STRUCTURAL ESTIMATION OF ALGORITHMIC PRICE COLLUSION IN LAHORE'S RIDE-HAILING MARKETS

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Abstract

This article explores Structural Estimation of Algorithmic price collision in Lahore. It is a survey of whether there is an algorithmic price collusion in the ride-hailing markets of Lahore, with a specific interest in whether the players in the markets use pricing algorithms to coordinate prices, and thus expose themselves to the risks of anti-competitive behavior. The research problem is evoked by the increased reliance on algorithms in pricing mechanism in dealings in digital markets, with special interest on the ride hailing systems particularly in Lahore as a highly-developed region in Pakistan. Possibility of algorithmic collusion in other markets has been recorded in previous studies, but there is still limited empirical data on the existence of such behavior in the emerging markets. This paper aims at characterizing the behavior of algorithmic price action, and evaluating the probable existence and potential benefit of collusion and the estimated effect of it on economics. There was a mixed-methods design and in combination, there were qualitative interviews of industry professionals and quantitative data based on market observations. The findings demonstrate that the price-setting patterns and algorithmic alterations are substantially correlated and this fact provides evidence on the existence of collusion mechanism. The results add to the knowledge of the digital market behavior and its regulation. The finals section of the study highlights the fact that there should be greater oversight over the usage of algorithms in the context of pricing within the ride-hailing business in Lahore to curb the anti-competitive behaviors.

Keywords: Algorithmic Price Collusion, Ride hailing, Lahore, Market Pricing, Competition policy, Structural estimation, Increasing Digitalization

Introduction

The ride-hailing sector has been experiencing an evolution within the past few years and it has been due to the mushrooming of companies like Uber, Careem and emerging domestic competitors. This sector has transformed the urban mobility in Lahore, Pakistan into a consumable and easily accessible service to meet the needs of consumers, including cheaper and time-saving transportation options, and also an employment location that could easily generate income in form of flexible work to the drivers. Such a tendency has made it possible to develop ride-hailing in such emerging economies as Pakistan, where informal transportation systems have been frequent. Nonetheless, with the emergence of pricing algorithm integration in this industry, different

problems have emerged especially through possible anti-competitive practices, which include algorithmic price collusion. Such issue occurs in the case when a rivalry could arise due to the alternative platforms that through their algorithms are able to synchronize their financial methods unwittingly or intentionally, thereby disassembling the concept of fair competition.

Such dimension as the increased amount of automated price algorithms influences the rationale of the market largely. More specifically, algorithms enabling prices adjustment according to the actions of competitors, changes in the demand, and consumer attitudes may end up having unintended consequences of firms substantively colluding with each other tacitly, i.e., without direct coordination. Although the topic of algorithmic price collusion has received significant coverage in the developed markets, including the United States and the European Union (Calvano et al., 2020; Rasmusen, 2019), few studies have been conducted to study what happens in developing countries, including Pakistan. In such markets, the frameworks to regulate digital platforms have not been fully developed which has led into a case where anti-competitive algorithms-led practices can either be ignored or unregulated. This research gap emphasises the importance of investigating the working of the algorithmic pricing in the ride-hailing market of Lahore as well as evaluating its capacity to promote anti-competitive behaviour in the Lahorian market.

This topic is not purely theoretical in terms of social science. There has been a distinct change with the study of influence of algorithms into the market behavior in the area of competition economics, particularly in markets with much influence of digital technologies. With the increase in the number of artificial intelligence and automation in more industries, the possibility of collusion through algorithms increases, which is hazardous to both the consumer market and efficiency. Recent literature has put forward the fact that the efficiency with which algorithms can coordinate prices, even when there is no direct communication between companies, is becoming a reality, and such an expansion of methods of traditional regulation is not sufficient (Binns & Hart, 2021). The introduction of such practices in sectors such as the movement of passengers spearheaded by companies such as ride-hailing poses big concerns regarding the regulation of markets with respect to the digital world.

This matter is especially topical in relation to a country such as Pakistan, where this industry is rapidly developing, yet there is the absence of rigorous regulations of the algorithmic price policy. Although the ride-hailing services are praised as means of improving mobility and offering income to people, the unregulated industry poses serious threats. Algorithmic pricing may translate to oligopolistic behavior in countries whose legal structures are not well developed and the small group of dominant platforms may coordinate goals through their algorithms and thus end up hiking the price and eliminating price competition in the market. With their expansion, consumers may end up enduring over-priced offers, which means that the actual benefit that is supposed to be provided by the ride-hailing services, including affordability and accessibility, will be eliminated.

This research can be motivated by the high rate of digital platforms network growth in the emerging markets along with the growing significance of algorithmic pricing in digital economies. The current trends in Pakistan have shown that services initiated by such apps as Uber and Careem

are becoming a fundamental part of everyday life of millions of the consumers in Lahore, which makes the implementation of reasonable control both a necessity and a challenge. Moreover, Lahore is highly urbanized, and the middle class is expanding, which easily explains why ride-hailing companies may achieve steady growth there, so it is significant to learn more about competitive dynamics that have impact on this market. It is against this background that this study seeks to fill these literature gaps by addressing the issue of possible algorithmic price colluding in the ride hailing algorithm market in Lahore to present governments with empirical evidence to take steps to stop such anti-competitive price fixing.

The need to carry out such research is precipitated by the greater implications of algorithmic collusion in other industries. Due to the growing presence of digital platforms worldwide, especially in areas such as e-commerce and transport, it is important to know how they work and who benefits or loses most controlled by this kind of algorithmic pricing? Investigations into the areas of mature markets revealed that algorithms potentially coordinate pricing intentionally or not, in which case consumer welfare can be under threat (Binns & Hart, 2021). Pakistan, which has a burgeoning IT network and an increasingly high rate of uptake of ride-hailing apps, is equally threatened. The study will also help in understanding more about how these algorithms cooperate and compete to create an atmosphere that inadvertently makes colluding easier, which will ultimately help regulation agencies know how to lay down effective policies.

Literature Review

The presence of algorithmic prices in the ease of collusion in the digital markets has attracted a lot of criticism in the recent past. In this literature review of the concept of algorithmic price collusion, this paper analyzes significant literature, methodologies, and frameworks of the subject of interest, given the situation of hailing ride services in Lahore, Pakistan. Through these, it shows an overview of the prevailing research, the examples of technological progress and models, the significant conclusions and their relevance as well as the untapped literature which this paper attempts to fill.

Algorithmic price colluding is a concept that happened to be significant in the digital domain, which uses automated mechanisms through digital stations to be able to fix costs. Dynamic pricing prices algorithms are used in places like e-commerce, airlines, and hospitality where the price can be shifted quickly according to factors in the market which are the price of competitors, the demand, and consumer preferences. Here unintentional phenomena may arise, like tacit collusion when a collusive adjustment of prices occurs, without communicating with each other, by means of prices which competitors adjust in a collusive fashion. The implications of tacit collusion through such algorithms were one of the first issues to be pointed out by He and Liu (2018) specifically with regards to digital markets, which cause less competition to be visible and more ambiguity in price-setting.

The impacts of algorithmic pricing of the traditional industries have been recorded in a number of studies. To elaborate, Zhu and Liu (2020) in airline market proved that dynamic pricing algorithms could unintentionally cause synchronized movement of prices when algorithms react to market circumstances in a certain similar manner. Elmaghraby and Keskin (2018) demonstrated in e-

commerce that platforms set to optimize their revenue in response to the algorithmic coordination may well harmonize their prices to limit the price competition and stabilize a market structure albeit monopolistic.

Bergemann and Bonatti (2019) continued to explicate the interconnection between the algorithmic pricing and the price coordination by emphasizing the role of coordinated pricing, which is elicited by the use of the algorithm, even though no certain communication is established. In the markets with high availability of data and advanced machine learning capabilities that enable algorithms to predict and copy the actions of competitors in prices, this is especially true. The growing use of artificial intelligence and machine learning in pricing algorithms has also helped to make collusion more effective since colluders can effectively use such AI tool to automatically change prices according to previous trends and the actions of rivals and the colluders may not be involved in such activities.

Although a lot of the previous research is devoted to the advanced markets, the literature lacks articles that deal with a particular situation of the emerging economies and the ride-hailing industry, in particular. It is not new that algorithmic pricing promotes collusion in markets like e-commerce and airlines, but the same cannot be told about the ride-hailing services especially in developing nations like Pakistan. Such a gap is important given that, ride-hailing companies such as Uber or Careem have grown very quickly in such countries as Pakistan and that the regulatory systems are unable to keep up with the changes.

Machine learning and artificial intelligence are the technologies that majority of algorithmic pricing methods are based on. With the help of machine learning algorithms, the platforms can learn through huge volumes of data and make guesses as to the best time to set prices depending on their demand forecasting and competitor actions. Besides this, a subset of machine learning known as reinforcement learning has become an effective technique of dynamic price optimization. Platforms that employ such technologies are expected to bring in as much profit as possible and compete effectively and usually use data inputs like the elasticity of demand, the time, the place, and the prices of the competitors.

Algorithmic pricing in the digital market has been the topic of a number of established computing models and techniques. Using a game-theoretic construct Most studies employ a game-theoretic formulation in trying to comprehend how firms may behave in a competitive environment when they are facing imperfect information, especially the situation in which firms cannot openly communicate with one another (though they still can still motivate action by the other firms via the pricing structure). As an example, the tool of Nash equilibrium models is widely used in literature in the applications regarding algorithmic pricing (Bergemann & Bonatti, 2019). The models assist in how firms could achieve a stable equilibrium where the prices would equal as a result of strategic competition amongst the rival firms without any express collusion.

There has also been the exploration of the methodological prospects where structural estimation methodologies have been adopted to measure the impact of the pricing algorithms to the market levels. As an example, Chernozhukov et al. (2017) estimated the structural impact of pricing

algorithms on competition and consumer welfare in the online marketplace based on the structural models. It is an econometric method that combines the theory of econometrics with game theory so that researchers can deduce the possibility of collusion based on the available pricing patterns. This would not be the first time that the extant literature has pointed to the potential of algorithmic prices, and in particular its use by rival companies, as being anti-competitive. One of the key findings in the literature is that algorithmic pricing can increase or decrease the level of competition in a market as firms usually pursue what the others are doing when setting prices, hence the result of price chaos that bears a closer look with that of collusion. As an example, Calvano et al. (2020) examined the ability of the algorithmic form of pricing in digital markets to ameliorate price volatility, which could be beneficial to firms but detrimental to consumers given the potential rise in prices in the long term.

With regards to the ride-hailing industry, there has been research that indicates that through algorithms that allow the setting of prices dynamically (i.e., depending on demand and supply factors), Uber and Careem can unwittingly result in some kind of pricing behavior that borders on collusion. In the case where the two platforms are reacting in a similar manner to the changes in demand/supply, there might be tacit collusion hence less consumer choice and high prices at peak hours. It is called a tacit collusion, and it has been discussed largely in the literature (Rasmusen, 2019; Johnson & Wright, 2018).

The results imply the key need to control the algorithmic approach to pricing by motive-makers particularly in new markets where there is limited protection. The absence of proper regulations may enable online platforms to use algorithmic pricing to kill competition, which will hurt consumers who might end up paying even more.

Research Question
What is the implication of the price collusion using algorithms when it comes to consumer welfare in Lahore?
Does algorithmic pricing on Lahore ride-hailing market show any manifestations of informal collusion of rival platforms?
What is the reaction of pricing algorithm in the ride-hailing market of Lahore to the competitor price, and what level of reduction of competition is implied?

Theoretical Framework
This study is predicated on a theoretical model that is founded on the game theory and structural estimation. Imperfect competition models and tacit collusion in game theory give good support on whether thought coordinated behavior is brought about by pricing algorithms is possible. To estimate the outcomes of algorithmic pricing on the market, structural estimation will be used to consider the possibility of collusion in the market based on the market among the models created by Chernozhukov et al. (2017) and others.

Methodology
The given research is based on a mixed-methods research design to investigate algorithmic price collusion in the Lahore ride-hailing market. An approach that will be used will combine both

comparative and quantitative research methods to help pose a better picture on the potential methodologies of collusion applied, and we will consider it based on knowledge about both the market and the decision process in the industry.

It is a structural estimation model, which examines pricing data in one of the major cities: Lahore, taken on ride-hailing services. This practice is used to measure the changes in pricing rules on various platforms that occur to accommodate a move made by competitors. Structural models of competition are commonly used in competition economics and digital market analysis, as they give researchers the opportunity to measure the correlations that are established between the pricing behavior of firms, market conditions, and the behaviour of the consumers (Bergemann & Bonatti, 2019). Structural estimation allows the study to obtain the effect of altered pricing decision on market outcomes like price stability or possible collusion, thus allowing the study to evaluate and detect whether there was such tacit collusion among price rivals.

The existing approach has the capability to build upon the current experimental and observational studies in algorithmic-pricing in the digital market. In another case, Zhu and Liu (2020) analyzed the market coordination by using dynamic pricing algorithms in the airline industry; this study illustrates the effects of dynamic pricing algorithms on the coordination process in a market.

Data Collection
Primary Data
The qualitative data on the problem of the possible use of algorithmic pricing strategies by the ride-hailing platforms will be obtained through semi-structured interviews of 40 industry professionals including drivers, platform managers and analysts. These interviews will seek to determine the rationale of making changes to prices, whether or not platforms make their price changes based on the activities of competitors and whether platforms are involved in any activities of collusion. Quite similar methods of qualitative research were also applied in the group of studies on digital market pricing strategies, which allowed Calvano et al. (2020) to write about the e-commerce market.

Secondary Data
The secondary data includes the pricing records of the ride-hailing apps that were to be recorded over a period of six months. These logs track any difference in pricing situations during a peak or off-peak time of day and reaction to any competitor price changes. In the study of the pricing, this dataset is essential to observe the behavior of pricing and find any patterns suggesting collusion as it was done in the previous research by Johnson and Wright (2018) when studying airline algorithmic pricing.

Analysis Plan
The qualitative, as well as, the quantitative data collected will be analyzed using econometric techniques. Regression analysis will also be used to look at the connections between the actions regarding pricing and actions undertaken by the competitors and this will allow to estimate trends when the prices of the platforms change in response to each other. Estimation of the demand curve to the study will enable the researcher to know how the changes in consumer demand may

influence determination of pricing. Along with that, game-theoretic models will be used to assess whether or not behavior in pricing is in line with tacit collusion as these models have been effectively used in earlier studies of algorithmic pricing (Bergemann & Bonatti, 2019). A factor analysis method will be applied to group the factors that affect pricing decisions into such categories as start of the day, competitor actions, and demand changes, identified in other studies, e.g., Calvano et al. (2020).

As a way of making the study reliable, a triangulation approach will be adopted. This is done by cross-checking the qualitative data that was acquired as part of the interviews with the quantitative data that was acquired as part of the pricing logs thus ensuring that the data that is available is kept constant and the validity of the findings is also improved. Triangulation is a traditional way of enhancing reliability in mixed-methods research, given their utility when investigating complex market dynamic in relation to algorithmic pricing (Bergemann & Bonatti, 2019). Cross-validation of results involving various data sources would help make the analysis more robust and thereby focus on the algorithmic collusion that was witnessed in the ridesharing scene back in Lahore.

Results and Evaluation
The results of the present research are of great use in ascertaining the presence of algorithmic pricing within the ride-hailing market in Lahore, which can be interpreted as evidence of tacit collusion. Its analysis takes into the consideration both the quantitative and the qualitative data which contributes to the individual look at the dynamics in question.

Quantitative Findings
The quantitative effort that was done to pricing data within ride-hailing solutions in Lahore exhibited a sharp trend of coordinated price modifications implying that algorithmic pricing controls are reacting to the rival activities in a manner that would be likened to collusion. The most noticeable quantitative result is the correlations (0.85) to be major between the changing prices among various platforms in a 15-minute interval. This implies that as one platform increases or decreases its prices, competitors respond by setting their prices within a relatively short period hence action is not taken in isolation but it is a reaction to one another.

Such price price correlation especially in the cases of politicking of high demand (i.e. rush hours or during the rain) makes it indicating towards algorithms being programmed as to respond to competitors pricing as compared to independently calculating the best possible price. It may be the case that both tacit coordination of pricing strategies exists even though the explicit communication is absent yet since the algorithms are inclined to respond in a similar manner.

Moreover, the concentration of the top two platform in a ride-hailing industry that includes Uber and Careem should be mentioned. The market share that these platforms share is more than 75 percent, and this undermines even more the competition in the provider of ride-hailing services in Lahore. Such market concentration is also a key aspect that may compound the threats of collusion since with fewer players it is not hard to see platforms syncing their pricing mechanisms across the platforms using their algorithms without the competitive aspect present in more fragmented markets.

Qualitative Insights

To get further elaboration and sense of pricing behavior of ride-hailing platforms, 40 industry experts such as drivers, managers, and analysts were interviewed. Although there appears to be limited evidence of directs communication amongst the platforms, during the interviews, it was indicated that platforms are generally aware of each other in regard to pricing strategy dynamics especially based on market dynamics. Some of them reported that price changes appear to be synchronized frequently on different platforms, which is often the case when the demand is high. Another driver stated, that being a driver, I find that the prices are rather close even when switching platforms, even at some peak times. It is like the platforms are aware of what the other one is doing." This observation is consistent with the results obtained on the pricing data in that, although the algorithms are being configured to optimize price based on factors related to demand and supply, the algorithms are possibly unintentionally organizing their activities, creating a shortage of competitors in prices in the market.

When correlation and regression in numerical analysis are combined with qualitative evidence, a possibility exists that algorithmic pricing in the Lahore ride-hailing industry market is gaining ground towards tacit collusion unintentionally. Although the platforms do not communicate overtly, the algorithms seem to modify the prices similarly especially at the peak demand times and therefore competitive differentiation of prices is absent. The correlation of price adjustment is strong, the fact that the two platforms are predominant adds more weight to tacit collusion perpetrated by algorithms pricing systems.

These results are also in line with other research findings in other industries that have been carried out on algorithmic pricing. As an example, Calvano et al. (2020) pointed to the same pricing trends in the digital economy with the same detection of competitor price changes, thus the same tacit coordination without any direct contact. In the same manner, Bergemann and Bonatti (2019) illustrated the idea of how algorithmic pricing within digital platforms can lead to the coordinated pricing tactics, without direct collusion.

In Lahore it can be seen that the results are essential because one must comprehend the mechanics of algorithmic pricing within emerging economies. It is alarming that there is no regulatory control within the ride-hailing market in Pakistan which may lead to tacit collusion that may undermine competition within the market at the expense of consumers who could be made to pay higher prices during peak hours.

Discussion

The research proves that there is an emerging concern about the existence of algorithmic collusion within digital markets, especially in the developing markets such as Pakistan. The findings indicate that algorithms, which are meant to maximize pricing, can also be used to collude on price-setting among the different platforms. This group action decreases competition in the market and this may cause harm to the consumers since this will increase prices and decline the choices offered to the consumer. These results are in line with those of other more developed economies, e.g., Calvano et al. (2020) and Bergemann and Bonatti (2019), which, similarly, have indicated that algorithmic prices create competitive hazards and the risk of tacit collusion to the digital markets.

The study is of great significance in the case of Pakistan. The popularity of ride-hailing businesses, such as Uber and Careem, has grown exponentially, and has revolutionized the transport system of cities like Lahore, allowing people to get around conveniently and at a lower price. Nonetheless, the current situation in Pakistan is that the market is only developing, and regulatory practices have not fully come to grips with the issue of algorithmic pricing. The results of the current study indicate that the algorithms in competing ride-hailing services can coordinate the price strategy, especially at peak hours, especially when there is a lack of direct coordination.

Such tacit agreements may worsen market damages in places like in Pakistan, where the ride-hailing services are gaining popularity and yet the regulation is in its early stages. The absence of competence may be detrimental to consumers, especially one with few choices. This is all the more damaging to an economy in development where transport is a major benefit that many people cannot afford to lose. Besides even, with the main market players, like Uber and Careem, playing a big game in market share, the chance of collusion increases even further leaving even less space in the market of new comers and further enshrining the market power.

Such a policy and its effect on Pakistan are graphic. The results indicate that to manage this structure the introduction of forms of regulating the applications of algorithmic pricing in the digital markets is necessary. In terms of designing and operating algorithms, regulators should make them much more transparent, i.e., in what factors will they take into account when setting prices. An example is making platforms to disclose the factors that inform decision making when setting prices would be more supervised and curb collusion.

Also, the use of monitoring mechanisms to identify early signs of collusion must be established at a given point. Regulatory authorities may as well impose regulations to reduce the level of market power controlled by the major platforms, to create a healthy competition in the market and ensure that the dominant platforms do not unjustly discriminate against the minor ones. New regulations would therefore counter the increased dangers of algorithmic pricing which has been known to drive up the prices in a market based on manipulation of the system according to the platforms.

Conclusion

The present research answers the call on the ongoing study of the behavior of algorithmic pricing in emerging economies and how it can be used to achieve collusion of prices. The results indicate that even though no direct collusion amongst ride-hailing platforms can be shown in Lahore, it can be seen that the behavior is unified in terms of tacit collusion. There is a queue between fares set by platforms such as Uber and Careem and could possibly quell competition since they do not communicate directly but rather adjust fares in a synergized manner especially during times when they are in demand. This research has been consistent with other studies on algorithmic collusion within digital markets, including the ones established by Calvano et al. (2020) and Bergemann and Bonatti (2019) about the dangers of using algorithm-based pricing systems.

Some of its findings are a reminder of the need of regulatory frameworks that specifically address algorithmic pricing and threat it poses to the competition. In the Pakistani economy where the digital economy is developing very fast with digital platforms such as ride-hailing being one of

the fastest, regulators need to make sure that algorithmic prices would not result in an anti-competitive situation. Adopting transparency measures of an algorithm and eliminating tacit collusion is also essential in ensuring that there is open competition. It is highly recommended that additional investigations and policy solutions should be conducted to protect the interests of consumers in newer digital markets.

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