Dear Competition and Markets Authority,

We are economists writing in response to the call for information about algorithms, competition, and consumer harm. Alexander MacKay is an assistant professor at Harvard Business School at Harvard University. Zach Brown is an assistant professor in the Department of Economics at University of Michigan. We have no interests other than promoting a better understanding of how algorithms will affect competition in the marketplace. Our own research relates directly to this topic.

We would like to draw your attention to a fundamental way in which algorithms can reduce competition and raise prices, thus generating consumer harm. In our attached paper, "Competition in Pricing Algorithms," we show that the nature of algorithm technology allows firms to adjust the frequency that they change prices and commit to automated pricing rules in advance. These features have the ability to increase prices *even in the absence of collusion*. In particular, competitive equilibria when firms choose algorithms, rather than prices, can have prices that are substantially higher than the competitive equilibria when firms simultaneously choose prices. Below, we provide a brief overview of our main points. Roughly, the sections below address questions 1 and 2, then 3, then 5, 7, and 8 from the call for information.

Algorithms Change the Pricing Game

The simultaneous price-setting model has been the foundation for the analysis of price competition by competition authorities worldwide. This model has been used to understand both competitive and collusive outcomes. The CMA's current report highlights the potential for algorithms to increase the risk of collusion within a simultaneous price-setting framework. We show something fundamentally different: algorithms have the ability to break firms away from the simultaneous price-setting model, obtaining higher prices without the need for collusion. In our framework, each firm pursues their own individual, short-run self-interest.

For example, consider an environment in which one large retailer has an algorithm that allows it to scrape rivals' prices and quickly react to price changes. Let's call this sophisticated retailer "***A***." How do slower rivals respond to ***A***'s high-speed algorithm? Rivals will learn that it is not worth trying to undercut ***A***'s prices, since any attempt to do so would be immediately met by a further price reduction by ***A***'s algorithm. Thus, ***A***'s algorithm limits the ability of rivals to gain market share through lower prices. In this way, the threat of ***A***'s algorithm softens price competition.

In this setting, there is limited incentive for ***A***'s rivals to compete on price. The rivals may "give up" on price competition, settling into a pattern where the rivals choose high prices and ***A*** sets lower prices. Note that they are not colluding—***A*** has simply outmaneuvered its slower rivals. However, even ***A***'s prices are higher than what would result with simultaneous price-setting

behavior. Thus, algorithms have the potential to raise the prices for all firms, even when firms act competitively.

Firms Already Employ Algorithms with These Features

In the attached paper, we demonstrate that the manifestation of these features is not speculative. In our empirical analysis, we study the five large online retailers in the U.S. We show that they have different pricing technologies, including weekly price updates, daily price updates, and price updates that occur within an hour. Firms with faster algorithms react to price changes by slower rivals. Furthermore, firms with faster algorithms have substantially lower prices than slower rivals, consistent with the model described above. Thus, though it may appear that a high-frequency algorithm is "competitive"—insofar as it results in lower prices for the adopting firm—it may result in higher prices for all firms!

The features that cause these impacts are widespread. Consider repricer.com, one of the larger third-party pricing algorithms. It provides services for sellers on Amazon, ebay, Walmart, and Google shopping. As of March 15, 2021, Repricer.com's home page states that it can react to price changes by competitors "in 90 seconds." Firms can choose this high-frequency option for $249 per month, or they can opt for slower "hourly repricing" for $79 per month.[1] Thus, even competitors that use the same third-party provider may have differences in pricing frequency, softening price competition. Second, a key feature offered by repricer.com, as well as other third-party algorithm providers, is the ability to commit to pricing rules in advance. These pricing rules incorporate reactions to rivals' prices and scheduling price changes at certain frequencies.[2] Moreover, this example illustrates how the standard model of price competition may be insufficient to analyze competition in the presence of algorithms. Asymmetries in pricing technology and automation are already important determinants of prices, especially in online markets. Through these features, all firms may realize higher prices and greater profits in competitive equilibrium.

Looking to the future, we also consider an environment where all firms in a market adopt high-frequency algorithms with the ability to automate price changes. In this case, we show that it is possible for firms to support collusive prices without resorting to collusive strategies. In particular, the collusive outcomes can be achieved with strategies that are linear functions of

[1] See https://www.repricer.com/pricing. Accessed March 15, 2021.

[2] See https://www.repricer.com/features, which states "Price up and down: Price upwards when the competitive environment allows, such as when competitors go out of stock, *increase their prices*, and when you're the buy box winner" [emphasis added]. And also: "Scheduler: Raise your game during quiet periods of the week by scheduling time-specific rules that optimize your repricing strategy." Accessed March 15, 2021.

rival's prices, e.g., for every $0.03 decrease of a rival's price, each firm reduces their own price by $0.01. Many current algorithms follow this simple linear form.

Challenges for Competition Authorities

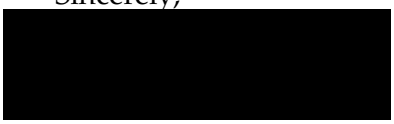
These impacts of algorithms raise two categories of challenges for competition authorities that wish to promote competition and protect consumer welfare. The first category is practical: without direct observation of the pricing technology used by firms, it may be difficult to *detect* the use of algorithms to raise prices. In the first example described above, firm ***A*** had a superior algorithm and lower prices than its rivals. Thus, prices can vary across firms in an affected market, and they may vary substantially. Competition authorities cannot narrow their focus to markets with periods of stable and equal price levels across firms, which occur in typical models of collusion with symmetric firms.

A related detection challenge concerns the possibility of all firms adopting high-frequency algorithms that are linear functions of rivals' prices. In our framework, such algorithms can deliver collusive prices, but they can also deliver prices that are much more competitive. The difference in strategies is not qualitative in nature, but quantitative: What are the values of the parameters of the algorithms, and do these values deliver a collusive outcome? Evaluating how close linear algorithms come to collusion would require detailed quantitative knowledge of demand. Thus, even if competition authorities were able to observe the exact technology used by firms, it would not be possible to assess consumer harm without a detailed econometric analysis.

The second category of challenges is conceptual: Can firms be punished for pursuing uniquely competitive outcomes? Competition authorities have traditionally targeted pricing behavior that involves a short-run sacrifice for a long-term gain, such as cartel agreements and predatory pricing. In both of these cases, violating firms deviate from the competitive price levels and give up short-run profit. With algorithms, higher prices can be achieved without any firm making a short-run sacrifice. In our view, traditional enforcement measures may not apply in such situations.

Online retailers are secretive about their use of algorithms. While our research provides insights about the impacts of pricing algorithms that respond to rivals' prices, detailed audits of algorithms used in practice would help shed additional light on these issues. For example, more specific information on how algorithms use rivals' prices would help guide potential regulatory remedies. Regulation may be used to limit the ability of firms to quickly react to rivals, either by directly limiting the processing of rivals' prices or by regulating firms to change prices with the same cadence, such as one per day. Given that there are costs and benefits associated with this type of regulation, more research is needed to fully understand the tradeoffs. We hope that CMA will play an important role in investigating these issues.

Sincerely,



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