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Uber for tractors? Opportunities and challenges of digital tools for tractor hire in India and Nigeria

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Abstract

Agricultural mechanization can contribute to agricultural transformation. However, there is a need to find institutional solutions allowing smallholder farmers, who play a key role in agricultural development, to access tractors even though they cannot afford their own. Hire markets hold promise for this, but tractor owners are often reluctant to provide services to smallholder farmers because of high transaction costs. To address this problem, start-ups and tractor manufacturers have developed ICT applications that aim to help smallholder farmers access tractors. This model has been coined *Uber for tractors,* suggesting strong similarities with the Uber service for ride hailing. Although receiving much advance praise, these models have not been rigorously analyzed. Studying *Hello Tractor* (Nigeria) and *EM3 Agri-Services* (India), this paper assesses how such models address the challenges of agricultural markets, which are characterized by spatial dispersion, the concentration of demand around peak seasons, and high transaction costs, among other problems. This paper explores the extent to which such models can help to improve tractor utilization and access to services by smallholder farmers. The paper acknowledges the potential of ICT-based tractor hire but finds that many of the thornier challenges of agricultural markets – which urban ride-hailing markets do not face – have yet to be addressed. The paper also finds that analog solutions such as booking agents and phone calls still trump digital ones and highlights the need for a supportive environment such as building (ICT) literacy. Last, the paper suggests that the advantages of ICT-based solutions over more traditional ways of organizing service markets are more mixed than commonly assumed. In brief, while the *Uberization of mechanization* has appeal, such models are not the silver bullet they are often portrayed to be. More research is needed on how to make such ICT-based efforts work, and it is important not to neglect alternative solutions.

Key Words

Agricultural mechanization, smallholder farming, ICT applications, digital agriculture, transaction costs, service markets

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1. Introduction

During the last decade, agricultural mechanization has re-emerged on the development agenda of Africa (Baudron et al., 2019; Diao et al. 2014) and unfolded rapidly in Asia (Takeshima, 2017; Wang et al., 2016). Mechanization allows farmers to overcome labor bottlenecks and expand farm production (Adu-Baffour et al., 2018; Baudron et al., 2019; Diao et al. 2014). However, while large-scale farmers can afford to buy tractors, there is a need to find institutional options allowing smallholder farmers, who play a key role in agricultural development, to access tractors even though they cannot afford to buy them. Without such options, mechanization can lead to the unequal distribution of land and wealth (Binswanger, 1986).

One such institutional option is service markets. Service markets played a key role in the history of today's mechanized countries. For example, as shown by Olmstead and Rhode (1995), service markets for reaping, though far from being "completely fluid" (p.51), contributed extensively to smallholder mechanization in the United States. Service markets also play a role in some of today's mechanizing countries. In India, harvesting services are popular and in Bangladesh only 2% of farmers own two-wheeled tractors but 72% of farmers access them (Diao et al., 2014). In many areas, however, such markets are hampered by high transaction costs – the searching, bargaining, and enforcing costs related to setting up contracts – and tractor owners are unwilling to provide services to smallholder farmers unless transactions are facilitated (Adu-Baffour et al., 2018; Daum & Birner, 2017).

One way to facilitate transactions may be the use of digital tools, which have received much attention in the quest to solve the challenges of rural markets (Aker et al., 2016; Baumüller, 2018; Daum, 2018; Malabo Montpellier Panel, 2019; Nakasone et al., 2014; World Bank, 2016) and have been shown to reduce the transaction costs related to service access by smallholder farmers (Campenhout, 2017; Deichmann et al., 2016). For mechanization, digital tools that aim to connect tractor owners and farmers have been developed by Hello Tractor1 in Nigeria; EM32, Trringo3 and farMart4 in India; Trotro Tractor5 in Ghana; and Rent to own6 in Zambia. For tractor owners, the use of such tools promises to reduce the transaction costs related to service provision, thereby allowing them to spread fixed costs

[1] https://www.hellotractor.com/home
[2] http://www.em3agri.com/
[3] https://www.trringo.com/
[4] http://www.farmart.co/
[5] https://www.trotrotractor.com/
[6] https://rtoafrica.com/

and reach economies of scale. For farmers who cannot afford their own tractor, such tools promise to reduce the transaction costs of accessing tractor services.

The abovementioned digital tools are referred to as Uber for tractors and the Uberization of mechanization. These phrases have been coined by the abovementioned ICT providers themselves and have been enthusiastically repeated by policymakers, donors, researchers and the media. The New York Times headlined an article on this approach with "How do you hail a tractor in India? All it takes is a few taps on your phone".7 The Uber comparison has generated a powerful narrative of change by suggesting that farmers can access tractors as easily as city dwellers can hail rides using Uber8. Uber, which owns no cars and employs no drivers, provides a digital marketplace where customers "schedule transportation with third party providers of such services" (Henten and Windekilde, 2015, p.12). The Cambridge Dictionary (2019) defines the term Uberize as the ability "to change the market for service by introducing a different way of buying or using it, especially using mobile technology". According to Henten and Windekilde (2015), Uber has significantly lowered transaction costs for searching, contacting and contracting for both passengers and drivers.

Uber-type ride hailing is popular in developing countries; whose cities are among the most promising markets for ride hailing. In Africa, Uber operates in 500 cities and had served 2 million customers by 2018 (Haas & Bird, 2018; Houeland, 2018). In India, Uber has 350,000 drivers, and a rival, Ola, has more than a million (Agrawal, 2018). However, there are differences between urban Uber-type ride hailing services and rural Uber-type tractor hiring. In urban areas, network coverage and literacy levels are higher, and roads are more developed (GSMA, 2017). Moreover, the density of customer demand is higher, as there are more potential customers per area, and each of them may hail rides daily. In contrast, farms are spatially dispersed, and farmers demand services only a few times per season (Binswanger and Rosenzweig, 1986). Furthermore, farmers located in the same area are exposed to the same climatic conditions and thus demand services at the same time (Binswanger and Rosenzweig, 1986), and deviations from the optimal (often narrow) farming window can lead to large yield drops (Sallah et al., 1997). This can bring large income losses, whereas the income loss related to delayed ride hailing is likely to be low. Also unlike driving a car, operating farm machinery is a skilled task and quality of the work on the field is unstandardized. Additional challenges of agricultural markets, including various types of risks and information asymmetry, have been summarized by Binswanger & Rosenzweig (1986).

[7] nytimes.com/2016/10/18/world/what-in-the-world/trringo-app-india.html
[8] https://www.uber.com

As outlined above, digital tools have received much advance praise and enthusiastic media attention for reducing the challenges faced by smallholder farmers in developing countries. This has helped to throw light on the grand challenge of smallholder mechanization and potentially to attract private sector interest into an otherwise neglected market. However, while many ICT applications, such as Uber-type approaches for smallholder mechanization, have been flagged as success stories, few of them have been rigorously studied (Baumüller, 2018), which would be needed for evidence-based policy-making. This can be problematic as success stories can lead to political lethargy if they suggest that solutions for problems exist, for example, that the Uberization of mechanization has solved the problem of findings ways to enable smallholder mechanization. This may lead to the neglect of alternative solutions and complementary policy actions.

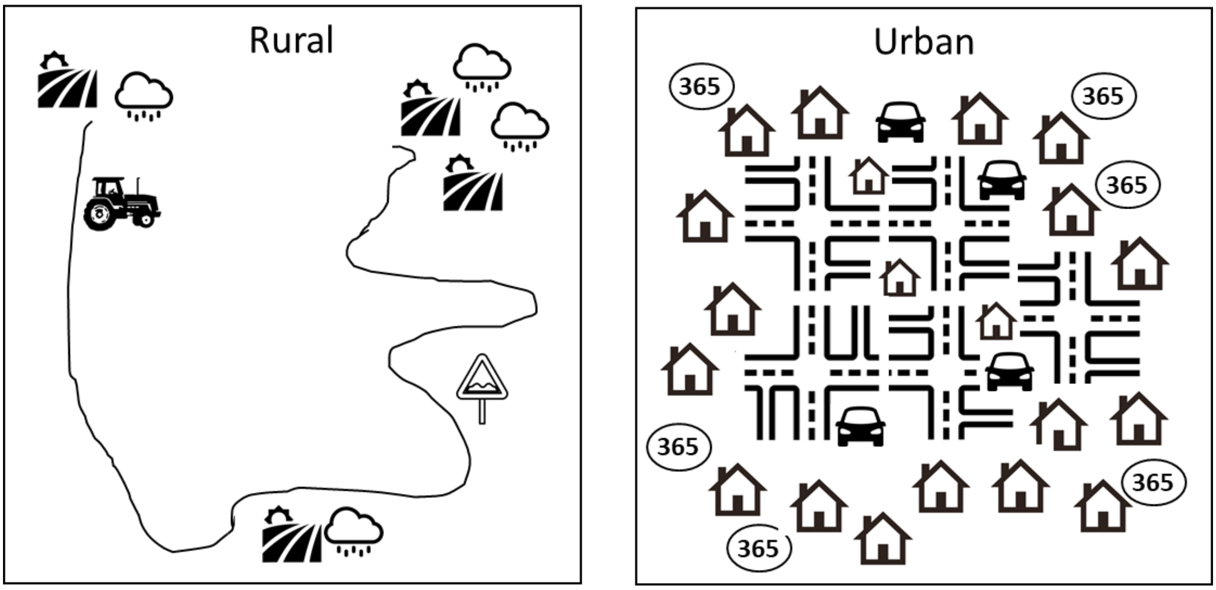
Against this background, this paper presents two case studies of two of the pioneering companies promoting ICT-based tractor hire services: Hello Tractor in Nigeria and EM3 Agri-Services in India. The objective of the paper is to investigate how these models address the thorny challenges of rural and agricultural markets and to disentangle what works, where, when and for whom and what does not work. In particular, the paper explores the degree to which such models are able to change the transaction costs of service markets – and thus the access of smallholder farmers to tractors. For this, the authors develop a theoretical framework, drawing largely on transaction cost economics, a branch of economics that compares which contractual arrangements emerge depending on the costs of exchange relationships (Williamson, 1985; Shelanski and Klein, 1995), as further explained below. Because the Uberization of mechanization has not been studied previously, this study used an explorative, mixed-methods approach with a focus on understanding the opportunities and challenges of the model. Future studies could also assess the effects of such models on tractor owners and farmers more quantitatively, for example, by conducting randomized control trials.

The paper proceeds as follows. In section 2, the authors present the theoretical framework, building on transaction cost economics. This framework will be used to compare how transaction costs differ between rural tractor hire and urban ride hailing and to show traditional ways to address transaction costs. Section 3 will show the status of mechanization and tractor hire markets in Nigeria and India. Section 4 presents the data collection methods. In section 5, the authors present the different Uber for tractor case studies and apply the theoretical framework to analyze how these companies address the challenges of agricultural markets and affect the transaction costs of tractor hire markets. Section 6 discusses and concludes the paper.

2. Theoretical Framework

Given the above-outlined differences in the frame conditions between Uber-type services for ride hailing and such services for tractors, which are also visualized in figure 1, the costs to make service provision happen are likely to be higher for tractor hire than ride hailing.[9]

Figure 1. Differences between tractor hire and ride hailing



Source: Authors

One way to look at such costs more systematically is to use transaction cost economics (TCE). TCE dates back to Ronald Coase (1937), who analyzed when firms should rely on service markets. Coase argued that using markets includes costs other than production and transportation costs (as suggested by neo-classical economics), as the parties of the exchange need to find each other and establish whether they can trust each other (information/sorting), negotiate terms of service (negotiation) and ensure that the terms are adhered to (monitoring, enforcement and compliance).[10] All these steps are associated with monetary costs as well as more elusive costs such as opportunity costs, which makes TC difficult to measure (Kherallah & Kirsten, 2002; Staal, Delgado and Nicholson; 1997). Going beyond firms, Williamson (1985) used TCE to analyze the costs of exchange for different contractual arrangements. Such an approach allows, for example, a comparison of contractual arrangements for mechanization, such as hire, ownership and cooperative models (Wander et al., 2003). For such comparisons, understanding the relative ranking of the TC associated with different contractual arrangements suffices, and no accurate calculations of actual TC are required (Wang, 2003).

[9] Depending on local labor economics this may or may not result in a continuous reliance on manual labor.
[10] TCE thus explicitly acknowledges that market actors are opportunistic and possess "self-interest seeking with guile" (Williamson, 1985, p. 47).

In general, TCE argues that markets rely on contractual arrangements that minimize the overall costs of the transaction, which comprise both transaction and production/transportation costs (Shelanski and Klein, 1995; Wander et al., 2003). When TC are too high, markets can fail, which can frequently be observed for developing countries' agricultural markets (Kherallah & Kirsten, 2002). Thus, contractual arrangements that reduce TC tend to enhance the participation of farmers in markets (Cuevas, 2017).

Transaction costs are determined by attributes such as uncertainty, specificity, frequency (Williamson, 1985), complexity (Shelanski & Klein, 1995), measurability (Barzel, 1982), and hold-up problems (Wander et al., 2003). For mechanization, additional attributes play a role, such as the spatial dispersion of farming and principle-agent problems. Principle-agent problems can arise when tractor owners hire operators who face moral hazards, for example, who lack motivation to perform maintenance, are inclined to steal diesel and line their own pockets (Daum & Birner, 2017), which can lead to a failure to adhere to the agreed-upon services. The abovementioned attributes may be interrelated. Table 1 shows how the attributes of TC differ between urban ride hailing and rural tractor hire.

Table 1. Transaction costs differences between urban ride hailing and rural tractor hire

	Key questions	Effect on TC	Major difference between ride hailing and tractor hire
Uncertainty	Are transaction partners available? Will service provider and customer show up (on time) and fulfill their terms?	The more uncertain, the higher the TC is.	Given the different densities, customer demand and service supply, uncertainties and their consequences are higher for tractor hire. This leads to different fallback positions and weak bargaining power for the customers of tractor hire.[11] For tractor owners, uncertainties also arise from a lack of knowledge on field conditions (e.g., the prevalence of tree stumps and stones, which can lead to breakdowns) and rainfall patterns.
Asset specificity	For how many different production stages and crops can the machinery be used?	The more specific, the higher the TC is.	Cars can be used for most forms of transportation. Tractors can be used for different production stages and crops but need to be equipped with the respective equipment (e.g., plows, planters, sprayers).

[11] In addition, as shown by Bowles and Gintis (1993), agents on the short side of non-clearing markets, which exist due to a lack of competition, can exercise power.

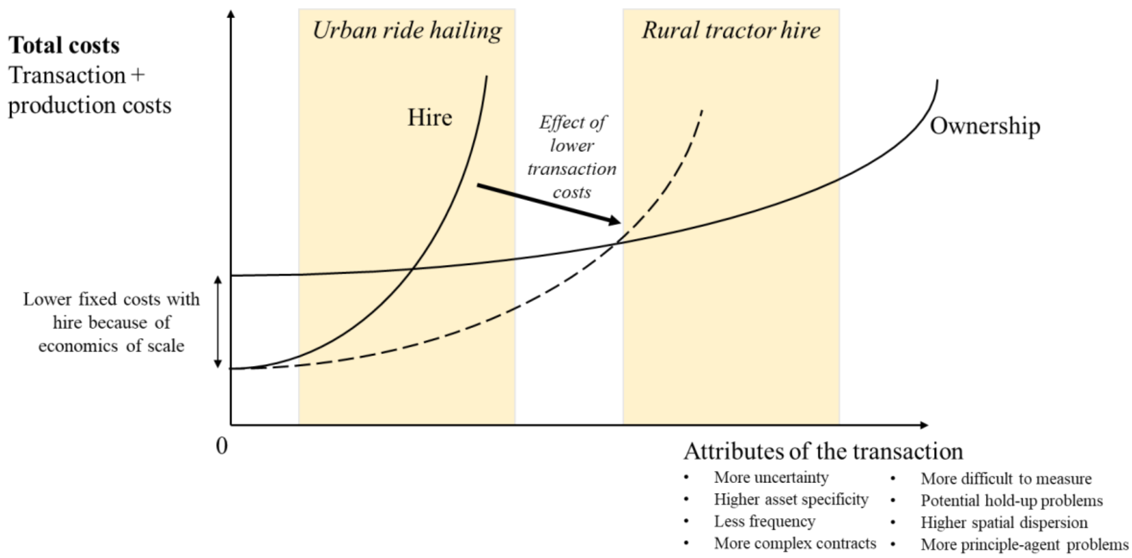
	Key questions	Effect on TC	Major difference between ride hailing and tractor hire
Frequency	How often are services provided?	The more regular services are, the more trust can build and the lower the scope for opportunism, therefore, the lower the TC.	The seasonality and synchronous timing of farming reduces the number of possible transactions per season.
Complexity	How complex do the contractual agreements need to be?	The more complex, the higher the TC is.	In contrast to ride hailing, where the two parties involved only need to agree on the distance and price, additional factors are of relevance for tractor service provision such as adequate plowing depth and speed, soil erosion control, and the prevalence of stumps and stones, which are difficult to monitor because of information asymmetry, which make contractual arrangements more complex.
Measurability	Can the service be easily measured?	The more difficult to measure, the higher the TC is.	Ride hailing can be judged easily by whether customers safely reach their destination (in time). For tractor hire, measuring the areas serviced is more difficult without measurement devices, and additional quality checks are needed (e.g., controlling the plow depth, weed coverage), which are more subjective measures.
Hold-up problems	Does a transaction failure affect other transactions?	The higher the risk and consequences are, the higher the TC.	Delays from late service can “hold-up” subsequent farm operations. For example, late plowing can lead to late planting and sharp yield drops; late processing can even lead to a loss of the produce.
Spatial dispersion	How spread is customer demand across space?	The more dispersed, the higher the TC is.	Given the spatial dispersion of farming, the distances between transactions are higher with regard to tractor hire, driving up the costs for fuel, for example, and creating room for principle-agent problems.
Principle-agent problems	How easy is it to monitor and control operators?	The easier to supervise, the lower the TC is.	Principle-agent problems affect both ride hailing and tractor hire. However, given the spatial dispersion of farming, monitoring and supervision costs are likely to be higher with regard to tractor hire.

Source: Authors

Table 1 suggests that transaction costs are higher for tractor hire than for ride hailing. TCE theory thus suggests that ride hailing more closely resembles spot markets, while agricultural mechanization would rely more on the ownership of machinery (Shelanski & Klein; 1995) due to service market failures. This can explain the abovementioned popularity of urban ride hailing as well as the reluctance of tractor owners to provide services to smallholder farmers or, alternatively, the reluctance of smallholder farmers to rely on service providers for access to farm power.

Figure 2 presents hypothetical cost curves to explain the emergence of mechanization markets. When the cost curve resembling tractor hire costs lies above that for ownership, one would expect that tractors owners would not offer services and farmers would not demand services (and instead rely on manual labor and animal traction or try to purchase their own tractor). When the cost curve resembling tractor hire costs lies below that for ownership, tractor owners are expected to provide services and farmers to demand such services. With low transaction costs, tractor hire is the rational choice because its costs are lower than ownership costs. Tractor hire helps tractor owners reach higher utilization rates and spread fixed costs. As indicated by the yellowish background on the left side, ownership in urban transportation markets is typically associated with higher costs than hiring; thus, ride hailing is more common. With higher transaction costs, tractor hire is no longer the rational choice. As indicated by the yellowish background on the right, this is mostly the case for rural agricultural mechanization. In this case, ownership would be the rational choice. Yet, given high machinery prices and the absence of capital markets, farmers are likely to continue to rely on manual labor.

Figure 2. Hypothetical cost curves of agricultural mechanization



Source: Authors

However, there are ways to reduce transaction costs and protect trading partners "from the hazards associated with exchange relationship" (Shelanski and Klein, 1998, p. 336). For the United States of America, Olmstead and Rhode (1995) showed that reaper services could emerge despite time constraints, transportation problems, and transaction costs that initially prohibited sharing and contracting. This can also be seen in figure 2: any solution to reduce transaction costs raises the odds that mechanization markets emerge by lowering the hypothetical cost curve for tractor hire. Table 2 shows some of the traditional solutions used to reduce the transaction costs related to mechanization markets. A common disadvantage of all these methods is that they constrain the potential area of service provision. In addition, while some reduce the transaction costs for service providers (such as informal demand pooling by farmers), they are associated with transaction costs for farmers (to organize themselves).

Table 2. Traditional ways to reduce transaction costs

Attributes	Non-ICT-based and ICT-based ways to reduce transaction costs	
	Providers	*Customers*
Uncertainty	Non-ICT-based: Using scouts to assess fields, relying on long term relationships, developing a "cropping calendar", requiring up-front payment, avoiding some types of customers (such as smallholder farmers) as a rule of thumb ICT-based: Software for fleet management and demand planning, using algorithms that minimize the travel time between requests, Internet of Things approaches that allow tractors to communicate and plan service provision, drone or satellite-based field assessments, requiring farmers to send pictures of fields, electronic scoring systems that allows assessment of customers	Non-ICT-based: Relying on long term and previous relationships, using social capital to ensure early service, long-term planning to ensure service provision (often tractor owners operate on a first-come, first-served basis), pay only after service delivery ICT-based: Showing waiting time until tractors arrive, public rating of service providers, up-front price calculation
Asset specificity	Non-ICT-based: Diversification, sharing of implements (e.g., using "Machinenringe"[12]) ICT-based: Sharing of implements supported by digital management platforms	Not applicable
Frequency	Non-ICT-based: Migration to other areas, relying on long term relationships ICT-based: Software optimizing service provision (incl. the migration to other areas); customer management platforms	Non-ICT-based: Relying on long term relationship ICT-based: Software optimizing service provision (incl. the migration to other areas); customer management platforms

[12] Groups of farmers (often neighbors, relative or friends) that each own machinery that they rent out to each other. An approach to shared machinery that is popular in Germany.

Attributes	Non-ICT-based and ICT-based ways to reduce transaction costs	
	Providers	*Customers*
Complexity	Non-ICT-based: Participate in training so that complex tasks can be executed more effectively ICT-based: Use of sensors in implements and automation of farm operations to "standardize" processes	Non-ICT-based: Participate in training to be able to better assess the quality of complex tasks ICT-based ways: Use of sensors in implements and automation of farm operations to "standardize" processes
Measurability	Non-ICT-based: Agreeing on objective measurements (such as measuring areas served with standardized ropes) and relying on objective judges to assess quality (such as extension officers) ICT-based: Using satellites, drones and machinery-based sensors to measure quality and GPS to measure area served	Non-ICT-based: Agreeing on objective measurements (such as measuring areas served with standardized ropes) and relying on objective judges to assess quality (such as extension officers) ICT-based: Using satellites, drones and machinery-based sensors to measure quality and GPS to measure area served
Hold-up problems	Not applicable because providers can cultivate their own fields first	Non-ICT-based: Partial mechanization (i.e., only part of the land to minimize risk), diversify crops so that services can be spread over a longer period, use of contractual penalty mechanism in case of late service provision ICT-based: Showing waiting time until tractors arrive
Spatial dispersion	Non-ICT-based: Use of brokers/agents to organize customers up front, focus on large-scale farmers ICT-based: Demand pooling using smartphone applications	Non-ICT-based: Informal demand pooling among neighboring farmers ICT-based: Demand pooling using smartphone applications
Principle-agent problems	Non-ICT-based: Performance of operations by machinery owners only, mileage recording, timed field work, owner/relative follows tractor, control by assistant operator, random field checks, limiting radius for effective oversight, fuel monitoring, customer calling, tractor owner organization to collectively refuse poorly performing operators ICT-based: Using GPS tracking and machinery-based sensors to monitor operators and maintenance	Non-ICT-based: Supervision and inspection of field work, use complaint mechanisms; involve experts (e.g., extension agents) and peers in assessment of work; participate in training to be better able to assess quality of work ICT-based: Electronic complaint mechanism and checklists for quality control, send pictures of served fields to experts or peers electronically, supervise field work using drones

Source: Authors

ICT tools may now provide additional mechanisms to reduce transaction costs. This has been shown by the use of ICT solutions for urban ride hailing (Henten and Windekilde, 2015). For example, digital tools have helped to reduce uncertainties for passengers by showing digital maps with the location of nearest service providers, by showing the waiting time until drivers arrive, by requiring drivers to be formally registered and allowing customers to rate them, and by informing passengers on the final price up front. For Uber operators, Uber's digital solutions help to reduce uncertainties by spatially showing customer demand and using algorithms that minimize the travel time between service provision. Following Benkler (2004), ICT applications can also reduce enforcement costs because they rely on enforcement mechanisms based on social relations and social capital (by rating service providers) rather than relying on state authorities to enforce contracts, which may be of particular relevance for countries with otherwise limited governance capacities. Similar digital solutions could also help *Uber for tractor* service providers. However, such providers face the additional task of addressing the fundamental challenges of rural markets that lead to high transaction costs and often transaction (or market) failures. Moreover, such Uber-type business models need to be more attractive than service provision using more traditional means to reduce transaction costs to be adopted by tractors owners and farmers

3. Status of mechanization and tractor hire in Nigeria and India

This paper examines the ICT-based tractor hire model in Nigeria and India. This section provides an overview of the status of smallholder mechanization and tractor hire markets in these countries.

Nigeria

Compared to India, which will be presented in the next section, agricultural mechanization is at a lower level in Nigeria. Takeshima and Salau (2010) assess that "owning and renting a plow is not common" and "access to a tractor is even rarer" (p.1). According to them, most of the land is cultivated with hand hoes, and the uptake of mechanization is low even for power-intensive operations such as land preparation, which are typically mechanized first. Actual numbers are not available, and estimates are contradictory. According to the latest estimates of the Food and Agriculture Organization (FAO) from 2007, Nigeria has a tractor population of 25,000. In contrast, extrapolating from LSMS-ISA data, Sheahan and Barrett (2017) estimate that there are 450,000 tractors. However, compared with annual tractor imports, this estimate seems to be a gross overestimation (Takeshima and Lawal, 2018). Sheahan and Barrett (2017) estimate that 1.6% of all farmers owned tractors in 2010/11 and that 25% accessed them. In contrast, Takeshima and Lawal (2018) argue that only 4% of all farmers own *or* hire tractors.

Adoption rates differ by farm size: of the 10% farms larger than 3 hectares, 10% own or hire tractors and 40% own or hire animal traction (Takeshima and Lawal, 2018). Adoption rates also differ by agro-ecological zones. For example, in cereal-crop growing Northern Nigeria, which has light soil and flat land, as many as 50% of all farms may use animal traction. This share is much lower in Southern Nigeria, where animal draft power is constrained by the tsetse fly, the cultivation of root and tree crops and heavy soils and hills (Takeshima and Lawal, 2018). In general, tractors are used for few activities, mainly around land preparation and transportation (Takeshima and Lawal, 2018).

According to Takeshima and Lawal (2018), 66% of the farmers using tractor services access them via neighbors and relatives as well as the private market, which is composed of medium-scale farmers as well as contractors and associations, both of which can own large fleets of tractors. A total of 28% of farmers hire tractors via public hire centers (Takeshima and Lawal, 2018). Such centers have been established since 1958 and became a policy priority during the 1970s. In the mid-1980s, they were "largely considered inefficient" and often abandoned (Takeshima and Lawal, 2018, p. X, referring to Akinbamowo, 2011). Since the 2000s, such centers were revived as Agricultural Equipment Hiring Enterprises (AEHE), this time as public-private partnerships, where the state supports private entrepreneurs (such as farmers, cooperatives and investors) with subsidized tractors (Takeshima et al., 2018). By 2016, 80 AEHEs had been established, each typically owning five four-wheeled tractors and five two-wheeled tractors plus attachments and sometimes owning harvesters and processing equipment as well (Takeshima and Lawal, 2018).

India

Indian agricultural mechanization started during the late 1950s (Bhattarai et al. 2018; Diao et al., 2014). From then until 2010, the number of draft animals declined from 80 million to 50 million, while the number of tractors rose from 37,000 to above 5 million (Singh et al., 2014; Singh, 2015). In 1960, there was one tractor per 3600 hectares; in 2013, this reached one tractor per 24 hectares (Bhattarai et al. 2018). In 2015, alone, 550,000 tractors were sold (Bhattarai et al., 2017). Tractor density is highest in Northern India but is on the rise across Southern and Western India as well: in 2012, 147 tractors were used per 1000 hectares in Haryana, 124 in Punjab, 40 in Rajasthan and 6 in Kerala (Bhattarai et al., 2017).[13] Most tractors are four-wheeled and average 42 horsepower (Singh, 2015). There

[13] Tractor densities are higher with higher cropping intensity, larger farm size and higher per capita income in the respective state (Bhattarai et al., 2017).

are approximately 300,000 two-wheeled tractors (power tillers), which are popular for wetland rice production and hilly areas (Singh, 2015).

Agricultural mechanization began with land preparation, followed by irrigation and processing. More recently, equipment for zero tillage, laser land levelers and combine harvesters became popular (Singh, 2015). Early mechanization was driven by large farms – during the 1960s, 96% of tractor owners possessed more than 10 hectares (Singh, 2015). However, farmers owning 4 to 10 hectares soon also acquired smaller tractors, and hire markets emerged (Binswanger, 1986; Diao et al., 2014). In the 1970s, 60% of the annual use of tractors was for service hire (Singh, 2015). By approximately 2010, 38% of all tractors were owned by farmers with more than 10 hectares, while farmers with less than two hectares owned 1% of all tractors (Bhattarai et al., 2018).

Rental markets increasingly make tractors “accessible to all segments of farmers, including smallholding and marginal farmers” (Bhattarai et al., 2017, p.5). Today, although 85% of all land holdings are smaller than 2 hectares, Bhattarai et al. (2018) estimate that up to 90% of farmland is prepared by tractors. Rental markets are organized around individual farmers providing services, cooperatives and forms of joint ownership, rural entrepreneurs, big firms with large tractor fleets for custom hire as well as public-private or purely public hire centers (Bhattarai et al., 2018). There are no numbers on how many smallholder farmers access tractor services. The Economic Times (2016) argues that rental markets are still unorganized, dominated by wealthy farmers and government-subsidized custom hiring centers with limited scale and reach as well as patchy, unsatisfactory and often late services.[14]

4. Methods

This paper is based on case studies of two start-ups that have been pioneering the *Uber for tractor* approach: Hello Tractor in Nigeria, which was the first to explore the potential to apply the concept of Uber to mechanization in developing countries, and EM3 Agri-Services in India, which pioneered this approach in India. This paper uses a mixed methods design, including qualitative and quantitative data collection methods (see also table 3). In each of the countries, stakeholder mapping exercises were conducted to identify the stakeholders who determine the functioning of the business models. For this, a participatory technique called “net-mapping” (Schiffer and Hauck, 2010) was used. “Net maps” are well suited to exploring the structure and functions of complex systems and to identify how different

[14] https://economictimes.indiatimes.com/small-biz/startups/how-startup-em3-agri-services-is-tackling-farmers-distress-the-uber-way/articleshow/53133968.cms

stakeholders influence these systems. “Net maps” were created performed with representatives of the companies, Hello Tractor and EM3. During the “net map” sessions, participants were first asked to discuss which stakeholders influence the ICT-based models. The answers were drawn on a large sheet of paper. Second, participants were asked how these stakeholders are linked (e.g., through flows of money, services, information or commands), and these linkages were drawn on the paper with differently colored arrows. Participants were then asked to identify the most important stakeholders in making the ICT-based approach work. The answers were indicated using influence towers. For this, respondents could place checker pieces: from none (indicating no influence) to 6 (indicating high influence). Finally, bottlenecks were identified, and solutions to overcome these bottlenecks were discussed.

Based on the stakeholder mapping, interviewees for qualitative in-depth interviews were identified, including representatives of the companies, tractor owners and other actors in the value chain, tractor dealers, tractor operators, mechanics and government officials. In the case of EM3, which has several company owned hire centers but more lately focused on a franchise model (as further explained below), 15 franchisees were interviewed. In the case of the Hello Tractor, 7 booking agents were interviewed. With some of these stakeholders, additional “net maps” were created. In addition to “net maps” and in-depth interviews, focus group discussions were organized. The use of qualitative methods allowed an in-depth exploration of the cases while also permitting the discovery of unexpected findings that emerged during the research. During the collection of the qualitative data, the authors followed the rigorous evaluation standards of qualitative research, including data collection until a point of saturation was reached (persistent observations), discussions with research peers (peer debriefing), and research participants and experts (member checks). In addition, using different data sources and methods helped to triangulate the collected data, thereby ensuring credibility and confirmability (Bitsch, 2005).

Table 3. Data collection methods and sample size

<table>
<tr><th colspan="2">Methods</th><th>EM3
India</th><th>Hello Tractor
Nigeria</th><th>Total</th></tr>
<tr><td rowspan="4">Qualitative Methods</td><td>Process net maps</td><td>2</td><td>12</td><td>14</td></tr>
<tr><td>Focus group discussions</td><td>2</td><td>3</td><td>5</td></tr>
<tr><td>Interviews with stakeholders</td><td>11</td><td>29</td><td>40</td></tr>
<tr><td>Interviews with franchisees or tractor owners</td><td>15</td><td>7</td><td>22</td></tr>
<tr><td>Quantitative Methods</td><td>Interviews with farmers</td><td>101</td><td>220</td><td>321</td></tr>
<tr><td colspan="2">Total</td><td>131</td><td>271</td><td>402</td></tr>
</table>

Source: Authors

The qualitative data were supplemented with a quantitative survey administered among farmers hiring tractors. In Nigeria, the survey was conducted in the Federal Capital Territory, and the sampling was performed as follows: 1) three of six farming communities where tractor owners provide services using the Hello Tractor device were randomly sampled; 2) in each community, a list of households willing to access mechanization services was obtained, thereby avoiding self-selection bias. The list had been previously collected by Hello Tractor booking agents. From this list, a total of 220 households were sampled. The final sample comprised 104 households who eventually decided to access mechanization via Hello Tractor and 116 who decided to rely on conventional, pre-existing ways to access services.

In India, the survey was conducted in Rajasthan, and the sampling was performed as follows: 1) two districts (Bundi and Kota) were purposefully selected based on the criteria that the EM3 franchisees had been in operation for one farming season; 2) EM3 users were sampled using snowball sampling and corresponding non-EM3 users were selected randomly from the same or neighboring gram panchayat using cluster sampling, resulting in a total of 101 tractor users.

In this paper, descriptive results from the surveys are presented to complement the findings derived from the qualitative methods described above

5. Results

This paper focuses on two case studies following the *Uber for tractor* approach: *Hello Tractor* in Nigeria and *EM3* in India, which are both presented in subsection 5.1. Based on these cases, the ways in which and the extent to which the two businesses change attributes of the transaction costs will be presented in subsection 5.2.

5.1. Uber for tractors – case studies

Hello Tractor (Nigeria)

Hello Tractor was founded in 2014 in Nigeria by Jehiel Oliver, an entrepreneur with a finance background, with the aim to connect “tractor owners to farmers through a digital app” (Foote, 2018). According to its founders, Hello Tractor has received around 1.2 million US$ in startup grant funding.[15] The key components of the Hello Tractor business model are a

[15] Out of this, the majority has been sub-granted to local partners for training, market development, and other ecosystem building activities. The total grants received translate to an average operating budget of less than 250K per year.

monitoring device that allows for the remote monitoring of tractors, costing 80 to 200 $US, and a digital booking platform that matches farmers with the nearest tractors.

The monitoring device records, for example, GPS data, fuel efficiency and operator activity, depending on the version chosen.[16] The recorded data can be accessed via smartphone or computer. Having real-time data promises tractor owners easier management of tractors and operators, for example, by showing maintenance needs and controlling fraud. The digital booking platform, which shows customers' requests and can be used for fleet management, promises to ensure high machinery utilization rates. For smallholder farmers, finding the nearest tractor via a digital booking platform promises to reduce the transaction costs of accessing tractor services. Given the potential for both tractor owners and farmers, Jehiel Oliver argues that Hello Tractor is "a hybrid. An Uber-meets-Salesforce for tractors" that is "connecting farmers in need of service to tractor owners, while also enhancing a tractor owner's existing business" (Foote, 2018).

Initially, Hello Tractor sold the monitoring device together with their own two-wheeled tractors, which they considered their "flagship" (Foote, 2018). However, the focus on machinery sales turned out to be not viable for various reasons, including the Nigerian recession at that time, which led to currency devaluation; the limited access to credit for tractor owners; and the low reach and durability of two-wheel tractors. In 2017, Hello Tractor started to focus exclusively on its digital solution, therefore collaborating with existing machinery dealers instead of competing with them. According to Hello Tractor founder Jehiel Oliver, 75% of all tractors sold in Nigeria are fitted with Hello Tractor devices (Foote, 2018). However, not all machines with the monitoring device are actually used to offer services to others; for example, the machines may be used on large farms. Additionally, some service providers use the tracking device but not the Hello Tractor booking platform. At the time of this study (October 2018), there were twelve contractors and association groups who applied Hello Tractor's Uber model, including the booking platform.[17] These 12 contractors and association groups owned, in total, approximately 800 tractors, out of which approximately 600 were equipped with the GPS device.

According to the findings from our research, the actual tractor hire process works as follows. The service can be requested via a smartphone application, but most farmers rely on the help of a booking agent because few Nigerian smallholder farmers own mobile phones – approximately 30%, when using unique subscribers as a proxy (GSMA, 2014). However,

[16] https://www.hellotractor.com/become-a-hello-tractor-service-provider#pricing

[17] In Nigeria, the term "contractors" refers to mechanization service providers who are not farmers themselves. "Contractors" can be individuals (managing between 5 and 10 tractors) or groups of investors that manage dozens or hundreds of tractors. Many tractor owners also register in "association groups". These tractor owners are typically farmers themselves, and most of them provide hire services. In such "association groups", which exist for each state, they coordinate service provision and often also agree on service prices.

fewer own smartphones: in 2018, approximately 13% of the population across urban and rural areas owned smartphones (Newzoo, 2018). Moreover, those owning phones often do not trust them to make transactions (Foote, 2018). Realizing this challenge, Hello Tractor has established a network of booking agents, a model that is also used by some traditional service providers. These agents create awareness about tractor availability and pool the demand from several smallholder farmers in a particular geographical for a 10% commission. The agents work with individual farmers or farmer cooperatives.

Booking agents are not always trusted by farmers, which is a challenge because the Hello Tractor model requires farmers to pay a commitment fee before the service is delivered. Farmers, however, prefer to see the tractor first. Levels of trust are particularly low when booking agents come from outside the farming community, which is a problem because most live in nearby towns and cities, and only a few are located within the farming communities. The location of the agents also means that they incur a high cost of transportation in accessing farming communities, which sometimes discourages the agents from going to areas with limited infrastructure. However, because booking agents come from outside the communities, often from urban areas, they are less constrained by social norms and rules. This has an advantage in that they seem to be more likely to accept requests from female farmers. Among the farmers accessing services interviewed for this study, 11% of those that relied on the Hello Tractor model were female, while the farmers using existing traditional methods were all male, as shown in table 4.

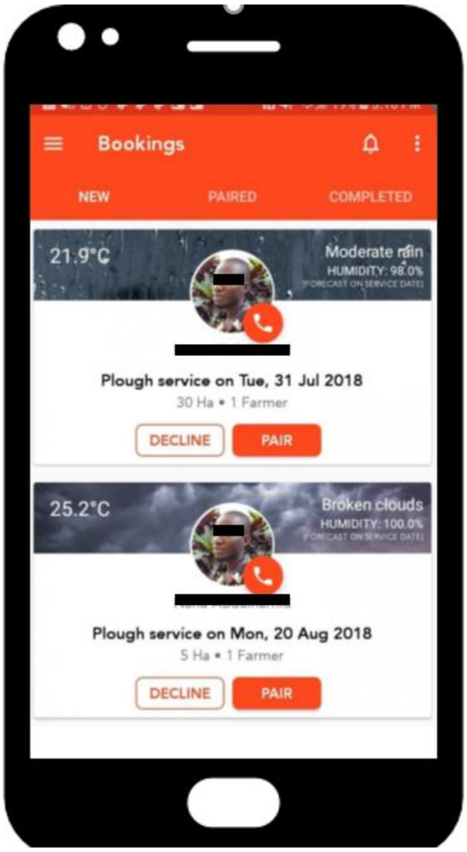
Table 4. Socioeconomic characteristics of surveyed farmers. Values rounded.

Variable	Hello Tractor (n=104)	Others (n=116)	P-value	Statistical significance at 5% level
Age household head (years)	38.4	42.8	0.0055	Yes
Female household head (%)	10.6	0	0.0003	Yes
Average land cultivated (ha)	6.5	7.1	0.4673	No
Access to credit (yes/no) (%)	3.9	3.5	0.8854	No
Access to extension (yes/no) (%)	40	4	0.0000	Yes
Off-farm incomes (yes/no) (%)	40.4	41.7	0.8397	No

Source: Authors

Once a sufficiently large number of requests is accumulated, the booking agents can submit a request for service through a Hello Tractor smartphone application. However, not all booking agents use this option. Although Hello Tractor claims to adequately train their booking agents, 3 out of 7 booking agents interviewed for this study complained that they lacked adequate knowledge to use the booking app and thus preferred to have their supervisors enter the request data.

Figure 3. Hello Tractor application for tractor owners showing requests from booking agents



Source: Authors

As seen in figure 3, the pooled requests include information on the farmer's details, the location, the type of service requested, the land size to be serviced and the nature of the farm plot (such as whether it has trees, stumps or stones). Once requests are transferred, Hello Tractor pairs the request with the nearest tractor owner. In cases where the demand in one location is not sufficiently large, that farming community is paired with nearby farming communities by a booking agent so that tractor use can be maximized and travel time minimized. Thus, the booking agent is an integral part of the digital platform. Thus far, the application software does not help to optimize tractor use and service provision. For example, it does not use any algorithms to optimize travel routes or the sequencing of requests – these decisions are still made by the tractor owners and operators.

If the tractor owner agrees to provide the service, after pairing (see also figure 3), he or she either provides the service directly or sends a tractor operator to provide the service. Tractor owners do not agree to provide services in all cases, as most of the farmers are located in rural areas, with bad roads affecting accessibility for both booking agents and tractor operators. According to the stakeholder interviews, operators sometimes refuse to deliver services in areas with bad roads, even when prearrangements have been made, as this can destroy the tractor equipment. In addition to reports of tractors that did not arrive for such reasons, there were also reports of tractors arriving late or breaking down during service delivery. In some cases, farmers also default: despite a commitment fee, customers reportedly may switch to other service providers if they are available earlier.

During service provision, the abovementioned GPS device helps tractor owners to supervise their operators. While having GPS records of their movements generally does ease supervision, this approach also confronts some challenges. For example, one of the interviewed tractor contractors reported a case where operators destroyed the device while being in the field so that they could not be monitored. Additionally, while the GPS device works offline, the transfer of data to the tractor owners requires good connectivity. This is not always guaranteed: 43% of the tractor owners complained about "blind spots" where there is limited internet access, which prevents them from monitoring their operators.

Because smallholder farmers, so far, do not actually use a smartphone app to book tractor services and instead engage with Hello Tractor indirectly through booking agents, the focus group discussions with the smallholder farmers showed that they were mostly not aware of that they were customers of Hello Tractor. This unawareness is not surprising because the prices and waiting times are similar to those of traditional service providers. As shown in table 5, there is no significant price difference at the 5% confidence level, but there is at the 10% level. Importantly, Hello Tractor service providers are mostly large contractors and part of large associations. Thus, any difference may also occur because service providers are larger and potentially better organized than owners of one or few tractors.

Table 5. Differences in mean costs and waiting time for plowing service.

Variable	Hello Tractor (n=104)	Others (n=116)	P-value	Statistical significance at 5% level
Price per ha (NGN)	28,490	32,078	0.0931	No
Waiting time (days)	5.48	6.47	0.0905	No

Source: Authors. 1 NGN is 0.0028 USD. Thus, Hello Tractor users pay, on average, 79 USD, while customers of other service providers pay 89 USD**.**

Direct benefits for smallholder farmers using tractor services are thus not apparent. However, if Hello Tractor contributes to creating a larger supply of tractor services, this may indirectly benefit smallholder farmers. For example, 30% of the interviewed tractor associations/contractors reported that the use of the GPS device helped them generate tractor use data, which helped them access loans from banks. These findings are in line with Hello Tractor founder Jehiel Oliver's own assessment, as he recently referred to his model as a “customer relation management platform” [18], which suggests that the platform is more focused on the service providers.

One needs to take into account that the benefits for service providers may differ depending on the type of provider. For individual tractor owners and small associations who own few tractors and operate within their own community, the advantages of participating in Hello Tractor’s model, where the booking agents receive a 10% commission, may be limited. This is because they do not travel far and often have well-established relations with their customers, which are both ways to minimize transaction costs. According to some stakeholders, some such tractor owners and small associations who own a few tractors also already have their own networks of booking agents as part of their tractor owner organizations. However, as mentioned above, the Nigerian mechanization market is also characterized by the existence of large contractors and associations, which own large fleets of tractors (in some cases several hundreds) and migrate across agro-ecological zones. Such large contractors and associations are not able to use the same strategies pursued by individual tractor owners to reduce transaction costs, e.g., working within the community and establishing longstanding customer relations. Thus, for large contractors who use their tractors in different regions, Hello Tractor’s technology may help to manage their tractor fleets, supervise operators and schedule demand up front with the help of booking agents – without which it may be difficult for them to coordinate and operate at a profitable scale.

EM3 Agri-Services Pvt. Ltd., India

EM3 was founded in 2014 by Rohtash Mal, a former executive in the telecommunication industry, and his son Adwitiya Mal, who has a background in finance. They had the aim to “Uberize” agriculture (Katz, 2016, para 3). At first, EM3 operated custom hire centers with their own machines, an approach that was later replaced by an “asset-light strategy”: a franchise model where franchisees own the machines and EM3 provides support functions. EM3 has received considerable start-up capital, including a 1.25 million USD equity capital by Aspada (Empea Institute, 2017). EM3 started operating in Madhya Pradesh, and in recent years, it has extended its work to Rajasthan, Uttar Pradesh, and Gujarat.

In Rajasthan, which is the focus of this study, EM3 operates under an agreement with the state government, signed in 2016. Under the agreement, EM3 establishes 300 custom hiring centers in 28 of the 32 districts of the state. Additional centers have been established by the tractor manufacturers TAFE and Mahindra & Mahindra. In total 1240 centers are planned to be established. The EM3 centers are based on a franchise model where EM3 provides know-how on service provision to the franchisees and helps them to acquire

[18] https://www.engineeringforchange.org/news/hello-tractors-business-saving-pivot-hardware-software/

customers. To achieve this goal, the franchisees pay 5% of every transaction to EM3 on a monthly basis. The machines have to be acquired by the franchisee, but the government of Rajasthan subsidies the equipment with 40% of the purchase value upon approval of the franchisee's application. In exchange, franchisees need to prove a minimum of 650 annual hours of service provision. By the end of the data collection for this study in September 2018, 29 out of the planned 300 centers had been established. By the end of 2019, 275 centers were established.

Before opening a franchisee, EM3 analyzes the frame conditions in the respective area, focusing on current levels of mechanization as well as projected demand; crops grown (i.e., whether crops are entitled to government minimum prices); levels of irrigation; average land size; operating costs for maintenance, diesel, and electricity; and customers' willingness to pay. Potential franchisees need to have the following: a good bank repayment history; access to a network of more than 500 farmers; knowledge of local geography, agriculture, machinery use and maintenance; a local trustee; and 200,000 rupees capital (2,500 euros).[19] Franchisees are typically already well-established service providers: 80% of the interviewed franchisees were working as private contractors before working with EM3. Others are agro-business dealers and medium- and large-scale farmers.

The mechanization service hire process works as follows. Farmers request services most often by contacting the franchisees directly – simply by walking in or calling – as most franchisees have been service providers before and already have trusted working relationships: 36% of the EM3 customers had a previous relationship with the EM3 franchisee. In addition to contacting the franchisee directly, farmers can also call an EM3 call center that then forwards the request to the closest franchisee using a digital platform. If local franchisees do not have the requested equipment, the call center contacts other EM3 franchisees or contractors from other areas, an approach that is common for more expensive equipment such as rice transplanters, laser land levelers, and harvesters (i.e., equipment that not all franchisees own). While service providers and customers often have longstanding working relations, there are also first-time customers. In such a case, EM3 field staff visits the farms to validate location, topography, accessibility and field sizes using GPS devices – a process that can, reportedly, take much time.

At the time of the study, it was not possible for farmers to request services using a smartphone application, as the app that is supposed to match farmers with service providers was still being developed. Whether there will be demand for such an application remains unclear. Among the surveyed households, 56% had access to a smartphone, with a large

[19] The overall project should then have a value between one and ten million rupees (12,500 and 125,000 euros).

variation depending on the farm size (see table 6). Phones have thus far been mostly used for calling, taking pictures and social media. Only 6% of the interviewed farmers reported having experience with applications for farming services.

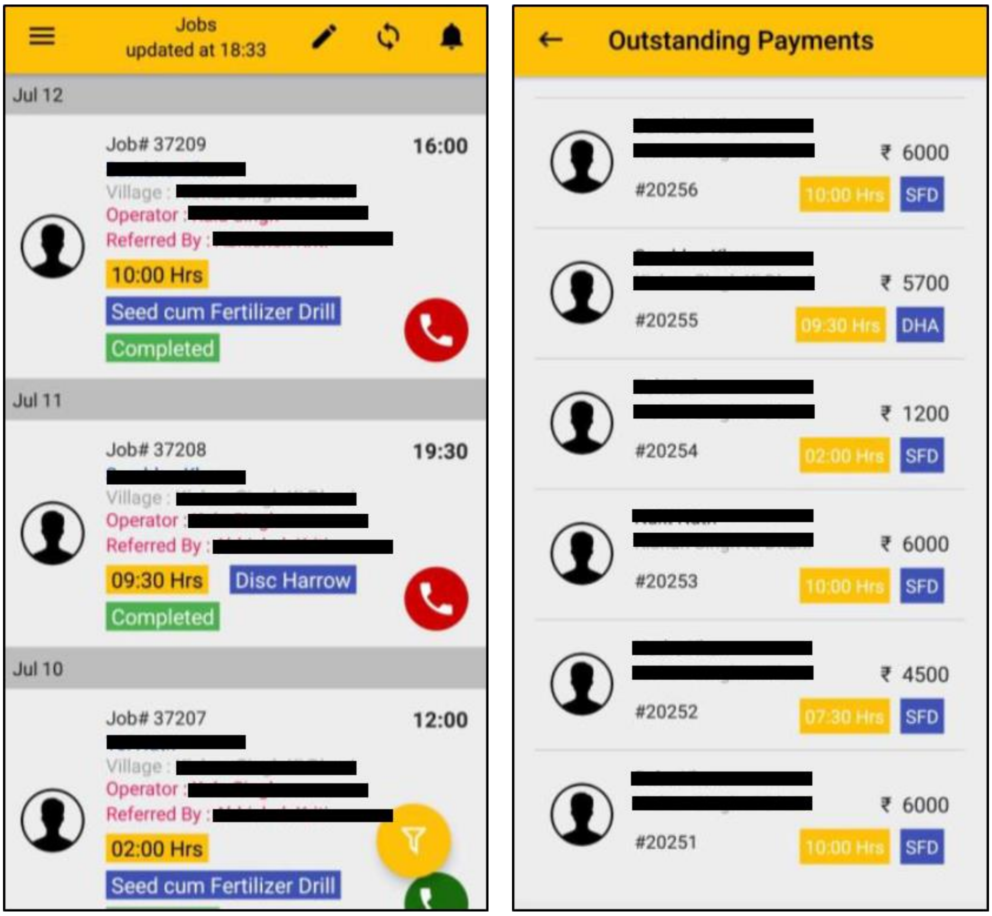
Table 6. Smartphone ownership rate among tractor users (n=101)

Land size (ha)	Smartphone ownership rate (%)
< 1	23
1 – 2	27
2 – 4	60
4 – 10	79
> 10	83
Overall	56

Source: Authors

While there was no smartphone app for farmers yet, service providers could use a digital platform for managing tractors, service requests and accounting (see also figure 4). Using the digital platform, they see requests that come in through the EM3 call center. They can also enter requests that come from farmers who personally visit the franchisee or from the franchisee directly. The franchisee will then enter the customer's name, type of service requested, date and farm size. The franchisees use the digital platform despite the abovementioned 5% fee, which has to be paid to EM3 for every transaction. Due to the subsidy offered by the state government, the franchisees need to prove that they have fulfilled 650 annual hours of service provision to qualify for the subsidy, which could only be done by entering information on service provision on the platform provided by EM3 at the time of the study. In the meantime, this data can also be verified with tracking devices on the tractors. If more than 50% of the subsidized tractors fail to meet the minimum requirement of hours, EM3 deducts a percentage as a security deposit, which is equivalent to 1-2 percent of the total investment in the machinery.

Figure 4. EM3 digital platform for managing tractors, service requests and accounting.



Source: Authors. On the interface to the left, franchisees can see customer requests, both outstanding and completed. On the interface to the right, they can see outstanding payments.

After the service is completed, farmers pay in cash but could also transfer the money via their banks to the franchisee, which can be done on the spot or within 15 days. All of the EM3 users interviewed for this study paid for the service in cash. Farmers can give feedback about the services provided to the franchisee directly or by contacting the EM3 call center. In the first case, franchisees may not forward complaints to EM3. In the absence of an application that is available to farmers, there is no application that can be used for feedback purposes.

Similar to the case of Hello Tractor, benefits for smallholder farmers seem to be mixed. For 36% of the customers who had trusted relationships with the service providers before they became EM3 franchisees, little has actually changed (other than receiving training from EM3 and being expose to "more value generating equipment"). They continue to directly engage with the service provider without any reliance on EM3 services. Moreover, EM3 customers pay similar service prices as customers who use other contractual arrangements. While the transaction costs for accessing tractors may be lowered through call centers, the verification of such requests takes a long time for new customers. On the upside, less upfront trust seems to be needed to access EM3 services compared to other service providers: while 65% of all farmers highlighted the importance of having a previous relationship with the service provider when choosing a contractual arrangement (other categories were price and quality, among others), only 15% of all EM3 users reported that this was a key criterion. However, this may be the case because EM3 users own more land and therefore have easier access to hire markets. Moreover, some types of machinery are more easily available to EM3 customers because each EM3 center has access to the machinery pool of the entire EM3 network. In some cases, the providers offer services with better machinery because they have access to subsidized machinery. Finally, while EM3 advertises that it makes tractors more accessible to smallholder farmers, across the tractor customers interviewed, EM3 was most popular with large farmers (see table 7).

Table 7. Source of mechanization among tractor users (n=101)

Land size (ha)	Own (%)	Contractors (%)	Farmer groups (%)	EM3 (%)	Others (%)
< 1	26	50	8	5	8
1 – 2	37	28	29	1	3
2 – 4	43	40	2	9	2
4 – 10	74	17	1	3	1
> 10	75	8	0	17	0

Source: Authors

Generally, it is important to keep in mind that the business model may hinge on continuous government support: 33% of the interviewed franchisees declared that they decided to work with EM3 only to access the subsidy, and 53% had doubts about whether the EM3 business model would be sustainable if it was not a prerequisite to accessing the machinery subsidy. However, it is important to keep in mind that these views reflect the state of mind at the beginning of EM3's presence in Rajasthan. In the meantime, EM3 has started to provide additional services to their franchisees such as selling inputs and procuring farm produce via them, which may have changed their views.

5.2. Determinants and effects on transaction costs

Based on section 5.1, this section assesses how the digital models promoted by Hello Tractor and EM3 address the attributes that determine transaction costs (see section 2). Table 4 summarizes this assessment. With regard to uncertainty regarding the fulfillment of the transaction, Hello Tractor seems to reduce uncertainty for service providers: booking agents check whether fields are serviceable and for migratory service providers, such agents organize customers up front. In contrast, the uncertainty for customers increased because the transaction requests must go through different actors – first through Hello

Tractor, who then pairs with a nearby tractor owner; then, the tractor owner also has to decide whether to carry out the transaction or not. Moreover, the chances of the transaction occurring for the customer depends on the aggregation of requests from other farmers by the booking agent. EM3 does not reduce the uncertainty for service providers, but relying upon a large network for franchisees reduces the risk related to machinery being unavailable for farmers. The same mechanism reduces the asset specificity for service providers. Neither Hello Tractor nor EM3 affect the attribute of complexity, nor do they reduce hold-up problems related to mechanization service provision. However, EM3 hopes to affect the attribute of frequency trough the marketing of inputs and procurement of farm produce trough the franchisees that was promoted more lately. This may increase the frequency of contacts and help to increase customer trust. Also, by being able to requests machinery from a larger pool of machinery from other centers, the attribute of frequency may increase in the case of EM3. Hello Tractor and EM3 enhance measurability through the GPS device. Through demand pooling, Hello Tractor and EM3 help to address the spatial dispersion of farming. By using GPS-enabled monitoring, Hello Tractor and EM§ reduces principle-agent problems. In brief, both Hello Tractor and EM3 seem to mainly affect transaction costs for tractor owners but not tractor users (smallholder farmers), who they are therefore only benefiting indirectly.

Table 8. Effects of Uberization of mechanization on attributes of transaction costs.

Attributes	Hello Tractor		EM3	
	Providers	*Customers*	*Providers*	*Customers*
Uncertainty	Field checks by booking agents, up-front payments For migratory service provider up-front customer pooling	-	-	Sharing of machinery across franchisees makes machinery more available
Asset specificity	-	-	Implement sharing across custom hire centers	-
Frequency	-	-	-	Sharing of machinery across franchisees widens range of machinery available to customers. Introduction of inputs and procurement trough franchisees may increase contact frequency
Complexity	-	-		-
Measurability	Using GPS devices for land measurements	Having access to GPS data from land measurements by providers	Using GPS devices for land measurements	Having access to GPS data from land measurements by providers
Hold-up problems	-	-	-	-
Spatial dispersion	Demand pooling with booking agents (similar to traditional markets), GPS matching	Demand pooling with booking agents (similar to traditional markets)	Demand pooling with booking agents (similar to traditional markets)	Demand pooling with booking agents (similar to traditional markets)
Principle-agent problems	GPS-based monitoring device	-	GPS-based monitoring device	-

Source: Authors

6. Discussion

By conducting two case studies, this paper aimed to explore the *Uberization of mechanization* narrative and to disentangle what, so far, works, where, when and for whom. In particular, the paper has assessed whether the digital approaches referred to as

Uberization have the potential to reduce the transaction costs related to tractor service markets, thereby leading to higher utilization rates of tractors and enhancing smallholder farmers' access to mechanization. The findings highlight the theoretical appeal of the *Uberization of mechanization* approach and its effects on transaction costs. However, the findings also show that, in practice, such ICT applications struggle with the thorny challenges of rural agricultural markets – many of which urban ride-hailing markets do not face – such as the concentration of demand around peak seasons and the scattered nature of farming (Binswanger and Rosenzweig, 1986). Another major difference, in particular in Nigeria, is that tractor hire markets are just emerging; thus, Uber for tractor approaches cannot merely transform existing markets – in part, they need to help create them.

The results also make clear that the image of smallholder farmers themselves using Uber-type apps to access tractor services is not accurate – at least not yet. Newspaper headlines indicating "all it takes is a few taps on your phone" [20] are thus misleading. In both case studies, farmers relied on "analog" solutions to access tractor hire services, such as booking agents and phone calls, approaches widely used by "non-Uberized" tractor owners as well. Instead, the tractor owners are the ones using ICT applications for monitoring and managing their tractors – to a higher degree in Nigeria and a lower degree in India. Importantly, smallholder farmers may benefit indirectly because Uberization helps tractor owners achieve higher utilization rates.

The challenges faced by ICT applications can partially, though not exclusively, be attributed to the lack of an enabling environment. This is not surprising. As noted by Deichmann et al. (2016) and Toyama (2015), technologies cannot address all barriers faced by farmers, and digital solutions need to be backed up by complementary infrastructure investments, including electricity and literacy. For example, Hello Tractor uses booking agents rather than a booking app for farmers, among other reasons, because of low (ICT) literacy among smallholder farmers. While Uber-type ride hailing requires only limited data to be entered by customers (i.e., only the destination), tractor hiring requires the recording of additional data (i.e., plot sizes, type of equipment, land conditions), some of which cannot easily be aided by visual tools. Moreover, tractor hire is associated with higher service charges compared to ride hailing, and the risk associated with late or nondelivery is much higher. Because the use of ICT applications depends on risk attitudes and the level of trust held by potential customers (Baumüller, 2018), this can hamper the use of Uber-type tools for tractors. As noted by Foote (2008) and supported by our study, few smallholder farmers in Nigeria trust mobile services sufficiently to make business transactions, such as hiring tractors, via an application if this includes an up-front payment. With a better legal

[20] nytimes.com/2016/10/18/world/what-in-the-world/trringo-app-india.html

framework and law enforcement, this could change. Instead of waiting for public action, ICT applications could also allow for the anonymous rating of service providers by tractor users – and by showing the results, create an accountability mechanism based on social capital (Benkler, 2004). Other potential improvements of the Uber-type ICT application studied here may be in the use of algorithms for the optimization of service provision (e.g., optimizing for travel time), thus moving beyond the mere aggregation of customer demand.

However, even with more supportive environments and better tools, the advantages of ICT-based models over more traditional ways of organizing service markets may be more mixed than commonly assumed. Tractor owners with one or a few tractors can reduce transaction costs and risks by limiting the radius of customers and focusing on trusted customers. When owning few tractors, this may suffice to reach high utilization rates while avoiding the commission fees attached to digital solutions (10% for Hello Tractor; 5% for EM3). Farmers and contractors with few tractors in industrialized countries often continue to rely on such techniques as well.[21] In contrast, new tractor owners and large contractors operating over large areas face uncharted territory. Uber-type solutions could help them achieve higher utilization rates by reducing the transaction costs related to organizing new customers. However, the ICT-enabled emergence of large contractors, owning dozens of tractors in the Nigerian case, may have implications for the market structure in service markets (e.g., it may lead to market concentration). Policymakers should monitor such markets to ensure that there is sufficient competition.

The two case studies show that the *Uber for tractor* approaches are not exact copies of the well-known Uber for ride hailing. Potentially, the Uber narrative has emerged driven by the desire to demonstrate that ICT solutions offer exciting new options for smallholder farmers, a strategy that is tailored to raising funds from development and philanthropic organizations. Obviously, "Uber for tractors" captured the imagination of a wide audience, leading to a cycle of positive reporting and the appearance of success (Hunsberger, 2014). As shown in this paper, a direct comparison with Uber ("all it takes is a few taps on your phone") does not yet reflect the reality of the smallholder farmer on the ground. However, given the stark difference in conditions faced by rural tractor hire markets compared to urban ride-hailing markets, this is not a surprise – in fact, it has to be expected. In their quest to make their digital business work amidst the challenges of rural and agricultural markets, the two providers studied here – Hello Tractor and EM3 Services – adapted their business model. Hello Tractor has gone a long way from a focus on selling "smart two-wheeled tractors" to selling GPS and software solutions for contractors. Likewise, in Rajasthan, EM3 successfully went from a contractor to a large-scale franchise company by offering digital

[21] For an overview of different contractors in Germany, see https://lu-web.de/redaktion/reportage-des-monats/

solutions that can contribute to making a government program work. Both approaches focus on technologies for tractor owners that help them to monitor and manage their tractors. Thus, while not providing a direct interface for smallholder farmers yet, both companies are nonetheless digital pioneers. Moreover, both models can claim to represent Uber for tractors if a broader definition of Uber is applied. The Cambridge Dictionary (2019) defines the verb *Uberize* as the ability “to change the market for service by introducing a different way of buying or using it, especially using mobile technology” – this definition squarely applies to both Hello Tractor and EM3 Services.

Our case studies suggest that it is nevertheless useful to disentangle what the powerful narrative of *Uber for tractor* stands for from what it does not stand for. Otherwise, development organizations, governments and the general public may tend to consider *Uber for tractors* to be the long-awaited “silver bullet” that can resolve all obstacles facing smallholder farmers in accessing mechanization services. Obviously, it cannot. Agriculture will never depend on software alone; it will remain dependent on the “hardware” – tractors and implements that are suited to local agronomic conditions, financial systems that make it possible to acquire them and the human skills required to use them well in sustainable production systems (Adu-Baffour et al., 2019; Daum & Birner, 2017). One also needs to acknowledge that the contracting models studied in this paper are not the only institutional arrangement that enables smallholders to access machinery services. Digital tools can also support cooperative arrangements among farmers, which are widespread in agriculture, for example, the abovementioned Maschinenringe, groups of farmers that each own machinery that they rent out to each other. Such solutions may also be supported by digital management platforms as well as data sharing arrangements (Griepentrog et al., 2019). Other alternative solutions are already digital. In Kenya, for example, Village Twitter, a bulk SMS-based version of Twitter requiring no smartphones, invented by a local chief and Safaricom, has been gaining momentum. Village Twitter allows tractor owners to send SMS messages advertising their service to up to 15,000 recipients for as little as one Kenyan shilling (Mayienga, 2019). These examples, as well as the two case studies presented, show that digital agriculture tools have a unique potential to overcome the challenges of mechanization in smallholder agriculture.

The case studies of Uber for tractor presented here also underline the role of local entrepreneurship in unlocking this potential. Uber for tractors was not invented by the large-scale digital companies that dominate the cyber world nor was it invented by the large-scale tractor manufacturers that dominate the world of agricultural machinery – it was invented by individual entrepreneurs who had the vision of bringing innovative ICT solutions to a business sector where the challenges of making such solutions work are greater than anywhere else: the poverty-stricken smallholder agriculture sector in developing countries – and this is perhaps the most promising dimension of Uber for tractors.

7. References

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