Regulating Inaction: The Case of Price Walking[*]

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We develop a theoretical model and evaluate its predictions using granular search, choice, and insurer pricing data around the introduction of "price walking" regulation in the UK motor insurance market. Prior to the policy, insurers benefited from customer inaction by keeping prices low to attract new customers whilst raising prices for pre-existing customers. Post-regulation, price incentives to new likely inactive customers fell, and product proliferation and market segmentation increased in line with insurer incentives. The net effect keeps customer benefits of switching high and maintains price penalties for inaction. These findings illustrate the difficulty of regulating markets with inertial consumers in the face of endogenous supplier responses.

1 Introduction

Many consumers are inert, failing to act even when the benefits of doing so are large (Andersen, Campbell, Nielsen, and Ramadorai, 2020; Choi, Laibson, Madrian, and Metrick, 2003; Madrian and Shea, 2001). Firms profit from these inert customers, who are often less educated and have lower incomes (Allen, Clark, and Houde, 2019; Fisher, Gavazza, Liu, Ramadorai, and Tripathy, 2024). In response, a range of indirect remedies have been applied, often with limited success, including encouraging competition (Hortaçsu, Madanizadeh, and Puller, 2017; MacKay and Remer, 2024) or "nudging" consumers through default options (Choi, Laibson, Cammarota, Lombardo, and Beshears, 2024). A more muscular approach that is increasingly being adopted is to directly regulate prices to protect customers (Agarwal, Chomsisengphet, Mahoney, and Stroebel, 2015; Campbell, Jackson, Madrian, and Tufano, 2011). The goal of this paper is to investigate these issues—consumer inaction, firm behavior, and the impact of direct price regulatory interventions—by studying a uniquely informative episode in the UK motor insurance market.

We study the impact of a fair pricing regulation introduced in the UK insurance market in 2022. This policy banned "price walking," whereby insurers offer low introductory prices to attract new customers while progressively raising prices for existing customers. As existing customers are not required to search for policies, they are potentially more likely to be inactive, creating the impetus for policy. The regulation aimed to change this practice by requiring firms to price consistently across their back books (i.e., the stock of existing customers) and their front books (i.e., the flow of new customers). The regulation thus introduces a trade-off for firms: raising prices to profit from the back book reduces their ability to attract new customers. We study how the implementation of the regulation affected both customer and insurer behavior in response to this trade-off.

We begin by developing a theoretical framework to capture the effects of price walking regulation, modelling a market in which all consumers begin by actively choosing among firms' offered products, but a fraction of consumers becomes inert following these initial choices. Firms face demand shocks in each period, capturing exogenous changes to their market shares, and set initial and renewal prices to maximise their profits, subject to prevailing regulation. We study Markov Perfect Equilibria of this model, and derive rich implications about firms' endogenous responses to both the announcement and implementation of price walking regulation. These responses include the reduction or elimination of "teaser" discounts on initial prices. The model delivers testable implications and highlights the difficulty

of improving welfare through regulatory intervention in markets with inertial consumers.

To test these predictions of the model, our analysis exploits a novel dataset on customer search, choice, and insurer pricing sourced from *Compare the Market*, the largest price comparison website in the UK motor insurance market. For 8 million insurance enquiries between 2019 and 2023, we observe the characteristics of customers that shop for car insurance, the set of different insurance products and prices that insurers offer them when they request a quote, and the product that they end up selecting.

We document four facts about how insurer behavior changed following the implementation of this regulation in the UK, all of which are consistent with the model. First, we show that insurers shrink the teaser rates they offer to customers who are less likely to search (i.e., those more likely to be inactive going forward). We classify customers as likely versus unlikely to be inactive in various ways: customers who have not searched in previous years as opposed to those who have previously made the effort to do so; and customers who are forced to search at the point of first obtaining a driving license or purchasing a new car rather than those who have voluntarily chosen to shop for insurance. In the run-up to the policy, across all these measures, likely inert customers' prices rise significantly relative to those who are more likely to search, both unconditionally and conditional on a tight set of controls.

Second, we show that firms respond to the policy by adjusting pricing. More specifically, following the policy implementation, firms offer new customers less competitive prices for products that have large back books of similar customers. These effects are large: increasing a product's back book from 0 to the 99th percentile decreases the probability that the product is the cheapest quote for a given customer by over ten times the unconditional mean.

Third, we document substantial product proliferation driven by the firms most affected by the policy. The top third of firms ranked by the size of their customer back books increase the number of products they offer by 50%, with other firms leaving their product offerings largely unchanged. In aggregate, the number of insurance products the average insurer offers in the market increases by 25%.

Finally, we show evidence that the regulation is ineffective at eradicating price increases for existing customers who do not switch their car insurance products. For customers who purchase insurance one year and shop again the next, we can directly compute how much money they would lose by not switching their insurance policy. Post-regulation, customers who do not switch their insurance product pay 40% above the price of the cheapest available

insurance product. While roughly half of this differential can be explained by the introduction of cheaper products through time and differences in non-price features across products, the remainder can be attributed to the price of their chosen insurance product increasing relative to the available alternatives. This evidence is consistent with the model's prediction that the regulation does not eliminate gains from search.

Collectively, our model and results show that the regulatory intent of banning direct price discrimination against inert customers does not ensure good outcomes. Prior to the policy, firms exploit customer inertia by price walking their back books, whilst leaving their front book prices untouched. After the policy, firms can (and do) still raise prices for the back book, but in so doing they become less competitive in the market for new customers—the additional regulation-induced cost means that inert customers are relatively less attractive than before the policy, so firms compete less aggressively for them. Additionally, firms adapt to the regulatory change by introducing new products to more finely segment the market. The net result of these supply-side responses is that inert customers still pay a penalty relative to those who shop, albeit in a different way. These results illustrate the difficulty of regulating household finance markets with inert customers when suppliers can endogenously respond to regulation.

The rest of the paper is organised as follows. The remainder of this section discusses related literature. Section 2 describes the institutional setting and the 2022 regulation. Section 3 sets up and solves the model, and discusses testable implications. Section 4 introduces our data. Section 5 describes our empirical approach to testing the model's predictions and our results, and Section 6 concludes. The appendix contains model-related technical details and proofs of the model's propositions.

1.1 Related Literature

Our paper contributes to several strands of literature. First, we contribute to the large literature studying inertia and inattention in household finance and insurance markets (e.g., Allen and Li, 2025; Fisher, Gavazza, Liu, Ramadorai, and Tripathy, 2024; Gottlieb and Smetters, 2021; Handel, 2013; Honka, 2014; Luco, 2019; Stango and Zinman, 2016). Many of these papers study how firms take advantage of inactive customers by price discriminating based on tenure. Inactive customers (who are often poorer and less financially sophisticated) pay higher prices than active customers for the same product, and implicitly pay regressive cross-subsidies. Our setting allows us to characterise the supply side of the market in greater

depth and document alternative means by which firms can take advantage of customer inaction, even when regulation seeks to prevent direct price discrimination against inert customers. [1]

Second, we contribute to the literature studying consumer protection regulations in consumer financial product markets; see Campbell (2006) for an insightful survey, and Campbell and Ramadorai (2025) for a book-length treatment. Agarwal, Chomsisengphet, Mahoney, and Stroebel (2015) and Nelson (2025) study the CARD Act, which limited credit card lenders' ability to discretionarily raise borrowers' interest rates over time. They find that this policy brought interest rates down for inactive customers and increased consumer surplus. The policy we study instead ties prices for a firm's existing customers to those it offers prospective customers. We show that firms respond to this type of policy by expanding the product space and segmenting the market, such that inactive customers continue to pay more than active consumers. More broadly, our results point to the range of channels by which firms can profit from customer inaction, and the complexities associated with predicting firms' endogenous responses when designing consumer protection regulation.

Third, we contribute to the literature on menu design and product proliferation. Prior papers study the proliferation of options that customers face in the market for consumer products, with explanations including preference heterogeneity, obfuscation (Ellison and Ellison, 2009), and screening (Rothschild and Stiglitz, 1976; Taburet, Polo, and Vo, 2025). We demonstrate an alternative driver of product proliferation in response to fair pricing regulation.

Fourth, our model contributes to the literature on behavior-based price discrimination.[2] Our benchmark model builds on the classic framework of Beggs and Klemperer (1992), with two new features. First, we introduce demand shocks to study the heterogeneous effect of back books on prices and market shares. Second, in line with regulatory concerns about consumer exploitation, we introduce naive consumers.[3]

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[1] Some of our findings on firms' responses to consumer inertia, such as product proliferation, share common features with those documented in the market for Medicare Part D insurance plans (e.g., Marzilli Ericson, 2014).

[2] See surveys by Armstrong (2006), Fudenberg and Villas-Boas (2006), and references therein.

[3] See Gabaix and Laibson (2006) and Heidhues, Koszegi, and Murooka (2017) for models of competition with naive consumers and surveys by Grubb (2015) and Heidhues and Kőszegi (2018).

2 Institutional Setting: Price Regulation in the UK Motor Insurance

In the UK, all vehicles must be insured by law. Insurers offer three levels of coverage: third party insurance is the legal minimum and covers damage to third parties; third party, fire, and theft additionally insures against fire damage or theft of the insured vehicle; and comprehensive insurance further covers medical expenses and damage or theft of the vehicle's contents.

Within each of the three levels of coverage described above, most insurers offer multiple insurance policies, which we henceforth refer to as insurance products. These products differ in their non-price characteristics, for example, whether insured drivers are covered when driving other cars. Table A.1 in the appendix provides some examples of the product offerings of a major UK insurance brand.

Contracts usually last one year and must be renewed annually. To renew, customers can (i) contact an insurer directly to select a product, (ii) use a price comparison website (the primary source of our data), or (iii) renew their existing policy. Renewal prices may change due to factors such as vehicle depreciation, driving experience, or, as discussed in this paper, dynamic pricing strategies.

Over 70% of new customers for UK motor insurance buy their insurance via a price comparison website.[4] A customer provides these platforms with details on the characteristics of the drivers to be insured, the car to be insured, the drivers' driving habits, and the desired level of coverage. These intermediaries pass these details on to a set of insurers, which return quotes to the customer, presented in a menu ordered from the cheapest to the most expensive. Figure A.1 in the Appendix provides an example of how a price comparison website displays the menu to a customer.

"Price walking" is the term used to describe an insurer ratcheting up prices for its existing customers over time, with renewing customers charged increasingly higher prices relative to similar new customers. Price walking is prevalent in many markets, and was particularly prevalent in UK insurance markets prior to 2022.[5]

In January 2022, the Financial Conduct Authority (FCA) implemented rules to combat price walking. It sought to end the "customer loyalty penalty," by requiring that the price

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[4]https://www.fca.org.uk/publication/market-studies/ms18-1-2-annex-2.pdf
[5]https://www.ft.com/content/03bde15c-323b-48eb-a392-d3a874001307

that insurers offered renewing customers for a product be no higher than the "equivalent new business price," which is the price they would offer an equivalent new customer. Notably, the policy included relatively little guidance on how to define or measure equivalence in this context.

This policy implementation followed a few years of public consultation around pricing practices in insurance. This began in 2018 when a consumer protection body complained to UK regulators about price walking in insurance markets.[6] Regulators responded by warning insurers to address these issues,[7] and beginning the research and consultation process that culminated in the rule change in January 2022. The policy, therefore, could be anticipated several years in advance of implementation.

3 Model

We consider a simple model that derives the implications of price walking regulation in a market where some consumers have inertia. There are overlapping generations of consumers. A unit mass of new consumers joins each period and stays for two periods. Each consumer needs to purchase a good ("insurance") in each of these two periods.

There are two horizontally differentiated firms indexed by $i = 0, 1$. As we explain below, firms are stochastically located on a Hotelling line, with firm i closest to endpoint i. Consumers are uniformly distributed on the unit interval and have linear transportation costs. As usual, a consumer's location can be interpreted not only as a physical feature, but also as the consumer's brand preferences. To simplify notation, we assume that goods have zero marginal cost, so we allow prices to be negative (corresponding to a negative profit margin, which firms may adopt to lock consumers in).

When facing a new consumer, firms cannot tell if they are facing someone who just joined or if the consumer is switching from a previous contract.[8] In each date $t = 1, 2, ...$, firm i sets a price p_t^i for consumers who sign a new contract and a renewal price r_t^i for those who remain with their previous contract.

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[6]https://icsr.co.uk/are-you-walking-into-a-price-problem-general-insurance-pricing-and-the-fca-remedies/

[7]https://www.fca.org.uk/publication/market-studies/ms18-1-2-interim-report.pdf

[8]Since, in reality, firms know the consumer's age, this should not be interpreted literally. Instead, this assumption captures the idea that the firm does not know if a consumer is a "shopper," who regularly looks for the best deal or if the consumer was forced to shop due to some personal circumstance, such as buying a new car or moving.

To understand the effect of price walking regulation on firms with different market shares, we assume that firms face a demand shock in each period. In our model, demand shocks shift the firm's location. Firm 0 is shifted to location $\ell = \varepsilon_t^0$ and firm 1 is shifted to $\ell = 1 - \varepsilon_t^1$, so higher taste shocks increase the firm's demand by moving it closer to the center. Demand shocks have support contained in $[0, \bar{\varepsilon}]$, where $\bar{\varepsilon} < 1/2$, and have a positive variance.[9] Demand shocks ε_t^i are i.i.d. across firms and time and publicly observed before firms set prices. Define the difference in shocks as $\Delta_t := \varepsilon_t^0 - \varepsilon_t^1$.

As mentioned previously, consumers purchase a good in each of two periods. In their first period, all consumers must actively choose from one of the two firms. We assume that consumers are myopic, meaning that they pick from the firm offering them the highest utility net of price and transportation costs in the period of joining, thereby ignoring the possibility of being locked into a contract due to inertia.[10] The period-1 net utility of a consumer located at ℓ who buys from firm 0 is:

$$V - c(\ell - \varepsilon_t^0) - p_t^0, \tag{1}$$

where the gross surplus V is large enough that everyone buys from some firm and $c > 0$ is the transportation cost, which parametrizes the firms' market power. If the consumer buys from firm 1, her period-1 net utility equals:

$$V - c(1 - \varepsilon_t^1 - \ell) - p_t^1. \tag{2}$$

Firm 0's demand among active customers is calculated by equating (1) and (2), which determines the location ℓ_t^* that makes the consumer indifferent between both firms:

$$\ell_t^* = \frac{1 + \Delta_t}{2} - \frac{p_t^0 - p_t^1}{2c}.$$

Since consumers are uniformly distributed on the unit line, the market share of firm 0 among

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[9]This non-overlapping support assumption ensures that firm 0 is closest to location 0 and firm 1 is closest to 1. Allowing for overlapping supports would obfuscate the link between taste shocks and the firm's demand, as a high enough taste shock could shift the firm beyond the midpoint of the unit interval, reducing the firm's demand.

[10]This assumption is consistent with inert consumers being "naive," who believe that they will switch in the next period. Shoppers may not be myopic: since they will switch to a new policy in the second period, ignoring the possibility of being locked into a contract is the correct belief.

active choosers equals:

$$s(\mathbf{p}_t; \Delta_t) := \left[\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c}\right]_0^1, \tag{3}$$

where $[z]_0^1 := \max\{0, \min\{z, 1\}\}$ is the truncation of z below by 0 and above by 1. Firm 1's market share among active choosers is symmetric:

$$1 - s(\mathbf{p}_t; \Delta_t) = \left[\frac{1 - \Delta_t}{2} + \frac{p_t^0 - p_t^1}{2c}\right]_0^1.$$

In the second period, a fraction λ of consumers remain with their original firm (they are "inert"), independently of the consumers' locations. There is a maximum amount that firms are allowed to charge in each period $K > c$. This maximum amount K can be due to a cap set by a regulator who oversees increases in the prices (common in insurance), the price after which consumers may start paying attention, or the amount of cash consumers have available to pay for this unanticipated expenditure. Because inert consumers are not price sensitive, firms in the no-regulation benchmark will set the highest renewal price possible: $r_t^i = K$.[11] With price walking regulation, firms are required to set the same price to joiners and incumbents in each period: $p_t^i = r_t^i$. The remaining fraction $1 - \lambda$ of consumers are "active," who shop around for a better contract every period.

Consumers who choose not to remain with their original contract return to the market in their second period, along with the new generation of consumers joining in the following period. They again choose to buy from the firm offering the highest utility net of price and transportation costs. So, without regulation, in each period, there is a mass 1 of new consumers (both inert and active shoppers) who buy a new product and a mass $1 - \lambda$ of active consumers who switch from their initial contract to a new one to take advantage of the lower price, as in equilibrium we must have $p_t^i \leq r_t^i = K$.

3.1 No Price Walking Regulation

Without price walking regulation, in each period t, firm i sets a price of a new contract p_t^i and a renewal price for customers who remain with an old contract r_t^i. We study Markov Perfect Equilibria ("MPE") of the game. Since there is no payoff-relevant connection between prices charged in different periods without price walking regulation, states are degenerate.

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[11]Setting some price limit is important with inert buyers because firms would otherwise set infinitely high renewal prices and no equilibrium would exist.

Because inert customers are not price sensitive, firms always charge the maximum price from customers who remain with an old contract: $r_t^i = K$.

Let $\delta \in (0, 1)$ denote the firms' discount factor. Firm 0's profits from a cohort that joins in period t equals:

$$\Pi_0^t := \underbrace{s(\mathbf{p}_t, \Delta_t)p_t^0}_{\text{Period 1 profits}} + \delta \left[\underbrace{\lambda s(\mathbf{p}_t, \Delta_t)K}_{\text{Period 2 inert profits}} + \underbrace{(1 - \lambda) E_t \left[s(\mathbf{p}_{t+1}, \Delta_{t+1})\right] p_{t+1}^0}_{\text{Period 2 active profits}} \right], \qquad (4)$$

where $\mathbf{p}_t := (p_t^0, p_t^1)$ is the vector of prices charged by each company. The first term is the firm's profit in the first period of cohort t, when all consumers are active shoppers. In the second period, a fraction λ of those customers remain with the firm and pay price K, as shown in the second term. Since those customers made an active choice in the period t, their demand is a function of period-t prices. The remaining $1 - \lambda$ of customers make an active choice in the second period, giving the profit in the last term. Firm 1's profits are symmetric.

At each t, firm 0 maximizes its expected discounted profits, which, using equation (4), can be written as:

$$\sum_{s=0}^{\infty} \delta^{t+s} E_t[\Pi_0^{t+s}] = s(\mathbf{p}_t, \Delta_t) \left[(2 - \lambda) p_t^0 + \lambda \delta K\right] + \sum_{s=1}^{\infty} \delta^{t+s} E_t \left\{ s(\mathbf{p}_{t+s}, \Delta_{t+s}) \left[(2 - \lambda) p_{t+s}^0 + \lambda \delta K\right] \right\}$$

To understand the firm's total demand in period t, recall that, in each period, there is a mass 1 of new joiners (all of whom choose actively) and a mass $1 - \lambda$ of active customers from the previous period. Among those $2 - \lambda$ total consumers, a proportion $s(\mathbf{p}_t, \Delta_t)$ picks firm 0. In the following period, a mass λ of new joiners become inert customers, remaining with firm 0 and paying the maximum price K (which is discounted by δ, since it is paid in the next period). Therefore, when setting its period-t price, firm 0 maximizes:

$$\underbrace{(2 - \lambda)s(\mathbf{p}_t; \Delta_t)}_{\text{Active demand at t}} \cdot p_t^0 + \delta \cdot \underbrace{\lambda s(\mathbf{p}_t; \Delta_t)}_{\text{Inertial demand at t+1}} \cdot K. \qquad (5)$$

Firm 1's objective function is symmetric:

$$\underbrace{(2 - \lambda)[1 - s(\mathbf{p}_t; \Delta_t)]}_{\text{Active demand at t}} \cdot p_t^1 + \delta \cdot \underbrace{\lambda[1 - s(\mathbf{p}_t; \Delta_t)]}_{\text{Inertial demand at t+1}} \cdot K. \qquad (6)$$

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Using the expression for market shares in (3), one finds that each firm's profit function is strictly concave in its own price. It can be shown that the MPE is interior. Calculating the first-order conditions of the maximizations of (5) and (6), gives the linear system:

$$p_t^1 - 2p_t^0 = -c(1 + \Delta_t) + \frac{\delta \lambda K}{2 - \lambda}, \qquad p_t^0 - 2p_t^1 = -c(1 - \Delta_t) + \frac{\delta \lambda K}{2 - \lambda},$$

which has the unique solution:

$$p_U^0(\Delta_t) = c - \frac{\delta \lambda}{2 - \lambda} K + \frac{c}{3} \Delta_t, \qquad p_U^1(\Delta_t) = c - \frac{\delta \lambda}{2 - \lambda} K - \frac{c}{3} \Delta_t. \qquad (7)$$

If there were no customers with inertia ($\lambda = 0$) or if firms were myopic ($\delta = 0$), they would charge the same prices as in a static Hotelling model with firms located at ε_0 and $1 - \varepsilon_1$ (namely, $p_t^0 = c + \frac{c}{3}\Delta_t$ and $p_t^1 = c - \frac{c}{3}\Delta_t$). Because of customer inertia, non-myopic firms charge lower prices in the first period to increase their market shares. This increased market share can then be used to obtain higher profits in the second-period, when firms charge the maximum price. The first-period price reduction is increasing in the gain from exploiting inert consumers (that is, it is increasing in the fraction of inert customers λ, the maximum price K, and on the discount rate δ). In equilibrium, all firms cut prices by the same amount, so the price reduction does not translate into a higher market share for any firm.

Substituting the equilibrium prices in the demand curve—equation (3)—gives the equilibrium market shares:[12]

$$s_U^0(\Delta_t) = \frac{1}{2} + \frac{\Delta_t}{6} \qquad s_U^1(\Delta_t) = \frac{1}{2} - \frac{\Delta_t}{6}. \qquad (8)$$

Notice that in this benchmark model without price walking regulation, prices and market shares are i.i.d. across time. Therefore, any serial correlation in our model can be linked to the price walking regulation.

3.2   Price Walking Regulation

Next, suppose regulation requires firms to charge the same price to joiners and those who remain with the policy. This means that firms can no longer hike the continuation price to K while offering a lower price to new customers. We impose the following mild condition to

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[12]Since $|\Delta_t| \leq \bar{\varepsilon} < \frac{1}{2}$, market shares are between 0 and 1, verifying that the equilibrium is interior.

ensure the equilibrium is interior:[13]

$$\bar{\varepsilon} \leq \frac{6 - 7\lambda + \sqrt{9(2 - \lambda)^2 - 8\delta\lambda^2}}{2(2 - \lambda)}.$$

To simplify the algebra, we also assume that K is large enough that maximum fee is not binding.[14]

Define the share of the period $t - 1$'s cohort who purchased from firm 0 as:[15]

$$x_t := s(\mathbf{p}_{t-1}, \Delta_{t-1}).$$

Firm 0's demand in period t equals

$$\underbrace{(2 - \lambda)s(\mathbf{p}_t; \Delta_t)}_{\text{Active demand at } t} + \underbrace{\lambda s(\mathbf{p}_{t-1}; \Delta_{t-1})}_{\text{Inertial demand at } t},$$

where the first term is the demand by new joiners and active customers from the previous period, and the second term is the demand by inert customers from the last period. Since firms are now required to charge the same price to both new and old customers, firm 0's period-t profits equal:

$$\widehat{\Pi}_t^0(\mathbf{p}_t, \Delta_t, x_t) := [(2 - \lambda)s(\mathbf{p}_t; \Delta_t) + \lambda x_t] \, p_t^0.$$

Symmetrically, firm 1's period-t profits equal:

$$\widehat{\Pi}^1(\mathbf{p}_t, \Delta_t, x_t) := [(2 - \lambda)[1 - s(\mathbf{p}_t; \Delta_t)] + \lambda(1 - x_t)] \, p_t^1.$$

Note that previous prices only affect a firm's current profits through the size of its current back-book: λx_t for firm 0, $\lambda(1 - x_t)$ for firm 1. Therefore, following Maskin and Tirole (2001), Markov states can be identified by the market shares in the previous period x_t. To simplify the expressions (and without loss of generality), it is convenient to work with market share

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[13]Since $\bar{\varepsilon} < \frac{1}{2}$, this condition always holds if $\lambda < 0.946$. For proportions of inert customers above this cutoff, the condition holds as long as the discount rate is not too high.

[14]Formally, we assume $c\left[\frac{2}{2 - \lambda(1-\delta)} + a\bar{\varepsilon} + \frac{b}{2}\right] \leq K$.

[15]We assume an arbitrary but exogenously fixed initial market share $x_0 \in [0, 1]$. It is straightforward to extend the model to allow for an initial period where both firms simultaneously enter the market, so they both have no initial market shares. Doing so does not change our results.

deviations from their means instead:

$$y_t := s(\mathbf{p}_{t-1}, \Delta_{t-1}) - \frac{1}{2}. \tag{9}$$

A Markovian strategy $p^i : [-\frac{1}{2}, \frac{1}{2}] \times [-\bar{\varepsilon}, \bar{\varepsilon}] \to \mathbb{R}$ specifies firm i's price as a function of the state y_t and the current net demand shock Δ_t.[16]

Proposition 1. *The game with price walking regulation has a unique MPE, in which firms choose the pure strategies:*

$$p_R^0(y_t, \Delta_t) = c \left[\frac{2}{2 - \lambda(1 - \delta)} + a\Delta_t + by_t \right] \tag{10}$$

and

$$p_R^1(y_t, \Delta_t) = c \left[\frac{2}{2 - \lambda(1 - \delta)} - a\Delta_t - by_t \right], \tag{11}$$

where $a := \frac{1}{2} \cdot \frac{2 - \lambda + \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{3(2-\lambda) + \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}} \in (0, \frac{1}{2})$ and $b := \frac{3(2-\lambda) - \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{2\delta\lambda} \in (0, 1)$.

Recall that Δ_t is firm 0's net demand shock and y_t is firm 0's excess market share. Symmetrically, $-\Delta_t$ and $-y_t$ are the net demand shock and excess market share of firm 1. The proposition above shows that in the unique equilibrium of the game, firms follow symmetric linear strategies.

As in the model without regulation, equilibrium prices rise with market power (captured by the transportation cost c). Firms also increase prices in response to positive demand shocks ($a > 0$). However, unlike in the model without regulation, prices now depend on the firms' back books. Since firms are not allowed to charge different prices from new joiners and existing customers, they trade off the extra revenue they can earn from its back book against the revenue loss from active customers. The larger the back book, the stronger the incentive to set a higher price.

Algebraic manipulations show that the pass through from demand shocks to price a is *decreasing* in the firm's discount factor δ and in the proportion of inert customers λ. Conversely, the pass through from back books to prices b is *increasing* in δ and λ. As in the model without regulation, prices converge to the equilibrium of the static model as the share of inert consumers vanishes ($\lambda = 0$) and prices no longer depend on the firm's back book ($b = 0$). As firms face a higher share of inert customers, the strategy of reducing current

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[16] All proofs are given in Appendix B.

prices to invest in a larger back book to be exploited in the future becomes more profitable, leading to a lower pass through of current taste shocks a and a higher pass through of back books b.[17]

Using the equilibrium prices from Proposition 1, we obtain the dynamics of equilibrium market shares:

Proposition 2. *In the MPE of the game with price walking regulation, states follow a stable, oscillating AR(1) process:*

$$y_{t+1} = -by_t + \left(\frac{1}{2} - a\right)\Delta_t,$$

where $a \in (0, \frac{1}{2})$ and $b \in (0, 1)$ are as defined in Proposition 1.

By Proposition 1, a firm increases its price in response to demand shocks by a factor $a \in (0, \frac{1}{2})$. Since the rival decreases its price by $|a| < \frac{1}{2}$, the firm's market share increases in response to a demand shock. This increase in market share allows the firm to build a greater back book, which the firm then exploits by charging a higher price in the next period. In equilibrium, market shares oscillate since firms with large back books charge higher prices, which reduces their future back books. Since b is increasing in δ and λ, oscillations are more pronounced when firms are more patient and when they face a greater share of inert customers.

We now consider how price walking regulation affects the average price of new policies. From equation (7), the average price of a new policy without regulation equals:

$$\frac{p_U^0(\Delta_t) + p_U^1(\Delta_t)}{2} = c - \frac{\delta\lambda}{2-\lambda}K.$$

From equations (10)-(11), the average price with price walking regulation equals:

$$\frac{p_R^0(y_t, \Delta_t) + p_R^1(y_t, \Delta_t)}{2} = \frac{2}{2 - \lambda(1-\delta)}c.$$

Comparing these two expressions, we find that the price walking regulation increases the

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[17]Unlike in the model without regulation, prices do not converge to the equilibrium of the static model as firms become myopic. Since even fully myopic firms internalise the contemporaneous revenue from its current back book, they still have a positive pass through: $b \to \frac{2\lambda}{3(2-\lambda)}$ as $\delta \to 0$.

average price of a new policy by:

$$(1 - \delta) \cdot \frac{\lambda}{2 - \lambda (1 - \delta)} \cdot c + \delta \cdot \frac{\lambda}{2 - \lambda} \cdot K > 0. \qquad (12)$$

Therefore, the model predicts an *increase in the average price of a new policy* following the adoption of a price walking regulation. Without regulation, firms offer large discounts in an attempt to attract more inert customers, who are then charged the highest possible price K upon renewal. Since the regulation reduces the price that firms charge from renewing customers, they offer fewer discounts.

Differentiating the previous expression, we find that the price jump is increasing in the fraction of inert consumers λ. Thus, the model predicts *larger price increases on policies sold to customers who are more likely to be inert.* Since offering price discounts to attract inert customers is more attractive the higher the proportion of inert customers, the price jump following the regulation is increasing in λ.

3.3 Welfare

We now consider how price walking regulation affects total surplus. In our model, because all consumers purchase coverage from some firm, total surplus depends only on allocative efficiency (captured by total transportation costs). Any price difference corresponds to a transfer between different customers and firms, which does not affect total surplus.

To maximize total surplus, each customer must purchase from the closest firm (since firms have the same marginal cost). This is achieved when both firms charge the same price, which is not the case both without and with price walking regulation. Without price walking regulation, firms tilt their price in response to taste shocks, which induces some customers to buy from the rival. This is the standard distortion from market power.

Price walking regulation reduces this distortion by dampening the pass through of demand shocks to prices, at a cost of introducing an additional source of inefficiency: since prices also depend on a firm's back book, the equilibrium allocation is distorted away from firms with large back books. The net effect depends on the proportion of inertial consumers (λ) and how firms weigh exploiting current versus future back books (δ):

Proposition 3. *There exists a cutoff $\delta_\lambda^* \in (\frac{1}{2}, 1]$ increasing in λ such that regulation increases total surplus if and only if $\delta > \delta_\lambda^*$. Moreover, regulation always reduces total surplus ($\delta_\lambda^* = 1$) if $\lambda > 0.554$.*

The proposition shows that price walking regulation can help when firms are sufficiently patient—i.e. their cost of capital is low enough—or when the share of active customers is high enough. However, if more than 55.4% of customers are inert, the regulation always hurts total surplus. Ironically, when enough customers are inert, price walking regulation ends up reducing surplus by creating large allocative inefficiencies as firms take turns in exploiting their back books.

The effect of price walking regulation on profits is generally ambiguous, as it increases the average price of a new policy but decreases the price of renewing a policy. More specifically, without price walking regulation, firms extract a high surplus from inert consumers, which leads them to compete intensely over new customers by offering cheap policies. Price walking regulation reduces the surplus from inert consumers, as it prevents firms from exploiting them without hurting the firm's sales to active shoppers. In turn, firms compete less intensely over new customers, charging a higher price.

When firms are allowed to charge high enough prices, the surplus-extraction effect dominates and price walking regulation reduces profits:

Proposition 4. *There exists $\bar{K}_{\delta,\lambda} > 0$ such that each firm's expected profit without regulation exceeds the one with price walking regulation if and only if $K \geq \bar{K}_{\delta,\lambda}$.*

To understand Proposition 4, note that without price walking regulation, profits increase linearly in the maximum fee since all inertial consumers pay K. With the regulation, profits do not depend on the maximum fee. Therefore, if the maximum fee is high enough, price walking regulation reduces profits.

When firms are sufficiently patient (they have low cost of capital), the competition effect dominates and price walking regulation raises profits:

Proposition 5. *There exists $\bar{\delta}_{K,\lambda} < 1$ such that each firm's expected profit with price walking regulation exceeds the one without regulation whenever $\delta > \bar{\delta}_{K,\lambda}$.*

Recall that, as calculated in equation (12), the model predicts an increase in the average price of a new policy after price walking regulation. Since our data only covers new policies, this is the relevant empirical prediction. To obtain the effect on all policies, we need to account for renewal prices as well. Because average prices are equal to average profits, Propositions 4 and 5 determine when the average prices of all policies increase or decrease with price walking regulation.

3.4 Anticipated Regulation

We now consider the effect of announcing the policy before it is implemented. Suppose a regulator announces, in period T, a price walking regulation that will start at $T + 1$. The announcement was not anticipated but is fully credible. Therefore, prices until the announcement followed the pattern described in Subsection 3.1.

In this subsection, we consider the MPE of the game starting at the announcement period T. In that period, firms are still able to charge different prices to new joiners and to those who remain with their old policy. However, they know that, from the next period on, they must charge the same price to all customers (including those who purchase in period T and remain with their policies).

Proposition 6. *The game starting at announcement period T has a unique MPE. In this equilibrium, firms play the following pure strategies:*

$$
p_A^0(y_t, \Delta_t) = \begin{cases} c\left[1 - \frac{2\delta\lambda}{(2-\lambda)[2-\lambda(1-\delta)]} + a\Delta_T\right] & \text{if } t = T \\ c\left[\frac{2}{2-\lambda(1-\delta)} + a\Delta_t + by_t\right] & \text{if } t > T \end{cases},
\tag{13}
$$

and

$$
p_A^1(y_t, \Delta_t) = \begin{cases} c\left[1 - \frac{2\delta\lambda}{(2-\lambda)[2-\lambda(1-\delta)]} - a\Delta_T\right] & \text{if } t = T \\ c\left[\frac{2}{2-\lambda(1-\delta)} - a\Delta_t - by_t\right] & \text{if } t > T \end{cases}.
\tag{14}
$$

where $a \in (0, \frac{1}{2})$ is defined in Proposition 1.

Comparing equations (7), (13), and (14), we find that in the announcement period T, the average price of a new policy increases by

$$
\frac{\delta\lambda}{2-\lambda}\left(K - \frac{2c}{2-\lambda(1-\delta)}\right) > 0,
$$

and in the implementation period $T + 1$, it increases by

$$
\frac{\lambda}{2-\lambda}c > 0.
$$

In sum, *average prices increase both at the announcement and the implementation period.* The intuition is as follows. Without regulation, firms charge low initial prices trying to attract more inert customers, who are then charged the highest possible price K upon renewal.

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In the transition period, these incentives are dampened, since firms know they will charge a lower price from inert customers in the future, so they have fewer incentives to attract a higher base today. However, they are still allowed to charge separate prices from consumers joining and renewing today. Starting in the implementation period $T + 1$, not only do firms have these same dampened incentives to cut prices due to lower future from inerts, but they are also unable to charge separate prices. Therefore, firms must give up profits on their inertial customer base if wish to lower prices to attract a higher future base. This further increases equilibrium prices.

3.5   Discussion and Testable Implications

The model presented in this section considers the testable implications of price walking regulation. In the unregulated benchmark, firms "invest" in their back books by cutting joiner prices today and recouping the discount by charging the renewal cap K to inert customers in the next period. The price-walking regulation ties the joiner and renewal prices and therefore weakens this investment motive, pushing up equilibrium joiner prices. Formally, average prices rise at both the announcement and implementation dates (Proposition 6), and remain higher thereafter.

The model also delivers sharp comparative statics across consumer groups. Because the pre-policy discount is larger when the prospective pool is more inert (higher λ), the regulation's price impact is increasing in λ. Put differently, the policy removes the ability to offer separate discounts to compete for likely-inert consumers, so the price of new policies for these consumers rise by more.

A central mechanism in the regulated equilibrium is the role of the inherited back book. With price walking banned, a firm's optimal price of a new policy increases in its back book because higher back books raise the firm's marginal revenue due to the price insensitivity of inertial consumers, even as it lowers competitiveness among active shoppers (Proposition 1). This mechanism implies that, holding contemporaneous demand shocks fixed, products with larger back books should be less likely to be competitively priced after the rule.

Importantly, the regulation does not eliminate gains to search. Prices continue to respond to contemporaneous taste shocks and to back books (Proposition 1), and market shares follow a stable, oscillating random process (Proposition 2). Intuitively, policies that accumulate share in one period tend to be more expensive in the next, so the identity of the cheapest offer turns over.

Finally, while the baseline model assumes a single product per firm, its logic has clear implications for the introduction of new products under the rule. Because a product that carries a large back book must charge a higher joiner price, a firm cannot simultaneously monetize its legacy customers and price aggressively for new business on that same product. Introducing a new product "resets" the back-book state for joiners and relaxes this constraint. The model therefore suggests stronger incentives for proliferation among firms with large back books.

In the model, we assumed that consumers buy the product for only two periods to simplify the formulas. It is straightforward to generalize our results for $N \geq 2$ periods. The MPE remains unique and linear, although the model now has $N - 1$-dimensional states (market shares among each cohort of buyers in the market). Following the same approach as in this paper, one can show that the regulation increases prices—with a price jump increasing in the proportional of inertial consumers λ—and leads market shares to follow a stable, oscillating $AR(N-1)$ model.

We also assumed that the value of the product was large enough that the whole market is served in equilibrium. We believe this is the appropriate assumption for car insurance, where all buyers are required to buy coverage. In other applications, extensive margin considerations may be important. With an extensive margin, price walking regulation further reduces surplus since an increase in joining prices reduces quantity.

4 Data

Our primary dataset is provided by *Compare the Market*, the largest price comparison website for the UK motor insurance market.[18] We obtain a random sample of 8 million motor insurance enquiries over the period January 2019 to December 2023. For each enquiry, we observe three types of data.

First, we observe all the information that the customer provides as part of their enquiry. This includes details on driver demographics (e.g., age and occupation); driving history (e.g., length of time holding a driving license, whether they made an insurance claim recently); details of the vehicle being insured; and details of the type of insurance being shopped for (e.g., comprehensive, third-party).

Second, we observe the specific menu of quotes that each customer receives. For every

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[18]https://www.actuarialpost.co.uk/article/compare-the-market-top-pcw-despite-most-expensive-quotes-22034.htm

product offered to each consumer, we observe the price, an anonymized identifier of the product being offered, and the firm offering it.

Third, we observe data on product choice. For each customer that selects a given product on their menu and 'clicks through' to complete the purchase with the insurer, we see the product that they selected.[19]

We supplement these data with *Consumer Intelligence* survey data from individuals who recently renewed car insurance during the period July 2019 to December 2023. Respondents report how their renewal offer compared to the prior year's price and whether they shopped around or simply accepted the offer without shopping. Conditional on having shopped around, they report their potential savings from switching, and whether they switched. They also provide their current insurance premium and details such as age, occupation, and household income.

Table A.2 in the Appendix compares the age distributions across our datasets. The Compare the Market data includes younger drivers both relative to Consumer Intelligence survey data, and relative to the overall population of UK drivers.

Together, these datasets offer a unique perspective on UK motor insurance markets around the pricing regulations. The price comparison data allows us to characterize insurers' pricing practices, the menus that customers face when they search, and the choices they make given these menus. Aggregating the choice data through time further enables us to build a proxy of insurers' back books of customers. The survey data enables us to characterize customers' decisions to search and their decisions to switch, all as a function of the price inflation they face at renewal. Finally, the policy implementation in 2022 allows us to study the endogenous responses of the market to regulation.

4.1 Summary Statistics

Table 1 summarizes our data on customer characteristics and the menus they are offered. The median customer in our sample is 29 years old, has driven for 7 years, and insures a car worth £4,855. The price of insurance varies with these characteristics. For example, prices are high for teenage drivers before declining sharply as these drivers gain driving experience. Similarly, customers with different cars face different insurance costs. In our analysis below,

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[19]If a customer completes a purchase by other means—for example, on the phone—we will not see this recorded as a sale, meaning this variable will underestimate customers' switching probabilities. For this reason, we collect additional survey-based data, described below, that characterise customers' decisions to switch insurance providers.

Table 1: Summary Statistics

	Mean	Median	Std. dev.	10th pctile	90th pctile
Customer characteristics					
Driver age	35	29	16	19	58
Years with licence	11	7	10	0	25
Car value (£)	8459	4855	14319	900	19900
Annual mileage	7508	6000	6950	3000	10000
Offered menu					
Numb. products	62	64	33	16	103
Numb. firms	25	26	13	5	41
Offered prices and dispersion within menu (£)					
Cheapest quote	1266	681	2818	242	2445
2nd − cheapest	246	33	1584	1	416
3rd − cheapest	421	72	2228	9	722
4th − cheapest	536	101	2554	16	922
5th − cheapest	623	127	2890	23	1106
Worst − cheapest	6957	4006	17051	1075	15633
Offered prices and dispersion within menu (% car value)					
Cheapest quote	55	15	186	3	126
2nd − cheapest	11	1	121	0	15
3rd − cheapest	19	2	167	0	28
4th − cheapest	24	2	190	0	38
5th − cheapest	29	3	206	0	47
Worst − cheapest	302	87	814	12	738

Note: This table reports summary statistics of the characteristics of the customers, offered quotes, and offered prices within each menu. For example, the average difference between the second-cheapest and the cheapest offers equals £246. Prices as a % of car value are computed by taking the offered annual premium, and dividing by the value of the car being insured.

we absorb this variation by including 'car' fixed effects for each combination of car brand, model, and registration year, akin to Argyle, Nadauld, and Palmer (2022).

Customers face large menus, with multiple products offered by many firms. The median customer receives 64 quotes for car insurance from 26 insurance firms. The number of quotes received varies dramatically across customers: the 10th and 90th percentiles equal 16 and 103, respectively. Products in our dataset are firm-specific—that is, even if two firms offer a similar type of contract to a customer, we treat them as separate products. In much of the analysis that follows, we absorb product-level variation using product fixed effects.

There is enormous variation in the price of insurance across customers. The median customer receives a quote of £681 for insurance, but for a customer at the 90th percentile the price is over three times as large. These price differences are not just the result of variation in the car being insured—when we divide prices by the value of the car, variation in the price of insurance across customers remains large.

There is also large variation in the quotes that the same customer receives from different insurers. For example, the median difference between the 5th cheapest and the cheapest offers is over £100, and some customers face price dispersion in insurance quotes that is an order of magnitude larger. This price variation could stem from differences in the firms' assessment of the cost of servicing a customer, variation in the non-price characteristics of different products, and various other features of the customer and insurer, such as whether the customer has an existing relationship with an insurer.

The granularity of our data allows us to isolate the variation in the price of insurance that stems from customer inertia, firm responses to this inertia, and regulations that seek to protect inert customers. For example, because we observe the menu offered to each customer, we can fully absorb customer characteristics with individual fixed effects, and thus compare prices that different firms offer to the same customer. Because firms offer the same products to different customers, we can look within-product, and study how firms vary prices across customers whilst holding constant the features of the contract they offer to customers. Finally, the regulatory shift in 2022 allows us to study changes in the market across different regulatory regimes.

Table 2 summarises our data on customer choice and customer search. 11% of enquiries result in a customer purchasing a product. As we explain below, we use this information to build up a proxy of insurers' back books of customers by aggregating these purchase decisions through time.

Customers tend to pick from the cheapest products on the menus they receive when they search: fewer than 20% pick outside the five cheapest products. These lower-ranked choices can be rationalised by the non-price characteristics of the products offered. For example, a firm may have a brand identity that customers value, perhaps because they trust the firm to pay out quickly in case of a claim. Moreover, as Table A.1 shows, insurers offer products with different characteristics—products with more add-ons tend to cost more. Thus, customers may also pick more expensive products because they value add-ons.

Approximately two-thirds of customers in our sample search in more than one year. We

Table 2: Summary Statistics: Search and Choice

	Percent of sample
Selected a product	11
Customer chose:	
cheapest product	43
top 2 products	62
top 3 products	72
top 4 products	78
top 5 products	83
Customer searched:	
in one year only	36
in multiple years	64
once in year	47
multiple times in year	53

Note: This table summarises the choice and search behaviour of customers in our sample.

analyze these repeat searchers in Section 5, where we proxy a customer's propensity to search based on whether they searched in the previous year. Of those customers who searched in a given year, around half searched more than once in that year. This may represent customers "shopping across terms," whereby they adjust their enquiries in search of better prices.

Motor insurance in the UK has become more expensive in recent years. Figure 1 shows the distribution of the cheapest quote for each enquiry in our data in 2019 and 2023. The price of car insurance for the median customer increased by 30% between these two dates. Anecdotally, this increase in the price of insurance was partly related to the inflation and supply-chain issues following the Covid pandemic, which increased insurers' costs.[20] Naturally, our identification approach is not based on these time-series trends, but instead leverages the granular cross-sectional variation in the data.

Given the large price dispersion shown in Table 1, the savings from switching insurers at renewal are potentially large. Realising these savings requires a customer to consider alternatives to their existing provider, and to switch if these alternatives are more appealing.

The Consumer Intelligence survey data allow us to investigate the decision to shop and the decision to switch. The left panel of Figure 2 uses these data, and displays customers' decisions to search for alternative providers at renewal as a function of how much their offered renewal price increased relative to the year before. Around 80% of customers report

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[20]https://www.ft.com/content/04a7ba0b-9ed1-4191-819c-9f88faa20a34

**Figure 1: Price of Insurance, 2019 and 2023**
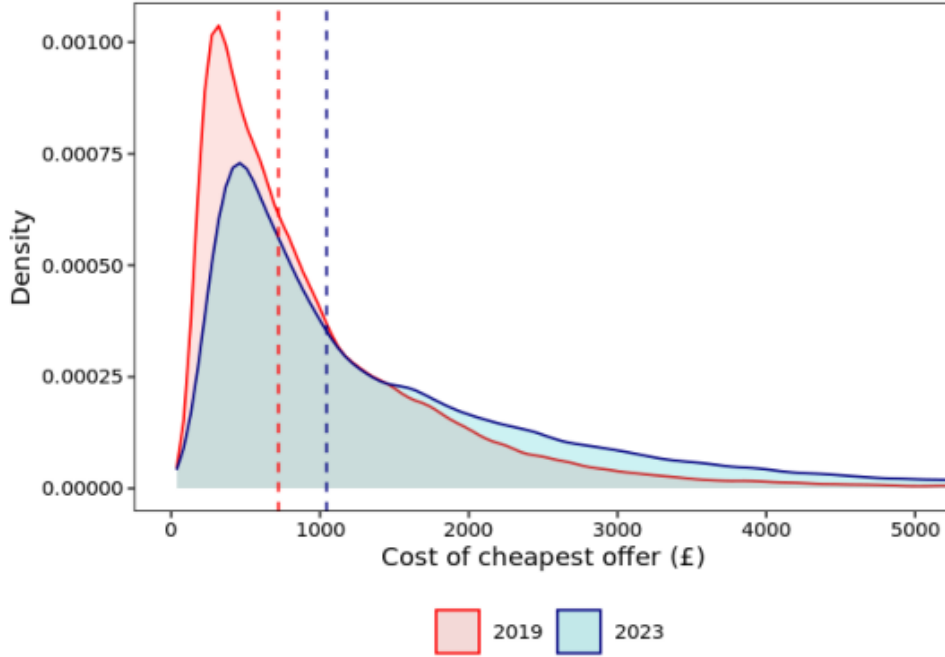
Note: This figure shows the distribution of the price of insurance in 2019 and 2023. In each year, we take all enquiries and plot the distribution of the cheapest offer across all enquiries. The dashed lines show the median in each year.

having shopped around to some extent, though this survey-based measure does not reveal how comprehensive this shopping-around process is. Customer search is in part triggered by changes in their renewal price. A customer whose renewal price is much higher than the previous year's price is over 20 percentage points more likely to search. More surprisingly, customers whose renewal prices were far below last year's price were also slightly more likely to search.

The right panel of Figure 2 shows how customers' decisions to switch insurers depend on their potential savings. Conditional on searching, around 50% report that they switched insurers. The switching rate increases steeply with the savings from switching, with a customer facing savings over £45 a year over 3 times as likely to switch as one facing savings under £5 per year.

We note here that these survey data represent a different sample to our main dataset, and

Figure 2: Search and Switching
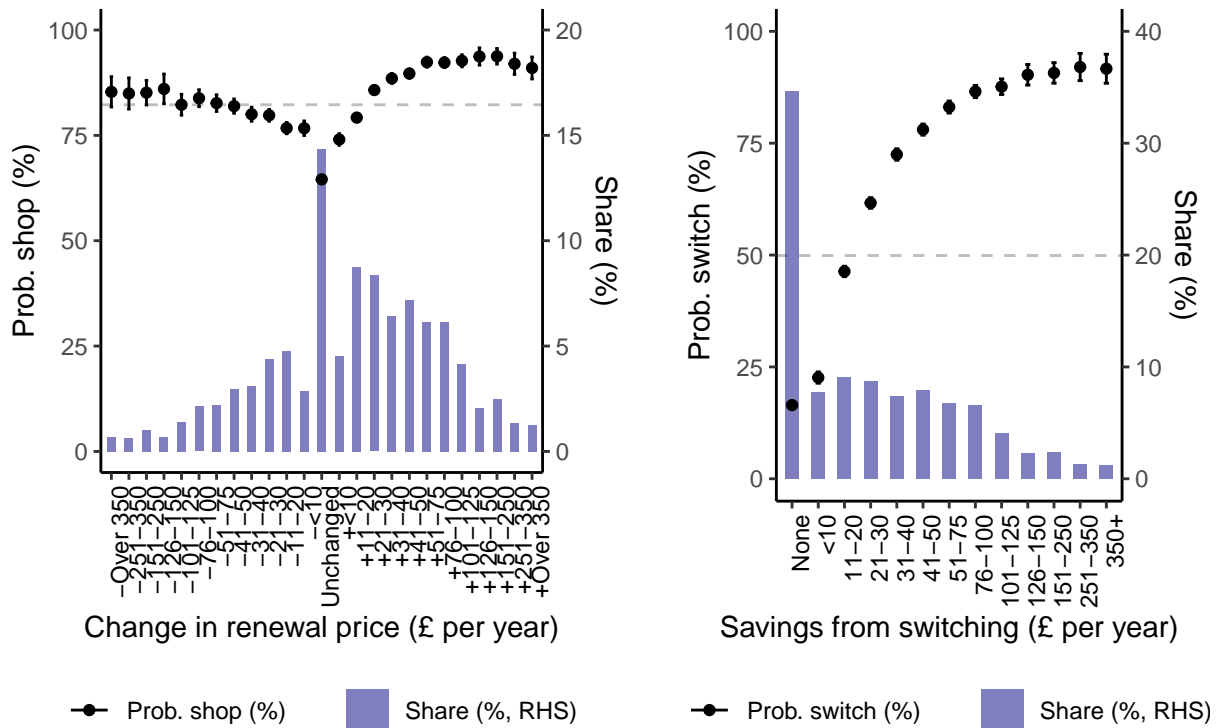
Notes: The left panel shows the likelihood of shopping as a function of the change in renewal price in the Consumer Intelligence survey data. Each survey respondent reports the change between their insurance premium in the previous year and their renewal offer. The bars show the distribution of customers across each bucket, and the points show the fraction in each bucket that reported shopping across different insurance providers, with 95% confidence intervals. The dashed line shows the average shopping probability across all buckets. The right panel shows the likelihood that renewing customers switch insurers as a function of the potential savings from switching in the Consumer Intelligence survey data. Each survey respondent who shopped around for quotes reports these potential savings. The bars show the distribution of customers across each potential savings bucket. The points show the fraction in each bucket that switched insurer, with 95% confidence intervals. The dashed line shows the average switching probability across all buckets.

that there are difficulties in translating these types of survey responses into concrete figures on how hard customers search and how frequently they switch. Nonetheless, we draw two broad conclusions from these figures: there are frictions in the process of searching for and switching insurers at renewal, and customers' decisions to search and switch are relatively sensitive to insurance prices.

4.2 Insurer Back Books

The 2022 pricing policy links the price a firm can charge a new insurance customer to the price it charges its existing back book of customers who purchased insurance from the firm in the past. To study this link, we construct proxy measures of a firm's back book of customers using our data on customer choice.

Our first proxy is the more granular, and most closely follows the 2022 regulations. The price-walking rules apply at the firm-product-customer type level: a firm cannot offer the same product at different prices to existing and prospective customers who are otherwise equivalent. As we recounted above, the regulations do not exactly define this equivalence. Based on our understanding of the policy implementation, we define an "equivalence class" (alternatively a customer type) as follows: (a) same birth year; (b) insuring cars in the same quintile of car values; and (c) shopping for the same level of cover, as defined in Section 2.

Moreover, at each time t, we measure the set of customers of a given type that are likely to renew a specific product offered by a specific firm using their choice data from one and two years prior. This is best illustrated with an example: Consider a customer born in 1980 with a car in the bottom quintile of the car value distribution, whose insurance policy expires on September 5, 2023. We compute a firm's back book for this product by counting the number of customers of each type who picked the same product in the 30 days around September 5, 2022 and September 5, 2021. Unless they switched in the meantime, these customers will renew around September 5, 2023, when the firm is trying to attract new customers of the same type to this specific product. Price walking regulation ties the price that can be offered to new customers to the price that can be offered to these renewing customers. We then convert this variable into a share, by dividing by its sum across all firms and products within a given type.

Some decisions—in particular, the decision to launch or retire a product—take place at the firm level. Hence we define a second proxy of the back book that aggregates the previous measure across customer types, as well as over time. We seek to measure the number of customers of any type that the firm has managed to attract in the past. To compute this variable for firm f at time t, we count the number of customers that purchased insurance from the firm in all months before time t. We then divide this by the total number of insurance contracts purchased across all firms over the same period, to convert this measure into a share.

Table 3: Back books: Summary Statistics

	Mean	Median	90th pctile	99th pctile
Product-segment back book				
Count	1	0	2	71
Share	0.006	0.000	0.018	1.000
Aggregate firm back book				
Count	9052	2365	28681	68752
Share	0.017	0.004	0.054	0.129

Note: Table summarises our proxies of the back book, as defined in Section 4.2. Segment-specific back books are summarized for the whole sample. Aggregate back books are summarized as at the middle of our sample, December 2021.

The first two rows of Table 3 summarise the product-level back book proxy. Our product and consumer type definitions are fine-grained, and we only count purchases over two months' of data to compute each back book. Hence, the average back book is small in absolute terms, but varies significantly across products and segments. In Section 5.2 we study how firms condition their pricing decisions on the back books of their products.

The final two rows of Table 3 summarise the distribution of our proxies of firms' aggregate back books. The average insurer in our sample has had thousands of customers select its products since the beginning of our sample. This is highly skewed: some small and new insurance brands have hardly any back book, whilst the largest have attracted over ten percent of aggregate insurance business in our sample.

5 Empirical Results

The model in Section 3 predicts a set of testable implications about the transition dynamics in the market around the announcement and introduction of the price walking regulation in a range of outcome variables, placing an important role on insurers' back books as well as consumer characteristics in explaining cross-sectional variation in these outcomes. In this Section, we uncover four main patterns in the Compare the Market data that illustrate how the 2022 pricing regulations have affected the motor insurance market. Overall, we find that these empirical results line up well with the model's main predictions.

5.1 Price Discounts to Inert Consumers

We begin our analysis by studying patterns in the initial price discounts offered to customers around the 2022 pricing regulations. The model in Section 3 predicts that these discounts are increasing in the likely level of inertia of customers, and as a result the regulation should cause greater price increases for customers more likely to be inert. In this Section, we show that this is corroborated in the data: customers who are ex ante more likely to be inactive experience steeper pre-2022 increases in the cheapest available quote, with no additional relative convergence once the rule comes into force.

Testing this hypothesis requires us to identify consumers who are likely to be inert and stay with the firm in the future. To do so, we leverage our data on customer search and customer characteristics, and identify three sets of consumers who are more likely to be inert.

Our first and second sets of likely inert consumers are based on the logic that an inert customer does not act unless forced to do so, whereas an active customer makes a discretionary choice to search. New drivers are forced to take out insurance when they obtain their license. Similarly, customers with a new car are forced to insure it. Hence, our first comparison is between the price of insurance through time for those customers who purchased a car within a month of shopping for insurance and the price of insurance for those who did not recently purchase their cars. The second comparison is between the price of insurance over time for those customers who obtained a license less than one year before shopping for car insurance and the price for those who did not. In each case, the proxy interprets the first group (forced searchers who are new drivers or have new collateral) as more inert, and the second as less inert.

Our third comparison uses data on repeat searchers. We divide our customer enquiries into two types: those in which we observed the same individual search for car insurance the previous year, and compare them to those who did not.[21] The former group we interpret as more-active searchers, and the latter as more-inert customers.

Naturally, our proxies of inertia are correlated with other characteristics beyond inertia. For example, drivers with a new license are more likely to be young, whilst customers who recently purchased a car are more likely to have an expensive car. As a result, we include a rich set of fixed effects—detailed below—to strip out the effects of these other variables. For example, we include fixed effects for the car being insured, defined as a combination of car

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[21]By construction, we can only compute this proxy of inertia from the second year of our sample onwards.

brand, model, and year of registration. This means that our car-based definition of inertia compares individuals insuring the same car, one of whom bought the car that month and one of whom did not.

Figure 3 shows trends in the cheapest offer a customer receives in their menu by customer type through time. We normalise this price by its value in 2022, the first year after the policy's implementation, such that the vertical axis measures the percentage difference in a group's price relative to 2022. For each of our proxies of inertia, we show the unconditional trends in the price of insurance in the left-hand panel, and in the right-hand panel we show these trends after stripping out fixed effects for the model of car, the driver's age, the insurance firm, and the insurance product. Each row shows the results for each of the three sets of inert consumers and their "control" comparison groups of more-active consumers.[22]

The top rows compare customers with newly-bought cars to those who bought their cars in the past. The price of insurance for those who recently bought a car (and hence, in some sense, were forced into shopping for insurance) was broadly flat in the years before the policy. By contrast, the price for those who had bought their car further in the past (and hence were not compelled to shop for insurance) fell by 20%. Put differently, before the policy implementation, there is a large relative increase in price for customers more likely to be inert relative to those more likely to search. After the policy implementation, despite the widespread disruption to car insurance markets post-Covid, the change in the price of insurance was essentially identical for the two groups.

This striking pattern—an increase in price for inert customers relative to those more likely to search—holds across all our sets of inert consumers in Figure 3. That is, it holds when we compare drivers who got their license this year to those who had a license for more than a year, as well as when we compare those that have new collateral relative to those who do not. It also holds when we compare prices for customers who searched the year before to those who did not. In each case, the pattern holds both unconditionally, as well as conditional on an expansive set of fixed effects.

These patterns in prices suggest that the effect of the regulation is to reduce the desirability of inactive customers. The model predicts that the regulation should affect prices on announcement as well as on implementation. As explained in Section 2, the thrust of the policy could be anticipated years in advance of its implementation. Three years before

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[22]We compute these statistics by regressing the log of the cheapest offer in a customer's menu on our inertia dummies, interacted with year fixed effects. Percentage changes are the exponential of the coefficients on the dummies minus 1, and confidence intervals are computed using the delta method.

Figure 3: Up-front Discounts to Inert Customers
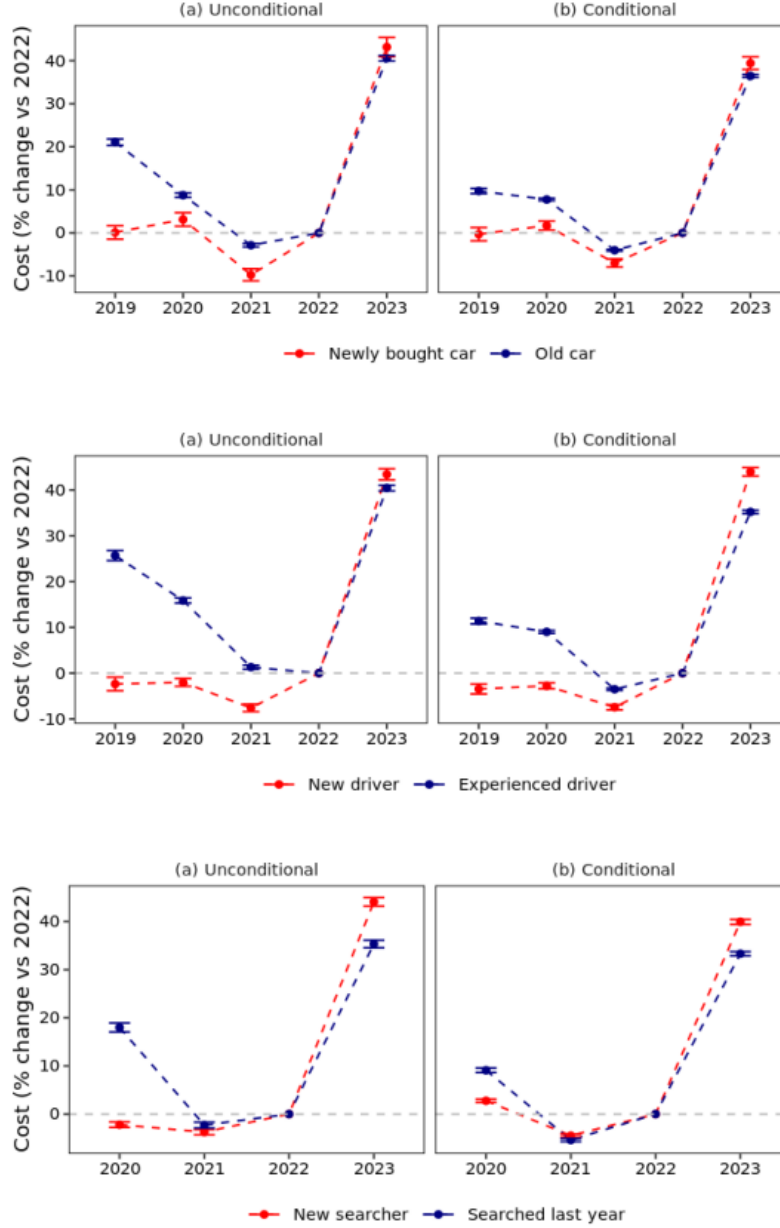
Note: The panels in this figure show differential trends in the price of insurance for different customer groups. Our sets of inert customers are shown in red, and our proxies of searchers are shown in blue. The first row shows results where we compare drivers who acquired their car in the last month to those who did not. The second row shows results where we compare drivers who acquired their license in the last year to those who did not. The third row shows results where we compare drivers who did not search for car insurance in the previous year. Controls include indicator variables for the car being insured, the driver's age, and the product quoted. We also include the new-driver and new-car indicators as controls in specifications where these are not the regressors of interest.

the policy, in 2019, inert customers could still be price-walked for a period of time without any cost in terms of competitiveness for new business. As the year of implementation approaches, the benefit of attracting new inert customers shrinks, as there are fewer years in which they can be "costlessly" price walked. Post-policy, there is no further change to how desirable inert customers are relative to searchers. This explanation is consistent with the convergence of prices for inert customers and searchers in the run-up to the policy, with no further convergence following policy implementation.

5.2 Pricing and Segmentation

We next study how the regulation affected insurers' pricing of their available products as a function of their back books. The model predicts that once price walking is banned, products with large back books should be less competitively priced. In this Section we combine our empirical measure of insurer back books with pricing behaviour around the introduction of the regulation to test this prediction.

Firms can adjust their quoting behaviour for a particular product (or a brand) and a particular customer in two ways: they can change the price at which they offer a product to a customer, or they can choose not to offer that particular customer the product at all. To capture the latter behaviour, we must define the set of potential products that could be offered to a customer. To do so, we create an expanded menu for each customer containing all products that were offered to any customer in the month of the enquiry, regardless of whether it was offered to that specific customer.[23]

We relate how competitive a firm's quotes to customers are to the firm's back book of customers of the same type (i.e., using the different proxies of the back book described earlier). We measure competitiveness based on whether a firm was at the top of the menu a customer faces (recall that Table 2 shows that top-of-menu products have a 43% likelihood of being chosen).

More precisely, we run different specifications of the following difference-in-difference linear-probability regression:

$$\text{top}_{ijt} = \beta_0 \text{BB}_{\theta(i)jt} + \beta_1 \text{Post}_t \text{BB}_{\theta(i)jt} + X_{ijt}\Gamma + \epsilon_{ijt} \tag{15}$$

where top_{ijt} is an indicator variable equal to 1 if product j gives the cheapest quote in

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[23]Clearly, for products not offered to the specific customer, we do not see what the price would have been, had it been offered.

response to customer i's enquiry at time t, and 0 otherwise; $\mathrm{BB}_{\theta(i)jt}$ denotes product j's back book for the type $\theta(i)$ of customer i at time t; Post_t is an indicator variable equal to 1 after the implementation of the pricing regulation in January 2022, and 0 otherwise; X_{ijt} is a vector of controls, including time fixed effects; and ϵ_{ijt} is an unobservable.

The different specifications allow for more or less aggregation of our dependent variable, for example whether j is the cheapest product in a customer's full menu, or if it is just the cheapest offered by firm f in that menu. Moreover, because we observe menus for each individual enquiry, we can perform our analysis within an individual customer enquiry. That is, our most stringent regressions compare the quotes that different insurers offer to *the same individual*. Additionally, we allow the coefficient on the back book to vary across firms—i.e., we look within individual firms to evaluate how much the effect of having a large back book on quoting behaviour changes following the implementation of the policy.[24]

Table 4 reports the coefficient estimates of these difference-in-difference regressions. Columns (1)–(3) report the results for the specifications with the dependent variable defined across all firms—i.e., top_{ijt} equals 1 if product j is the cheapest quote in response to customer i's enquiry at time t, and 0 otherwise. Specifications (1) and (2) are similar, although (2) is more stringent as it includes enquiry fixed effects. Specification (3) features brand-level slopes. Across all three specifications, the key difference-in-difference coefficient of interest (i.e., the effect of the back book after the policy relative to before the policy) is negative, meaning that firms with large back books price less competitively after the policy change.

The results are economically large. According to the estimates in columns (3), moving from the 1st to the 99th percentile of the back book (Table 3) implies a decrease in the probability of a firm giving the cheapest quote of 9%. This is over ten times the average unconditional probability that a given product is the cheapest quote.

The left panel of Figure 4 shows results of a time-varying version of the regression in Column 3 in Table 4, with quarterly coefficients on the back book, the main variable of interest. The effect on pricing kicks in sharply at the time the policy is introduced. There are no significant pre-trends. This is intuitive: in Section 5.1 we showed that firms reduced their teaser rates for inert customers in anticipation of the policy's implementation, as the expected present value of attracting an inert customer decreased. However, the ability of firms with large back books to price competitively for new business only fell when the policy was actually implemented, and firms had no incentive to act prior to this implementation.

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[24]Anecdotally, a minority of brands did not engage in price walking even before the policy.

Table 4: Competitiveness and Back Books

	Cheapest in menu			Cheapest in firm		
	(1)	(2)	(3)	(4)	(5)	(6)
Product back book	0.065***	0.065***		0.293***	0.318***	
	(0.00182)	(0.00182)		(0.00986)	(0.00721)	
Product back book × post	-0.091***	-0.091***	-0.090***	-0.388***	-0.423***	-0.451***
	(0.00232)	(0.00232)	(0.00257)	(0.01085)	(0.00849)	(0.00886)
Fixed effects						
Segment-month	Yes	No	No	Yes	No	No
Segment-product	Yes	Yes	Yes	Yes	Yes	Yes
Product-month	Yes	Yes	Yes	Yes	Yes	Yes
Enquiry	No	Yes	Yes	No	No	No
Firm-enquiry	No	No	No	No	Yes	Yes
Varying slopes						
Firm back book	No	No	Yes	No	No	Yes
Mean dep. var.	0.007	0.007	0.007	0.184	0.184	0.184
Observations	729,584,529	729,584,529	729,584,529	729,584,529	729,584,529	729,584,529

Note: This table reports the coefficient estimates of different specifications of regression (15). Standard errors are clustered at the product-segment-month level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1.

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Figure 4: Pricing and Back Books
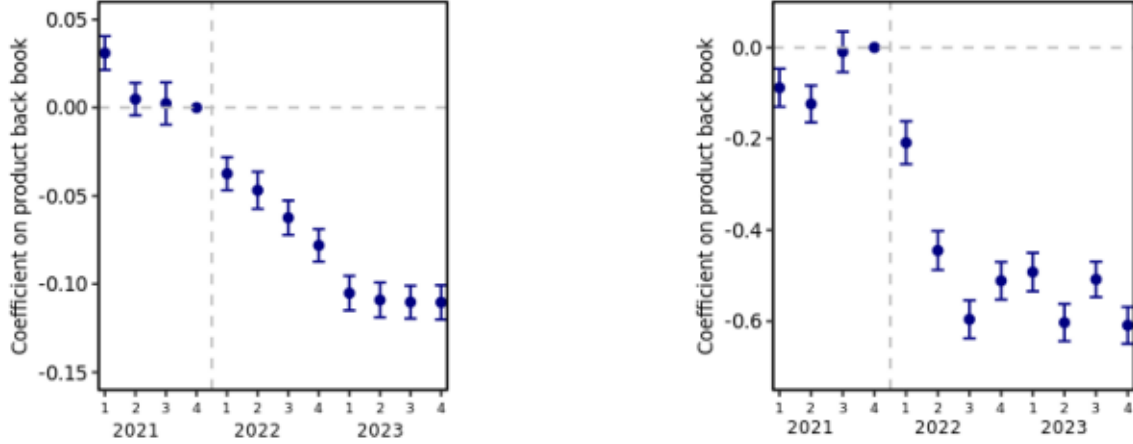
(a) Across-Firm Pricing & Back Books   **(b) Within-Firm Pricing & Back Books**

Note: The figures show, through time, the relationship between how competitively a product is quoted and its back book. The left panel displays the coefficients of the regression $\text{top}_{ijt} = \beta_t \text{BB}_{\theta(i)jt} + X_{ijt}\Gamma + \epsilon_{ijt}$, where all variables are defined in the text and the controls are those in the third column of Table 4. The right panel shows results of the regression $\text{top}_{ijt} = \beta_t \text{BB}_{\theta(i)jt} + X_{ijt}\Gamma + \epsilon_{ijt}$, where variables are as defined in Section 5.2 and controls are those in the sixth column of Table 4.

Columns (4)–(6) of Table 4 report the estimates of the specifications in which the dependent variable is more disaggregated—i.e., top_{ijt} equals 1 if product j is the cheapest amongst all products offered by firm f in response to customer i's enquiry at time t, and 0 otherwise. In each specification, after the policy change, products with large back books become less likely to be the cheapest product offered by a firm. The magnitudes are again economically large, though slightly smaller than the firm-level results of Columns (1)–(3). Moving from the 1st to the 99th percentile of the back book (Table 3) implies a decrease in the probability that a product is a firm's cheapest offer of 45%. This is around 2.5 times the average probability that a given product is the cheapest a firm offers.

The right panel of Figure 4 shows results of a time-varying version of the most stringent product-level regression (Column (6) in Table 4). Once again, the effect coincides with the introduction of the policy, and there are no significant pre-trends.

These results confirm the model's predictions regarding pricing and back books, and in particular the oscillating pattern in firms' competitiveness predicted in Proposition 2.

Products that have attracted a large amount of a particular type of customer in the past are now less competitive when competing for new customers of this type. This operates across all products—products with large back books are less likely to appear at the top of a customer's menu than products with no back book after the regulation. It also operates within firms: firms adjust prices across the products they offer in response to each product's back book, such that if a given product becomes uncompetitive by virtue of having a large back book, the firm can steer consumers to alternative products by pricing them competitively.

5.3 Product Proliferation

We now study the introduction of new products around the change in regulation. As explained in Section 3.5, the regulation introduces an incentive for firms to introduce new products, and this incentive is stronger for firms with large back books. We find support for this prediction in the data: following the change in regulation in 2022, the number of products offered by insurers increased sharply, and more so for firms with large back books.

As a warm-up to more tightly identified evidence, the left panel of Figure 5 displays some interesting aggregate effects. The black dashed line shows that the average brand had 25% more products on offer at the end of our sample period than it did at the beginning.

We now disaggregate this pattern of product proliferation across firms. The left panel of Figure 5 displays the number of products offered per firm for groups of firms with back books of different sizes. We focus on firm-level (rather than segment-specific or product-specific) back books because, once a product is introduced, it is generally introduced to many different segments.[25] We focus on the back book over the whole prior sample period, rather than just those contracts renewing in a given month, as once a firm introduces a product it tends to offer this product for a long period of time.[26]

We find that firms with large back books fully account for the increase in the total number of products on offer after the policy. The largest (top-tercile) firms with the largest back books increased the number of products they offered by approximately 50% after the policy, from approximately 4 to 6. All other firms left their product offerings broadly unchanged.

We formalize this result in a difference-in-difference regression. We relate the total number of products a firm offers in a given month prods_{ft} to its back book BB_{ft}, using the

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[25]On average, a product returns a quote in 43% of enquiries.

[26]For example, of the products quoted in 2019, the first year of our sample, two-thirds were still being quoted in 2023.

Figure 5: Products per Insurer, 2019–2023

(a) Trends by Back Book

(b) Difference-in-Difference
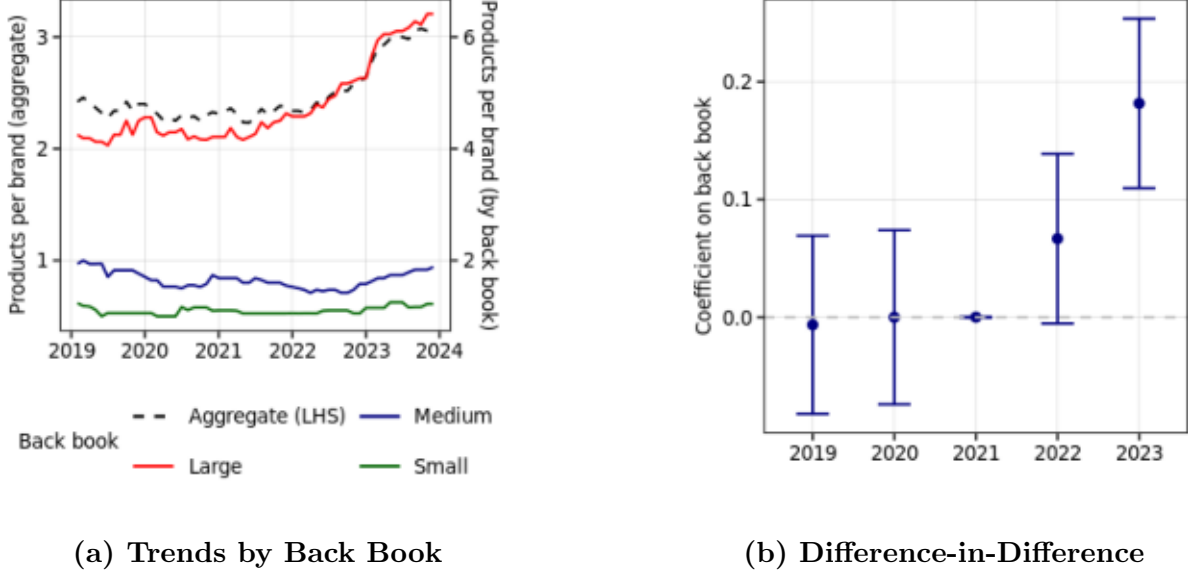
Note: Figures show the number of products offered by insurers through time and by the size of the firm's back book. Black dashed line in left panel shows the aggregate number of products offered each month by all insurance brands, divided by the total number of brands. Colored lines in the left panel show the average number of products per insurance brands according to the size of the brand's back book. Back books are defined as in Section 4.2 and are grouped into tertiles. Right panel shows the coefficients on a firm's back book in the two-way fixed effects regression relating a firm's products to its back book shown in equation 16. The points denote show the coefficients on the back book each year, with 95% confidence intervals.

following regression:

$$\text{prods}_{ft} = \beta_t \text{BB}_{ft} + \delta_t + \delta_f + \epsilon_{ft}, \tag{16}$$

where δ_t and δ_f are year and firm fixed effects, respectively. As explained in Section 4.2, a firm's aggregate back book share in a given month is defined as all customers who shopped with that firm in all prior months, as a percentage of the total customers across all firms in the same period.

The right panel of Figure 5 displays the estimates of the coefficients β_t. These estimates formalise the intuition from the time series evidence. There is no evidence of any pre-trends. After the policy implementation, we observe a sharp increase in the size of menus offered by the firms with the most incentive to expand their menus—those with large back books. The magnitudes of the coefficients in the right panel of Figure 5 are smaller relative to the magnitudes in the left panel, because the largest firms fully account for the increase in

product offerings—i.e., the effect is non-linear—whereas equation (16) is linear in the back book.

5.4   Gains to Search

The 2022 pricing regulations aimed to eliminate direct price discrimination between inert and active consumers. The model predicts that this will not eliminate the gains to search, as prices will still increase for inactive customers. We now provide evidence that indeed the regulation did not eliminate customers' benefits of searching and switching insurers, which remain large.

To show this, we construct a simple measure of the benefits from switching insurance, as follows. We leverage the fact that we observe a subset of customers purchase an insurance product one year, and then search again the following year. In the subsequent search, we can compare the price of their original product—to which they would renew if they did not switch products—to the price they could get if they switched.

More precisely, we restrict our sample to customers who purchased a product in a given year and searched again the following year, and for whom the product chosen in the first year appears in the menu in the second year. We then compute the savings they would get if they switched to the cheapest product in the menu rather than renewing the insurance policy they chose initially. This approach assumes that the quote a renewing customer receives is the same as the quote they are offered for the same product and the same insurer if they search via a price comparison website—arguably a conservative measure relative to the annual renewal quotes received in the mail.[27] As a result, we only perform this analysis for the period after the introduction of the policy, when prices for new customers and renewers were equalised.

The blue line in Figure 6 shows the distribution of these savings across customers, as a percentage of the price of the cheapest option in a customer's menu. It shows that the median customer could cut the price of their insurance by around 40% by switching to the cheapest quote as opposed to sticking with their existing product.

The red and green lines in Figure 6 decompose these potential savings. The red line strips out the effects of new products appearing on the menu, by computing savings relative only to the set of products that were available when the customer first took out insurance. New

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[27]See, for example, Adams, Hunt, Palmer, and Zaliauskas (2021) who show very low take-up rates in an RCT that tests customer responses to such annual renewal prompts to beneficially switch savings accounts.

Figure 6: Costs of Inertia: Decomposition
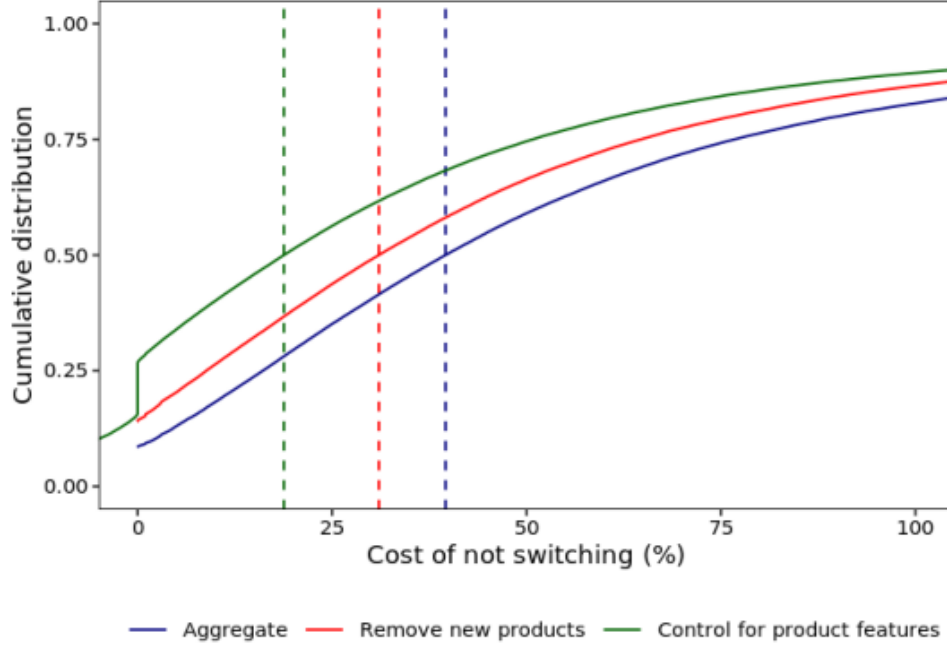
Note: This figure shows the distribution of the excess cost of a customer's chosen product one year after they chose it. We take the subset of customers that purchase a product and search again the following year. We define the incumbent product as the product purchased in the first year. The excess cost equals the extra percentage cost of the incumbent product in year two relative to the cheapest offer in the customer's menu in year two. The blue line shows the distribution of total excess costs. The red line computes the excess cost of the customer's product relative to the cheapest product in the menu that was also available the year previously. The green line repeats this calculation, then subtracts the excess cost that the customer paid the previous year. Dashed vertical lines show medians.

products account for approximately a quarter of the gains from switching for the median customer.

The green line in Figure 6 further controls for differences in the non-price features of different products. Customers may pick a product that is not the cheapest if it has some desirable non-price characteristics. We account for this in Figure 6 by subtracting the initial difference in price between the product chosen and the cheapest product available at that time. Thus, if a customer chose a product 20% more expensive than the cheapest in one year, and a year later the product remains 20% more expensive than the cheapest, we would compute their savings as 0.

These non-price characteristics explain some of the savings from switching products, but even after controlling for them and removing new products, the median customer pays over 20% more than they need to a year after taking out insurance. This 20% represents the customer's chosen product becoming more expensive relative to alternative products the customer was offered, but opted not to purchase.

These patterns are consistent with insurers continuing to profit from inert customers, even when they are prevented by the price-walking regulations from directly discriminating against their existing customers.

6   Conclusion

We study the impacts of regulatory intervention in markets with inactive consumers and price-discriminating firms. We develop a simple theoretical framework to study this issue, and derive predictions about how suppliers endogenously respond to such regulatory intervention. The model is geared towards studying a unique episode in the UK motor insurance market, around the introduction of regulatory policy seeking to eliminate "price walking," in which insurers kept prices low for new customers, whilst simultaneously raising prices for existing customers. The ambition was to stop insurers profiting from customer inaction following their initial active choice of insurance product.

We test the predictions of the model by studying granular search and choice data in this market. Consistent with these predictions, we find that insurers endogenously responded to the policy by reducing the price discounts offered to likely inactive customers, especially those with large "back books" of customers. We also find substantial product proliferation by insurers with large back books, in a seeming attempt to segment the market further. The endogenous responses of market participants to the regulatory policy resulted in maintaining a high price penalty for inactive existing customers, contrary to the goals of the policy. Moreover, the benefits to searching remain substantial despite the intervention.

Prior research has revealed that encouraging competition and nudge-style interventions can have limited effects on improving outcomes in markets with inertial consumers. Our findings reveal that these difficulties extend to the use of muscular regulatory intervention when customers are inert and suppliers adapt their responses to regulation.

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APPENDIX

A Additional Tables and Figures

Feature	Platinum	Gold	Standard	Essential
Motor legal protection	✓	✓	optional	optional
Roadside breakdown cover	✓	optional	optional	optional
Personal belongings cover	£300	£300	£200	×
Windscreen cover	✓	✓	✓	×
New car replacement	✓	✓	✓	×
Driving other cars (conditional)	✓	✓	✓	×
European cover for up to 90 days	✓	✓	✓	×
Audio equipment cover (aftermarket)	✓	✓	✓	×
Onward travel	✓	✓	×	×
Cost for indicative quote	£884.69	£840.55	£816.04	£750.76

Table A.1: Admiral car insurance products

Note: Table shows the four products offered by Admiral, a major UK car insurer. Products are vertically differentiated, with a higher price charged for policies with extra features.

Age group	Compare the Market	Consumer Intelligence	Population
16-29	50	11	14
30-39	16	16	17
40-49	11	17	18
50-59	9	21	19
60-69	11	22	15
70+	3	13	17

Table A.2: Datasets: shares by age

Note: Table shows the sample shares by age group for our main dataset (Compare the Market), our renewals survey data (Consumer Intelligence) and the population of England & Wales based on national survey data.

Figure A.1: Example of Price Comparison Website Menu

Note: Figure show the top of a menu of quotes for an insurance enquiry made via Compare the Market.

B Proofs

Proof of Proposition 1.

We assume the equilibrium is interior and verify that this is the case later. Let

$$x_t := s(\mathbf{p}_{t-1}, \Delta_{t-1})$$

denote the Markov state in period t. We will later rescale x_t to express it in terms of deviations from the mean.

Firm 0's Bellman equation is:

$$V_0(x_t; \Delta_t) = \max_{p_t^0, x_{t+1}} \left[(2 - \lambda) \left(\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c} \right) + \lambda x_t \right] p_t^0 + \delta E_t \left[V_0 (x_{t+1}, \Delta_{t+1}) \right]$$

subject to

$$x_{t+1} = \frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c}.$$

Standard arguments from dynamic programming (boundedness, discounting, and strict concavity of the "per-period utility" in p_t^0) give the first-order ("FOC") and envelope conditions:

$$\left[(2 - \lambda) \left(\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c} \right) + \lambda x_t \right] - \frac{2 - \lambda}{2c} p_t^0 - \frac{\delta}{2c} E_t \left[\frac{\partial V_0}{\partial x} \left(\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c}, \Delta_{t+1} \right) \right] = 0,$$

$$\frac{\partial V_0}{\partial x} (x_t; \Delta_t) = \lambda p_t^0.$$

Substitute the envelope at $t + 1$ at FOC to obtain firm 0's Euler condition:

$$\left[(2 - \lambda) \left(\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c} \right) + \lambda x_t \right] - \frac{2 - \lambda}{2c} p_t^0 - \frac{\delta \lambda}{2c} E_t \left[p_{t+1}^0 \right] = 0. \tag{A.1}$$

Symmetrically, firm 1's Euler condition is:

$$\left[(2 - \lambda) \left(\frac{1 - \Delta_t}{2} - \frac{p_t^1 - p_t^0}{2c} \right) + \lambda(1 - x_t) \right] - \frac{2 - \lambda}{2c} p_t^1 - \frac{\delta \lambda}{2c} E_t \left[p_{t+1}^1 \right] = 0. \tag{A.2}$$

Define the sum of prices as:

$$S(\Delta_t, x_t) := p^0(\Delta_t, x_t) + p^1(\Delta_t, x_t).$$

The following lemma establishes that in any MPE the sum of prices does not depend on the demand shock Δ_t and or on the state x_t:

Lemma 1. *In any MPE, the sum of prices equals* $S(\Delta_t, x_t) = \frac{4c}{2 - \lambda(1 - \delta)}$.

Proof. Add the Euler conditions of both firms (A.1) and (A.2):

$$S_t = \frac{4c}{2 - \lambda} - \frac{\delta \lambda}{2 - \lambda} E_t \left[S_{t+1} \right]. \tag{A.3}$$

Define the operator $(Tf)(z) := \frac{4c}{2 - \lambda} - \frac{\delta \lambda}{2 - \lambda} E \left[f(Z') | Z = z \right]$ on the set of bounded functions f of $Z = (x, \Delta)$. The operator T is a contraction in the sup norm with modulus $\frac{\delta \lambda}{2 - \lambda} < 1$. Hence, by the Banach fixed-point

theorem, it has a unique solution. Substituting a constant verifies that the solution is:

$$S_t = \frac{4c}{2 - \lambda(1 - \delta)} \qquad \forall t.$$

$\square$

To simplify notation, define the average price implied by Lemma 1 as $M := \frac{S}{2} = \frac{2c}{2 - \lambda(1-\delta)}$. Fixing an MPE, define the price difference as $d_t := p_t^1 - p_t^0$. Subtracting the Euler conditions of both firms (A.1) and (A.2) and rearranging, gives

$$(2 - \lambda)\left(\Delta_t + \frac{3}{2c}d_t\right) + \lambda\left(\Delta_{t-1} + \frac{d_{t-1}}{c}\right) + \frac{\delta\lambda}{2c}E_t[d_{t+1}] = 0. \tag{A.4}$$

As done in the text, redefine the state in terms of deviation from its mean:

$$y_{t+1} := x_{t+1} - \frac{1}{2} = \underbrace{\frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c}}_{x_{t+1}} - \frac{1}{2} = \frac{\Delta_t}{2} + \frac{d_t}{2c}.$$

Lemma 2. *There exist constants A and B such that the linear strategies*

$$p^0(y, \Delta) = M + A\Delta + By, \qquad p^1(y, \Delta) = M - A\Delta - By \tag{A.5}$$

constitute an interior MPE.

Proof. The proof is constructive: we find the constants A and B under which the linear strategies above solve the Euler conditions (A.1) and (A.2). With (A.5),

$$d_t = -2(A\Delta_t + By_t), \tag{A.6}$$

so

$$y_{t+1} = \frac{\Delta_t}{2} + \frac{d_t}{2c} = \left(\frac{1}{2} - \frac{A}{c}\right)\Delta_t - \frac{B}{c}y_t.$$

Moving d_t one period forward and taking expectations, gives

$$E_t[d_{t+1}] = -2\left(A\overbrace{E_t[\Delta_{t+1}]}^{0} + BE_t[y_{t+1}]\right) = -2BE_t[y_{t+1}],$$

so by the previous condition

$$E_t[d_{t+1}] = -2B\left[\left(\frac{1}{2} - \frac{A}{c}\right)\Delta_t - \frac{B}{c}y_t\right] = -2B\left(\frac{1}{2} - \frac{A}{c}\right)\Delta_t + \frac{2B^2}{c}y_t. \tag{A.7}$$

Substitute (A.6) and (A.7) into (A.4):

$$0 = (2 - \lambda)\left[\Delta_t - \frac{3}{c}(A\Delta_t + By_t)\right] + 2\lambda y_t + \frac{\delta\lambda}{c}\left[-B\left(\frac{1}{2} - \frac{A}{c}\right)\Delta_t + \frac{B^2}{c}y_t\right]$$

$$= \left[(2 - \lambda)\left(1 - 3\frac{A}{c}\right) - \delta\lambda\frac{B}{c}\left(\frac{1}{2} - \frac{A}{c}\right)\right]\Delta_t + \left[2\lambda + \delta\lambda\left(\frac{B}{c}\right)^2 - 3\frac{B}{c}(2 - \lambda)\right]y_t.$$

IV

Since this condition must hold for all (Δ_t, y_t), the terms inside each bracket must be zero. Let $a := \frac{A}{c}$ and $b := \frac{B}{c}$. The condition on the term multiplying y_t becomes:

$$b^2 - 3\frac{2-\lambda}{\delta\lambda}b + \frac{2}{\delta} = 0.$$

This quadratic expression is positive at $b = 0$ and negative at $b = 1$. Therefore, it has two positive roots: the smallest lies between 0 and 1 and the largest is greater than 1. The relevant root is the smallest:

$$b^* = \frac{3(2-\lambda) - \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{2\delta\lambda} \in (0, 1),$$

since a root greater than 1 would lead to an exploding path for p_t, violating the assumption that prices must be bounded.

The condition on the term multiplying Δ_t is:

$$(2-\lambda)(1-3a) - \delta\lambda b\left(\frac{1}{2} - a\right) = 0 \therefore a = \frac{2 - \lambda - \frac{\delta\lambda b}{2}}{3(2-\lambda) - \delta\lambda b}.$$

Substituting the expression for b gives:

$$a^* = \frac{2 - \lambda - \frac{\delta\lambda}{2}b^*}{3(2-\lambda) - \delta\lambda b^*}.$$

To conclude the proof, we need to verify that the Euler conditions of both firms (A.1) and (A.2) hold. This is equivalent to verifying that their sum and difference (A.3) and (A.4) conditions hold. Their sum (A.3) holds by the construction of M, as $p_0^t + p_1^t = 2M = S$. Their difference (A.4) holds by the choice of $A = a^*c$ and $B = b^*c$. □

We now show that the MPE is unique:

Lemma 3. *There exists at most one interior MPE.*

Proof. Let (p^0, p^1) be the interior MPE constructed above. Let $(\tilde{p}^0, \tilde{p}^1)$ also be an interior MPE. Define

$$\tilde{d}(\Delta, x) := \tilde{p}^1(\Delta, x) - \tilde{p}^0(\Delta, x), \qquad e(\Delta, x) := d(\Delta, x) - \tilde{d}(\Delta, x).$$

We claim that $e(\Delta, x) = 0$ for all (Δ, x).

Since $(\tilde{p}^0, \tilde{p}^1)$ is an interior MPE, it must also satisfy the Euler conditions (A.1)-(A.2), so equation (A.4) must hold for both d and $\tilde{d}$:

$$(2-\lambda)\left(\Delta_t + \frac{3}{2c}d_t(\Delta_t, x_t)\right) + \lambda x_t + \frac{\delta\lambda}{2c}E_t\left[d_{t+1}(\Delta_{t+1}, x_{t+1})\right] = 0,$$

$$(2-\lambda)\left(\Delta_t + \frac{3}{2c}\tilde{d}_t(\Delta_t, x_t)\right) + \lambda x_t + \frac{\delta\lambda}{2c}E_t\left[\tilde{d}_{t+1}(\Delta_{t+1}, \tilde{x}_{t+1})\right] = 0,$$

where

$$x_{t+1} = \frac{1 + \Delta_t}{2} + \frac{d_t}{2c}, \qquad \tilde{x}_{t+1} = \frac{1 + \Delta_t}{2} + \frac{\tilde{d}_t}{2c}. \tag{A.8}$$

V

Subtracting one from the other, gives

$$(2-\lambda)\frac{3}{2c}\underbrace{\left[d\left(\Delta_t,x_t\right)-\tilde{d}\left(\Delta_t,x_t\right)\right]}_{e(\Delta_t,x_t)}+\frac{\delta\lambda}{2c}\left\{\underbrace{E_t\left[d\left(\Delta_{t+1},x_{t+1}\right)\right]-E_t\left[\tilde{d}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]}_{*}\right\}=0. \qquad (A.9)$$

Consider the expression in *:

$$* = E_t\left[d\left(\Delta_{t+1},\tilde{x}_{t+1}\right)-\tilde{d}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]+E_t\left[d\left(\Delta_{t+1},x_{t+1}\right)-d\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]$$

$$= E_t\left[e\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]+E_t\left[d\left(\Delta_{t+1},x_{t+1}\right)-d\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]$$

By equation (A.6), we have

$$d(x,\Delta)=-2\left[A\Delta+B\underbrace{\left(x-\frac{1}{2}\right)}_{y}\right].$$

Therefore,

$$* = E_t\left[e\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]+E_t\left\{-2\left[A\Delta_{t+1}+B\left(x_{t+1}-\frac{1}{2}\right)\right]+2\left[A\Delta_{t+1}+B\left(\tilde{x}_{t+1}-\frac{1}{2}\right)\right]\right\}$$

$$= E_t\left[e\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]+2BE_t\left(\tilde{x}_{t+1}-x_{t+1}\right)$$

Substituting (A.8) gives

$$* = E_t\left[e_{t+1}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]-\underbrace{\frac{B}{c}}_{b}e(\Delta_t,x_t).$$

Plug back in (A.9):

$$\frac{3(2-\lambda)}{2c}e\left(\Delta_t,x_t\right)+\frac{\delta\lambda}{2c}\left\{E_t\left[e_{t+1}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]-be(\Delta_t,x_t)\right\}=0$$

$$\therefore\left[3(2-\lambda)-\delta\lambda b\right]e\left(\Delta_t,x_t\right)+\delta\lambda E_t\left[e_{t+1}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]=0$$

By the previous lemma, b^* solves the quadratic equation:

$$b^2-3\frac{2-\lambda}{\delta\lambda}b+\frac{2}{\delta}=0\therefore 3\left(2-\lambda\right)-b\delta\lambda=\frac{2\lambda}{b},$$

so the previous condition can be written as the functional equation:

$$e\left(\Delta_t,x_t\right)=-\frac{\delta b}{2}E_t\left[e_{t+1}\left(\Delta_{t+1},\tilde{x}_{t+1}\right)\right]. \qquad (A.10)$$

We claim that $e\left(Z\right)=0$ for all Z is the unique solution of (A.10). By substitution, one verifies that it is a solution. To show uniqueness, define the operator $(\tilde{T}e)(z):=-\frac{\delta b}{2}E\left[e(Z')|Z=z\right]$ on the set of bounded functions e of $Z=(x,\Delta)$. Recall that $b^*\in(0,1)$, so $0<\frac{\delta b}{2}<1$. Therefore, $\tilde{T}$ is a contraction in the sup norm, so it has a unique fixed point by the Banach fixed-point theorem. This establishes that the Euler conditions have a unique bounded solution, which is the unique interior MPE. $\square$

Proof of Proposition 2.

Substitute the equilibrium prices (10) and (11) in the definition of state (9).

Proof of Proposition 3.

Before presenting the proof, we obtain the expressions for the loss in total surplus with and without price walking regulation. As before, define the cutoff type as:

$$\ell^* = \frac{1+\Delta}{2} - \frac{p^0 - p^1}{2c} = \frac{1+\Delta}{2} + \frac{d}{2c}, \tag{A.11}$$

where $d := p^1 - p^0$. Total transportation costs among shoppers equal:

$$c\left[\int_0^{\ell^*} |\ell - \varepsilon_0|\, d\ell + \int_{\ell^*}^1 |\ell - (1-\varepsilon_1)|\, d\ell\right] = \frac{c}{2}\left[\varepsilon_0^2 + \varepsilon_1^2 + (\ell^* - \varepsilon_0)^2 + (1 - \varepsilon_1 - \ell^*)^2\right].$$

The efficient ("first-best") allocation minimizes transportation costs by setting the cutoff exactly in between both firms:

$$\ell^{FB} = \frac{\varepsilon_0 + 1 - \varepsilon_1}{2} = \frac{1+\Delta}{2}.$$

Substituting in equation (A.11), gives $d = 0$. Therefore, total transportation cost among active customers is minimized by setting the same price for both firms.

Define the loss of surplus associated with cutoff ℓ as:

$$\frac{c}{2}\left[\varepsilon_0^2 + \varepsilon_1^2 + (\ell - \varepsilon_0)^2 + (1 - \varepsilon_1 - \ell)^2\right] - \frac{c}{2}\left[\varepsilon_0^2 + \varepsilon_1^2 + (\ell^{FB} - \varepsilon_0)^2 + (1 - \varepsilon_1 - \ell^{FB})^2\right],$$

which, using $\ell^{FB} = \frac{1+\Delta}{2}$, can be expressed as

$$c \cdot \left(\ell - \ell^{FB}\right)^2. \tag{A.12}$$

Note that the surplus loss only depends on the demand shock through the first-best threshold ℓ^{FB}.

Using the cutoff among active customers (A.11) and the fact that there is a mass $2 - \lambda$ of such customers, we obtain the active cohort's loss of surplus relative to the first best:

$$(2-\lambda)c\left(\frac{1+\Delta_t}{2} + \frac{d_t}{2c} - \ell^{FB}\right)^2 = (2-\lambda)c\left(\frac{1+\Delta_t}{2} + \frac{d_t}{2c} - \frac{1+\Delta_t}{2}\right)^2 = \frac{2-\lambda}{4c}d_t^2.$$

Inertial consumers (mass λ) keep last period's assignment, so their cutoff at t remains at

$$\ell_{t-1} = \frac{1+\Delta_{t-1}}{2} + \frac{d_{t-1}}{2c}.$$

Their deviation from the first best ℓ_t^{FB} equals:

$$\ell_{t-1} - \ell_t^{FB} = \frac{\Delta_{t-1} - \Delta_t}{2} + \frac{d_{t-1}}{2c}.$$

Substituting in equation (A.12) and using the fact that there is a mass λ of interial customers, we obtain

their surplus loss period t:

$$\lambda c \left(\frac{\Delta_{t-1} - \Delta_t}{2} + \frac{d_{t-1}}{2c} \right)^2 .$$

Combining the surplus loss among active and inertial customers, we obtain the surplus loss among all consumers in period t conditional on the demand shocks:

$$\frac{2-\lambda}{4c} d_t^2 + \lambda c \left(\frac{\Delta_{t-1} - \Delta_t}{2} + \frac{d_{t-1}}{2c} \right)^2 . \tag{A.13}$$

We now use expression (A.13) to evaluate the surplus loss in each case.

No Regulation

Recall that without regulation, in the unique MPE, active customers face prices:

$$p_t^0 = c - \frac{\delta\lambda}{2-\lambda} K + \frac{c}{3} \Delta_t, \qquad p_t^1 = c - \frac{\delta\lambda}{2-\lambda} K - \frac{c}{3} \Delta_t,$$

so the difference equals:

$$d_t = p_t^1 - p_t^0 = -\frac{2}{3} c \Delta_t \quad \forall t.$$

Substituting in (A.13), gives the surplus loss conditional on the shock realizations:

$$\frac{2-\lambda}{9} c \Delta_t^2 + \lambda c \left(\frac{\Delta_{t-1}}{6} - \frac{\Delta_t}{2} \right)^2$$

Since net shocks are symmetric around zero, we have $E[\Delta_t] = 0$ for all t. Denote the variance of each period's taste shock by $\sigma^2 := Var(\Delta_t) = E[\Delta_t^2]$ and recall that $E[\Delta_t \Delta_{t-1}] = 0$ since shocks are i.i.d. with zero mean. Taking expectations, we obtain the expected surplus loss:

$$\frac{2-\lambda}{9} c\sigma^2 + \lambda c\sigma^2 \left(\frac{1}{36} + \frac{1}{4} \right) = \frac{4+3\lambda}{18} c\sigma^2 . \tag{A.14}$$

Note that K and δ affect average price levels but not the price difference, so they drop out of the misallocation cost.

Regulation

As calculated in equation (A.6), the MPE with price walking regulation has

$$d_t = -2 \left(A\Delta_t + By_t \right),$$

where $A = ac$, $B = bc$, and

$$b = \frac{3(2-\lambda) - \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{2\delta\lambda}, \qquad a = \frac{2 - \lambda - \frac{\delta\lambda}{2} b}{3(2-\lambda) - \delta\lambda b}.$$

The state $y_t := x_t - \frac{1}{2}$ evolves according to

$$y_{t+1} = -by_t + \left(\frac{1}{2} - a \right) \Delta_t.$$

VIII

Note that $y_t \perp \Delta_t$ (since Δ_t is i.i.d.). Moreover, y_t has unconditional mean zero and unconditional variance

$$Var(y_t) = \frac{\left(\frac{1}{2} - a\right)^2}{1 - b^2} \sigma^2.$$

To calculate the loss per active customer, note that

$$E[d_t^2] = E\left[\left(-2\left(A\Delta_t + By_t\right)\right)^2\right] = 4c^2\sigma^2\left[a^2 + \frac{b^2}{1 - b^2}\left(\frac{1}{2} - a\right)^2\right],$$

where we used the expression for the unconditional variance of y_t and $E[\Delta_t y_t] = 0$. Hence,

$$E\left[\frac{2 - \lambda}{4c}d_t^2\right] = (2 - \lambda)c\sigma^2\left[a^2 + \frac{b^2}{1 - b^2}\left(\frac{1}{2} - a\right)^2\right].$$

For the loss of inertial customers, note that

$$\frac{\Delta_{t-1} - \Delta_t}{2} + \frac{d_{t-1}}{2c} = \left(\frac{1}{2} - a\right)\Delta_{t-1} - \frac{1}{2}\Delta_t - by_{t-1}.$$

Because $\Delta_t \perp (y_{t-1}, \Delta_{t-1})$ and $\Delta_{t-1} \perp y_{t-1}$, we have

$$E\left[\left(\frac{\Delta_{t-1} - \Delta_t}{2} + \frac{d_{t-1}}{2c}\right)^2\right] = \left[\frac{1}{4} + \frac{\left(\frac{1}{2} - a\right)^2}{1 - b^2}\right]\sigma^2.$$

Substituting these expressions in (A.13), gives the expected surplus loss:

$$c\sigma^2\left\{(2 - \lambda)a^2 + \left[(2 - \lambda)b^2 + \lambda\right]\frac{\left(\frac{1}{2} - a\right)^2}{1 - b^2} + \frac{\lambda}{4}\right\}. \tag{A.15}$$

Surplus Comparison

Comparing (A.14) and (A.15), we find that regulation has higher total surplus if and only if:

$$\frac{4 + 3\lambda}{18} \geq (2 - \lambda)a^2 + \left[(2 - \lambda)b^2 + \lambda\right]\frac{\left(\frac{1}{2} - a\right)^2}{1 - b^2} + \frac{\lambda}{4}, \tag{A.16}$$

where $b := \frac{3(2-\lambda) - \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{2\delta\lambda}$ and $a = \frac{2 - \lambda - \frac{\delta\lambda}{2}b}{3(2-\lambda) - \delta\lambda b}$.

Define α as the unique root in $(0, 1)$ of

$$\alpha^3 - 11\alpha^2 + 38\alpha - 13 = 0,$$

and let $\bar{\lambda} := \frac{2\alpha}{1+\alpha} \approx 0.554$. It can be shown that for any $\lambda < \bar{\lambda}$, there exists a cut-off $\delta_\lambda^* \in (\frac{1}{2}, 1)$ strictly increasing in λ such that condition (A.16) holds if and only if $\delta > \delta_\lambda^*$. For $\lambda > \bar{\lambda}$, the condition fails for all δ.

Proof of Propositions 4 and 5.

We start by calculating the expected profits without regulation. Firm 0's profits in period t equal:

$$\Pi_{t,0}^{NR} := (2 - \lambda) s_t p_U^0(\Delta_t) + \lambda s_{t-1} K.$$

Using the equilibrium prices from equation (7), market share among active choosers from (8), and the unconditional expectations: $E[\Delta_t] = 0$, $E[\Delta_t^2] = \sigma^2$, and $E[s_{t-1}] = \frac{1}{2}$, we obtain:

$$E[s_t p_U^0(\Delta_t)] = \frac{c}{2} - \frac{\delta \lambda K}{2(2 - \lambda)} + \frac{c}{18}\sigma^2.$$

Substituting in the previous equation, we obtain firm 0's expected per-period profit under no regulation:

$$E[\Pi_{t,0}^{NR}] = \frac{\lambda(1 - \delta)}{2} K + \frac{2 - \lambda}{2}\left(1 + \frac{\sigma^2}{9}\right) c. \tag{A.17}$$

By symmetry, this expression is also firm 1's expected per-period profit.

Next, we calculate the expected profits with price walking regulation. Since firm 0 now sells to all customers at the same price $p_R^0(y_t, \Delta_t)$, its profits in period t are:

$$\Pi_{t,0}^{R} := [(2 - \lambda) s_t + \lambda x_t] \cdot p_R^0(y_t, \Delta_t).$$

Substituting the equilibrium objects s_t, p_t^0, and $x_t = y_t + 1/2$ using from Propositions 1 and 2, and using the fact that $E[\Delta_t] = E[y_t] = 0$, $\Delta_t \perp y_t$, and $Var(y_t) = \frac{(\frac{1}{2} - a)^2}{1 - b^2}\sigma^2$, we obtain firm 0's expected per-period profit with price walking regulation:

$$E[\Pi_{t,0}^{R}] = \frac{2c}{2 - \lambda(1 - \delta)} + c\sigma^2 \left\{ (2 - \lambda) a \left(\frac{1}{2} - a\right) + [\lambda - (2 - \lambda) b] \frac{b\left(\frac{1}{2} - a\right)^2}{1 - b^2} \right\}, \tag{A.18}$$

where a and b are as defined in Proposition 1. By symmetry, firm 1's expected profits are the same.

Proof of Proposition 4. Note that the expected profits without regulation—equation (A.17)—increase linearly in K, whereas expected profits with regulation are not affected by K. Therefore, for any $\delta < 1$ and any $\lambda > 0$, there exists K is large enough such that the expected profits without regulation exceed the ones with regulation. It can be shown that $E[\Pi_{t,0}^{R}] > \frac{2 - \lambda}{2}\left(1 + \frac{\sigma^2}{9}\right) c$, so the cut-off $\bar{K}_{\delta,\lambda}$ is strictly positive. $\square$

Proof of Proposition 5. Since the expressions in equations (A.17) and (A.18) are both continuous in δ, it suffices to consider the limit as $\delta \nearrow 1$. From (A.17), we immediately get:

$$\lim_{\delta \nearrow 1} E[\Pi_{t,0}^{NR}] = \frac{2 - \lambda}{2}\left(1 + \frac{\sigma^2}{9}\right) c. \tag{A.19}$$

We now turn to the limit of

$$E[\Pi_{t,0}^{R}] = \frac{2c}{2 - \lambda(1 - \delta)} + c\sigma^2 \left\{ (2 - \lambda) a_\delta \left(\frac{1}{2} - a_\delta\right) + [\lambda - (2 - \lambda) b_\delta] \frac{b_\delta\left(\frac{1}{2} - a_\delta\right)^2}{1 - b_\delta^2} \right\}, \tag{A.20}$$

as $\delta \nearrow 1$, where

$$a_\delta := \frac{1}{2} \cdot \frac{2 - \lambda + \sqrt{9(2 - \lambda)^2 - 8\delta\lambda^2}}{3(2 - \lambda) + \sqrt{9(2 - \lambda)^2 - 8\delta\lambda^2}}$$

X

and

$$b_\delta := \frac{3(2-\lambda) - \sqrt{9(2-\lambda)^2 - 8\delta\lambda^2}}{2\delta\lambda}.$$

The first term in (A.20) converges to c as $\delta \nearrow 1$.

To simplify the expression inside brackets, let $\alpha := 2 - \lambda$ and $\beta := \sqrt{36(1-\lambda) + \lambda^2}$. Then, we have:

$$a_1 = \frac{1}{2} \cdot \frac{2 - \lambda + \sqrt{36(1-\lambda) + \lambda^2}}{3(2-\lambda) + \sqrt{36(1-\lambda) + \lambda^2}} = \frac{\alpha + \beta}{2(3\alpha + \beta)},$$

$$b_1 = \frac{3(2-\lambda) - \sqrt{36(1-\lambda) + \lambda^2}}{2\lambda} = \frac{3\alpha - \beta}{2\lambda}.$$

Note that

$$\frac{1}{2} - a_1 = \frac{1}{2} - \frac{\alpha + \beta}{2(3\alpha + \beta)} = \frac{\alpha}{3\alpha + \beta}. \tag{A.21}$$

By construction (see proof of Proposition 1), b_1 solves:

$$b_1^2 - 3\frac{\alpha}{\lambda}b_1 + 2 = 0,$$

which can be rearranged as

$$\frac{\lambda - \alpha b_1}{1 - b_1^2} = \frac{\lambda}{3}. \tag{A.22}$$

Use (A.21) to obtain:

$$(2-\lambda) a_\delta \left(\frac{1}{2} - a_\delta\right) \to \alpha a_1 \left(\frac{1}{2} - a_1\right) = \frac{\alpha^2(\alpha + \beta)}{2(3\alpha + \beta)^2}.$$

Use (A.21) and (A.22) to obtain:

$$[\lambda - (2-\lambda) b_\delta] \frac{b_\delta \left(\frac{1}{2} - a_\delta\right)^2}{1 - b_\delta^2} \to \frac{\lambda - \alpha b_1}{1 - b_1^2} \cdot b_1 \left(\frac{1}{2} - a_1\right)^2 = \frac{\lambda}{3} b_1 \left(\frac{\alpha}{3\alpha + \beta}\right)^2 = \frac{\alpha^2(3\alpha - \beta)}{6(3\alpha + \beta)^2},$$

where the last equality substituted $b_1 = \frac{3\alpha - \beta}{2\lambda}$. Combining these expressions, gives:

$$(2-\lambda) a_\delta \left(\frac{1}{2} - a_\delta\right) + [\lambda - (2-\lambda) b_\delta] \frac{b_\delta \left(\frac{1}{2} - a_\delta\right)^2}{1 - b_\delta^2} \to \frac{\alpha^2(\alpha + \beta)}{2(3\alpha + \beta)^2} + \frac{\alpha^2(3\alpha - \beta)}{6(3\alpha + \beta)^2} = \frac{\alpha^2}{3(3\alpha + \beta)}.$$

Substituting back in (A.20), we find:

$$\lim_{\delta \nearrow 1} E[\Pi_{t,0}^R] = c + c\sigma^2 \frac{\alpha^2}{3(3\alpha + \beta)}. \tag{A.23}$$

Using equations (A.19) and (A.23), the difference in per-period profits becomes:

$$\lim_{\delta \nearrow 1} \left\{ E[\Pi_{t,0}^R] - \lim_{\delta \nearrow 1} E[\Pi_{t,0}^{NR}] \right\} = \left\{ 1 - \frac{\alpha}{2} + \sigma^2 \left[\frac{\alpha^2}{3(3\alpha + \beta)} - \frac{\alpha}{18} \right] \right\} c. \tag{A.24}$$

By the definition of α,

$$1 - \frac{\alpha}{2} = \frac{\lambda}{2} > 0. \tag{A.25}$$

XI

With some algebraic manipulations, one obtains:

$$\frac{\alpha^2}{3\,(3\alpha + \beta)} - \frac{\alpha}{18} = \frac{\alpha}{18} \cdot \frac{9\alpha^2 - \beta^2}{(3\alpha + \beta)^2}.$$

Use the definitions of α and β to write:

$$9\alpha^2 - \beta^2 = 9(2 - \lambda)^2 - \left[36\,(1 - \lambda) + \lambda^2\right] = 8\lambda^2,$$

so that

$$\frac{\alpha^2}{3\,(3\alpha + \beta)} - \frac{\alpha}{18} = \frac{4\alpha\lambda^2}{9\,(3\alpha + \beta)^2} > 0. \tag{A.26}$$

Substituting (A.25) and (A.26) in (A.24), gives:

$$\lim_{\delta \nearrow 1} \left\{ E[\Pi_{t,0}^R] - \lim_{\delta \nearrow 1} E[\Pi_{t,0}^{NR}] \right\} = \left\{ \frac{\lambda}{2} + \sigma^2 \left[\frac{4\alpha\lambda^2}{9\,(3\alpha + \beta)^2} \right] \right\} c > 0.$$

Proof of Proposition 6.

The game starts at period T (announcement date). Let V_0 denote firm 0's Bellman equation with price walking regulation, as specified in the proof of Proposition 1. This coincides with firm 0's value function for periods $t > T$. Let W_0 denote firm 0's value function at T:

$$W_0(x_T, \Delta_T) = \max_{p_T^0} \left\{ (2 - \lambda)s(\mathbf{p}_t, \Delta_t)p_T^0 + \lambda x_T K + \delta E_T \left[V_0(x_{T+1}; \Delta_{T+1}) \right] \right\},$$

subject to

$$x_{t+1} = \frac{1 + \Delta_t}{2} + \frac{p_t^1 - p_t^0}{2c},$$

and analogously for firm 1.

Calculating the first-order condition and using the envelope condition applied to V_0, we obtain the optimality condition at T:

$$(2 - \lambda)\,s(\mathbf{p}_T, \Delta_T) - \frac{2 - \lambda}{2c}\,p_T^0 - \frac{\delta\lambda}{2c} E_T[p_{T+1}^0] = 0,$$

and the symmetric condition for firm 1:

$$(2 - \lambda)[1 - s(\mathbf{p}_T, \Delta_T)] - \frac{2 - \lambda}{2c}\,p_T^1 - \frac{\delta\lambda}{2c} E_T[p_{T+1}^1] = 0,$$

Adding the optimality conditions of both firms at T gives:

$$(2 - \lambda) - \frac{2 - \lambda}{2c}\,\left(p_T^0 + p_T^1\right) - \frac{\delta\lambda}{2c} \left\{ E_T[p_{T+1}^0] + E_T[p_{T+1}^1] \right\} = 0.$$

As shown in Proposition 1, the sum of prices after regulation satisfies:

$$p_{T+1}^0 + p_{T+1}^1 = \frac{4c}{2 - \lambda(1 - \delta)}$$

(independent of Δ_{T+1}). Substituting in the previous expression and rearranging, gives:

$$p_T^0 + p_T^1 = 2c - \frac{4c\delta\lambda}{(2-\lambda)\left[2-\lambda(1-\delta)\right]}. \tag{A.27}$$

Subtracting the two optimality conditions of both firms at T and using the expression for s, gives:

$$(2-\lambda)\left(\Delta_T + \frac{p_T^1 - p_T^0}{c}\right) + \frac{2-\lambda}{2c}\left(p_T^1 - p_T^0\right) - \frac{\delta\lambda}{2c}\left\{E_T[p_{T+1}^0] - E_T[p_{T+1}^1]\right\} = 0. \tag{A.28}$$

Equation (10) gives:

$$E_T[p_{T+1}^0] = c\left[\frac{2}{2-\lambda(1-\delta)} + a\underbrace{E_T[\Delta_{T+1}]}_{0} + by_{T+1}\right] = c\left[\frac{2}{2-\lambda(1-\delta)} + by_{T+1}\right]$$

and

$$E_T[p_{T+1}^1] = c\left[\frac{2}{2-\lambda(1-\delta)} - a\underbrace{E_T[\Delta_{T+1}]}_{0} - by_{T+1}\right] = c\left[\frac{2}{2-\lambda(1-\delta)} - by_{T+1}\right].$$

Therefore,

$$E_T[p_{T+1}^0] - E_T[p_{T+1}^1] = 2cby_{T+1} = bc\left(\Delta_T + \frac{p_T^1 - p_T^0}{c}\right), \tag{A.29}$$

where the last equality used the definition of the state y_t and the demand function s to write

$$y_{T+1} = \frac{\Delta_T}{2} + \frac{p_T^1 - p_T^0}{2c}.$$

Substituting equation (A.29) in (A.28) and rearranging, gives:

$$p_T^1 - p_T^0 = -c\frac{2(2-\lambda)-\delta\lambda b}{3(2-\lambda)-\lambda\delta b}\Delta_T = -2ac\Delta_T. \tag{A.30}$$

Equations (A.27) and (A.30) are a linear system of two equations and two unknowns, which have the unique solution:

$$p_T^0 = c\left[1 - \frac{2\delta\lambda}{(2-\lambda)\left[2-\lambda(1-\delta)\right]} + a\Delta_T\right],$$

and

$$p_T^1 = c\left[1 - \frac{2\delta\lambda}{(2-\lambda)\left[2-\lambda(1-\delta)\right]} - a\Delta_T\right].$$