $\log(s_{j|g})$.

(2) we use lagged prices to instrument for price. To instrument for the within-nest market shares $\log(s_{j|g})$, we use the number of within-nest products. Both the estimated price coefficient and the log of the within-nest market shares are highly significant. Demand is more elastic than in the logit case although the difference in median own-price elasticity is small.

5.3 Supply Estimates

Taking the estimated demand parameters as given, we next describe how to estimate the supply side. Our approach is to use the equilibrium conditions of the model to derive an expression for the marginal cost of the upstream firm and then use observed product characteristics that affect these marginal costs to get an estimate of the marginal cost parameters as well as the vector of relative bargaining power parameters λ. Throughout the analysis, we assume the bargaining parameters do not change throughout the sample, i.e., we estimate one bargaining parameter for each publisher-retailer combination (which does not depend on the type of vertical contract). In addition to assuming the bargaining parameters do not vary with the type of vertical contract, we assume that the demand parameters as well as the marginal cost parameters remain the same across the two periods, which means that the change in prices only reflects the change in the type of vertical contract. Identification of the bargaining parameters therefore comes from the change in prices as a result of switching from the wholesale model to the agency model.

The marginal cost of the upstream firm can be obtained as the difference between the input price and the upstream margin where the input price in the wholesale model is the wholesale price and in the agency model the share of the price that goes to the upstream firm, i.e.,

$$mc_j^U = \begin{cases} w_j - m_j^U, & \text{if wholesale;} \\ (1 - r_j)p_j - m_j^U, & \text{if agency.} \end{cases} \tag{28}$$

The wholesale price w_j in the wholesale model is a fraction of the recommended price (see footnote 13). Since recommended prices are observed and the fraction of the recommended price received by the publishers was 70 percent during the wholesale period, we can treat w_j in equation (28) as known when estimating the model.[20] We are therefore left with estimating the royalty r during the agency period, as well as the upstream margins under both wholesale and agency.

The upstream margin, when agency contracts are used, is obtained by solving equation (23) for m^U, which gives, using matrix notation,

$$m^U = -\left(T^U \cdot \Delta\right)^{-1} (1 - r)s, \tag{29}$$

where T^U is an ownership matrix whose (j, k)th element is 1 if products j and k are published by the same publisher and zero otherwise and Δ is a matrix of market share derivatives with respect to price whose (j, k)th element is given by $\partial s_k/\partial p_j$ in equation (18).[21]

The upstream margin when wholesale contracts are used can be found by solving the equilibrium condition in equation (22) for m^U—we show in Appendix C that, using matrix notation, this can be written as

$$m^U = -\left(T^U \cdot Z^w + E^D \left(T^U \cdot S\right) \frac{1 - \lambda}{\lambda}\right)^{-1} s, \tag{30}$$

where E^D is a vector whose jth element is given by $E_j^D = \left(\pi^D - d^D\right)^{-1} \left(\partial \pi^D/\partial w_j\right)$, Z^w is a matrix that captures how market shares change through changes in equilibrium prices, and whose (j, k)th element is given by

$$Z_{jk}^w = \alpha s_k \left(1 - s_k + \gamma(1 - s_{k|g})\right) \frac{\partial p_k^*}{\partial w_j} - \sum_{\substack{l \neq k \\ \text{same nest}}} \alpha s_l \left(s_k + \gamma s_{k|g}\right) \frac{\partial p_l^*}{\partial w_j} - \sum_{\substack{l \neq k \\ \text{not same nest}}} \alpha s_l s_k \frac{\partial p_l^*}{\partial w_j},$$

and S is a matrix with market shares on the diagonal and the differences in markets shares when

[20] According to industry insiders (see for instance thepassivevoice.com/an-authors-perspective-on-the-hachette-amazon-battle) this fraction did not change from the 70 percent that was used during the first agency period.

[21] We use $\cdot$ to indicate an entrywise (Hadamard) product.

product j is not offered as off-diagonal elements, i.e.,

$$S = \begin{bmatrix} s_1 & -\Delta s_2^{-1} & \dots & -\Delta s_N^{-1} \\ -\Delta s_1^{-2} & s_2 & \dots & -\Delta s_N^{-2} \\ \vdots & \vdots & \ddots & \vdots \\ -\Delta s_1^{-N} & -\Delta s_2^{-N} & \dots & s_N \end{bmatrix}. \tag{31}$$

In equation (31), Δs_k^{-j} is defined as the additional market share for product k when product j (and all other products that are part of the downstream-upstream combination du) is not offered , i.e., $\Delta s_k^{-j} = s_k^{-du} - s_k$, with s_k^{-du} defined as in equation (20). Note that if product j and k are part of the same downstream-upstream combination du, then if j is not offered, k is not offered as well, resulting in $\Delta s_k^{-j} = -s_k$.[22]

Note that E^D will depend on the vector of downstream margins m^D, which, using matrix notation, can be written as

$$m^D = -\left(T^D \cdot \Delta\right)^{-1} s, \tag{32}$$

where T^D is an ownership matrix whose (j,k)th element is 1 if products j and k are sold by the same retailer and zero otherwise.

As shown by equation (29), the upstream margin under the agency model depends on the agency royalty r, whereas equation (30) shows that under wholesale the upstream margin depends on the bargaining power parameter λ. Rather than estimating both λ and r directly, we take a different approach. Specifically, as shown in Appendix C, we can use the first-order condition of the bargaining game under agency in equation (24) to solve for the vector of relative bargaining parameters λ as a function the vector of royalties r, downstream margins m^D, and upstream margins m^U, i.e.,

$$L = -(A + T^D \cdot B^D + (T^D \cdot Z^r)m^D)^{-1}(E^U(T^D \cdot S)), \tag{33}$$

where $L = \lambda/(1-\lambda)$, E^U is a vector whose jth element is given by $E_j^U = \left(\pi^U - d^U\right)^{-1}(\partial\pi^U/\partial r_j)$, B^D is a matrix whose (j,k)th element is given by $r_k s_k(\partial p_k^*/\partial r_j)$, and Z^r is a matrix that captures how market shares change through changes in equilibrium prices, and whose (j,k)th element is

[22]Using matrix S, the difference between profits and disagreement profits can be written as $\pi^U - d^U = (T^U \cdot S)m^U$ for the upstream firm and as $\pi^D - d^D = (T^D \cdot S)m^D$.

given by

$$Z^r_{jk} = \alpha s_k \left(1 - s_k + \gamma(1 - s_{k|g})\right) \frac{\partial p^*_k}{\partial r_j} - \sum_{\substack{l \neq k \\ \text{same nest}}} \alpha s_l \left(s_k + \gamma s_{k|g}\right) \frac{\partial p^*_l}{\partial r_j} - \sum_{\substack{l \neq k \\ \text{not same nest}}} \alpha s_l s_k \frac{\partial p^*_l}{\partial r_j}.$$

The downstream margin under agency is given by $m^D = rp - v$, which, assuming zero marginal cost v for the downstream retailer, implies that we can directly obtain m^D as a function of r.[23] So for a given vector of agency royalties r we can directly obtain the downstream margin under agency m^D as well as use equation (29) to obtain m^U, which we can then use to solve for λ using equation (33). The bargaining parameters λ can then be used together with m^D from equation (32) to obtain the upstream margin m^U under wholesale using equation (30). Upstream marginal costs are a function of the upstream margins according to equation (28). This allows us to estimate a linear marginal cost equation in which we let $\log\left(mc^U_j\right)$ depend upon observed product characteristics z_j and an unobserved characteristic ν_j serves as an error term, i.e., $\log\left(mc^U_j\right) = z'_j\eta + \nu_j$.

We use the two-stage least squares estimates for the nested logit model shown in column (3) of Table 6 to estimate the supply side. Table 7 gives the parameter estimates of the publishers' marginal cost equation for various specifications of the bargaining model. Specification (A) of Table 7 gives the parameter estimates of the publishers' marginal cost equation for the bargaining model as well as the estimated bargaining parameters. As cost shifters we include the logarithm of the number of reviews, the number of pages, weeks since release, and weight of the printed version of the book as well as a fiction dummy and publisher and week fixed effects. All marginal cost shifters except for the log of the number of pages are significantly different from zero and have the expected signs.[24] The estimated bargaining power parameters for this specification are also shown in Table 7. All estimates of the bargaining parameters are statistically significant. The average of the estimated bargaining parameters is 0.533, which suggests the publishers have slightly more bargaining power than the retailers. However, there is substantial variation in the estimated bargaining parameters across publishers with Penguin Random House and HarperCollins—the two largest trade publishers by units sold in 2016—having above average bargaining power and Hachette and Simon & Schuster the least.[25]

[23] Alternatively, a retailer's marginal cost v can be estimated alongside the other parameters.

[24] Authors' royalty payments in the book market are traditionally set as a function of the suggested list price, which itself is a function of book characteristics. An alternative interpretation of the marginal cost of an e-book is that it represents the opportunity cost of not selling a hard cover of the same book with some probability.

[25] According to purchases made through outlets tracked by NPD BookScan, the ranking of the Big 5 publisher in terms of units sold in 2016 is (1) Penguin Random House; (2) HarperCollins; (3) Simon & Schuster; (4) Hachette; and (5) Macmillan.

Table 7: Parameter estimates of the bargaining model

Variable	(A) Bargaining model Coeff.	Std. Err.	(B) Take-it-or-leave-it contracts Coeff.	Std. Err.	(C) Retailers have all bargaining power Coeff.	Std. Err.	(D) Publishers have all bargaining power Coeff.	Std. Err.	(E) Bargaining model Coeff.	Std. Err.
Marginal cost publishers										
constant	1.243	(0.635)*	0.922	(1.140)	1.724	(1.196)	0.966	(0.799)	1.224	(0.664)*
log(number of reviews)	0.077	(0.020)***	0.081	(0.066)	0.024	(0.068)	0.129	(0.032)***	0.077	(0.020)***
log(number of pages)	0.027	(0.098)	0.013	(0.167)	-0.036	(0.178)	0.024	(0.138)	0.029	(0.102)
log(weeks since release)	-0.159	(0.021)***	-0.214	(0.042)***	-0.126	(0.036)***	-0.221	(0.033)***	-0.160	(0.021)***
fiction indicator	-0.255	(0.040)***	-0.256	(0.116)**	-0.114	(0.104)	-0.364	(0.078)***	-0.253	(0.042)***
log(weight printed book)	0.206	(0.066)***	0.225	(0.118)*	0.197	(0.103)*	0.235	(0.070)***	0.204	(0.066)***
Marginal cost retailers (agency period)										
Barnes & Noble	—		—		—		—		0.308	(2.074)
Amazon	—		—		—		—		0.643	(0.691)
Bargaining parameters Amazon										
Hachette	0.358	(0.138)***			0.000		1.000		0.394	(0.153)***
Harper Collins	0.803	(0.191)***			0.000		1.000		0.792	(0.177)***
Macmillan	0.547	(0.238)**			0.000		1.000		0.558	(0.219)**
Penguin Random House	0.538	(0.069)***			0.000		1.000		0.563	(0.079)***
Simon & Schuster	0.371	(0.117)***			0.000		1.000		0.430	(0.116)***
Bargaining parameters Barnes & Noble										
Hachette	0.425	(0.092)***			0.000		1.000		0.425	(0.108)***
Harper Collins	0.902	(0.157)***			0.000		1.000		0.926	(0.147)***
Macmillan	0.595	(0.146)***			0.000		1.000		0.599	(0.143)***
Penguin Random House	0.536	(0.063)***			0.000		1.000		0.549	(0.071)***
Simon & Schuster	0.256	(0.123)**			0.000		1.000		0.269	(0.131)**
Objective function	0.251		0.294		0.349		0.420		0.249	
Log-likelihood function	-621		-689		-761		-840		-618	
Vuong-stat			2.047		4.451		6.558			
(p value)			(0.020)		(0.000)		(0.000)			
Number of Observations	853		853		853		853		853	

Notes: Bootstrapped standard errors shown in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Marginal cost specifications for the publisher include a constant, publisher fixed effects, and week fixed effects. Estimates are based on the 2SLS estimates for the nested logit model shown in column (3) of Table 6.

Table 7 also gives marginal cost estimates for several alternative supply side models. In column (B) we estimate the supply side assuming the publishers make take-it-or-leave-it offers in the wholesale model, and the retailers make take-it-or-leave-it offers in the agency model. Although most estimated marginal cost parameters do not differ much from the ones estimated in column (A), the objective function values for the two specifications suggest the bargaining model outperforms the take-it-or-leave-it model. However, the two models are non-nested. The bargaining model assumes the bargaining parameters are constant across the two types of vertical contracts, while with take-it-or-leave-it contracts the publishers have all the bargaining power in the wholesale model and retailers have all the bargaining power in the agency model. To formally test which model gives the best fit to the data, we use a Vuong test (Vuong, 1989). The p value of the Vuong-stat in column (B) of Table 7 is close to zero, which means according to this test, the bargaining model provides a better fit than the take-it-or-leave-it model. In column (C) and (D) of the table, we report the marginal cost estimates of specifications in which we assume either the retailers (in column (C)) or the publishers (in column (D)) have all the bargaining power. Specification (C) gives a better fit to the data than specification (D). Although the specification with all the bargaining power assigned to the retailers does a reasonable job in fitting the data, as indicated by the objective function value, estimating the bargaining power parameters still gives a better fit to data, as shown by the p value of the Vuong-stat.

When estimating specification (A) we have assumed that the marginal cost of the retailers is equal to zero during the agency period. In specification (E) we drop this assumption and estimate the retailers' marginal costs alongside the marginal cost of the publishers. Although not significant, the estimated marginal cost for Amazon is about 64 cents, whereas the marginal cost for Barnes & Noble is 31 cents. Although the differences are small, the estimated bargaining power parameters are mostly higher than in specification (A). Notice that the fit of the model has slightly improved when estimating the marginal costs of the retailers during the agency period, so we will treat this as our preferred specification in the remainder of the paper.

Table 8 gives the estimated royalty parameters during the agency period for specification (E) of Table 7. The average royalty share across retailers and publishers is 0.307, which is about the same as the 30 percent that was typically used during the first agency period (between 2010 and 2012). Agency royalties are higher at Amazon than Barnes & Noble, which can be explained by Amazon's better bargaining position due to it's size relative to Barnes & Noble. The differences in agency royalties between the publishers are much higher for Barnes & Noble than for Amazon.

Table 9 reports the implied margins for the bargaining model estimates in column (E) of Table

Table 8: Royalty parameter estimates

	Amazon		Barnes & Noble		Average
Hachette	0.332	(0.061)***	0.316	(0.087)***	0.324
HarperCollins	0.323	(0.084)***	0.181	(0.128)	0.252
Macmillan	0.290	(0.103)***	0.256	(0.144)*	0.273
Penguin Random House	0.339	(0.045)***	0.317	(0.074)***	0.328
Simon & Schuster	0.341	(0.059)***	0.376	(0.064)***	0.359
Average	0.325		0.289		0.307

Notes: Bootstrapped standard errors shown in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are for specification (E) in Table 7.

7. The table reports figures for both the wholesale and agency models. The table shows that the publishers' margins went up for most of the publishers when switching to agency contracts. On the other hand, the retailers' margins went down as a result of the switch, although this mostly reflects the negative marginal cost estimates during the wholesale period. Note that these results are consistent with the theoretical model of Section 2. Figure 2 illustrates this point by showing that upstream profits are higher under agency and downstream profits are higher under wholesale.

Table 9: Prices, margins and market shares

	Retail price	Wholesale price	Margin	Marginal cost	Market share
	Panel A. Wholesale period				
Retailers					
Amazon	8.72	8.62	6.43	-6.33	0.83
Barnes & Noble	9.91	8.62	6.19	-4.89	0.17
Publishers					
Hachette	10.47	9.16	1.67	7.49	0.24
HarperCollins	9.97	9.09	3.32	5.77	0.09
Macmillan	7.53	6.88	2.13	4.75	0.02
Penguin Random House	8.86	8.40	2.83	5.58	0.53
Simon & Schuster	10.79	9.76	1.35	8.41	0.12
	Panel B. Agency period				
Retailers					
Amazon	11.35	7.55	3.16	0.64	0.74
Barnes & Noble	11.11	7.71	3.10	0.31	0.26
Publishers					
Hachette	12.63	8.53	2.75	5.79	0.21
HarperCollins	10.56	7.86	2.83	5.03	0.11
Macmillan	10.69	7.73	2.75	4.98	0.10
Penguin Random House	10.89	7.30	3.02	4.23	0.46
Simon & Schuster	11.98	7.70	2.47	5.23	0.12

Notes: Estimates are for specification (E) in Table 7.

The negative marginal cost estimates for the retailers during the wholesale period are a direct result of the relatively large retail margin estimates. Note that these margins are estimated using the demand side only and do not rely on any assumption we have been making regarding the supply side. Because the difference between the retail price and wholesale price is relatively small (i.e., on average 10 cents for Amazon), the only way these large retail margins can be rationalized is by negative downstream marginal costs. Put differently, despite having sufficient market power to raise prices, Amazon was intentionally setting low prices during the wholesale period. Possible explanations that are consistent with these findings are the use of a loss-leader strategy, or a strategy of customer acquisition in Amazon's ecosystem (see Section 5.3 of De los Santos and Wildenbeest, 2017, for a more detailed discussion of Amazon's pricing strategies in the e-book market). Under these interpretations, negative marginal cost estimates represent the value to the retailers of bringing in consumers beyond selling the e-book. Note that if we ignore this part of the margin and purely look at the difference between the retail and wholesale price during the wholesale period and compare this to the margins during the agency period, it is clear that the retailers, like the publishers, did benefit from moving to agency in terms of actual profits. During the initial agency period that started in 2010, the e-book market was much less mature than during the second transition, which may explain why Amazon was objecting to the first agency transition, while was willing to go along in 2014.

6 Counterfactual Analysis of the Most Favored Nations Clause

The settlements between DOJ and the Big Five publishers in 2012 explicitly banned the use of MFN clauses for a period of five years. In this section we study what happens to agency prices when MFN clauses are reinstated, which starting in 2017 is again a possibility. According to the DOJ the MFN clauses that were used during the initial switch to agency contracts in 2010 were essential for making the entire industry shift towards agency agreements, with the switch from wholesale to agency leading to higher consumer prices. Even though the largest publishers are again using the agency model and MFN clauses were not instrumental for making the switch to this second period of agency pricing, this does not mean that MFN clauses are unlikely to have a further impact on pricing once permitted again. The reason for this is that MFN guarantees a retailer who prefers a higher royalty, if it raises the royalty for one publisher, the retail price will remain the same relative to other retailers. This encourages retailers to increase royalties, which results in higher retail prices (see also Johnson, 2017).

Table 10: Prices, royalties and margins MFN

	No MFN			MFN		
	Price	Royalty	Margin	Price	Royalty	Margin
Retailers						
Amazon	11.12	0.325	3.16	11.44	0.333	3.36
Barnes & Noble	11.12	0.289	3.06	11.44	0.325	3.59
Publishers						
Hachette	12.99	0.324	2.71	13.47	0.364	2.49
HarperCollins	10.26	0.252	2.75	10.41	0.260	2.76
Macmillan	11.49	0.273	2.74	11.52	0.276	2.74
Penguin Random House	10.60	0.328	2.98	10.92	0.345	3.02
Simon & Schuster	12.05	0.359	2.45	12.39	0.399	2.19

Notes: Estimates are based on the bargaining model estimates reported in specification (E) of Table 7. The reported results only include titles which are sold by both stores in the last week of the sample.

To simulate what happens to retail prices when MFN agreements are used, we use the marginal cost estimates from specification (E) of Table 7 to simulate equilibrium prices and royalties, using the restriction that the same title should have the same prices at both Amazon and Barnes & Noble. This restriction will not only affect the pricing FOC but also the royalty FOC, assuming that contracts between publishers and retailers are renegotiated. The implications of using MFN on prices, royalties, and margins are shown in Table 10. The table shows that royalties increase across the board, with Barnes & Noble seeing the biggest changes among the retailers and Hachette and Simon & Schuster among the publishers. Even though retail prices go up as well, by about three percent on average, this price increase is not enough to prevent margins from going down for about half the publishers. Moreover, there is a lot of variation in price changes. Although 75 percent of price changes is within -1 and 5 percent, non-fiction books saw a sales-weighted average price increase of 8.7 percent, whereas the average sales-weighted price change for fiction books is only 2.2 percent. The market is typically less competitive for non-fiction books, which may explain the large difference in price effects across book categories.

7 Conclusions

In this paper we have studied the effects of the transition from wholesale contracts to agency contracts in the e-book market that occurred in the period from 2014 to 2015. Using a difference-in-differences analysis, we have shown that prices went up by 16 percent following the switch at Amazon, but went down 2 percent at Barnes & Noble. We have theoretically shown that if an upstream and downstream firm are bargaining over input prices, retail prices will be higher or lower under agency depending on the relative bargaining power of the firms.

Our structural model extends this theoretical model to allow for competition among publishers and retailers, multi-product firms, and nested logit demand. We have shown how to estimate this model using sales rank data, prices, and book characteristics. Estimates of the bargaining model have shown that the bargaining power is on average about equally distributed between retailers and publishers, although there are large differences in estimated agency royalties between retailer-publisher pairs. Moreover, the bargaining model better fits the data than a model in which input prices are determined using take-it-or-leave-it contracts. The results from a counterfactual analysis in which we reinstate MFN clauses lead to changes in consumer prices of about three percent, with changes of up to nine percent for non-fiction books.

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A Proof of Proposition 1

Proof. We show that the wholesale model leads to a strictly higher price than the agency model when the upstream firm has all of the bargaining power and a strictly lower price when the opposite is true. The proposition then follows from the continuity of the equilibrium prices with respect to λ.

Suppose first that the upstream firm has all the bargaining power, i.e., $\lambda = 1$. Using (4), the first order condition in the wholesale model is

$$p^w - c^U - c^D = \phi(p^w)\left(2 - \phi'(p^w)\right) \tag{A1}$$

where the subscript 'w' denotes the equilibrium price in the wholesale model. Note that this condition corresponds to the first order condition in the take-it-or-leave-it case analyzed by Johnson (2017). Using (13), the first-order condition for the agency model is

$$p^a - c^U - c^D = \phi(p^a)\left(\frac{c^U}{p^a - \phi(p^a)}\right) \tag{A2}$$

where the subscript 'a' denotes the agency price. We show by contradiction that the agency price must be lower than the wholesale price.

Suppose not, i.e., suppose $p^a \geq p^w$. Because the slope of the right hand side of (A1) is less than 1 by assumption, there is a unique solution to (A1). Further, because $p^a \geq p^w$, it must be true that

$$p^a - c^U - c^D \geq \phi(p^a)\left(2 - \phi'(p^a)\right)$$

Combining this with (A2) yields

$$\phi(p^a)\left(\frac{c^U}{p^a - \phi(p^a)}\right) \geq \phi(p^a)\left(2 - \phi'(p^a)\right),$$

Using $1 - r = c^U/(p^a - \phi'(p^a))$, this gives

$$1 - r \geq 2 - \phi'(p^a),$$

which is a contraction because $1 - r \leq 1$ and $2 - \phi'(p^a) > 1$. This establishes that $p^a < p^w$ when the upstream firm has all the bargaining power.

Next, consider the case in which he downstream firm has all the bargaining power, i.e., $\lambda = 0$.

The first-order conditions for this care are

$$p^w - c^U - c^D = \phi(p^w)$$

and

$$p^a - c^U - c^D = \phi(p^a)\left(1 + c^U \frac{p^a(1-\phi'(p^a))}{(p^a - \phi(p^a))^2}\right).$$

Note that the condition for p^a corresponds to agency take-it-or-leave-it case analyze by Johnson (2017). Proceeding again by contradiction, suppose $p^a \leq p^w$. Because the right hand side of (A) has slope less than 1, there is a unique solution for p^w, and the supposition that $p^a \leq p^w$ implies

$$p^a - c^U - c^D \leq \phi(p^a).$$

Combining this with (A) yields

$$\phi(p^a)\left(1 + c^U \frac{p^a(1-\phi'(p^a))}{(p^a - \phi(p^a))^2}\right) \leq \phi(p^a).$$

But since $\phi'(p^a) < 1$, all terms in parentheses on the left hand side of this inequality are positive, which means that the term between brackets exceeds one, which yields a contradiction. Thus, $p^a > p^w$ when the buyer has all the bargaining power. ■

B Price derivatives

Wholesale model

The total derivative $d\pi_k^U/dw_j$ is given by

$$\frac{d\pi_k^U}{dw_j} = \frac{\partial \pi_k^U}{\partial w_j} + \sum_{k=1}^{N} \frac{\partial \pi_j^U}{\partial p_k}\frac{\partial p_k^*}{\partial w_j}, \tag{A3}$$

where

$$\frac{\partial \pi_k^U}{\partial w_j} = \begin{cases} s_k & \text{if } k = j, \\ 0 & \text{if } k \neq j. \end{cases}$$

The derivative $\partial \pi_j^U / \partial p_k$ is given by

$$\frac{\partial \pi_j^U}{\partial p_k} = \begin{cases} m_j^U \alpha s_j \left(1 - s_j + \gamma(1 - s_{j|g})\right) & \text{if } k = j, \\ -m_j^U \alpha s_k \left(s_j + \gamma s_{j|g}\right) & \text{if } k \neq j \text{ and in same nest,} \\ -m_j^U \alpha s_k s_j & \text{if } k \neq j \text{ and not in same nest.} \end{cases}$$

Similarly, the total derivative $d\pi_k^D / dw_j$ is given by

$$\frac{\partial \pi_j^D}{\partial w_j} = \frac{\partial \pi_k^D}{\partial w_j} + \sum_{l=1}^{N} \frac{\partial \pi_j^D}{\partial p_l} \frac{\partial p_l^*}{\partial w_j}, \tag{A4}$$

where

$$\frac{\partial \pi_k^D}{\partial w_j} = \begin{cases} -s_k & \text{if } k = j, \\ 0 & \text{if } k \neq j. \end{cases}$$

The derivative $\partial \pi_j^D / \partial p_k$ is given by

$$\frac{\partial \pi_j^D}{\partial p_k} = \begin{cases} -s_j + m_j^D \alpha s_j \left(1 - s_j + \gamma(1 - s_{j|g})\right) & \text{if } k = j, \\ m_j^D \alpha s_k \left(s_j + \gamma s_{j|g}\right) & \text{if } k \neq j \text{ and in same nest,} \\ m_j^D \alpha s_k s_j & \text{if } k \neq j \text{ and not in same nest.} \end{cases}$$

The price derivatives $\partial p_l^* / \partial w_j$ are derived by totally differentiating the retail price-first order conditions in equation (17). The solution is

$$p_{ww}^* = [\pi_{pp}^D]^{-1}[-\pi_{pw}^D].$$

The (k, l)th element of π_{pp}^D is given by

$$\pi_{pp}^D = T^D(k, l) \frac{\partial^2 \pi_j^D}{\partial p_k \partial p_l}.$$

Straightforward calculations yield the following expression for the derivatives on the right-hand side of this equation:

$$\frac{\partial^2 \pi_j^D}{\partial p_k \partial p_l} = \begin{cases} 2\frac{\partial s_j}{\partial p_j} + m_j^D \frac{\partial^2 s_j}{\partial p_j \partial p_j}, & \text{if } j = k = l, \\ \frac{\partial s_j}{\partial p_l} + m_j^D \frac{\partial^2 s_j}{\partial p_j \partial p_l}, & \text{if } j = k \neq l, \\ m_j^D \frac{\partial^2 s_j}{\partial p_k \partial p_k}, & \text{if } j \neq k = l, \\ \frac{\partial s_j}{\partial p_k} + m_j^D \frac{\partial^2 s_j}{\partial p_k \partial p_j}, & \text{if } j \neq k,\ l = j, \\ m_j^D \frac{\partial^2 s_j}{\partial p_k \partial p_l}, & \text{if } j \neq k,\ j \neq l,\ k \neq l. \end{cases}$$

The own-price and cross-price derivatives are given in equation (18). The second derivatives are given by

$$\frac{\partial^2 s_j}{\partial p_k \partial p_l} = \begin{cases} \alpha\left(1 - 2s_j + \gamma(1 - s_{j|g})\right)\frac{\partial s_j}{\partial p_j} - \alpha\gamma s_j \frac{\partial s_{j|g}}{\partial p_j} & \text{if } j = k = l, \\ \alpha\left(1 - 2s_j + \gamma(1 - s_{j|g})\right)\frac{\partial s_j}{\partial p_l} - \alpha\gamma s_j \frac{\partial s_{j|g}}{\partial p_l} & \text{if } j = k \neq l, \\ -\alpha\left(s_j \frac{\partial s_k}{\partial p_k} + s_k \frac{\partial s_j}{\partial p_k}\right) - \alpha\gamma\left(\frac{\partial s_k}{\partial p_k} s_{j|g} + \frac{\partial s_{j|g}}{\partial p_k} s_k\right) & \text{if } j \neq k = l, \\ -\alpha\left(s_j \frac{\partial s_k}{\partial p_j} + s_k \frac{\partial s_j}{\partial p_j}\right) - \alpha\gamma\left(\frac{\partial s_k}{\partial p_j} s_{j|g} + \frac{\partial s_{j|g}}{\partial p_j} s_k\right) & \text{if } j \neq k,\ l = j, \\ -\alpha\left(s_j \frac{\partial s_k}{\partial p_l} + s_k \frac{\partial s_j}{\partial p_l}\right) - \alpha\gamma\left(\frac{\partial s_k}{\partial p_l} s_{j|g} + \frac{\partial s_{j|g}}{\partial p_l} s_k\right) & \text{if } j \neq k,\ j \neq l,\ k \neq l. \end{cases}$$

The within-group price derivatives are given by

$$\frac{\partial s_{j|g}}{\partial p_k} = \begin{cases} \alpha(\gamma + 1)s_{j|g}(1 - s_{j|g}) & \text{if } j = k, \\ -\alpha(\gamma + 1)s_{k|g}s_{j|g} & \text{if } j \neq k \text{ and in same nest}, \\ 0 & \text{if } j \neq k \text{ and not in same nest}. \end{cases}$$

The (k, l)th element of π_{pw}^D is given by

$$\pi_{pw}^D = T^D(k, l)\frac{\partial^2 \pi_j^D}{\partial p_k \partial w_l}.$$

Straightforward calculations yield the following expression for the derivatives on the right-hand side of this equation:

$$\frac{\partial^2 \pi_j^D}{\partial p_k \partial w_l} = \begin{cases} -\alpha s_j\left(1 - s_j + \gamma(1 - s_{j|g})\right) & \text{if } j = k = l, \\ \alpha s_k(s_j + \gamma s_{j|g}) & \text{if } j \neq k,\ j = l \text{ and in same nest} \\ \alpha s_k s_j & \text{if } j \neq k,\ j = l \text{ and not in same nest} \\ 0 & \text{otherwise.} \end{cases}$$

Agency model

The total derivative $d\pi_k^U/dr_j$ is given by

$$\frac{d\pi_k^U}{dr_j} = \frac{\partial \pi_k^U}{\partial r_j} + \sum_{k=1}^{N} \frac{\partial \pi_j^U}{\partial p_k} \frac{\partial p_k^*}{\partial r_j},$$

where

$$\frac{\partial \pi_k^U}{\partial r_j} = \begin{cases} -p_k s_k & \text{if } k = j, \\ 0 & \text{if } k \neq j. \end{cases}$$

The derivative $\partial \pi_j^U/\partial p_k$ is given by

$$\frac{\partial \pi_j^U}{\partial p_k} = \begin{cases} (1-r_j)s_j + m_j^U \alpha s_j \left(1 - s_j + \gamma(1 - s_{j|g})\right) & \text{if } k = j, \\ -m_j^U \alpha s_k \left(s_j + \gamma s_{j|g}\right) & \text{if } k \neq j \text{ and in same nest}, \\ -m_j^U \alpha s_k s_j & \text{if } k \neq j \text{ and not in same nest}. \end{cases}$$

Similarly, the total derivative $d\pi_k^D/dr_j$ is given by

$$\frac{\partial \pi_j^D}{\partial r_j} = \frac{\partial \pi_k^D}{\partial r_j} + \sum_{l=1}^{N} \frac{\partial \pi_j^D}{\partial p_l} \frac{\partial p_l^*}{\partial r_j}, \tag{A5}$$

where

$$\frac{\partial \pi_k^D}{\partial r_j} = \begin{cases} p_k s_k & \text{if } k = j, \\ 0 & \text{if } k \neq j. \end{cases}$$

The derivative $\partial \pi_j^D/\partial p_k$ is given by

$$\frac{\partial \pi_j^D}{\partial p_k} = \begin{cases} r_j s_j + m_j^D \alpha s_j \left(1 - s_j + \gamma(1 - s_{j|g})\right) & \text{if } k = j, \\ m_j^D \alpha s_k \left(s_j + \gamma s_{j|g}\right) & \text{if } k \neq j \text{ and in same nest}, \\ m_j^D \alpha s_k s_j & \text{if } k \neq j \text{ and not in same nest}. \end{cases}$$

The price derivatives $\partial p_l^*/\partial r_j$ are derived by totally differentiating the retail price-first order conditions in equation (23). The solution is

$$p_{rr}^* = [\pi_{pp}^U]^{-1}[-\pi_{pr}^U].$$

The (k,l)th element of π^U_{pp} is given by

$$\pi^U_{pp} = T^U(k,l)\frac{\partial^2 \pi^U_j}{\partial p_k \partial p_l}.$$

Straightforward calculations yield the following expression for the derivatives on the right-hand side of this equation:

$$\frac{\partial^2 \pi^U_j}{\partial p_k \partial p_l} = \begin{cases} 2(1-r_j)\frac{\partial s_j}{\partial p_j} + m^U_j \frac{\partial^2 s_j}{\partial p_j \partial p_j}, & \text{if } j = k = l, \\ (1-r_j)\frac{\partial s_j}{\partial p_l} + m^U_j \frac{\partial^2 s_j}{\partial p_j \partial p_l}, & \text{if } j = k \neq l, \\ m^U_j \frac{\partial^2 s_j}{\partial p_k \partial p_k}, & \text{if } j \neq k = l, \\ (1-r_j)\frac{\partial s_j}{\partial p_k} + m^U_j \frac{\partial^2 s_j}{\partial p_k \partial p_j}, & \text{if } j \neq k,\ l = j, \\ m^U_j \frac{\partial^2 s_j}{\partial p_k \partial p_l}, & \text{if } j \neq k,\ j \neq l,\ k \neq l. \end{cases}$$

The (k,l)th element of π^U_{pr} is given by

$$\pi^U_{pr} = T^U(k,l)\frac{\partial^2 \pi^U_j}{\partial p_k \partial r_l}.$$

Straightforward calculations yield the following expression for the derivatives on the right-hand side of this equation:

$$\frac{\partial^2 \pi^U_j}{\partial p_k \partial r_l} = \begin{cases} -s_j[1 + \alpha p_j(1 - s_j + \gamma(1 - s_{j|g}))] & \text{if } j = k = l, \\ \alpha p_k(s_j s_k + \gamma s_k s_{j|g}) & \text{if } j \neq k,\ j = l \text{ and in same nest} \\ \alpha p_k s_j s_k & \text{if } j \neq k,\ j = l \text{ and not in same nest} \\ 0 & \text{otherwise.} \end{cases}$$

C Derivation $\mathbf{m^U}$ (wholesale) and $\mathbf{m^D}$ (agency)

Derivation $\mathbf{m^U}$ (wholesale)

Equation (22) relates upstream margins to downstream margins, which can be used to solve the upstream margins as a function of the downstream margins. First, rewrite equation (22) as

$$E^D_j\left(\pi^U - d^U\right)\frac{1-\lambda}{\lambda} + \frac{\partial \pi^U}{\partial w_j} = 0, \tag{A6}$$

where $E_j^D = \left(\pi^D - d^D\right)^{-1} \left(\partial \pi^D / \partial w_j\right)$. Using equation (A3) and taking into account the ownership structure, we can write $\partial \pi^U / \partial w_j$ as

$$\frac{\partial \pi^U}{\partial w_j} = s_j + \sum_{k \in \Omega^U} \left(m_k^U Z_{jk}^w\right),$$

which, using matrix notation, can be written as $s + (T^U Z^w) m^U$. Taking into account the ownership structure and using $\pi^U - d^U = (T^U \cdot S) m^U$, we can write the bargaining first-order condition in equation (A6) as

$$s + \left(T^U \cdot Z^w + E^D \left(T^U \cdot S\right) \frac{1-\lambda}{\lambda}\right) m^U = 0.$$

Solving for m^U gives

$$m^U = -\left(T^U \cdot Z^w + E^D \left(T^U \cdot S\right) \frac{1-\lambda}{\lambda}\right)^{-1} s.$$

To derive an expression for E^D, first note that we can write equation (A4) as

$$\frac{\partial \pi^D}{\partial w_j} = -s_j + \sum_{k \in \Omega^D} \left(B_{jk}^D + m_k^D Z_{jk}^w\right),$$

where $B_{jk}^{Dw} = -s_k (\partial p_k^* / \partial w_j)$. In matrix notation this is $-s + T^D \cdot B^{Dw} + (T^D \cdot Z^w) m^D$. Moreover, since $\pi^D - d^D = (T^D \cdot S) m^D$, we get

$$E^D = \left(\left(T^D \cdot S\right) m^D\right)^{-1} \left(-s + T^D \cdot B^{Dw} + \left(T^D \cdot Z^w\right) m^D\right).$$

Derivation $\mathbf{m^D}$ (agency)

Equation (24) relates upstream margins to downstream margins, which can be used to solve the downstream margins as a function of the upstream margins. First, rewrite equation (24) as

$$E_j^U \left(\pi^D - d^D\right) \frac{\lambda}{1-\lambda} + \frac{\partial \pi^D}{\partial r_j} = 0, \tag{A7}$$

where $E_j^U = \left(\pi^U - d^U\right)^{-1} \left(\partial \pi^U / \partial r_j\right)$. Using equation (A5) and taking into account the ownership structure, we can write $\partial \pi^D / \partial r_j$ as

$$\frac{\partial \pi^D}{\partial r_j} = A_j + \sum_{k \in \Omega^D} \left(B_{jk}^D + m_k^D Z_{jk}^r\right),$$

where $A_j = p_j s_j$ and $B^D_{jk} = r_k s_k(\partial p^*_k/\partial r_j)$. In matrix notation this is

$$A + T^D \cdot B^D + (T^D \cdot Z^r)m^D.$$

Taking into account the ownership structure and using $\pi^D - d^D = (T^D \cdot S)m^D$, we can write the bargaining first-order condition in equation (A7) as

$$A + T^D \cdot B^D + \left(T^D \cdot Z^r + E^U(T^D \cdot S)\frac{\lambda}{1-\lambda}\right)m^D = 0.$$

Solving for m^D gives

$$m^D = -\left(T^D \cdot Z^r + E^U\left(T^D \cdot S\right)\frac{\lambda}{1-\lambda}\right)^{-1}(A + T^D \cdot B^D).$$

Alternatively, solving for $L = \lambda/(1-\lambda)$ gives

$$L = -(A + T^D \cdot B^D + (T^D \cdot Z^r)m^D)^{-1}(E^U(T^D \cdot S)).$$

D Additional Specifications DID Analysis

Table A1 gives the results for several alternative specifications. To see to what extent serial correlation is an issue we aggregate the daily prices into weekly and monthly price observations. As shown in the first two rows of the table, the estimates are very similar to those of the main specification for both Amazon and Barnes & Noble. The dataset also contains prices of non-Big Five publishers. These smaller publishers typically kept using wholesale contracts throughout the sample. Including other publishers as an additional control group slightly reduces the magnitude of the price change at Amazon and makes the effect insignificant at Barnes & Noble. Including print book prices has no effect on the estimates in comparison to the main estimates. Table A2 splits out the effect of the switch to agency by publisher for popular books only. A comparison with Table 4 shows that the effects of the switch are larger for popular books for all publishers, which is consistent with our findings that the overall effect of the switch is larger for popular books.

To analyze if the effects can be attributed to the switch from wholesale to agency model and not to other shocks that may have occurred around the switching dates, we run a placebo test in which we replicate the analysis using prices for the printed version of the e-book. Since printed titles remained under the wholesale model, one would not expect to see a significant change in

Table A1: Robustness analysis

Specification	DID Estimator agency×Big Five		R-squared	Number of observations
	Panel A: Amazon			
Aggregated by week	0.145***	(0.009)	0.437	92,889
Aggregated by month	0.139***	(0.009)	0.466	21,545
Including other publishers	0.128***	(0.009)	0.374	886,047
Including print-book prices	0.151***	(0.010)	0.423	473,793
	Panel B: Barnes & Noble			
Aggregated by week	-0.014***	(0.007)	0.275	94,654
Aggregated by month	-0.020***	(0.007)	0.280	21,940
Including other publishers	0.011	(0.007)	0.301	943,308
Including print-book prices	-0.019***	(0.008)	0.255	462,781

Notes: The table presents difference-in-differences coefficients estimates for different sample and control specifications. Dependent variable is log(*price*). The specifications include week fixed effects (month fixed effects when aggregated by month) and controls as the main specification. Standard errors (clustered by book) in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

prices for those books. Table A3 shows the results for the main specification in which we do not make a distinction by publisher, as well as the results split out by publishers. The table shows that for print books sold at Amazon there is no overall effect. The effects by publishers is in most cases small or not significantly different from zero. However, Hachette is an exception: prices for print books went down by 11 percent around the time of the switch. This can be explained by some of the bargaining tactics that were used in the period before the switch, including selling books at list prices. Notice that we also find an effect for Hachette books sold at Barnes & Noble; however, the effect goes the other way. For the other publishers we do not find an effect at Barnes & Noble.

Table A2: Effect of the switch to agency by publisher (popular books only)

	Amazon			Barnes & Noble		
	Baseline	30-day window	7-day window	Baseline	30-day window	7-day window
Agency × Harper Collins	0.229***	0.234***	0.251***	-0.098**	-0.094***	-0.024
	(0.051)	(0.075)	(0.077)	(0.045)	(0.027)	(0.020)
Agency × Hachette	0.162***	0.009	0.045	0.064*	0.068	-0.022
	(0.054)	(0.035)	(0.029)	(0.037)	(0.045)	(0.028)
Agency × Simon & Schuster	0.366***	0.308***	0.210**	0.037	0.043	-0.018
	(0.054)	(0.098)	(0.081)	(0.054)	(0.058)	(0.046)
Agency × Macmillan	0.423***	0.097	0.012	0.040	-0.001	-0.024
	(0.145)	(0.101)	(0.061)	(0.054)	(0.042)	(0.035)
Agency × Penguin Random House	0.430***	0.446***	0.405***	0.125***	0.083**	0.122***
	(0.052)	(0.069)	(0.075)	(0.034)	(0.040)	(0.033)
R-squared	0.585			0.731		
Number of observations	31,892			32,446		

Notes: The table presents difference-in-differences coefficient estimates by publisher for popular books only. The baseline specification includes switching interaction coefficients for each publisher. As publishers switched at various dates, the windowed coefficients are obtained from separate regressions using observations around the time of the switch of each publisher. All specifications include controls as in the main specification. Dependent variable is log(*price*). Week fixed effects included. Standard errors (clustered by book) in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A3: Placebo tests on the effect of switch to agency on print book prices

	Amazon		Barnes & Noble	
	Overall	By publisher	Overall	By publisher
Agency × Big Five	-0.006		0.012***	
	(0.005)		(0.004)	
Agency × Harper Collins		0.000		-0.002
		(0.010)		(0.008)
Agency × Hachette		-0.108***		0.051***
		(0.012)		(0.008)
Agency × Simon & Schuster		0.030***		0.005
		(0.009)		(0.008)
Agency × Macmillan		0.025**		-0.002
		(0.010)		(0.008)
Agency × Penguin Random House		0.026		
		(0.021)		
R-squared	0.647	0.648	0.657	0.657
Number of observations	484,368	484,368	464,131	464,131

Notes: The table presents difference-in-differences coefficient estimates by publisher and for Big Five publishers using log(*price*) of print books as the dependent variable. The specification includes switching interaction coefficients for each publisher, week fixed effects and controls as the main specification. Standard errors (clustered by book) in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.