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Taxi apps, regulation, and the market for taxi journeys

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ABSTRACT

This paper attempts to provide a starting point for discussion on how smartphone-based taxi applications ('apps') have changed the market for taxi journeys and the resulting implications for taxi market regulation. The paper focuses on the taxi apps and their impact on taxi markets. It provides a brief history of taxi regulation before outlining the underlying economic rationales of its current form in many parts of the world, characterised as the "QQE" framework (quantity, quality and economic controls on operators). It argues that current regulation assumes that taxi markets are subject to three sets of problems that require correction by regulatory intervention, namely: those associated with credence goods, problems related to open access and those resulting from transactions occurring in a thin market. It is then proposed that taxi apps solve both the credence good and thin market problems whilst largely mitigating the problems associated with open access. The paper then presents some potential problems for taxi apps, namely the potential for instability on supply and demand sides, collusion and monopoly. It also discusses concerns about driver background checks and safety. The paper concludes by arguing that instead of restricting the growth of the taxi market, regulators should focus on reducing the likelihood of monopoly and collusion in a taxi market led by apps.

1. Introduction

By early 2013, 61% of cellphone subscribers in the US were using smartphones (Nielsen, 2013). Similar trends of rapid growth are apparent worldwide (IDS, 2014). The growth of the global smartphone market has been accompanied by an increasingly diverse and sophisticated market for smartphone applications (henceforth "apps"): pieces of software that are downloaded onto personal devices for free or for a small charge in order to perform a specific niche task, typically related to entertainment, communication, mapping or locating services and retailers. There are a number of transport apps which aim to connect smartphone users seeking a ride with users in the locality who are prepared to provide one. The supplier can operate in a similar manner to a taxi: using the app to locate passengers, drive them to their destinations and charge them according to a fare structure based on the time and distance of the trip (as measured by the app) set by the app provider. Similarly, the passenger can use the app like a taxi service in order to request a ride. The app sends the request to the nearest available driver who then either accepts or declines the trip. In recent years, taxi apps have become well established: Uber, the market leader, reports 1.1 m ride requests per week generated by its 3.8 m users (Tiku, 2013). As of December 2014, it was operating in 230 cities across fifty countries (Uber, 2014a). Competitor, Lyft operates in thirty US states (Lyft, 2014) and Hailo is present in a dozen major cities across Europe, the US and Asia (Hailo, 2014). In China, Didi Dache and Kuaidi Dache

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combined have 150 m users (Russell, 2015); Ola Cabs and TaxiForSure are major aggregators present in multiple Indian cities (Shrivastava, 2015).

Despite their popularity and wide geographical spread, "taxi" apps are the subject of fierce public debate. The surge pricing models used by leading apps, under which price discrimination occurs according to a pricing algorithm based on local supply and demand, have sparked much public and media discussion (Economist, 2014), as has valuation of the app firms (Bloomberg, 2014) and their occasionally haphazard public relations (Griswold, 2014). However, the most consequential controversy centres on the legal issues arising from their ability to circumvent the regulations in force in established taxi markets (Daus, 2012). Uber, in particular, has faced legal challenges from incumbent taxi operators in a number of cities who claim that its drivers offer unfair competition as they do not carry the same regulatory burden as incumbents (Eskenazi, 2014; Diamandis, 2014). Entry controls are at the centre of this debate. Almost all North American and European cities cap the number of taxis using a permit, or medallion, system. As supply is capped, operating permits appreciate and thus represent good investments (Cummings, 2009; Ecetin and Eryigit, 2011), whose value is threatened by the additional supply added by "taxi" apps (Washington Post, 2014; New York Times, 2014; Wall Street Journal, 2014). For this reason, this paper will focus on apps which allow drivers to circumvent existing regulation (taking Uber as a case study), rather than app which make existing taxi supply more efficient (such as Ola and Didi).

However, although the debate continues between pro-regulation incumbents and the advocates of taxi apps, there is little recognition of several key questions that are central to this discussion. Namely, what are the underlying rationales for regulating taxi markets? How are they currently regulated? How are taxi apps changing the market for taxi journeys? And what implications does this have for the current regulatory framework?

The literature on public transport has paid little attention to these questions. There are studies which think through the potential of smartphone technology to change the way in which public transport systems are managed (Goldwyn, 2014). There are also numerous technical studies on the application of smartphone technology to the existing licensed taxi sector (Chen, 2014; Ruyuan and Yan, 2012) and a few opinion pieces which lay out points of contention associated with taxi apps and the entrance of unlicensed providers into the taxi market (see Walton, 2014). There is also legal research which deals with the legal implications of smartphone technologies in the taxi market (Daus, 2012). There is, however, no work on the impact of this growing technology on the market for taxi trips and its implications for regulation, taking into account the rationale for its current form.

Taxi apps are a recent phenomenon, which have the potential for positive impacts on urban transportation. It is likely that that taxi apps would not greatly impact mass transit as the price difference between bus and urban rail systems and taxis means that the latter would not generally substitute for the former, although it may in exceptional circumstances (i.e. journeys with luggage, tight time constraints, etc.) Taxi apps would have a greater impact on private motor vehicle use. Lower fares and lower transaction costs may lead to the substitution of private motor vehicle trips for taxi trips. This has implications for levels of car ownership and the use of public space.

This paper aims to provide an opening for discussion on these questions. The following section (Section 2) outlines the history of taxi regulations and gives a brief overview of its current form. Section 3 reviews the rationale underpinning current taxi regulation. In order to maintain a manageable scope, this paper will restrict itself largely to US and Canadian taxi markets, although cases from other countries are flagged. It argues that current regulation is based on the view that the taxi market suffers from several problems: the "credence good" problem, the open access problem and the thin market problem. The following section (Section 4) describes how taxi apps have changed the market for taxi journeys. It claims that taxi apps turn a historically thin market into a thick one whilst simultaneously solving the resulting problems (such as congestion) by acting as efficient clearing houses. Section 4 focuses on the example of Uber, the market leader in terms of trip volumes. The penultimate section (Section 5) then suggests some possible difficulties for "taxi" apps, drawing on "core theory". It also discusses concerns about background checks and passenger safety. The paper concludes by arguing that current taxi market regulations should not attempt to restrict the growth of taxi apps, but should instead focus on the possibility of future monopoly and collusion.

2. Taxi market regulation: history and current forms

The roots of modern taxi market regulation lie in the Great Depression of 1929 in US cities. The global economic downturn created mass unemployment. Many newly unemployed workers entered the taxi industry illegally, circumventing quality regulations by purchasing and running cheap vehicles as taxis, most of which were in a poor, often dangerous, state of repair. As unemployment rose and average incomes fell, demand for taxi trips plummeted just as supply surged. This mismatch of supply and demand led to disputes between drivers (both legal and illegal) over fares; turf wars began between existing firms; and "bandit firms" emerged, operating outside legislation. Anger at the proliferation of "bandit cabs", perceived as illegal and unfair competition, led to a major taxi driver strike in New York City in 1934. The Washington Post (1933) sums up the public attitude towards the turmoil in the taxi industry:

> Cut-throat competition in a business of this kind always produces chaos. Drivers are working as long as sixteen hours per day, in their desperate efforts to eke out a living. Cabs are allowed to go unrepaired. ... Together with the rise in the accident rate there has been a sharp decline in the financial responsibility of taxicab operators. Too frequently the victims of taxicab accidents must bear the loss because the operator has no resources of his own and no liability insurance. There is

no excuse for a city exposing its people to such dangers.

[cited by Koehler, 2008]

The policy controversy over bandit cabs led to the inclusion of taxis in the Interstate Commerce Act in 1935, giving the state power to regulate prices, and secondly, to the Hass Ordinance issued by the City of New York in 1937 which introduced a strict permit regime removing the city's ability to issue new licences, a move which effectively froze taxi numbers. It is alleged that Mayor Jimmy Walker took a bribe from incumbent taxi firm, Parmalee, to introduce the medallion cap (Koehler, 2004). As drivers retired or left the industry, taxi numbers dropped from 21,000 in 1931 to 11,000 in 1947 (Cummings, 2009). Almost all US cities followed New York's example and implemented permits freezes and fare controls (Frankena and Pautler, 1984), thus adding two extra dimensions to the earlier focus on service quality.

Cooper et al. (2010) present a three-part framework for the analysis of taxi market regulation which contains the following elements:

(1) *Quality Control:* i.e. controls on vehicle age, appearance, disability requirements, all enforced by testing and inspections.
(2) *Quantity Control:* i.e. controls on the number of taxis in a particular jurisdiction modified according to analyses of demand, Significant Unmet Demand (SUD), latent demand, projections of future demand or local politics and vested interests.
(3) *Economic Controls:* i.e. fare setting based on regular analyses of operator costs and revenues with the aim of providing fair compensation for operators and stable prices for passengers through cross-subsidisation of fares (i.e. off-peak fares subsidies on-peak trips, Harris, 2003).

The "QQE" framework is considered the standard regulatory model for the taxi industry (Cooper et al., 2010). Each section of the framework can be applied differently depending on the section of the taxi market: namely the "cruising" and "dispatch" markets. The "cruising" market refers to taxis which are allowed to pick up passengers direct from the street without prior booking; "dispatch" refers to taxis which are linked to a dispatch office which directs to the driver to passengers who have booked by telephone. There is considerable overlap between both sections: if allowed by regulators, taxis may straddle both markets. For example, a driver may take dispatch calls but also pick up street hail passengers when the dispatch business is light or street hail trips are plentiful (i.e. weekend evenings). In some jurisdictions all taxis must be linked to a dispatch (i.e. Canada), whilst others keep the two markets separate (i.e. London and New York City). The two segments are often subject to different regulations, for example entry into the New York dispatch market is far easier than into the cruising market and different service standards apply to each. However, regardless of regional variations, from the 1930s the majority of jurisdictions in the US enforced regulations from each part of the QQE framework on their local taxi markets (Frankena and Pautler, 1984). Many other countries followed suit, such as the UK (Toner, 2010), New Zealand (Gaunt, 1995, 1996; Morrison, 1997), Sweden (Marell and Westin, 2002), Ireland (Barrett, 2008, 2010) and Turkey (Ecetin and Eryigit, 2011).

However, to the growing ranks of free-market economists in the 1970s, taxi market regulations appeared to be a prime example of unwieldy state regulation stifling competition and innovation. The implicit pact between regulators and industry, in which the latter accepted limited margins if protected from competition by the former, represented the overreach of the Keynesian welfare state. In keeping with economic policies across a range of sectors (i.e. airlines, road freight and a wide range of other public services), the taxi industry was seen as a fitting subject for deregulation, namely the simple removal of state regulations, which has been characterised as "roll back neoliberalism" (Peck and Tickell, 2002). With the basic expectation of increased supply, lower fares and higher levels of innovation in both dispatch and cruising markets, taxi markets in the US began to deregulate from around 1980. Given the decentralised structure of taxi market governance in the US – with each jurisdiction setting its own policies – there was considerable geographical variation. However, twenty-three US cities deregulated their taxi markets to some extent during this period, removing either permits, fare controls, or both. Dempsey (1996) and Teal and Berglund (1987) provide overviews of the deregulatory experiences of these cities.

The removal of quantity controls in a number of US cities caused supply to increase by an average of between 19% and 23% (Dempsey, 1996; Teal and Berglund, 1987). The majority of new entrants were independent operators driving their own cabs. A shortage of capital meant very few had access to dispatch systems; most were limited to the cruising market. Consequently, in many cities with low street hail trip densities (most US cities other than New York and San Francisco where flagging down passing cabs in dense downtown cores is commonplace), these new entrants flocked to the few locations that offered guaranteed passenger trips: cab stands, airports and large hotels. The resulting oversupply at these locations meant long waiting times for drivers, low wages as the number of trips per shift dropped and, in an echo of the Great Depression cab market, frequent disputes over passengers. "Clogging" at stands, airports and hotels also took these markets away from dispatch drivers who would previously pickup street hail passengers in periods when there were few dispatch calls. This cut profits for dispatch firms as the most profitable trips were being "skimmed" by the new entrants to the cruising market, which deterred new firms from entering the dispatch market. Furthermore, in cities which removed both quantity and economic (abolishing standard fares), prices in both cruising and dispatch markets rose by an average of 29% per year (Dempsey, 1996). Dispatch firms upped prices in an attempt to maintain profits after losing stand and airport markets to the newcomers. Fare rates had traditionally lagged cost increases, so it is also likely that dispatch firms raised fares immediately after the lifting of economic controls so that their prices could "catch up" with costs. The new entrants charged prices higher than the

old fare rates in order to make up for lengthy waiting times and fewer trips per shift. This resulted in the counter-intuitive and perverse outcome where deregulations intended to increase supply and consequently reduce costs to consumers resulted in the opposite effect.

Whilst free entry did lead to an initial surge of supply, cab numbers fell to slightly above pre-deregulatory levels as many new entrants left the industry due to the long hours and low incomes (Dempsey, 1996; Teal and Berglund, 1987; PWC, 1993). New entrants did not have the capital to invest in dispatch links and dispatch firms were forced onto the back foot, struggling to maintain revenues: with little capital to invest in technology to improve competitiveness and with no incentive to do so due to the absence of new competing firms. Stung by clogging, higher fares and operator quarrels, many US cities re-established entry and economic controls.

3. The rationales behind taxi regulation

The regulation of the market for taxi journeys is based on the assumption that it is subject to several fundamental problems, which must be corrected by regulatory intervention. These are that a taxi ride is a "credence" good and that regulation is required to protect the consumer from negative outcomes during the use of such goods; the industry cannot operate with open access for supply as it would lead to lower efficiencies, falling wages and unacceptable externalities; and that the market for taxi trips is a thin one, which means that incumbents should receive regulatory protection in exchange for providing acceptable services at slim margins (Dempsey, 1996). Lower efficiencies, falling wages and spot price gauging may well explain the problems with deregulation in numerous US cities outlined above.

3.1. The credence good problem

A credence good is a good or service whose quality cannot be determined by the consumer until after it has been consumed – and even then it may not always be possible. Medical services and car mechanics are commonly cited examples of credence goods – i.e. the customer has no way of knowing if her car genuinely needs the expensive repair recommended by the mechanic, and she may have no way of knowing if the repair was worthwhile even after it has been completed. Alfred Kahn (1971) states that this leaves consumers with a "limited ability to judge the quality of products and hence to keep it at acceptable levels even when they have a wide range of suppliers to choose from".

In an unregulated market for credence goods, the lack of certainty surrounding quality means that the market either breaks down because customers abandon it for alternative markets in which quality is more reliable, or it remains at a low equilibrium with only a few tentative transactions. Akerlof's (1970) seminal paper on the used car market provides both a useful example of the problem and two potential solutions. Without regulation in the market, used cars become credence goods for the average buyer. The market for used cars is undifferentiated: there is no way for the average buyer to tell the difference between a "lemon" (US-slang for a faulty used car) and a "cherry" (a good used car). It can be assumed that the true value of a "cherry" is higher than that of a "lemon". However, only the dealer can tell the two apart. This represents an asymmetry of information. Conscious of their disadvantaged position and not trusting the dealer's word, customers will only be prepared to pay the going rate for a "lemon", a price well below that of a "cherry". Likewise, if the customer is only willing to pay for a "lemon", then there is no incentive for dealers to spend time seeking out "cherries" as they will sell for the same price as lemons: significantly below their true value. Furthermore, the owner of a "cherry" will not take his car to this market because he knows it will not sell for its true value: The "lemons" drive the "cherries" from the market, in an example of Gresham's Law – "the bad drives the good from the market".

This scenario, Akerlof argues, can be remedied by the introduction of costly market signals. High quality suppliers use costly signals, unavailable to low quality dealers, to assure customers recognise their superior products. High profile TV or newspaper advertisements would be an example (i.e. "Trust us, we only sell cherries") as they would typically be out of reach of poor quality suppliers. Conversely, 'cheap talk' signals (such as pamphlets) would not engender customer trust and would fail to differentiate the market. It can also be solved through regulation which provides the information that would allow customers to pick out the "cherries" from forecourts full of "lemons", allow dealers to charge more for them and encourage owners with "cherries" to bring them to the market. Provision of full service histories would enable this to occur, although they may require verification by a third party.

The same imperfect information problem applies to the taxi market (Shreiber, 1975; Douglas, 1972). A taxi journey is a credence good (Balafoutas et al., 2011) because the passenger is unable to discern the relationship between the quality and quantity of the good (the comfort and length of a taxi journey) and its price (the fare) until it has been consumed (i.e. until the ride is over). This gives the provider (the driver) an incentive to cheat (i.e. to overcharge, take a circuitous route or operate a substandard vehicle). His hand is further strengthened by the high cost of finding a second taxi and the fact that elasticity of demand is low in the taxi market: if a single driver lowers her prices or increases the quality of her service, then it is unlikely to lead to an upsurge of custom as an individual operator cannot send out a strong enough signal to differentiate the market by herself. Passengers will only be willing to pay the going rate for the dominant (probably rather mediocre) service level in the market. Their choices will also be heavily influenced by the high cost of searching for another taxi. This tendency drives higher quality from the market.

The preferred solution has been to differentiate the market through regulation. If passengers do not have the ability to judge quality in relation to price before the ride, then they should be protected by minimum standards and price controls which maintain a stable pricing structure, decent service quality and a reliable, non-arbitrary relationship between price and quality. The pricing structure should allow for some level of differentiation (i.e. allowing luxury taxicabs or seven-seater cabs to charge more). However, the level of differentiation is restricted as the regulator typically has limited resources to check and enforce the service standards required for each service level.

However, the assumption that a taxi trip is a credence good has been challenged: a passenger is seldom completely clueless as to the distance and cost of the ride they require, furthermore, whilst individual taxi operators cannot provide a strong enough signal to the market, taxi firms are able to differentiate the market through advertising (see Coffman, 1977; Harris, 2003). But these challenges pre-date the role of smartphone technology in addressing the credence good problem. Leaving aside specialist "taxi" apps (discussed in the next section), smartphone technology also provides instant access to route mapping which helps passengers to estimate the quantity of the good needed (i.e. the length of the trip).

3.2. The open access problem

When entry into taxi markets is not restricted by quantity controls, then the experience of many US cities suggests that large numbers of new entrants will come into the market. These new entrants will be attracted by the relatively low upfront capital costs of entry – little more than the price of a second hand car. This influx has several major implications.

In a market with a large number of suppliers and a high volume of transactions, additional supply will not affect prices (i.e. an extra grain farmer will not affect the global price of grain). However, in taxi markets, which are limited to relatively small geographical jurisdictions, the entry of additional supply can influence local prices and thus impact the profits of incumbent drivers. If the upsurge of supply is not matched by equal increases in demand, then the efficiency of the market will decrease. Operators will make fewer passenger trips per shift whilst their costs remain relatively static. If large numbers of new entrants lack dispatch links, as happened in many US cities in the 1980s, then driver waiting times as cab stands, hotels and airports will increase, eating away at marginal profits and increasing the incentive for price-gouging and the aggressive solicitation of tips. Without strict fare controls, in such a market, drivers will increase their prices to make ends meet. There will be increased incentive for drivers to lower quality in order to cut costs. As a result, incomes will fall for all operators, quality will decline and compliance with fare structures will drop. Quantity controls are thus needed to maintain market efficiency and safeguard the incomes of incumbent drivers (Shreiber, 1975).

It is also argued that the proliferation of operators caused by open access will lead to unacceptable externalities. Every additional taxi contributes to air and noise, costs which are born by the wider public (Shreiber, 1975). Open entry to the taxi market risks a "tragedy of the commons" scenario, in which open access to a resource (i.e. the taxi market) leads to cumulative externalities, which ultimately destroy that resource. Garrett Hardin's (1968) influential essay is widely referenced in the taxi market literature as a justification for entry controls in taxi markets. There are, however, numerous counter arguments. Concerns about pollution resulting from open access might be similarly misplaced. Taxis represent a small fraction of the total private motor vehicles in any given city, yet are singled out and subject to quantity restrictions on the basis of their potential impact on air quality, whilst other far more numerous categories of vehicle, like private cars, are not (Coffman, 1977). If the aim is to improve air quality, then restricting taxi numbers will be far less effective than imposing strict emissions standards on all motor vehicles on public roads (Frankena and Pautler, 1984).

There is also a perception that the increase in taxi numbers following the lifting of access barriers would lead to unacceptable congestion externalities (Shreiber, 1975). However, this assumption can be criticised on two grounds. Firstly, Frankena and Pautler (1984) reject entry controls on the grounds of congestion. They argue that there is little evidence to suggest that, if entry controls were lifted, taxi numbers would become inefficiently high. They also claim that numerical restrictions risk "waiting time externalities" for passengers, leading to underproduction in the market, a side effect of which would be higher private car use. They also note that cities without a history of entry restrictions (London and Washington, DC) do not suffer congestion externalities. Secondly, from the economic perspective, it is debatable whether taxis can cause congestion externalities. For an externality to occur there must be an unpriced resource. Each additional user of that resource then increases the cost of usage for all other users. However, in the taxi case it is hard to identify. Economists typically do not consider access to the market itself as an unpriced resource. It could be the case that access to taxi ranks, hotels, airport and other local demand hotspots is the unpriced resource if entry is free and unrestricted. A congestion externality would occur in such locations only when the number of taxis increased to the point at which each additional cab increased the costs for all other cabs in that location. However, such an externality would be localised, which casts doubt upon the ability of open access taxi systems to create significant congestion externalities.

3.3. The "thin market" problem

A thin market has a low number of buyers and sellers. This "thinness" reduces the probability of a match being made between supply and demand, which keeps the total number of transactions in the market at a low level. This has been observed in housing markets (Gan and Zhang, 2006), CO_2 permit markets (Liski, 2001) and airline markets (Yetiskul et al., 2005). Prices in a thin market tend to be unstable. By contrast, a thick market has a large number of buyers and sellers, high transaction numbers and low price volatility (Gan and Li, 2004).

The taxi market has the characteristics of a "thin market" (Häckner and Nyberg, 1995; Gallick and Sisk, 1987). Demand is typically thinly geographically dispersed; supply must either drive around and locate a passenger by chance, or locate one using a telephone dispatch system, which has a limited capacity for transactions (restricted by the number of lines and dispatch employees). Certain journeys are more costly for the operator than others: a short city centre trip may be less costly per mile than a longer suburban trip from which the driver might typically return without a fare in the absence of demand. Rather than allowing operators to use flexible pricing to reflect the variation in trip costs, fare controls are enforced to smooth out price volatility, which is a characteristic response to a thin market. More profitable trips subsidise less profitable ones (Harris, 2003). Traditionally, regulators have set fares so as to ensure affordability for passengers whilst providing thin margins for operators. To compensate for these narrow margins, regulators have typically entered an implicit pact with operators under which they protect incumbents from competition from new entrants (Dempsey, 1996). Although such a pact may restrict the market to a relatively small number of suppliers, fare controls prevent more dominant suppliers from raising prices even if they have captured a large share of the market.

In sum, taxi regulations are based on the assumptions that a journey is a credence good; open access would lead to oversupply; and that the market is a thin one. These failings are likely to be interdependent. For instance, open access would enable large numbers new drivers to enter the market and compete for the sparse and scattered demand characteristic of a thin market. The resulting low efficiencies would prompt drivers to attempt cost cutting and overcharging, problems associated with credence goods.

The following section discusses how the appearance of "taxi apps", such as Uber, has changed the market and significantly allayed the rationales for taxi market regulation outlined above.

4. The impact of taxi apps: how Uber changes the market

In markets with imperfect information, such as the taxi market, changes in transaction costs and strategic complementarity may cause thick or thin market externalities, which can move the market towards one of many possible equilibria (Matsushima and Kobayashiv, 2006). Uber lowers entry barriers for operators by allowing them to function in a similar manner to taxis, but without the substantial cost of buying or hiring a taxi permit or medallion. This significantly decreases to entry barriers for supply. The ease and speed with which the app can be downloaded, coupled with cashless payment systems and high rates of smartphone ownership, reduces transaction costs for the passenger. However, lower transaction costs on the demand side assume a certain level of supply, which will vary between jurisdictions. The supply needed to reduce transaction costs relative to the established taxi market remains an open empirical question – and one frequently discussed by regulators (Flegenheimer, 2015). However, for the purposes of this paper, adequate supply is assumed.

By lowering entry barriers on supply and transaction costs for demand, Uber moves a traditionally thin market towards a new equilibrium as a thick market. This transformation occurs through a thick market externality, that is: the perception of an increase in supply brings more demand to the market; likewise, the impression of increased demand brings more supply to the market; both sides see their chance of finding a match in the market as high (Diamond, 1982; Howitt and McAfee, 1987). More specifically, the existence of large number of smartphone users with a high profile taxi app, like Uber, creates the impression of abundant demand amongst operators who enter the market in order to service it. Conversely, smartphone users perceive the large number of operators entering the market as evidence of readily available supply. Both parties perceive their chance of finding a ride or a passenger as good: they see themselves as entering a thick market in which they will quickly find a match. This thickness is brought about in conjunction with effective market differentiation through different service levels offered at different price points (i.e. different vehicle types).

In contrast to static taxi pricing, in which cross-subsidisation between trips must occur to maintain consistent fares (Harris, 2003), Uber charges passengers according to a predetermined pricing structure which allows the fare to move between a fixed price floor and ceiling. Prices are set according to an algorithm based on the service level and the relationship between supply and demand in the local market and is calibrated to reflect price sensitivity. The passenger must agree to the cost of the journey before its commencement. The cost of the trip is known upfront and is consistent and non-arbitrary. This prevents discriminatory spot-market price gouging by drivers (see Balafoutas et al. (2011), for an example of spot-market price gouging). At peak times, however prices can reach 7.5 times the base rate, which has caused anger amongst passengers wishing to travel at these periods of very high demand (i.e. New Year's Eve). Price discrimination is generally viewed as "unfair" when prices are increased in response to a supply shortage, even in the presence of direct substitutes, such as public transport or regulated taxis (Kahneman et al., 1986), although, it has become accepted in some markets, such as the airline industry where it has operated since the 1980s (McAfee and Te Velde, 2006).

Despite the controversy, price discrimination by Uber has two effects: firstly, it stokes demand as price sensitive passengers are able to take rides outside of surge pricing times for prices generally below those of licensed alternatives (Silverstein, 2014) without having to subsidise rides taken during surge periods, as they would in regular taxi with static prices. In this sense, the pricing strategy makes the taxi market's notoriously inelastic demand curve (Teal and Berglund, 1987; Gwilliam, 2005; Shreiber, 1975) more flexible. Secondly, unlike the airline industry, Uber can use pricing to add supply to the market. During surge periods, demand outpaces supply, causing a price surge, which encourages more drivers to enter the market in order to benefit from the temporary spike in fares. This influx of drivers then slows the price surge. Inciting supply was the original purpose of surge pricing: there were regular supply shortages at weekends in Boston in 2012 when large number of

drivers would stop driving before the weekly Saturday night peak in demand that occurred after eleven o'clock when residents began leaving bars and restaurants. Following the implementation of price discrimination, drivers stayed in the market after 11 pm in order to take advantage of higher "surge rates". Surge pricing appears to introduce elasticity into a supply curve, which has previously found to be relatively inelastic (Camerer et al., 1997; Faber, 2014).

By thickening the taxi market, Uber solves a significant matching problem. Matching supply and demand requires an intermediary to act as a clearinghouse for transactions. As both parties are using the same app, the software must provide an efficient centralised two-way clearing house which can process transactions whilst overcoming the congestion: the clog of transactions which need to be processed common in thick markets (Niederle et al., 2007). This problem is solved by the application itself whose capacity is more than adequate to process the required number of transactions instantaneously, a task beyond a traditional telephone-based dispatch system that is limited by staffing levels and the number of phone lines. Congestion is thus avoided through rapid processing times, whose brevity is further reinforced by issuing suppliers with "exploding" offers. Under the "exploding offer" system, a driver must respond to the offer of a journey, accepting or rejecting it within fifteen seconds, which ensures fast supply-side response times. After the completion of the ride, both drivers and passengers send feedback on each other to the operator who creates ratings for both which will be visible to both supply and demand sides. Constant and public peer-review allows passengers to avoid poor operators, and operators to dodge troublesome passengers (a benefit unavailable to regulated taxis). This removes one aspect of the imperfect information problem from both sides of the clearinghouse (see Slee (2014) for the limitations of Internet reputation systems): passengers are unlikely to get a driver who has a history of offering a sub-standard service.

Uber also goes some way to dealing with the problem faced by many US cities after they lifted quantity controls: new entrants without dispatch equipment, operating solely in the cruising market, cluster at demand spikes (i.e. hotels, airports and taxi stands) causing local over-supply. Uber effectively increase supply and provides those new entrants with low-cost access to dispatch services, which enables entrants to quickly locate passengers. This eliminates the need to wait for walk-up passengers at traditional centres of demand, like hotels and cab stands, which avoids local oversupply, stops public disputes amongst operators and lessens the externalities associated with increased supply, such as localised congestion.

In short, Uber first creates the conditions necessary for the establishment of a thick market by lowering barriers to entry for supply and reducing transaction costs for demand. This type of market requires an efficient clearing house in order to function efficiently. In principle, a clearinghouse solves the three main challenges in such a market: sufficient volumes of transactions, congestion and safety (Niederle et al., 2007). It achieves adequate volumes of transactions in the market through a thick market externality; evades congestion by using automated technology to link supply and demand, rather than dispatch centres with a limited number of human operators; and it ensures service standards through user feedback. In this sense, it successfully solves the thin market problem. The array of service levels offered the customer through clear signalling provides effective market differentiation, allowing suppliers within the Uber model to offer better quality without being driven out of the market. Again, the feedback mechanism helps to minimise the gap between the quality advertised and that supplied. In this sense, the Uber model largely solves the problems associated with credence goods.

The following section suggests some potential problems facing the market for "taxi" apps.

5. Problems

Despite their recent success, the conceptual economic literature on taxi markets suggests that taxi apps, including Uber, may face some fundamental problems.

As taxi market apps do not have exclusive jurisdictions, any number of apps can operate fleets of drivers in the same city and charge according to their own pricing structures. There may be considerable overlap between fleets, with some drivers belonging to more than one. Smartphone users can also download multiple apps for little or no cost. This situation, in which the transaction cost of switching between apps is low, could conceivably lead to instability in the market through the following mechanism:

If the fares offered by popular "app A" through its pricing algorithm, drop too low, then drivers may move to, the less popular "app B" which offers higher fares. Driver may also be enticed by one-off payments, similar to the $1000 Uber offered to drivers switching from competitor, Lyft in 2014 (Saitto, 2014). An influx of drivers may, in turn, lower "app B's" prices (if "app B" uses a pricing algorithm) and raise "app A's", quickly inverting the incentives for drivers, who may then return to "app A". Passengers will follow drivers from "app A" to "app B" once their migration has caused prices fall in the latter, and will subsequently follow driver back to "app A". This price volatility and lack of reliability may cause demand to abandon the market in favour of near substitutes: if passengers do not know which app to use or how much their journey is likely to cost, then they may well exit the market and take the bus, thinning the market.

Dempsey (1996) argues that fundamental imperfections in the structure of the taxi market may, theoretically, lead to chronic instability in fare bargaining between drivers and passengers in a market without price controls. Drawing on Core Theory, an offshoot of Game Theory, he argues that the taxi market represents a game with an empty core. This means that players in the game can continually form new coalitions which beat existing coalitions. He uses an example from the economist, J. Wiley:

> For example, say that three strangers are willing to pay up to $7 each for a cab to the airport. Two cabs stop nearby. Each cab can carry one or two passengers, and each driver is willing to make the trip (with either one or two passengers) for a

minimum of $6. Given these demands and costs, the worst-off or excluded player can block any arrangement by tempting some players to abandon others for a more attractive arrangement. Suppose, for instance passengers A and B force driver X down to her minimum $6 total fare, thus yielding for A and B a fare of $3 each. As a result, passenger C is stuck paying at least $6 to travel alone with driver Y. But driver X could gain an added $2 by dumping B and offering C a ride for $5-which C should accept because a $5 fare is cheaper than a $6 fare. This new coalition between X, A and C however, is vulnerable in turn to raiding by the excluded players, Y and B. Now passenger B faces a trip alone with driver Y at a fare of at least $6, and both will improve their lots if they attract passenger C with a $4 fare offer, which Y and B split between themselves and which C will prefer to the $5 that C pays as a member of the existing X–A–C coalition. This coalition instability occurs for every possible combination of players.

Dempsey's argument focuses on identifying an "empty core" on the demand side. However, competition between multiple apps, each with the ability to set its own prices, suggests that a market for journeys could have "empty cores" at both the demand side, as per Wiley's example, but also at the supply side. This situation may persist until a single app dominates the market, at which point, the problem of fundamental instability is replaced by those of a monopoly supplier, such as the ability to set prices above marginal costs and to act indifferently to market signals due to the absence of the discipline brought by competition. It is also possible to avoid such discipline through collusion with competitors. Faced with instability and a thinning market, competing apps may choose to agree on price levels in order to provide stability. Such collusion may not necessarily be to the benefit of passengers or drivers.

Furthermore, although, Uber effectively deals with the problems associated with credence goods and successfully thickens the market for taxi trips, it does not completely solve the open access problem. Linking drivers to passengers via a smartphone based dispatch system does mitigate the problem of "clogging". However, this can only occur until additional supply cannot be absorbed by the market. At this point, efficiencies are likely to fall and driver wages to decrease as the additional demand prevents the pricing algorithm from "surging", or rising above the fare floor. The marginal cost to Uber of putting an additional driver on the street is negligible. Although Uber's income per trip (a percentage of the total fare) may fall as "surge" pricing becomes rarer, the company may seek increased trip volumes, further thickening the market, as a way to maintain revenues. If adequate increases are not forthcoming, then drivers may leave the market, just as supply fell away after an initial surge in many US cities with open access regimes.

The feedback mechanism may effectively guard against substandard service quality. However, several high profile cases have brought into question Uber's ability to protect passengers from serious crimes, those far beyond the comparatively minor violations that the feedback model is designed to detect. In 2104, an Uber driver in New Delhi was charged with raping a female passenger, two Chicago-based drivers were accused of sexually assaulting passengers in two separate incidents (BBC, 2014) and a San Francisco driver attacked a male passenger with a hammer (Ho, 2014). These incidents and others like them prompted claims that Uber's background checking procedures were too lenient and that, consequently, Uber's service was significantly less safe than that of licensed taxi firms.

Uber and its competitors currently require drivers to submit their details to the company. In Uber's case these details are then passed on to Hirease, a private company, which performs background verification (Uber, 2014a, 2014b). However, critics argue, that Uber does not take driver fingerprints, without which there is no clear way of telling if the information submitted is definitely related to the driver or fabricated. Furthermore, a driver is only screened for drugs if there are passenger complaints against him (Jiang, 2015). Fingerprinting and drug testing are mandatory in the background checking procedures of most US and Canadian taxi markets. Public background checking, it is argued, is more thorough as regulators have access to state records, such as criminal records databases and other sources of information (i.e. in the US, F.B.I records) not available to private screening companies (Isaac, 2014).

However, despite the allegedly more thorough background checks, there are still numerous incidences of serious crimes against passengers, overwhelmingly female, carried out by licensed taxi drivers in their vehicles. In recent years, licensed taxi drivers have been connected or charged with serious sexual crimes in Guelph (CBC, 2015), Washington DC (Stabley, 2014), Austin (Denny, 2014), Delaware (Beck, 2014), Los Angeles (Castellanos, 2012), Toronto (Lamcja, 2014), Vancouver (Lindsay, 2010), Chicago (Huffington Post, 2014) and Seattle (Pulkinnen, 2014), among other cases. There are also cases from other jurisdictions with similar background checking systems, such as the UK where similar cases have occurred in Liverpool (Liverpool Echo, 2014), Leicester (Leicester Mercury, 2014) and London (Addley, 2009).

In the cases involving licensed drivers, the reports tend to focus on the crimes committed by the driver. There is an emphasis on his individual culpability and deviancy. The crimes are seldom seen as resulting from the failure of background checking procedures carried out by regulators. However, although the reports of crimes by drivers using Uber do pay some attention to the responsibility of the perpetrator, the stress is on the alleged failings of the app provider to effectively prevent such crimes through back ground checks. The burden of responsibility is placed on the provider rather than the driver. This difference may stem from the perception of Uber as a large, predatory private-sector firm, which skims rent from its drivers and threatens small local operators. However, the taxi firms perceived as under threat are also part of the private sector. Many of them are also rent seeking: it is commonplace for driver to rent permits/medallions from taxi firms, often paying a substantial percentage of their daily income. Drivers usually have to pay an additional charge for the dispatch link. Many licensed firms also lease the cars to drivers in order to limit their costs and liabilities (Cooper et al., 2010).

Whilst critics of Uber argue that crimes committed on-duty by Uber drivers are a result of the company's background checking procedures – failure to detect a clear signal from the driver's records that he poses a threat – the prevalence of

similar cases in the licensed taxi market suggests that this is a problem of the wider market for taxi trips, be they through an app or a licensed taxi firm.

The current debate focuses on the relative stringency of the background checks carried out by Uber and public regulators; each arguing that its procedure is more effective at detecting signals from driver behaviour in order to keep passengers safe. But it matters less whose procedure is most stringent, it is more a case of which system is associated with the lower incidence of crimes against passengers per trips taken. If Uber can match the rate of crime of the licensed taxi industry with, let it be assumed, a more lenient checking regime then this may indicate that official controls are tighter than they need to be. Such a case could also suggest that Uber enjoys a different advantage, such as selection bias in driver recruitment. However, if Uber's crime rate is significantly higher than the licensed taxi sector, then it may indicate that improvements to the company's background checking procedures are needed. This could mean bringing them in line with licensed taxi firms. Only thorough empirical work can answer this question, however gaining access to data held by a private company may hinder this endeavour.

Overall, the prevalence of serious crimes against passengers by drivers both in the licensed taxi market and those using taxi apps, suggests that it is an industry wide problem; one associated with the market for trips. Additionally, any system of background checks is based on induction: the past behaviour of an individual is used as the basis for predicting his likely future actions. That system cannot begin to predict undesirable behaviour for a particular occupation if the individual has not committed any to date. This is a problem common to both taxi apps providers and public regulators.

6. Conclusions

The major rationales for regulation of taxi markets are: the need to mitigate problems associated with "credence goods"; to correct issues arising from open access; and to ensure returns for suppliers operating in a thin market. These rationales result in the regulation of taxi numbers, fares and service standards, a regulatory framework that has been in place since the early 1930s. Taxi apps have brought about a significant change in the market, which has implications for the existing regulatory framework. The thickening of the market for taxi trips mitigates the need for quantity restrictions. Sparse and geographically spread demand can be met with supply at the appropriate price. Post-trip feedback, in high volumes, helps to maintain service standards across a range of levels, removing the need for regular external checks. The serious crime problem appears to be an issue for the industry as a whole and not merely restricted to taxi apps, though more empirical work is needed on the issue. The high volumes of trips in a thick market of individual operators without fare controls would keep price volatility low. If these trip volumes are catered for by apps which are in competition, then strict price controls may not be necessary.

Apps do, however, still pose some challenges. Fierce competition between apps may lead to instability on both demand and supply sides with the resulting uncertainty driving demand from the market, reversing the earlier thickening process. Conversely, a lack of competition may grant a single app a monopoly in the market, allowing it to set prices and extort both passengers and drivers. Potential remedies for these contrasting scenarios include supply side collusion, in which two or more market leading apps set prices and service levels in order to stabilise the market and prevent thinning. However, these decisions may not necessarily be made with the benefit of passengers and drivers in mind. In this sense, the market created by taxi apps may come to take on some of the characteristics of the established taxi market it sought to circumvent. Both taxi apps and the established taxi market may co-exist in the same jurisdiction. However, the circumstances under which this is best achieved are unclear. It may involve taxi apps taking on certain characteristics of the established market, such as standardised background checking procedures, or it could mean incumbents utilising certain technologies to increase efficiency. Both processes could occur by choice or as a result of regulation.

Regulation is another potential solution. Bearing in mind the arguments made in this paper – that Uber effectively removes two of the underlying rationales for taxi market regulation (and largely mitigates the third) – regulators should shift their focus away from responding to calls from incumbents to restrict the growth of this market by banning taxi apps and enforcing existing regulatory frameworks. Instead, regulators should allow taxi apps to thicken the market. The focus of regulatory interventions should be on the possibility of future monopoly and collusion in a market led by smartphone apps, a regulatory approach that may look very different to the current "QQE" framework.

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