Pushcarts to Platforms: Measuring Food Delivery Apps' Effect on Street Vendors' Location Preferences in the Global South. Case Study: Surakarta, Indonesia

By

Prathito Andy Wisambodhi

Bachelor of Science in Architecture
Institut Teknologi Bandung
Indonesia (2014)

Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

Master in City Planning

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 2021

Author____
Department of Urban Studies and Planning
July 28, 2021

Certified by ____
Andres Sevtsuk
Charles and Ann Spaulding Career Development Associate Professor of Urban Science and Planning
Department of Urban Studies and Planning
Thesis Supervisor

Accepted by____
Ceasar McDowell
Professor of the Practice
Chair, MCP Committee
Department of Urban Studies and Planning

Pushcarts to Platforms: Measuring Food Delivery Apps' Effect on Street Vendors' Location Preferences in the Global South. Case Study: Surakarta, Indonesia

By

Prathito Andy Wisambodhi

Bachelor of Science in Architecture
Institut Teknologi Bandung
Indonesia (2014)

Submitted to the Department of Urban Studies and Planning on July 28, 2021 in partial fulfillment of the requirements for the degree of Master in City Planning

Abstract:
How does online commerce affect the offline presence of retail, food, and beverage (F&B) establishments in cities? While extensive literature exists on e-commerce's effect on the retail industry, its impact on retailers' location preference and in particular street vendors in the Global South has been less explored. E-commerce and food delivery apps (FDA) change search costs for customers and could therefore change the desirability of locations for retailers. Yet, most existing retail economic studies are specific to brick-and-mortar establishments in the Western urban context, despite street vendors' rapid adoption of online commerce and the Asia Pacific region's lead in the global e-commerce growth rate even before the COVID-19 pandemic.

This thesis focuses on the effect of FDA on the growth trend and location preferences of F&B street vendors in Indonesia, using the city of Surakarta as a case study. By using spatial analysis and interviews, the thesis analyzes four hypotheses about the changes in street vendors' presence, clustering, and location preferences based on street vendor location data collected in 2014 and 2019 on the same set of streets. The results show a negligible change in location preferences for street vendors of all kinds and a more pronounced change for F&B vendors after controlling for street vendor growth. Without growth control, FDA has a minimal effect on the change of F&B street vendors' clustering and location preference which was also validated by the interviews. Finally, the thesis discusses data limitations and future opportunities that could inform policies on street vending and online delivery services.

Keywords: street vendor, location theory, e-commerce, retail, delivery, walkability

Thesis advisor: Andres Sevtsuk
Title: Charles and Ann Spaulding Career Development Associate Professor in Urban Science and Planning
Thesis reader: Sarah Williams
Title: Associate Professor of Technology and Urban Planning; Director, Leventhal Center for Advanced Urbanism
Thesis reader: Jason Jackson
Title: Ford Career Development Assistant Professor in Political Economy and Urban Planning

Acknowledgments

I could not have delivered this thesis on food delivery without the many experiences I have had and people I have encountered at MIT during a global pandemic – both remotely and in-person. This thesis is also my love letter to the vibrant street life of various cities in Southeast Asia that I have previously called home, to which food vendors are essential. In doing so, I owe immense gratitude to:

My advisor, Andres Sevtsuk, whose endeavor in making cities more walkable has been an inspiration even before I came to MIT. I am indebted to you for your steady guidance, generous feedback, and constant encouragement in this thesis and my time as a researcher at the City Form Lab. Thank you for sharing your wealth of knowledge, enthusiasm, and optimism in this thesis from when it was a nascent idea through to the final submission. I could not have asked for a better advisor.

My readers, Sarah Williams and Jason Jackson whose work, teaching, and valuable comments have augmented this thesis. Sarah's supervision during my stint at the Civic Data Design Lab made me a more responsible data communicator and designer. Jason's research on the political economy of ride-hailing industry especially in Southeast Asia (with Rida Qadri) improved my understanding of the invisible drivers behind the visible street life.

My professors and colleagues at DUSP and Harvard. Bish Sanyal, Larry Vale, John Taylor who attended my defense, raised important points, and enriched this work. Yuan Lai, Gabriella Carolini, Rida Qadri, Eric Robsky Huntley, Dennis Frenchman, Kate Mytty, John Kennedy, Andrea Chegut, and Jill Kelly who have made time to chat with me during the infancy of this thesis. Statistical support was provided by data science specialist Jinjie Liu, at the Institute for Quantitative Social Science, Harvard University.

Ellen Rushman, Mary Jane Daly, Sue Delaney, Karen Yegian, and everyone at DUSP HQ, I cannot thank you enough for providing student support and being an anchor during these challenging times.

The people in Indonesia especially as I could not travel to Surakarta in person. I am thankful for Kota Kita Foundation for the location data. I would also like to thank Paramitha Rahayu, Rufia Andiniputri, and Eldora Aristian of Universitas Sebelas Maret Surakarta; Mas Kris of Rame-Rame Jakarta; and Vallin Tsarina, Regy Septian, and Ferry Fernando of Urban+ for taking the time to discuss this topic. Lembaga Pengelola Dana Pendidikan for the assistance throughout my graduate studies.

The 6 street vendors in Surakarta who have been willing to share their stories with me. This thesis is impossible without you, *matur nuwun*.

My friends in Greater Boston area and fellow DUSPers who have been the greatest part of my MIT journey. My wonderful MCP classmates and friends for exemplifying intellect and compassion at the same time, particularly my Torino and Design@DUSP friends. I would also like to thank MIT AIS for the support. Lastly, MWR who has been the best cheerleader, reader, and discussion partner.

To my parents and brother, I dedicate this thesis to you. This accomplishment would not have been possible without you, your unwavering support, prayers from the other side of the globe, and love – that often takes form in food.

Whether it is over a table full of *nasi padang* in Blok M, a big plate of chili crab at Ang Mo Kio, or Flour coffee by Massachusetts Avenue, I hope that we all can soon share food in person again.

Table of Contents

List of Abbreviations and Glossary

Bakul	Carrying basket
DPR	Dewan Perwakilan Rakyat / People's Representative Council of Indonesia
FDA	Food delivery apps
F&B	Food and beverage
GDP	Gross Domestic Product
Gelaran	Mat
Gerobak	Pushcart
GoJek	Indonesian tech start-up offering services like ride-hailing, food delivery, package delivery, in one application, using ojek as the fleet.
IDR	Indonesian Rupiah
ILO	International Labour Organization
LDUI	Lembaga Demografi Universitas Indonesia
NGO	Non-governmental organization
MSME	Micro, small, and medium enterprises
Ojek	Motorcycle taxi
Paguyuban	Community group
Pikulan	Carrying pole
POI	Points of interest
SME	Small and medium enterprises
Tenda	Tent
UCLG	United Cities and Local Governments
UNA	Urban Network Analysis
UNS	Sebelas Maret University, Surakarta (previously Universitas Negeri Surakarta)
Warung	Kiosk
WIEGO	Women in Informal Employment: Globalizing and Organizing

Chapter 1. Introduction

1.1 Background

As online commerce and food delivery services grow rapidly, how do they alter the landscape of urban retail and food and beverage (F&B) establishments? Even before the COVID-19 pandemic, online transaction volume grew by $300 billion between 2006 and 2016 in the United States alone (Spivak, 2018) while the Asia-Pacific region leads the global growth rate (Bain, 2019). Studies also show that online commerce restructures brick-and-mortar establishments in America differently, where smaller retails and restaurants are more likely to find challenges in the competition (Collison, 2020; Sevtsuk, 2020). The COVID-19 pandemic lends a perspective on the extreme importance of small businesses' survival, as almost 100,000 American small businesses, including restaurants and retailers, closed permanently (Yelp, 2020) resulting in the loss of 5.5 million jobs (Peterson, 2020). While at the same time, online commerce giant Amazon and many food delivery apps (FDA) posted record profit (Lucas, 2020; Kohan, 2021*)*. However, despite the large data and literature of e-commerce's effect on the conventional retail industry, its impact on the presence of offline retail, food, and beverage (F&B) establishments at the city level has yet to be explored extensively. Even within existing studies, fewer are written on the Global South context and informal retailers (Fang, 2020; Pettersson, 2018).

While online marketplace concepts hailed from the Global North, similar platforms have proliferated in the developing world and adopted local customs. One example is Indonesia's first *decacorn* (start-up companies with a valuation of minimal $10 billion) *GoJek,* a home-grown tech company offering online motorcycle and car ride-hailing, food and package delivery services, and mobile payment in one mobile application (The Jakarta Post, 2019). Before the pandemic, the application also enabled customers to even order cleaning, beauty, and massage services to their home. However, unlike American FDA, GoJek's food delivery service encompasses street vendors (Rahman, 2021) which allows customers to order food from informal F&B providers who do not occupy a brick-and-mortar space. GoJek also rely on motorcycle taxi, locally called *ojek*, as the delivery fleet. These localized services demonstrate e-commerce's and food delivery services' uniqueness in the Global South context.

As food delivery services allow customers to order food from street vendors remotely, this thesis focuses on the apps' effect on street vendors' presence in Indonesian cities. Indonesian media, scholars, and politicians have endorsed FDA's positive effect on people involved in the informal economy. At one point, GoJek claimed to contribute 1% to Indonesia's GDP. Yet, they are either anecdotal (Choudhury, 2019), industry-sponsored (Lembaga Demografi Universitas Indonesia, 2019), or limited in their scale and study period (Manullang & Limbong, 2019). The state also proves to have a cordial relationship with tech companies, reflected by the president's support of GoJek ride-hailing services amidst tension between conventional taxis and ojek in 2015. However, similar to the western world, the effect on the built environment and retail landscape remains understudied.

Small retail and F&B establishments are an important part of the urban built environment. In America, a study suggested that locally-owned retailers can contribute three-times as much to the local economic activity as their retail chain competitors (Civic Economics, 2002). Physically, they provide community space (Fullilove, 2020), improve walkability by providing 'eyes on the street' (Jacobs, 1992), and offer an important source of livelihood to immigrant communities (Bhimji, 2010). In the Global South, street vending offers employment to millions of the urban poor and rural-urban migrants as cities witness record growth in urbanization, middle class population, and wealth (International Labour Organization, 2018). However, as skill mismatch between the migrants and city jobs exists, street vending provides a low-barrier occupation for them (Bhowmik, 2005). As of 2018, more than 60% of the world population is employed in the informal economy, many turns to the street. The low overhead cost makes vending an attractive choice, as vendors pay a relatively low fee to rent a vending site (Sevtsuk, 2020) whether to city officials or other stakeholders through formal or informal means (McGee & Yeung 1977; Jellinek, 1976). The latter often accompanied with hostile government's attitude and a cat-and-mouse relationship with the state as street vending has varying legal status across different geographies.

Studies have shown that FDA could threaten the survival of small F&B businesses, yet no research has empirically examined its effect on street vendors. While intuitively FDA should allow for additional profit to F&B business owners, a heuristic study across the United States claims that restaurants' profit decreased despite the increased FDA transactions and revenue (Collison, 2020). Based on the study FDA transactions often generate modest revenue, especially when they charge high commission rate, which can be as high as 30% per order. At the same time, online delivery orders substitute in-person transactions significantly. This decreases restaurants' profitability over time, burdening small business-owners and indicating the online service cannibalizing the offline entities (Sharma, 2021). In the Indonesian context, some small business owners complained about GoJek's recent hike in commission rate, echoing threats of cannibalization (Djumena, 2021).

In a more extreme example, FDA companies attempt to optimize their service by centralizing restaurant amenities into *cloud kitchens*, or delivery-only kitchen spaces shared by different tenants. While this concept allows aspiring F&B entrepreneurs to start a business with low overhead cost, in practice most cloud kitchen tenants are established fast food chains (Loizos, 2019). Moreover, as FDA relies fully on delivery workers who often are under precarious working conditions (de Freytas-Tamura, 2021), FDA could potentially rid physical F&B establishments of their benefits to society.

In the paucity of similar study in the Global South context, Surakarta, Indonesia offers a promising site as a case study. Despite the city's small size, it boasts a high retail density as the city center has around 220 retail establishments per square kilometer. As a comparison, the retail landscape of Cambridge, MA, New York, NY, and Singapore is at least three times less dense (Sevtsuk, 2020). More importantly, Surakarta is known for its democratic institutions and progressive governance around street vending and citizen participation. The city's then-mayor, Joko Widodo, attracted domestic and international spotlight for achieving a peaceful vendor relocation policy from the street to purpose-built markets without any violent seizure and eviction - which was uncommon for Indonesian cities in 2005, before the advent of ride-hailing and food delivery apps (Majeed, 2012). The small town's achievement was monumental to restore public trust in government (Natawidjaja, 2015) and arguably bolstered Widodo's successful presidential campaign in 2014. However, many relocated vendors struggled as they were alienated from their original customers: passers-by and pedestrians. They struggled to survive and eventually sold their stalls and returned to the streets (Taylor and Song, 2016).

This demonstrates street vendors' mobility and ability to act on their feet, choosing an optimal site with heavy pedestrian traffic. Along with the rapid penetration of online goods and food delivery services in the Indonesian street vending scene, vendors may no longer prioritize pedestrian traffic as one of their location criteria. The online platform might incentivize vendors to seek a site that is optimal for delivery pick-up instead of pedestrian traffic, ultimately changing street vendors' location preferences. In this thesis, I explore questions around those themes using quantitative and qualitative methods, to uncover if and how food delivery apps impact the growth of street vendors and their location preferences in Surakarta.

The result from this research however, might not be representative of other cities across the Global South as there is heterogeneity within street vending policy. Also, differences in population size, density, and wealth could lead to different results. Yet, other cities can still draw valuable lessons from street vending regulations and participatory process in Surakarta to envision more equitable streets and public spaces in the era of delivery apps.

1.2 Scope

This research draws from literature written on location theories, street vending governance, and technology adaptation in the informal economy. Contemporary urban retail location models have bridged neoclassical retail economic theories and built form studies (Sevtsuk, 2020; 2014). However, they assume urban retailers only as brick-and-mortar entities occupying permanent spaces and exclude mobile street vendors in the model because of the different flexibility in their location-seeking process. Brick-and-mortar establishments have lower flexibility compared to street vendors, as deciding a permanent location requires careful considerations to balance expenses and potential revenue. For them, mistakes from location choice can be extremely costly as rental and overhead cost are often high.

However, mobile street vendors might find optimal vending site at a lower cost due to their flexibility and mobility. In theory, mobile vendors can seek the most profitable location while running their business at the same time.

The definition of *street vendor* is built on previous literature on informal economy and the built environment, centering on works focused in the Global South. Multiple scholars have defined street vending as a heroic entrepreneurship (De Soto, 2003) and a survival strategy (Banerjee and Duflo, 2012), however, this thesis focuses on street vendors as an essential component of the urban retail landscape. Spatially, I use Bhowmik's (2005) definition of street vendors as a seller who does not commence trade in a site with permanent structure.

Indeed, the term 'Global South' is an inaccurate simplification of heterogenous geographical, economic, and political contexts. While this thesis does not dive into the debates around the terminology, it borrows the ideas from scholars who used a comparative Global North and South lens to frame the shared phenomenon across South and Southeast Asian cities (Roy, 2009; Roy and Ong, 2011). Moreover, there are similarities within street vending practice in the developing world where the comparative North-South framework can be useful.

Despite the umbrella 'street vendor' terminology, understanding vendors as a homogenous monolith is highly inaccurate. Street vendors' operation can be stationary as they can sell goods at the same location regularly such as public spaces and sidewalks. They could also be mobile by moving from one place to another while selling goods to customers. In terms of scale, they can either be as small as a one-person business or as large as a multiple people operation yielding a stable profit (Sevtsuk, 2020; Batreau and Bonnet, 2014; Brata, 2008). While in terms of temporality, their business could only last for a short period (Banerjee and Duflo, 2011) or could be so long term that they became associated with the identity of their occupied place (Yatmo, 2008).

The heterogeneity of vendors' sold goods is also correlated their location preferences. Vendors can sell staple goods such as prepared food and beverage or even specialty goods like auto parts. Even within the category of vendors selling prepared food and beverage, the distinction between the food products could impact location preferences. For example, vendors selling food with on-site preparation require a facility to wash dishes unlike vendors selling pre-packaged food. While this thesis groups food and beverage vendors as a category, this heterogeneity should be considered.

In terms of vendors' physicality, I identify their typology based on the varying degrees of mobility and permanence. Yatmo (2018) categorized Indonesian vendors into vendors who are operating in a semi-permanent kiosk (*warung*) (Figure 1), with a pushcart (*gerobak*) (Figure 2), under a tent (*tenda*) (Figure 3), with a carrying pole (*pikulan*) (Figure 4), with a carrying basket (*bakul*) (Figure 5) and on a mat (*gelaran*) (Figure 6). Additionally, I expand the definition to include 2 extra categories: vendors working on a stand and vendors whose stall is attached to a vehicle such as motorcycles or mini trucks. This thesis focuses on mobile vendors who operates in a permanent location, as mapping and keeping track of vendors who are mobile on a daily basis is more complicated.

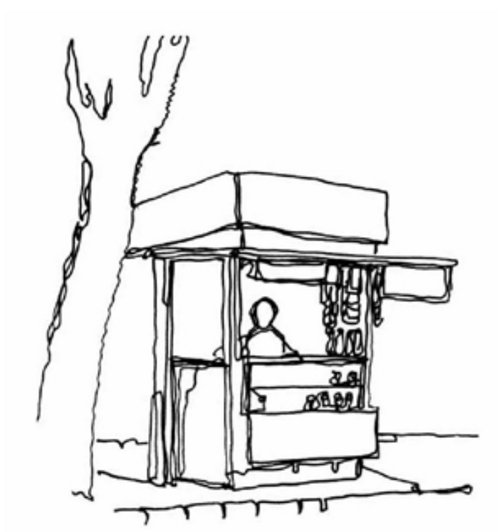


Figure 1. *Warung* or kiosk (Source: Yatmo, 2008)

Figure 2. *Gerobak* or pushcart (Source: Yatmo, 2008)

Figure 3. *Tenda* or tent (Source: Yatmo, 2008)

Figure 4. *Pikulan* or carrying pole (Source: Yatmo, 2008)

Figure 5. *Bakul* or carrying basket (Source: Yatmo, 2008)

Figure 6. *Gelaran* or mat (Source: Yatmo, 2008)

I define online delivery service as an umbrella term covering a third-party mobile platform serving both goods and food delivery. Goods delivery platforms allow users to determine the pick-up and drop-off location and connect the user to the nearest delivery ojek driver as matched by the app's algorithm. The user could be a customer purchasing goods through online transaction or a business owner selling goods online. The service is charged to the person who made the order. The delivery courier will follow an optimized travel route determined by navigation services like Google Maps. In the absence of delivery jobs, ojek drivers also offer ride-hailing or food delivery services.

Unlike goods delivery service, food delivery limits customers to select food providers. Customers pay additional delivery and service fee through the platform, while restaurants also pay a commission to the platform which can be as high as 30%. Similar to goods delivery service, ojek drivers pick up the prepared food from the food providers and deliver it to customers. Unique to the Indonesian context, food delivery platform embraces informal street vendors as an F&B provider. Local tech company like GoJek even emphasizes their role in fostering the informal economy by this inclusion.

As with other ride hailing labor schemes globally, platforms in Indonesia do not formally employ delivery couriers. Two major platforms in Indonesia, Jakarta-based GoJek and Singapore-based Grab, respectively commenced operation in mid-2015 and early 2016 and have a valuation of at least $10 billion and $40 billion. Both companies identify delivery couriers as 'partners' and do not provide fixed salary and benefits. Both platforms started by offering ridehailing services and now have expanded to include multitudes of services, including online payment, goods and food delivery, in one mobile application. Gojek brands their food delivery service as GoFood and goods delivery service as GoSend, while Grab calls their food delivery service as GrabFood and goods delivery service as GrabExpress.

Along with the introduction of delivery apps, I examine the change in street vendors' presence and location preferences between two periods: 2014 and 2019 (Figure 7). Each year indicates an era before and after the advent of online delivery platforms. Particularly I am focusing on food and beverage vendors as they provide staple goods and food delivery usage is more prominent compared to other delivery service. I will use the findings from all kinds of street vendor on average as a comparative benchmark. I am also limiting the study to mobile vendors that are stationary throughout their operations as they are more likely to use delivery services compared to vendors who are mobile while trading their goods. Mapping the latter is also more challenging as vending location change throughout the day.

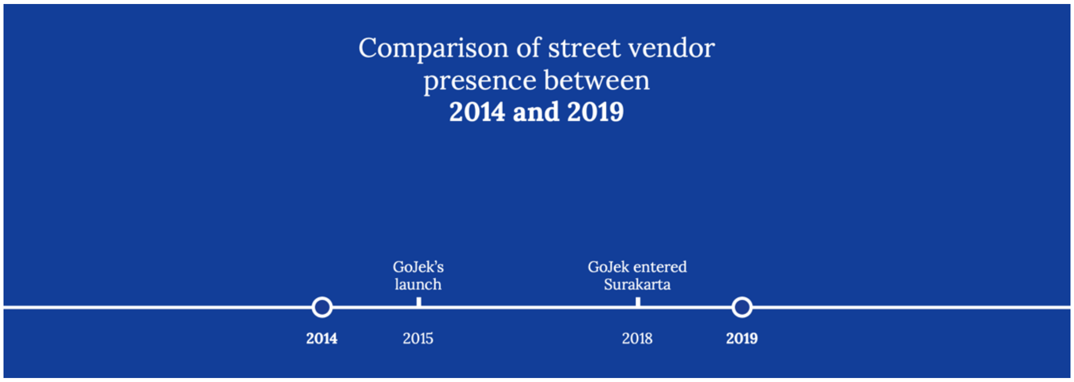


Figure 7. Timeline of GoJek's entry to Surakarta and the research time scope

Despite street vending legalization in Surakarta, vendors location data remain limited. The official street vendor dataset does not identify street vendor location and is not robust. Traditionally, this could be attributed to several reasons: street vendors' mobile nature, informal status, higher likelihood to be a short-lived business, and tumultuous relationship with the state. Therefore, I rely on past location surveys by academics and alternative approaches to develop a street vendor location dataset in 2019.

I use retail location dataset collected in a survey by the MIT City Form Lab in 2014. The dataset encompasses formal and informal retailers in downtown Surakarta. Each entry has the information of retail establishment's spatial typology (indoor or outdoor), kinds of sold goods, and a photograph. However, equivalent dataset in 2019 is not available. FDA companies could be a potential data source as they collect the location point, operating hours, contact information, transaction history, and product details of every vendor on the platform. However, this data is proprietary and unavailable to the public.

Therefore, I collected street vendor location data in 2019 by using Google Street View amidst the international travel restriction in the pandemic (Figure 8). I mapped street vendor location in 2019 on the same set of streets surveyed in 2014. However, some streets in the 2014 dataset have no Google Street View counterpart in 2019. Thus, I removed those streets and ended up with 356 street segments in the sample. As both 2014 dataset and 2019 Google Street View images were taken in the daytime, comparing the two datasets cancels the spatiotemporal bias that exists within each dataset in isolation. This is important because vendors operation have spatiotemporal dimension, for example some vendors are only operating at night. In the end, every sampled 356 street segment has the information of street vendor presence in 2014 and 2019 that is now comparable.

Figure 8. Collecting vendor location data from Google Street View

I recognize that any change in location preferences for street vendors might not be a direct function of profit optimization akin to brick-and-mortar establishments. Street vendors’ informal status could pose challenges in legal and regulatory aspects which might factor into their location preferences. For example, an informal vendor might prefer a less crowded place to ensure less policing in the area. As such, drawing a causal relationship merely from quantitative analysis proves to be challenging. However, the legalization of street vending in Surakarta might make street vendors’ location criteria resemble conventional establishments’.

While statistical inference might explain the change of a given street point’s attractiveness, they could not perfectly explain *why* it changed. Therefore, I interview street vendors, local experts, and researchers to understand whether food delivery apps have any impact on changing location preference. In the later chapters, the thesis will discuss the methodology in detail. Conversely, I will also address the limitation of the study and rooms for future research.

1.3 Structure

This thesis is structured in five chapters. The following chapter (Chapter 2) will review and synthesize literature in three categories: urban retail location theory, the dynamic of street vending governance both in Indonesia and the developing world, and the adoption of mobile commerce in the informal economy. The second half of chapter two will identify four hypotheses that serve as a foundation for the research questions. Chapter 3 presents the case study and its context in further detail before discussing the data. Chapter 4 will cover the methods to answer the four research questions and the findings. I present the findings as a synthesis of our quantitative model, literature review, and interviews. Finally, Chapter 5 concludes the thesis and suggests directions for future research.

Chapter 2: Literature Review

While the thesis focuses on Indonesia, the topic of interest bears relevance to theoretical fields produced by scholars in the Global North and other countries in the developing world: location theories, informal street vending, and technology adoption in the informal economy. Using location theories as a lens allows me to examine street vending as a space-occupying and profit optimizing retailer in the urban area. Yet as the theories were mainly developed in Europe and North America, they assume retail and F&B establishment to be a brick-and-mortar entity that is a product of formal processes with no physical flexibility. As such, I review literature written on the governance of street vending and the informal mechanisms to contextualize retail location theories to the street vendor context.

In the era of delivery apps, rapid adoption of technology might alter street vendors' operating mechanisms. As e-commerce and food delivery apps (FDA) models expand rapidly in the Asia Pacific region their services adapt to the local socioeconomic contexts. Therefore, many scholars have studied small and medium enterprises' adoption of mobile technology especially as mobile phones become more affordable. While relatively nascent, this subfield enriches the existing scholarly works around conventional small and medium enterprises (SME) and street vending in the developing world. At the same time, the field's infancy means that some research questions are not yet explored, particularly around the effect of delivery apps on vendors' location preferences. The following sections provide a foundation for this thesis' hypotheses, research questions, and methodology to understand if and how technology impacts street vendors' location preference.

2.1 Retail Location Theory and E-Commerce

Historically, urban economists have modeled the city as a featureless plain (Hotelling, 1929; Lösch, 1954; Huff, 1963; Christaller, 1966) which measure distance as Euclidean. In more recent years, scholars incorporate urban built form and street geometries to model distance (Deakin, 1991), develop metrics to quantify pedestrian access to retail establishments (Handy and Niemeyer, 1997), and predict retailers' performance based on location (Sevtsuk, 2014). Yet, e-commerce and FDA may have changed the equation as they allow people to purchase goods without having to access physical stores. The following segments reconcile neoclassical retail location theories and accessibility metrics under the context of e-commerce and FDA.

2.1.1 Neo-classical location theory

Neo-classical location theories suggested that retail establishments cluster for several reasons. Hotelling's law (1929) asserts that mobile retailers selling the same type of goods are attracted to each other as each vendor perceives the other vendor's location as optimal. Therefore, the law predicts that two retailers located on the ends of a line would eventually be adjacent to each other at the center of the line, creating a cluster. Hotelling contended that this clustering is not socially optimal, as they deprive retail amenities for people who live at the ends of the line and subsequently increase travel costs for those customers. He argued that if the retailers were symmetrically located on the quarter-distance point from each line's end, it would divide the market coverage equally between the two retailers and minimize customers' travel cost.

Yet, Eaton and Lipsey (1975) claimed that clustering would be advantageous for customers. By having retail clusters, customers can easily compare the prices and qualities of similar goods without having to spend an additional cost to travel to other locations. This reduces *search cost*, or the cost that customers need to search and compare goods before making a purchase. These goods are identified as *comparison goods* (Sevtsuk, 2014) which includes food and beverage. As such, clustering will be beneficial not only for non-competing stores but also competing stores as their agglomeration would draw a larger pool of customers.

Empirically, comparison goods have been proven to spatially cluster in a dense urban environment (Sevtsuk, 2014). Using a spatial econometric model of retailers in Cambridge and Somerville MA, the study represented street network as a graph and extensively used pedestrian accessibility metrics to determine retailers' location choice factors. The findings argued that clustering was highly important for stores. If all neighboring buildings in a 100-meter radius contain stores than the likelihood of a particular building to also accommodate a store was 30% higher than in a case where no neighboring stores were present. Based on the theories and empirical research, I expect that mobile vendors, especially food and beverage providers, are more likely to cluster spatially.

2.1.2 Accessibility metrics

Historically, location theories have been using Euclidean distance to model cities, disregarding urban built form and assuming cities as a featureless plain. Scholars in the built environment field have developed accessibility metrics to increase the model's accuracy by acknowledging the complex geometry of urban built forms such as buildings, streets, and rivers. Therefore, representing street network and destinations as a graph (Sevtsuk, 2014). This thesis' street network modeling follows the same suit and uses *network distance* or *radius* that accounts for street morphology instead of using Euclidean distance or radius.

I use gravity index to measure the attractiveness of a given location to other destinations conditional on a function of distance (Hansen, 1959). In another word, the gravity index of a given destination captures the potential maximum number of trips to a destination by estimating the number of people in its surrounding that can conveniently access the destination conditional on their travel mode. Therefore, it projects the potential maximum of a destination's attractiveness instead of representing the actual number of trips generated by past travel data. The component of gravity index will be specific to the chosen mode of transportation, as different modes have different maximum comfortable distance. Intuitively, people are more likely to travel intercity using a motorized vehicle instead of on foot, as the former is more convenient.

Two modes to measure accessibility to F&B establishments in the delivery apps' era are walking and motorcycle (ojek). The former represents the pedestrian trips by customers who are still going to stores in-person while the latter reflects delivery couriers' trips to fulfill online transactions. In American urban environments like Cambridge, MA, walking remains the most common mode to access retail establishments (Sevtsuk, 2014). This research in Surakarta will hold the same assumption, especially since Surakarta's retail density is three-times higher than Cambridge's (Sevtsuk, 2020). The high density suggests that walking is relatively easy to access these retailers, except for larger shopping activities such as bulk grocery or specialty shopping.

Measuring gravity index for pedestrian access is a function of *walking radius* and *distance decay*. Walking radius allows us to constrain pedestrian accessibility analysis to a theoretical maximum walking distance or time. Distance decay enriches the estimate of pedestrian trips by introducing a decay effect that has an inverse exponential relationship to the increase of travel time (Handy and Niemeyer, 1997). This suggests that the likelihood of people walking decreases as walking distance increases because people perceive longer walks to be less convenient. Handy and Niemeyer (1997) empirically estimated that the maximum walking time for pedestrian accessing retail establishments is 10 minutes and approximated distance decay rate of 0.18 in the Californian context. Sevtsuk (2018) predicts higher distance decay parameter in the tropics at 0.4, indicating a more exponential inverse relationship between people's willingness to walk and distance. This suggests a shorter maximum comfortable walking distance for people in the tropical regions on average, as pedestrian comfort is closely correlated with moderate climate.

Ojek (motorcycle) accessibility is an important indicator to measure a retailer's suitability for delivery service purely from a spatial perspective. As mentioned in the previous chapter, platform ojek drivers are responsible to deliver food and goods. Aside from delivery jobs, the drivers also provide regular transportation services, filling in the lack of reliable mass public transit. As a common paratransit phenomenon across the Global South, studies on informal motorcycle taxi services are worldwide (Wadud, 2020; Evans, O'Brien, and Ch Ng, 2018). However, there is no strong consensus on the average distance of a motorcycle taxi trip. A study shows that most ojek trips in major Indonesian cities such as Bandung and Yogyakarta are under 5km (Kusuma, 2019). Yet, the difference in built form, traffic pattern, and ride-hailing companies' surge pricing mechanisms complicates estimating an ojek's maximum travel radius for ride-hailing, let alone delivery services. I will discuss and estimate these parameters and their limitations in detail on Chapter 3.

In summary, gravity indices for both pedestrian and ojek estimate accessibility for customers visiting a store in-person and delivery couriers. Intuitively, pedestrian trips have a shorter maximum radius compared to a motorcycle ojek, thus the gravity index's parameter will be unique to each mode. A high pedestrian gravity index illustrates a retail establishment's attractiveness for pedestrian customers located in a 10-minute walking radius from an establishment, while a high ojek gravity index illustrates the same establishment's attractiveness for delivery drivers who are more comfortable to cover a much larger radius. I use the latter to approximate an establishment's *deliverability*, or how suitable is an establishment for delivery services purely based on its location and ease of access for delivery drivers.

2.1.3 Built environment and e-commerce

The advance of e-commerce has introduced an unequal restructuring of urban retailers and F&B establishments in the United States. Large capital enabled large-scale and chain stores to adapt to the e-commerce model by creating their own online marketplace or introducing a hybrid concept in their physical store (Sevtsuk, 2020). Conversely, smaller stores might find more challenges in retaining a comparative advantage to survive the competition (Collison, 2020). The effect of online commerce also varies on retailers based on their kinds of sold goods. Stores selling unique goods such as bookstores might be more sensitive to e-commerce whereas stores selling search goods like convenience stores might still perform very well.

A recent study found that online food delivery services in America cannibalizes restaurants' livelihood (Collison, 2020). By using credit card transactions data, the study found that FDA transactions substitute a large number of in-person transactions. However, FDA transaction only generates modest revenue due to the high commission rate imposed by the platform. Thus, restaurants' profitability decreases despite the increase in restaurants' revenues suggesting incremental cannibalization. Smaller and independent restaurants are also more prone to cannibalization compared to larger chains. The findings provided an evidence to speculations around FDA's negative impacts on restaurants, that have been discussed in popular media (Popper, 2020; Tsai, 2020).

Decreasing presence of physical retailers can be detrimental to a neighborhood's walkability and sustainability. Many studies suggest that walkable retail is an important part of a walkable city framework, which could encourage fewer car trips and reduce carbon emission (Hack, 2013). Physical retail establishments and restaurants also provide community spaces (Fullilove and Merrifield, 2020) and 'eyes on the street' (Jacobs, 1961) or public surveillance that makes walking experience safer. A study also found that local retailers can contribute three-times as much to the local economic activity as their retail chain competitors (Civic Economics, 2002). While seemingly a humble entity, urban retail and F&B establishments are an important part of a walkable city.

2.2 Street vending governance and location preferences

While location theories could explain brick-and-mortar establishments' location preferences, they might not be able to directly explain street vendors'. In many cases, vendors could not operate in places where retail location theories predict to be the most optimal, as the theories underestimate the additional cost and informal mechanisms to guarantee street vendors' safety and sustainability.

As hostility against informal vendors remains, the following subsections discuss the true operating cost of street vending through the lens of globalization and informality as a mode of planning (Roy and Ong, 2011; Roy, 2009). Furthermore, I review literature written on street vending governance and state-sponsored vendor relocation efforts in Surakarta to illustrate street vendors' spatial flexibility when faced with adversity. I also refer to the works of Indonesian scholars who have examined street vendors' location preferences (Perdana, Rahayu, and Hardiana, 2020; Rahayu, 2016). As such, the following theoretical discourses enable a qualitative understanding of the socio-economic and policy context behind street vendor's location choice that is not explicitly captured in location theories.

2.2.1 Street vending and visual order

More than 60% of the world's population relies on the informal sector for livelihood, including street vending (ILO, 2018). As such, scholars in various fields have written literature around street vending, drawing case studies from the Global South. Indeed, the term 'Global South' is an inaccurate simplification of heterogenous geographical, economic, and political contexts. While this thesis does not dive into the debates around the terminology, there are similarities within street vending practice in the developing world where the generalized Global South framework can be useful.

One key similarity is street vendors' informal mechanisms to survive and operate safely in public spaces (Bhowmik, 2005) as a result of state-enabled hostile environments. Across different countries, street vendors have been aggressively seized, removed, policed, by local authorities (Adama, 2020; Yatmo, 2008). These may play a large role in street vendors' location preferences that balances profitability and security.

Security becomes more important as cities in the Global South aspire to look more like the 'Global North'. Across the developing world, cities set 'global' cities such as New York, London, and Tokyo as a development benchmark (Roy and Ong, 2011), including a reverence to the image of orderliness (Adama, 2020) and the absence of informal economic activities, reflecting the state's tendency to infer functionality from merely a visual order (Scott, 1999). For post-colonial Southeast Asian cities in particular, development is perceived as a way to catch-up to modernity that is associated with their past colonizers which are countries in the Global North.

Many Southeast Asian cities, including Surakarta, attempt to replicate Singapore's urban development model (Roy and Ong, 2011). Singapore's appeal is in its transformation from a struggling British colony with limited resources into a cosmopolitan, modern, and developed global city with a high quality of life (Hussain, 2015). Scholars argue that developing cities often perceive these improvements to be reproduceable by developing physical infrastructure alone without reforming the socio-political institutions (Roy and Ong, 2011).

However, replicating an urban development model can be harmful as the socio-political context that enables that model is not as easily replicable. In the Singapore example, the city-state relocated itinerant street vendors to purpose-built *hawker centers* through a heavy top-down approach. First introduced in the 1970s, hawker centers are indoor facilities with clean water and electricity installments often located in dense residential and commercial areas, allowing F&B establishments to sell hygienic food at a relatively affordable price (Tung, 2020). Surakarta has followed suits by relocating vendors to purpose-built markets and designated public spaces (Majeed, 2011).

Yet, street vendor relocation in Surakarta has generated limited success. Hawker centers in Singapore are planned hand-in-hand with high-density public housing complex developed by the country's Housing Development Board (HDB) (Tam, 2019), encouraging pedestrian customers from a comfortable walking distance. Singapore state agency Urban Redevelopment Authority oversees the city-state masterplan process, which include new HDB towns and hawker centers. Moreover, 90% of land in Singapore is publicly owned (Haila, 2019). On the other hand, purpose-built markets with relocated vendors in Surakarta often located at the city's periphery due to spatial constraints. In the following sections I will discuss Surakarta's relocation case in more detail.

Interestingly, Singapore has reintroduced traditional street vending area by constructing faux pushcarts (Figure 9) in its major tourist attractions as an attempt to recreate a nostalgic charm associated with the city's history as a melting pot for different cultures and itinerant hawker culture in the past. The trend demonstrates street vending's monetizable cultural values that can become a city's comparative advantage for tourism and branding. On a global scale, cities in the Global North like Los Angeles have been pursuing policies around street vendor legalization and protection (WIEGO, 2018). These urban design and policy cases could reform the 'ideal' visual order of 'developed cities' that cities in the Global South desperately aspire to emulate.

Figure 9. A faux pushcart on the pedestrianized Smith Street, Singapore. Photo taken from Google Street View.

2.2.2 Informal mechanisms and location preferences

Developing cities' aspirations for a visual order are reflected in street vending governance and street vendors' response to ensure security. Many cities in the Global South perceive vendors as being out-of-place (Yatmo, 2008) and unorderly (Adama, 2020; Gibbings, 2016), which might correlate with the state's hostility towards street vending despite its importance. As a response, vendors employ various kinds of mechanisms to ensure their security, which might in turn influence their location preferences.

The mechanisms can be tactical and temporal, as demonstrated by vendors in Abuja, Nigeria who are always alert and ready to run to escape the police or preferring to operate in times when policing is less present (Adama, 2020). They can also take form in social and informal relationships, as social networks allow vendors to pass information (Adama, 2020) and ease new vendors to enter the existing street vending scene (Bhowmik, 2005).

Yet the power dynamics in the relationship are not always balanced. In many cities vendors often pay informal retribution fees to larger and more established street vendors (Batreau and Bonnet, 2014), people who falsely claim to be government officials (Noble, McGee, and Yeung, 1977), and thugs (Jellinek, 1979) to avoid hostility. In Surakarta, vendors used to bribe the municipal government and local police force to ensure their safety (Majeed, 2011). These mechanisms demonstrate informality as a mode of planning (Roy, 2009) that determines street vendors' location preferences.

While retail location theories allow us to estimate street vendors' location choice as a means to optimize profit by balancing cost and revenue, they underestimate the cost of *being* informal. Vendors' dependence on various informal mechanisms to ensure security is difficult to capture and internalize as a generally universal model. As such when these costs get too high, they become barriers for vendors to locate in places with the highest potential revenue.

2.2.3 State-sponsored relocation

As exemplified in Singapore and Surakarta, city governments often opt to relocate street vendors to a new site as a way to manage informal vendors, either temporarily or permanently (Noble, McGee, and Yeung, 1977). Relocation planning process offers an opportunity of a democratic policymaking exercise involving the participation of relevant stakeholders, which are more likely to result in a more sustainable and mutually beneficial policy (Taylor and Song, 2016; Sudarmo, 2008).

Yet, a field study and interviews of street vendors relocation in Surakarta found varying success even after a participatory planning process (Taylor and Song, 2016). Taylor and Song found that vendors who were relocated to Klithikan Notoharjo market remained operating in the relocated site while almost all relocated vendors in the Panggungrejo market returned to their original sites on the streets. The former received more media attention as it was Indonesia's first peaceful vendor relocation project. The city also offered bus services to the new markets, financial assistance, business trainings, rental and tax relief to the vendors (Majeed, 2011). On the other hand, there were less public attention on the Panggungrejo relocation and smaller government assistance to the relocated vendors.

As such, relocated vendors found challenges in surviving and returned to their original site. Especially when the vendors rely on pedestrian traffic as their customer base. When relocation focuses only on the image and appearance of public space, it could disregard the importance of financial aid, skills and training, and access to loans that can help vendors build a new customer base and compete with other traders in a more formal marketplace (Taylor and Song, 2016; Rahayu, Werdiningtyas, and Musyawaroh, 2017). Many vendors in Panggungrejo market eventually sold their stalls, contradicting De Soto's (2000) argument that assigning formal property titles would be a panacea to poverty alleviation. This example indicates the importance of democratic and participatory processes to understand street vendors' location preferences for mutually beneficial street vendor management strategies.

2.2.4 Traditional factors in street vending location choice

Indonesian scholars have done an extensive empirical study on street vendors' location preferences before the introduction of FDA. Proximity to customers and pedestrian traffic are extremely important for street vendors in both megacities like Jakarta (Rame-Rame Jakarta, 2020) and smaller cities like Surakarta. In a street vendor survey done in Surakarta in 2014, more than half of the sample were adjacent to other retail amenities and almost 90% of the sample operate in a permanent location. This is especially apparent in prepared F&B vendors (Rahayu, Andini, and Putri, 2016). As of 2018, a field study in a street vendor cluster nearby University of Sebelas Maret suggests that foot traffic and clustering remain as important for street vendors amidst the very early days of FDA in Surakarta (Perdana, Rahayu, and Andiana, 2020). These past findings provide a foundation what constitutes traditional factors in street vendors' location preferences in Surakarta.

2.3 Technology adoption and the informal economy

A large literature is written on mobile technology adoption by street vendors, yet studies examining its effect on vendors' location choice remains limited. While originally a product of the Global North, mobile technology such as e-commerce, FDA, and digital payment have expanded to the developing economies adapting to the local socio-economic context. As a result, scholars in various countries in the Asia Pacific region have extensively studied small and medium enterprises' operation after the introduction of digital payment (Shen, 2020), mobile commerce (m-commerce) (Pipitwanichakarn and Wongtada, 2018; Kurnia, Choudrie, Mahbubur, and Alzougool, 2015), and the subsequent barriers in adopting those technology (Rahayu and Day, 2017). Despite technology's promises in empowering street vendors to make more informed decisions (Mramba et al., 2020), the question of how technology impacts a vendor’s location preference remains understudied.

Indonesian studies focusing on the effect of FDA on street vendors’ location preference are also limited. In 2018, GoJek sponsored a country-wide survey on FDA’s effect on SMEs’ business performance across Indonesian major cities (Lembaga Demografi Universitas Indonesia, 2019), yet it does not focus on street vendors’ location preferences. Existing studies around the change of travel behavior induced by delivery apps are also limited to a neighborhood scale and specific only to customers’ travel behavior (Manullang, 2019). Acknowledging these limitations, the following section synthesizes existing research on street vendors’ and small business owners’ adoption of technology as a foundation for our hypotheses and research questions.

2.3.1 Acceptance of technology

The extensive literature in this field indicates the rapid growth of mobile technology adoption in street vending practices. In 2018, Pipitwanichakarn and Wongtada found high usage of mobile commerce applications in F&B street vendors in Bangkok, where they found a large number of relatively educated vendors who are technologically savvy and perceive street vending as an entrepreneurial choice instead of a necessity. In the Indonesian context, University of Indonesia’s Lembaga Demografi estimated that in 2019 SMEs who are using GoJek’s FDA GoFood contributed IDR 34.1 trillion to the Indonesian economy (US$ 2.3 billion as of March 2021). This study contrasts previous findings in 2013, when scholars wrote about the slow rate of technology adoption in the SMEs (Rahayu and Day, 2016). This could indicate an astronomical growth of technology adoption between 2013 and 2019.

In general, empirical measurement of technology adoption from street vendors’ perspective is still at its infancy. Scholars in the business entrepreneurship studies asserted that street vendors are more likely to adopt new technology if there are environmental and peer pressure (Ashraf, Thongpapanl, and Auh 2014). As discussed, ride-hailing and delivery service companies like GoJek are growing rapidly and enjoying extensive media fanfare. Given these conditions, I assume that street vendors are adopting FDA at a relatively fast pace in Surakarta. The street vendor interviews in Chapter 4 validate this assumption.

2.3.2 Effects on SMEs' livelihood

Existing GoJek-sponsored studies reported remarkably positive result on the effects of FDA to the livelihood of small and medium F&B enterprises' owners. In 2020, University of Indonesia's Lembaga Demografi surveyed 1,000 micro, small, medium enterprises (MSME) owners registered in GoJek's FDA across 8 major Indonesian cities that did not include Surakarta. Nearly 40% of them only joined GoJek during the pandemic. 18% of the sample are semi-permanent store owners, which may or may not include street vendors. The study found that 93% of the MSMEs experienced an increase in transaction volume and within those responses, 74% experienced a minimum 10% increase. However, the aggregated result makes it harder to identify the effect on street vendors alone. The lack of other independent studies to support this result also makes cross-validation impossible, especially after the increase of GoJek's FDA commission rate in 2021 (Djumena, 2021).

2.4 Hypotheses and Research Questions

Building on the literature synthesis, this thesis poses four hypotheses and research questions. Understanding the governance of street vending, their informal mechanisms to ensure safety, and the traditional factors behind location choice augments retail location models for street vendors in the developing economies context. As street vendors adopt new technology and online delivery services, I pose the following questions:

Question 1: Has the number of street vendors changed in Surakarta between 2014 and 2019, if so how and why?

Hypothesis 1: I hypothesize that the number of street vendors have grown as the city's population and wealth increase amidst rapid urbanization. Extensive literature has been written on the correlation between urbanization and positive growth of street vendors presence. I am interested in finding out if such relationship is reflected in this thesis' data.

Question 2: Have street vendor preferences towards clustering changed with the introduction of delivery services?

Hypothesis 2: I hypothesize that in 2019 street vendors perceive clustering to be less important compared to 2014 as delivery services reduce customers' search cost. I speculate that delivery service platforms are widespread in 2019 so that online transactions constitute a fair amount of overall street vendors sales and perhaps substitute some in-person transactions. As such, I expect that street vendors' attitude towards clustering is changed in 2019.

Question 3: Did the importance of location choice factors change for street vending? If so, how?

Hypothesis 3: I hypothesize that *deliverability* metrics have become more important factors behind location preferences in 2019 compared to 2014. Deliverability metrics explain a location's suitability for delivery services, purely from the spatial point of view. As the usage of delivery platforms and FDA are more widespread, I speculate that the traditional predictors of street vendors' presence would be less important for street vendors in 2019.

Question 4: Did the change of clustering and location choice factors differ for food and beverage vendors? If so, how?

Hypothesis 4: I hypothesize that the change in clustering and location choice factors would be more pronounced in street vendors who are exclusively selling food and beverage products. Food and beverage are a staple need and comparison goods; therefore, I speculate that FDA use would be more prevalent compared to other delivery services. Thus, I expect that the heightened FDA use will be reflected in a more dramatic change in both clustering and the importance of location choice factors for the F&B vendors subset compared to all kinds of street vendor.

Chapter 3. Case Study and Data

This chapter explores the case study in detail before discussing the available data for analysis. I also explain the juxtaposition between Indonesian ‘internet’ and informal economy, particularly in Surakarta’s context. The second-half of this chapter explains the data collection, challenges in a data-poor environment, data limitations, and underlying assumptions. I conclude the chapter by walking through the variables necessary for the quantitative analysis.

3.1 Case Study

As the world’s fourth-largest country and third-largest democracy, Indonesia bears resemblances to many other developing countries. Between 2014 and 2019, the country has enjoyed stable GDP growth of 5% and astronomical growth of internet users of 178%. In 2019, almost half of the country’s population have internet access and there are 341 million mobile subscriptions, larger than the country’s population of approximately 250 million people (World Bank, 2019). Yet, 70% of the country’s working force is still informally employed, similar to the average of informal employment in developing countries (Loayza, 2016).

The rise of gig labor model, online delivery, and ride-hailing platforms have seen resistance from non-platform drivers. Yet, Joko Widodo’s presidential cabinet endorsed and supported the online platforms citing their benefit to the “*ekonomi kerakyatan*” (the people’s economy) (Gojek Indonesia, 2015). However, some city governments challenged the central government’s view and imposed local restrictions on ride-hailing apps. The country’s relatively recent decentralization allowed cities to enact city-level regulations that can contradict the national government’s agenda. The same decentralization effort enabled direct elections of city mayors, which brought victory to Joko Widodo’s mayoral campaign in Surakarta in 2004.

The provincial city of Surakarta offers a promising case study as it has enjoyed a progressive history of street vendor management which has attracted domestic and international attention. While most Indonesian cities often resorted to aggressive seizure and eviction to *manage* street vendors who occupy public space, Surakarta municipal government under Joko Widodo started dialogues with street vendors and their representatives allowing a democratic relocation process. While the city initially banned GoJek ride-hailing services, it allowed FDA's operations (Isnanto, 2017). The following sections will explore our case study's context in greater detail.

3.1.1 Indonesia and the 'internet economy'

In 2019, Google dubbed Indonesia as the leader in Southeast Asia's internet economy (Google, Bain, and Temasek 2019). Google's e-Conomy SEA report suggested that Indonesia's internet economy grew 40% annually. The internet economy definition loosely covers "*online travel (flights, hotels, vacation rentals); online media (advertising, gaming, subscription music and video on demand); ride hailing (transport, food delivery); e-commerce; and digital financial services (payments, remittance, lending, investment, insurance)*" (Google, page 9). Yet in Indonesia, no other company have stronger association with the term other than GoJek, a local-grown tech start-up founded by a Harvard Business School alumnus Nadiem Makarim (who became the country's Minister of Education in 2019 under Widodo's administration) whose offering includes ride-hailing, food delivery, goods delivery, mobile payment, and even home massage. GoJek became the country's first *decacorn*, or a startup with a valuation of at least $10 billion, and claimed to contribute to 1% of Indonesia's GDP (Lembaga Demografi Universitas Indonesia, 2019).

Unlike online platforms in the west, GoJek's service model has been adapted to the local Indonesian context. For example, GoJek's ride-hailing services capitalize on existing informal motorcycle taxi service (*ojek)* and GoJek's FDA (GoFood) includes street vendors as food and beverage providers. The food delivery service connects customers to a large number of street vendors, micro, small, and medium enterprises who will hand over the prepared meal to GoJek ride-hailing drivers for delivery. Customers can also rely on GoJek's goods delivery service *GoSend* to buy products remotely, by purchasing directly from any vendor of their choice either by phone or other e-commerce platform and request for a GoJek-affiliated ojek driver to pick up the purchased goods and deliver them to the customer's location. All of these transactions can be paid by using GoJek's online payment product, GoPay, or by cash.

GoJek appeals to the Indonesian nationalism in their branding campaign, as they claim to be substantial to the Indonesia's economy and global reputation. In 2018, a GoJek sponsored study reported that the micro, small, and medium food enterprises who made themselves available on the GoFood application contributed US$ 2.3 billion to the national economy (Lembaga Demografi Universitas Indonesia, 2019). This finding is important for GoJek to claim their positive role in fostering *ekonomi kerakyatan* or 'the people's economy' (The Jakarta Post, 2020), which is an anti-colonial concept introduced in the Indonesian constitution that promotes economic activities for communal well beings instead of individual's profit generation (Dewan Perwakilan Rakyat, 2015). The campaign's success is illustrated by the state's endorsement in 2015 during the rowdy protests of non-GoJek affiliated drivers against GoJek, which led to The Ministry of Transportation banning GoJek's ride-hailing services. However, the ban was short-lived as President Joko Widodo vetoed the minister, citing GoJek's importance in addressing the society's transportation needs and *ekonomi kerakyatan* (BBC News, 2017; The Jakarta Post, 2015).

Government's endorsement might relieve companies like GoJek from stringent regulations, while at the same time it could ameliorate city governments' perception of the informal economy. The latter could be beneficial for street vendors, as historically many Indonesian cities resorted to aggressive seizure and relocation involving the city police force to manage street vendors. Yet, Surakarta has employed diplomatic and lenient approaches in managing street vendors, which offers an interesting site of study as FDA gains popularity within the street vendor communities.

3.1.2 Surakarta

Over the years Surakarta's street vendors continue to grow, many attributed it to the government's progressive attitude toward street vendors (Rahayu, Werdiningtyas, and Musyawaroh, 2016). Peaceful vendor relocations and progressive street vendor management have attracted the attention of both Indonesian and international scholars to this city of one-half million people. The predominantly Javanese Muslim city also enjoys a high population diversity as Christian and Chinese-Indonesians constitute sizable minority groups. Despite the small area, Surakarta is on par with New York City in terms of population density at 11,000 people per square kilometer and even boasts a higher retail density than New York City, at 217 establishments per square kilometer (Sevtsuk, 2020). As the economic center of 2-million people living in the Greater Surakarta area, the city receives additional 200 new vendors annually (Solo Pos, 2018) in which 40% of them are from surrounding rural areas. Many vendors are associated with site-specific community groups (*paguyuban*) who play an important role in representing street vendors' demands in the civic society.

Surakarta's diverse populations live in relative peace and are highly engaged in civic activism, both potentially are byproducts of the city's inter-sectarian conflict in the past. The 1997 Asian Financial Crisis exacerbated inequality in the city as many people lost their jobs and turned to informal work including street vending.

The Banjarsari Park conflict is often noted as the catalyst behind Indonesia's first peaceful vendor relocation. In the 100 by 100-meter open space located in an affluent neighborhood, the park is a trading site for almost 1,000 vendors at its peak (Majeed, 2011; Ariyadi, Adishakti, and Kristiadi, 2005). In 2004, a conflict between vendors and the surrounding wealthy residents erupted as residents complained about the loss of public space, traffic congestion, petty crime, and street littering allegedly introduced by the vendors. On the other hand, vendors claimed that they have paid illegal exorbitant fees to government agencies and police to avoid eviction.

Amidst violent vendor relocation in Indonesian cities, Surakarta pursued a diplomatic approach. The newly and first-democratically elected mayor of Surakarta at the time, Joko Widodo, organized more than 50 meetings where he invited street vendor representatives to have dialogues, lunches, and dinners with him over 6 months. The mayor's approach, assisted by local university and NGOs (UCLG, 2010; Majeed, 2011) including Kota Kita Foundation and SOMPIS (*Solidaritas Masyarakat Pinggiran Surakarta* – Solidarity of the Marginal Societies of Surakarta), resulted in the vendors agreeing to relocate to purpose-built markets and designated public spaces conditional on a set of demands (Sudarmo, 2008). The demands included stall ownership certificates, provision of shelter and new vendor carts, training and education for vendors, access to business loans, tax exemption for the first 6 months, new bus routes for customers to purpose-built markets, and media promotions of the new markets (Taylor and Song, 2016; Natawidjaja, 2015; UCLG, 2010).

As peaceful vendor relocation was uncommon for Indonesian cities at that time, the story attracted national and international attention. Widodo's approach and success gave him a pro-poor and humble image which a study suggested had “restored Indonesian public trust in the government” (Natawidjaja, 2015). This might have bolstered his subsequent and successful political campaigns as Jakarta governor in 2012 and Indonesian president in 2014.

Yet the peaceful relocations affect vendors differently based on the time of relocation and their sold goods. UCLG (2010) found that some relocated vendors selling automotive-related goods in Klithikan Notoharjo Market experienced a 200-400% revenue increase and that they generated new economic activities in the surrounding neighborhood. While vendors who were relocated in subsequent programs with fewer media fanfare and vendors who were selling F&B returned to the streets (Taylor and Song, 2016). Various research by Indonesian and international scholars have found that the purpose-built markets and relocation policies deprived F&B selling vendors of foot traffic and their main customer base (Rahayu, Werdiningtyas, and Musyawaroh, 2016; Perdana, Rahayu, and Hardiana, 2019). On the other hand, vendors selling specialty goods such as automotive spare parts are less sensitive, corroborating retail location theories.

Field studies at the neighborhood level found that the heterogeneity within F&B vendors suggests varying location preferences. Rahayu, Werdiningtyas, and Musyawaroh (2016) found that vendors who prepare food on-site are highly likely to prefer staying in one place, while mobile food vendors are more likely to sell food that has been prepared off-site. The probability of F&B clustering also varies by the kind of food they sell. As of 2018, F&B vendors who are clustering behind Sebelas Maret University remain dependent on foot traffic (Perdana, Rahayu, and Hardiana, 2019) even as FDA has started to penetrate the city. As the studies are limited to local geography and not addressing FDA usage, a city-wide empirical study by using location data might reveal how technology might change street vendors’ location preferences.

3.2 Data

Location data and street network are key to this thesis’ analysis. By using the location data of street vendor and points of interest, I can identify the variables that could predict street vendors’ presence. These variables are also important for the *spatial lag regression* analysis, which becomes the main quantitative method in this thesis. While I will discuss the regression in greater detail in Chapter 4, this model quantifies the magnitude and significance of the predictors of street vendors' presence. In the regression model, the street vendors' presence is described as the *dependent variable* while the predictors of street vendors' presence are called the *independent variables.* In another word, the independent variables are the potential explanation behind the dependent variable.

This thesis' dependent variable is derived from street vendor location data which I collected from Google Street View and research bodies such as Kota Kita Foundation and MIT City Form Lab. The independent variables are based on the street characteristics and points of interest location data. The following section will discuss the variables, data collection, and limitations in greater detail.

3.2.1 Dependent variable

Street vendor location data

I use street vendors' location data collected in 2014 and 2019 to measure the change in street vendor presence before and after the rise of delivery apps. The 2014 vendor location data comes from a field survey done by the City Form Lab and students from Singapore University of Technology and Design, covering 356 street segments dispersed around downtown Surakarta. Each survey entry contains the information of the vendors' kinds of sold goods and photographs. Based on the existing data, I manually identified the vendors' typology from the photographs and created a subset of F&B vendors for vendors who are exclusively selling prepared food and beverage, whether produced and consumed on-site or off-site.

In the absence of similar street vendor data in 2019, I mapped and labeled vendors' locations using Google Street View. I surveyed the same street segments from the 2014 data, documented their typology, and sold goods based on visually observing Google Street View images of Surakarta in 2019. However, some streets from the 2014 survey did not have any Google Street View counterpart in 2019. Therefore, I removed those streets from the sample. In the end, the data consists of 356 street segments, 277 street vendor points in 2014, and 532 street vendor points in 2019 suggesting street vendor presence grow at nearly 100%. Within that sample, F&B vendors account for 172 in 2014 and 410 in 2019 indicating a more than 100% growth over 5 years.

The street vendor location data needs to be aggregated to a spatial *unit of observation* that remains constant between 2014 and 2019. This is important to create a panel dataset in which I can compare the number of observed street vendors of the same location before and after delivery apps. By having a fixed unit of observation, I would be able to know how many vendors each street is gaining or losing between 2014 and 2019.

Street point data

The unit of observation needs to be granular to capture precise street vendors' location information and neighbor relationships. In the raw data, the most granular unit of observation is represented by street segments as a line. However, the segments have varying lengths. Additionally, the same street segment may have a local variation of vendor density, as my observation shows that most vendors crowd around a particular point that is most strategic within a street segment especially adjacent to a point of interest. For example, in front of a traditional market, next to an entry to a park, or by a school gate. Thus, aggregating the vendor location data to the street segment removes the fine-grain vendor density information that is important for the analysis.

Therefore, I distributed location points at a 5-meter interval on every street segment to create a more granular unit of observation. This generated 6,590 street points along with all sample street segments (Figure 10). Each point will have a Boolean value to indicate street vendor presence within its 2.5-meter network radius. A street point will have a value of 1 if there is at least one vendor within a 2.5-meter network radius from that street point and 0 otherwise (Figure 11).

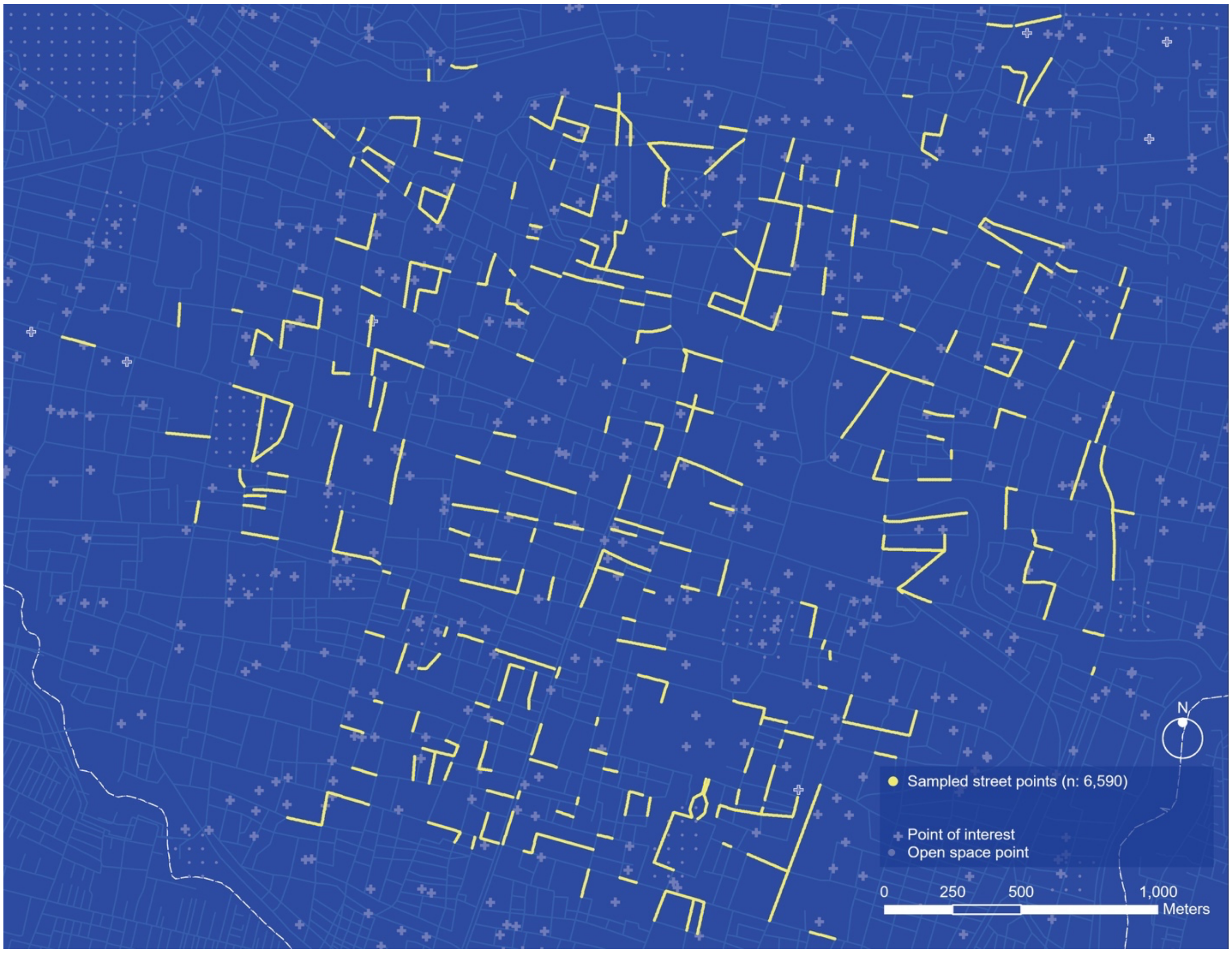


Figure 10. Sample area (n = 356 street segments) divided into street points at 5-meter interval (n = 6,590).

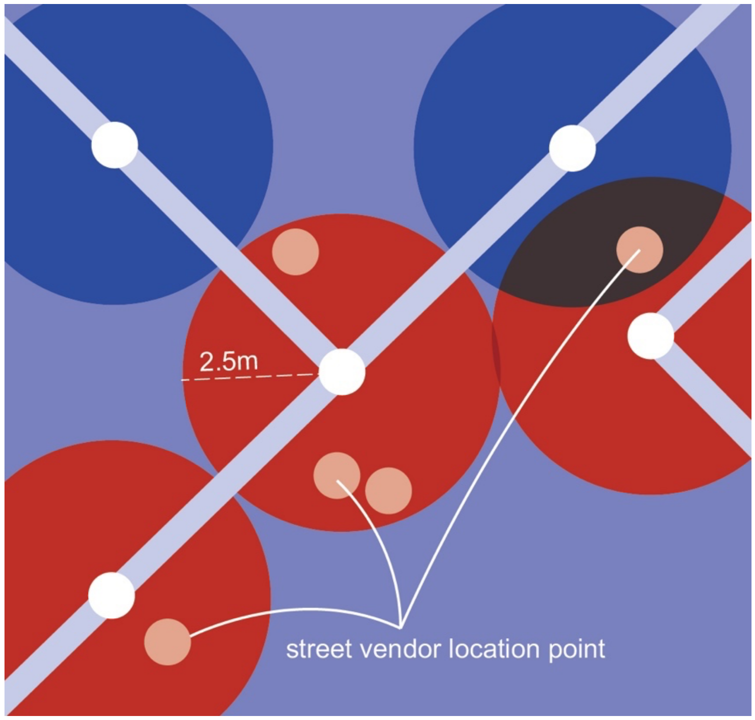


Figure 11. Diagram showing the 2.5-meter search radius (red and blue circles) from each street point (white point). Each street point within the blue circles will have a value of 0 since there is no street vendor presence within its search radius. While each street point within the red circle will have a value of 1 as there is at least 1 street vendor within its search radius. Street vendor location point that falls in the intersection between two search radii will be assigned to the street point that is located on a closer street.

Using street points also enables us to capture street vendor neighbor relationships. Since vendors can occupy spaces as small as 2-by-2 meters, one vendor can have multiple neighboring vendors within a vendor cluster. Currently, there is no consensus on the maximum network radius that defines a vendor cluster, therefore I tested several thresholds: 25m, 50m, 75m, and 100m. Based on the test, 50m generated the best fit in my data, which means that two vendors will be considered as neighbors in the same cluster so long that the distance between them does not exceed 50-meter (Figure 12). Previous work on brick-and-mortar stores clustering in Cambridge, MA suggests 100-meter as the maximum distance (Sevtsuk, 2014). Street vendor's smaller scale means that the plausible distance should not exceed 100-meter. Similar to network radius' definition, this distance considers the street morphology as well. The neighbor relationship information will be captured in a *spatial weight matrix*, which is essential for the spatial lag regression.

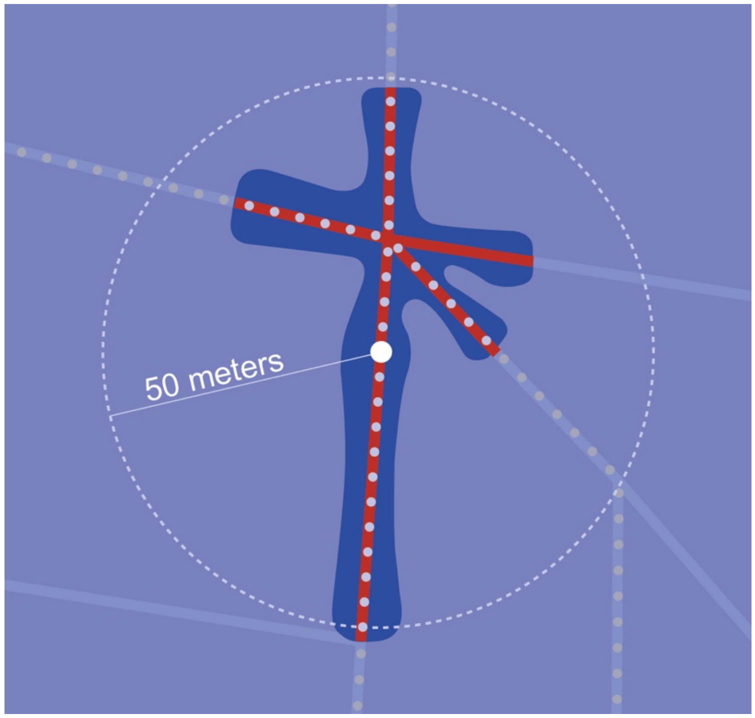


Figure 12. Diagram defining a 50-meter network radius (red lines) from a a street point (white point) compared to the 50-meter Euclidean radius (white dashed line). Points on the red lines are the neighboring street points to the street point in white.

Even after aggregating street vendor location to street point, the number of street point with vendor presence in 2019 remains a lot larger than 2014. In 2014, 238 street points contained at least one street vendor while 6,352 points contained no street vendor (Figure 13). While in 2019, 449 street points contained at least one street vendor while 6,141 points contained no street vendor (Figure 14). After subsetting the vendors who are exclusively selling food and beverages, the number of street points with at least one vendor grew from 153 in 2014 and 371 in 2019 (Figure 15), suggesting more than 100% growth. These growths of street points with street vendor presence are consistent to street vendors' growth in the raw data.

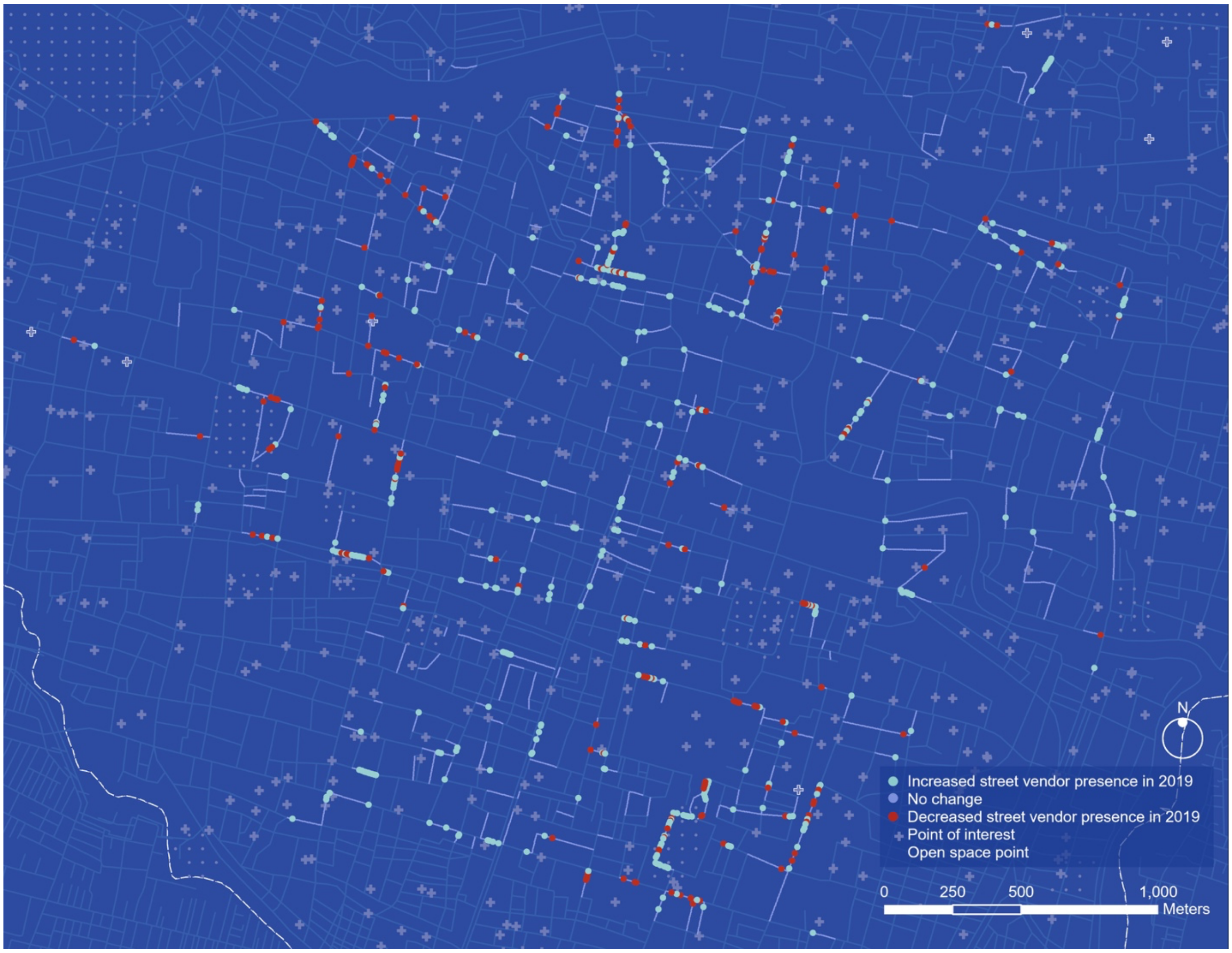


Figure 13. Map of the 6,590 street points indicating whether each point have gained or lost any kind of street vendor presence.

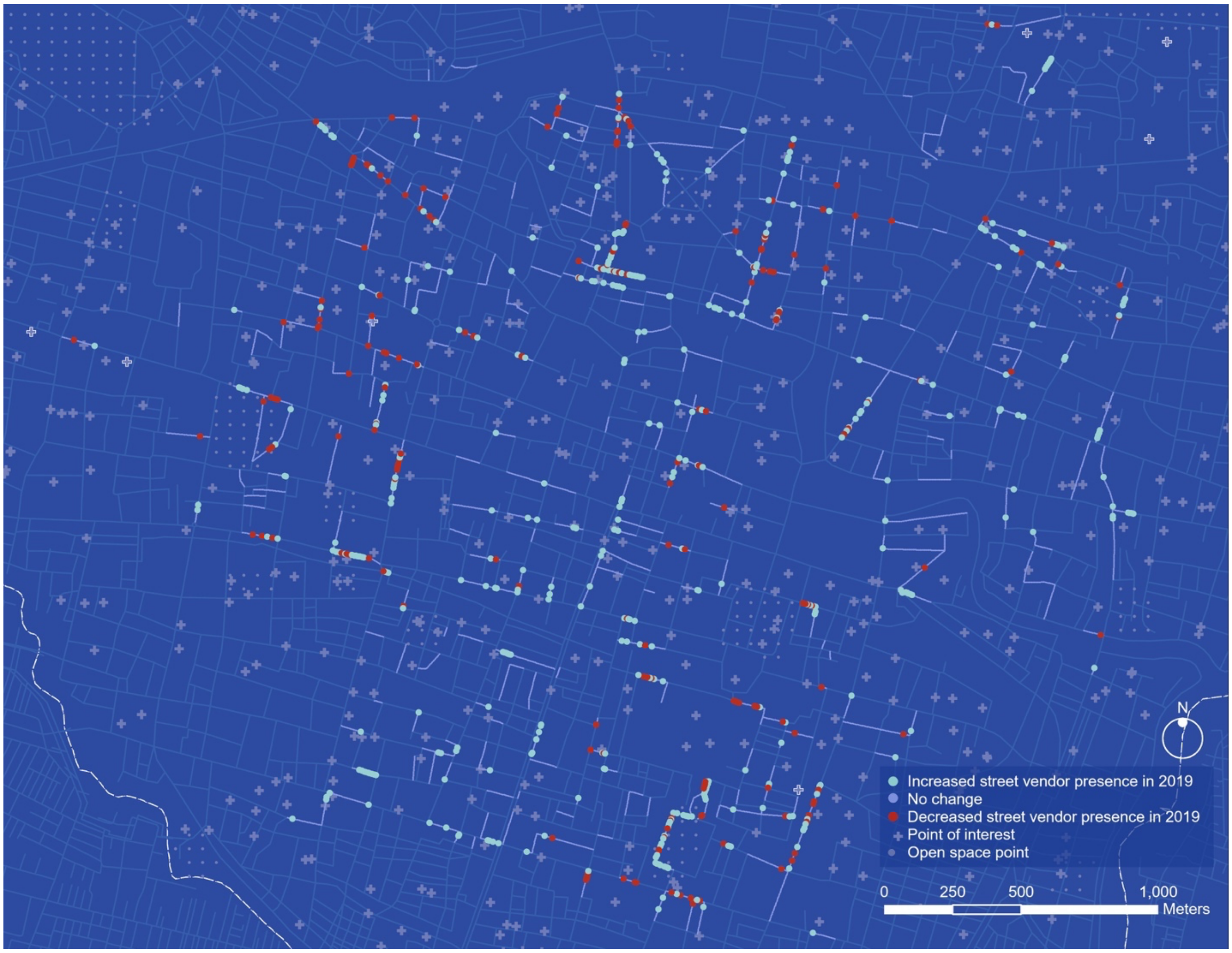


Figure 14. Map of the 6,590 street points indicating whether each point have gained or lost food and beverage (F&B) street vendor presence

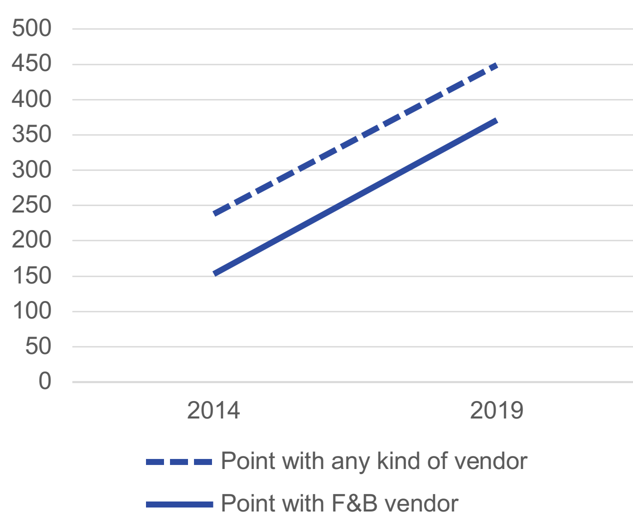


Figure 15. Growth of street points with street vendor presence between 2014 and 2019

3.2.2 Independent variables

I identify several independent variables that could explain the driving factors behind street vendor presence. The variables are correlated with the underlying assumption in my research hypotheses – street vendors' location preferences have changed as delivery apps reduce customers' search costs. I speculate that since delivery apps allow customers to purchase goods from their home or office, pedestrian traffic's importance behind location choice would diminish. Instead, I hypothesize that location factors that enable easier delivery pick-up would be more important for street vendors.

To test these hypotheses, I categorized my independent variables into two groups: *deliverability* and *walkability to points of interest*.

Deliverability variables measure a street point's attractiveness for delivery couriers. They include variables that are correlated with ease of delivery pick-ups, such as motorcycle accessibility to population centers and street width. Street points with higher motorcycle accessibility indicate a larger potential customer base that is within a reasonable delivery coverage. Similarly, street points located on a wider street suggests better visibility and larger waiting space for delivery couriers and their motorcycle.

Walkability to points of interest variables estimates a street point's attractiveness for pedestrians. They include walkability from each street point to shopping centers, healthcare facilities, education amenities, places of worship, and open space. Previous studies have suggested the importance of points of interest adjacency for foot traffic and vendors' location choice. The following sub-sections will discuss the variables and the methods to measure them.

Deliverability

Deliverability includes two variables, delivery couriers' accessibility to population centers by motorcycle and the street width. The former is measured by calculating the gravity index (Hansen, 1959) which estimates the potential number of delivery orders considering purely from the network distance. I used the following formula to capture the gravity index for ojek delivery couriers:

$$G[i]^r = \sum_{j \in G-\{i\}, d[i,j] \leq r} \frac{W[j]}{e^{\beta d[i,j]}}$$

Where W[j] is the weight of a population center *j* that is reachable from a street vendor *i* within the network radius *r*, *d[i, j]* is the distance between street vendor *i* and population center *j* along the shortest available network path, and β (beta) is the distance decay parameter between i and j. I weigh the population center by its count so that every single population center's weight is 1. Ideally, the model's weight should correspond to the number of population and jobs at each street. However due to the absence of high-resolution population data and Downtown Surakarta's relatively homogenous built form density, I pursued a simplified weighting approach. To estimate the β or distance decay parameter, I used a maximum delivery radius (*r*) of 3 kilometers and plotted various estimates. Similar to the other analysis, the gravity index uses network radius instead of Euclidean radius.

Using 0.0005 as a beta value yields a result where 50% of the delivery cases are within 1.4 kilometers (Figure 16) and generates the highest goodness-of-fit in our statistical model. This is shorter compared to a field interview in larger Indonesian cities (Kusuma, 2017) where the researchers found that the majority of motorcycle ojek ride-hailing trips are below 5km.

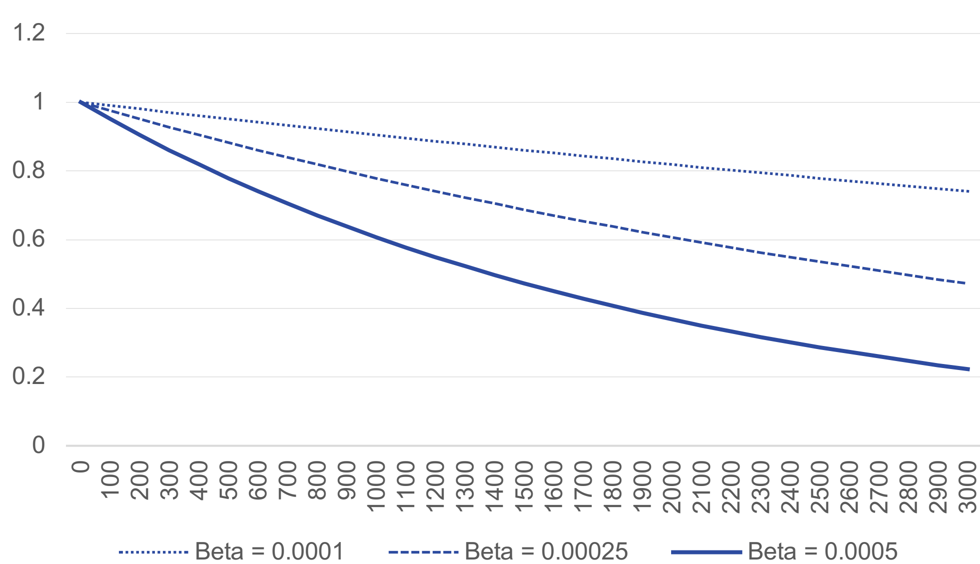


Figure 16. Estimating the beta parameter for the motorcycle ojek gravity index

I approximate the location of population centers by distributing points at every 50-meter interval along the streets of Surakarta and neighboring municipalities. As Surakarta has a relatively flat topography and relatively uniform built form density, this method will capture Surakarta's population based on the street density. I included the streets in neighboring municipalities to capture plausible delivery trips that cross the city limits but are still under the 3-kilometer threshold. Specifically, I included streets that are located within a 4-kilometer network radius from street vendors located on the Surakarta city limit to remove *edge effects*. Edge effect is a selection bias created by omitting the population centers' that technically falls under FDA delivery coverage yet are beyond Surakarta's jurisdiction. Without removing this effect, the deliverability index for a street vendor might be grossly underestimated, especially for vendors close to the city limit.

Estimating population by street density is unideal, however, it is the second resort in this context given the lack of residential and employment census at a block level. This process will represent neighborhoods with a higher street density as areas with higher population density, which could be misleading as informal neighborhoods might have higher inhabitant density at the building level. Furthermore, some informal neighborhoods might not have the street networks represented on maps which could lead to undercounting. Yet, this process can approximate population density at a more granular level in a demographic data-poor context.

Street Width

Street width is an important proxy to measure ease of delivery ojeks' access to a street vendor and street vendors' visibility. Based on our observations, I speculate that vendors on wider streets are more visible and accommodating for two reasons. First, higher visibility means that ojek drivers will find the vendor easier and finish their delivery task efficiently, which will increase the driver's revenue and performance rating. Second, wider streets allow ojek drivers to park their motorcycles temporarily in relative ease, while waiting for the food preparation. I measured the street width in our sample by measuring road reserve width using satellite imagery for the absence of official street data. Since wider streets could be correlated with better pedestrian visibility and higher foot traffic, the walkability to point of interest variables are an important control to remove confounders in the street width variable.

Points of Interest (POI)

Points of interest (POI) often serve as a human activity center and generate a large number of pedestrians who are likely to be street vendor customers. Vendors adjacent to POI often become convenient and walkable destinations for people to fulfill their basic needs. Therefore, measuring the accessibility from every street vendor location to certain types of POI demonstrates the attractivity of each street vendor for potential customers. The POI include traditional markets, shopping malls, healthcare facilities (hospital and clinic), places of worship (mosque and church), educational facilities (elementary school, junior high school, high school, and university), and open space (Table 1).

I collected the POI location data from Kota Kita Foundation, which mostly are in point data format except for open space. To make a uniform dataset, I converted all open space polygons into points by dividing the polygons into 25 by 25-meter grids with a centroid. This exercise also makes pedestrian access modeling from the open space more accurate, especially for larger open spaces. I treat the POI data as constant across 2014 and 2019, assuming no new significant development between those years.

	n	mean	standard deviation	median	min	max	range	SE
All vendors 2014	6590	0.036	0.19	0	0	1	1	0.0023
All vendors 2019	6590	0.068	0.25	0	0	1	1	0.0031
F&B vendors 2014	6590	0.023	0.15	0	0	1	1	0.0019
F&B vendors 2019	6590	0.056	0.23	0	0	1	1	0.0028
Population Centers (Gravity, r = 3,000m)	6590	2789.623	985.88	3149.24	0	3660.93	3660.93	12.1446
Street width	6590	5.074	3.17	4	1.5	19	17.5	0.039
Market (Gravity, r = 400m)	6590	0.276	0.47	0	0	2.46	2.46	0.0058
Mall (Gravity, r = 400m)	6590	0.016	0.09	0	0	0.85	0.85	0.0011
Clinic (Gravity, r = 400m)	6590	0.097	0.22	0	0	1.26	1.26	0.0027
Hospital (Gravity, r = 400m)	6590	0.042	0.14	0	0	0.99	0.99	0.0017
Mosque (Gravity, r = 400m)	6590	0.924	0.62	0.81	0	2.97	2.97	0.0076
Church (Gravity, r = 400m)	6590	0.296	0.37	0.22	0	1.68	1.68	0.0045
Elementary school (Gravity, r = 400m)	6590	0.878	0.68	0.79	0	3.6	3.6	0.0083
Middle school (Gravity, r = 400m)	6590	0.276	0.35	0.21	0	1.97	1.97	0.0043
High school (Gravity, r = 400m)	6590	0.352	0.43	0.26	0	2.53	2.53	0.0053
University (Gravity, r = 400m)	6590	0.071	0.2	0	0	1.32	1.32	0.0024
Open space (Gravity, r = 400m)	6590	1.317	2.69	0	0	14.16	14.16	0.0331

Table 1. Descriptive statistics of the dependent variables (all vendors 2014, all vendors 2019, F&B vendors 2014, F&B vendors 2019) and the independent variables.

Similar to our deliverability index, I use the gravity index to measure the attractiveness of every street vendor location point to its surrounding POI. In the analysis, the street vendor location points become the origin points and POI as the destination.

$$G[i]^r = \sum_{j \in G-\{i\}, d[i,j] \leq r} \frac{W[j]}{e^{\beta d[i,j]}}$$

In this case, W[j] is the weight of a point of interest *j* that is reachable from a street vendor *i* within the network radius *r* and *d[i,j]* is the distance between street vendor *i* and point of interest *j* along the shortest available network path. I use the network radius (*r*) of 400-meter, which indicates the maximum search distance for pedestrian customers from the POI. I estimate the distance decay parameter at 0.004 and alpha at 1, as commonly used for the analysis in a tropical context (Sevtsuk, 2018). By using these parameters, I expect that street vendors that are walkable from POI in under 5 minutes are more attractive to people.

3.3 Data Limitations

The alternative data collection process in our analysis poses several limitations. Aside from the potential biases in estimating population density, the underlying assumption behind delivery trips' maximum distance, and POI treatment as constant there are at least five other concerns.

First, the street vendor location data in both 2014 and 2019 only captured a single snapshot that represents a year-round condition. The location survey done in 2014 and Google Street View images taken in 2019 only mapped vendors at a particular time on a day of the year, therefore it could not record the nuanced existence of street vendors that are often defined by seasonality and temporality even within the same day. For example, since the survey and Google Street View images were taken during the daytime, they will not record vendors that are operating exclusively in the nighttime. However, as I am comparing two snapshots of two different years, the direct comparison should even out the selection bias in the individual yearly dataset. For example, since the 2014 survey and 2019 Google Street View images both represent the daytime condition, comparing the two would still yield a valid result.

Second, the absence of official and comprehensive street vendors' location data at a city-scale means that I can only examine streets as a sample instead of a population. This means that our sample is limited to the 356 street segments that were surveyed in 2014 and available on Google Street View in 2019. These streets are also centered around Surakarta's downtown. As such, a more accurate estimation calls for larger sample size that is representative of the city's other areas.

Third, I assume that most of surveyed vendors have adopted mobile technology, as the official data of street vendors from food delivery apps are proprietary and difficult to acquire. This limitation might introduce an *omitted variable bias*, which means that the phenomenon represented in a variable might actually accounts for something else. However, based on the interview, I find that a large number of vendors are indeed using delivery apps, one vendor went to say that 80% of vendors in the same area are on the app. However, the interview findings are also anecdotal, which leave rooms for a more comprehensive data collection. The interview section will discuss how the findings validate these assumptions.

Fourth, the delivery motorcycle ojek accessibility variable might have a confounding interpretation. As I measure motorcycle accessibility by gravity index, the variable is not limited to explain accessibility for delivery couriers alone, but also customers who use a motorcycle to come to street vendor locations. Interview findings suggest that most motorcycle trips to street vendors in the downtown area are taken by delivery couriers.

Fifth, the model does not include vehicular traffic as a potential predictor of street vendor presence. In many major cities across the Global South, peripatetic street vendors often cluster around traffic congestion where they could sell food and beverage to idle cars and other vehicles. However, the lack of data on vehicular traffic flow in Surakarta and the relatively small city size makes me assume vehicular traffic to be a negligible predictor of street vendor presence especially in comparison to pedestrian accessibility.

Chapter 4. Methodology and Findings

In this chapter, I discuss the methods and findings from each research question. The chapter begins by discussing the methodology and exploratory analysis. Then, I will cover each research question by explaining the research methods and resulting findings. Lastly, I incorporate the qualitative findings from our interviews with street vendors and Indonesia-based researchers to ground-truth our quantitative findings.

4.1 Methodology

This research employs both quantitative and qualitative approaches. The quantitative method relies on clustering analysis and spatial statistics techniques such as spatial autocorrelation metrics and spatial lag regression. Spatial autocorrelation metrics indicate the likelihood of near observations to share similar characteristics or autocorrelation (O'Sullivan, 2010) measured by Moran's I index and spatial lag coefficient. The results from the spatial regression model quantify the magnitude and statistical significance of street vendors' clustering preferences and factors behind location preferences on average.

As discussed in the data section, the regression analysis examines street vendors' location preferences based on a place's deliverability and accessibility to points of interest. A street point with a high regression coefficient in the deliverability metrics indicates a place that is strategically located for delivery services, while a regression coefficient in the pedestrian accessibility metrics demonstrates the place's attractiveness for pedestrian customers. By creating individual regression model in both 2014 and 2019, I can understand the change of importance of each preference.

To validate our spatial analysis and statistical findings, I interview street vendors, researchers, and academics in Indonesia. I conducted semi-structured phone interviews with 6 street vendors in Surakarta who are registered on GoFood's website. Additionally, I spoke with Rame-Rame Jakarta, a research organization based in Jakarta who has mapped street vendors' spatial and temporal patterns on Jakarta's major shopping street. I also contacted researchers and faculty members at Surakarta's Sebelas Maret University (UNS) who have empirically researched street vendors' location preferences on various locales of Surakarta pre-FDA.

4.2 Exploratory Findings

Before running regression analyses, I check for spatial autocorrelation in the data and identify the pairwise correlation between street vendor presence and our independent variables. I did the former by running spatial autocorrelation diagnostics on the ordinary least square regressions where I found a statistically significant Lagrange Multiplier (LM) and Moran's I value, confirming spatial autocorrelation. I also found a high Akaike Information Criterion and robust LM (spatial lag) which suggests that a spatial lag model can correct for spatial autocorrelation.

In the correlation analysis, I observe a positive correlation between street vendor presence and wider street, walkability to open space, and traditional market (Figure 17). This positive correlation is consistent in both years and for both street vendors on average and F&B vendors. The relationship corroborates previous studies that have suggested these three factors as the traditional predictors of street vendor presence (Rahayu, Andini, and Putri, 2016), suggesting the lasting importance of visibility and pedestrian access to public places for vendors despite the introduction of delivery apps.

Other interesting findings are the change of correlation sign between some factors and street vendor presence. Factors like pedestrian accessibility to mall and mosque had negative correlation with street vendor presence in 2014 which turned positive in 2019. On the flipside, pedestrian access to clinic and middle school had positive correlation with street vendor presence in 2014 and negative correlation in 2019. These changes are consistent for street vendors on average and F&B vendors. However, their correlation values appear to be close to 0 suggesting minor change.

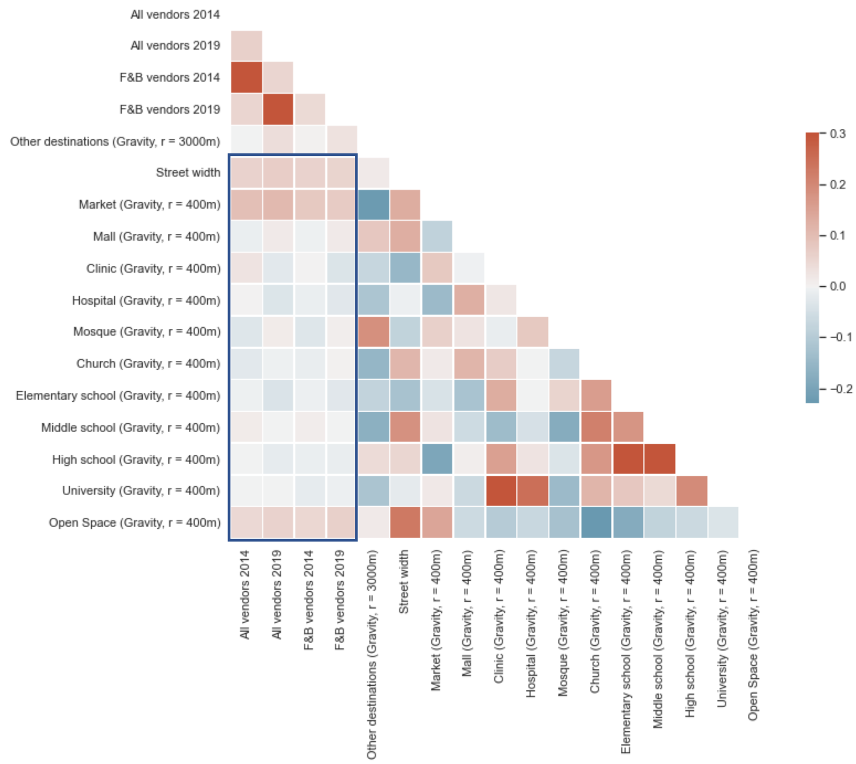


Figure 17. Correlation heatmap

4.3 Question 1: Has the number of street vendors changed in Surakarta between 2014 and 2019, if so how and why?

4.3.1 Methods

I rely on street vendor data comparison and literature review to answer this question. As I have street vendor location datasets on the same set of streets in 2014 and 2019, I could directly analyze street vendor growth in the sample. I also reviewed official statistics, city reports, and past literature on urbanization and street vending to support my findings.

4.3.2 Findings

The dataset shows a doubled presence of street vendors in 2019 compared to 2014. The growth is particularly larger for F&B vendors, as their size expanded by more than 100% from 172 to 410 (Figure 18). This finding reflects the city official report, stating consistent annual growth of street vendors due to rural-urban migration. In the aggregated urban areas of Central Java province, including Surakarta, the average per capita expenditure on food and non-food products grew at 2.3 times between 2005 and 2013 (Badan Pusat Statistik, 2014). This suggests that the population's wealth has increased on average, enabling people to spend more on shopping and eating outside of home. As previous research works suggest (Bhowmik, 2005; Noble, McGee, and Yeung, 1977), lack of formal employment opportunities and skill mismatch between the talent pool and formal employment motivates the new workforce to work as street vendors.

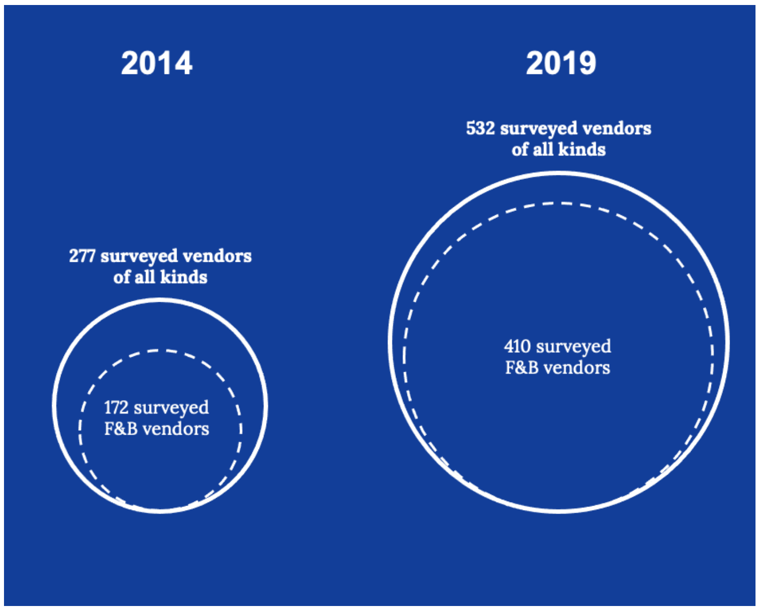


Figure 18. Growth of street vendor presence between 2014 and 2019

Yet, what is unique to Surakarta is its progressive governance and management of street vending, which might encourage vendors' growth even stronger. Based on the interviews, vendors in officially designated vending areas are charged a mere Rp2,000 (US$0.14 as of April 2021) by the city daily, as long as they operate within the approved time window. Most interviewed vendors start their operations at 5 pm and close up at midnight as the city forbids daytime vending in certain designated areas. I also learned that vendors who are operating in the city's main public square (*Alun-alun*) which is within Surakarta Sultanate Palace (*Keraton Surakarta*) ground are charged IDR 5,000 (US$0.34 as of April 2021). The interviews support Surakarta's claim in employing a zero-conflict approach in street vendor management as stated by previous studies (Rahayu, Andini, and Putri, 2016).

Interestingly, I also observe a new group of vendors who are educated and chose to be street vendors as a path to entrepreneurship. I found university students running F&B street stalls, actively using social media and FDA as a marketing tool. They see street vending as a low-cost first step to establish an offline presence and test their business feasibility. One of the young vendors who started the business from home and relying solely on e-commerce platforms perceive that offline retail presence, pedestrian customers, and incidental purchases are still important to grow the business. To lower the overhead costs, they rely on family relatives to run their pushcart stall and rent a small space in front of a permanent food stall. The permanent food stall collects the rental fee and allows the vendor to open only after the food stall closes in the afternoon. The vendor also rents a pushcart storage space at a low fee in a house nearby their vending site. This informal storage practice is also present in other interviews, even in some instances, house owner waives rental fee when they have a strong relationship with the vendors despite not being family relatives. It shows that despite the new generation of technology-literate vendors, the informal system and offline presence remain an affordable path to enter the market.

4.4 Question 2: Have street vendor preferences towards clustering changed with the introduction of delivery services?

4.4.1 Methods

Clustering analysis

First, I identify street vendor clusters in 2014 and 2019 to get a preliminary understanding of the change in street vendors clustering. By using Urban Network Analysis' (UNA) clustering tool, I can input two parameters to define a cluster: minimum cluster size and the maximum distance. Minimum cluster size sets the minimum number of vendor points constituting a vendor cluster, while maximum distance sets the furthest distance between two vendor points to be considered as a part of the same cluster. The UNA tool incorporates the street network's geometry into its distance function which makes their cluster definition more accurate and intuitive. In our analysis, I use 5 vendors as the minimum cluster size and 50 meters as the maximum distance. Additionally, I ran a sensitivity test to ensure our parameter's robustness by using three different parameters, 25m, 50m, and 100m. I found that 50m gives the most robust result and agrees with the intuitive definition of a street vendors' cluster. It is also consistent with the maximum distance for spatial weight matrix as discussed in the *Data* subsection.

Second, I randomly picked equal-size samples from both years to allow for an objective comparison after controlling for street vendor growth. In both 2014 and 2019, I picked 200 vendors from the overall street vendor dataset and 150 F&B vendors from the F&B vendors' data subset. Comparing randomly picked equal-size sample will control for the large growth of vendor's presence between 2014 and 2019. Conversely, comparing the clustering metrics of the full sample will increase the likelihood for a stronger clustering indicator in 2019 just because vendor presence has doubled from 2014. I identify the regression results using the full sample to the results in the *absolute term*. Therefore, comparing the randomly picked equal-size sample between the two years controls for street vendor's growth, removes confounding variables, and captures the change of street vendors' clustering preferences in its *relative term*. The result in the relative term can explain the true change of street vendors' clustering preferences while the result in the absolute term will align with the street vendor clustering perception by customers (Sevtsuk, 2014). Due to the strong growth of street vendor presence, this thesis will focus on the change of clustering in its relative term.

Moran's I Index

The Moran's I index calculates the spatial autocorrelation of street vending's distribution as a value between -1 and 1. The index translates "a non-spatial correlation measure to a spatial context" (O' Sullivan, 2010) by incorporating the *spatial weight matrix* in its calculation. As briefly mentioned in the Data subsection, a spatial weight matrix is an *n* by *n* matrix that describes the relationship of each street vendor point with neighboring vendors within a specified network distance. Similar to the construction of the maximum distance in the UNA's clustering tool, I used 50m as the maximum neighbor distance. This results in a matrix where each cell has a value of 1 if two street vendors are located within a 50-meter network radius from each other and 0 otherwise. I constructed the spatial weight matrix by using the origin and destination cost function on the UNA plugin for Rhino which allows the measurement of street vendor's adjacency by the network radius instead of using a Euclidean distance. This function will correctly include all street vendors that are located 50m away after acknowledging the street morphology from a street vendor of interest and exclude street vendors that are within a 50-meter Euclidean radius but are not accessible within a 50-meter walk from the street vendor of interest.

Similar to the clustering comparison, I used a randomly picked equal-size sample of 200 street vendors and a subset of 150 F&B vendors to generate the Moran's I index in the relative term. This exercise will control for street vendor growth and capture the true comparison in street vendors' clustering phenomenon. I used GeoDa to run Moran's I by using the following formula:

$$I = \frac{\Sigma_i \Sigma_j \, \mathrm{w}_{ij} \, \mathrm{z}_i \, . \, \mathrm{z}_j / \mathrm{S}_0}{\Sigma_i \, z_i^2 \, / \, n}$$

With w_{ij} indicating the elements of the spatial weight matrix, n stating the number of total observations, S_0 referring to the sum of all weights ($\sum_i \sum_j w_{ij}$), and z_i stipulating the deviation of a variable x from its means x. When the Moran's I yields a value closer to 1, it indicates that street vendors attract each other while a value closer to -1 suggests that street vendors repel each other. Moran's I's value of 0 implies that the spatial configuration of street vendors is random.

Spatial lag regression

I use regression to quantify the relationship between street vendor's presence, deliverability metrics, and pedestrian accessibility metrics to points of interest on average. As discussed in the *Data* section, I use the surveyed 6,590 street points as our unit of observation, where each point will have a value of 1 when there is at least 1 street vendor in the street point's proximity or 0 otherwise. Therefore, street vendor presence becomes the model's *dependent variable*. On the other hand, I have two groups of *independent variables* that explains the potential factors behind street vendor's location choice: *deliverability* and *pedestrian accessibility* metrics. The former quantifies how strategic is a street vendor location for delivery services and the latter quantifies how strategic is a street vendor location for pedestrian customers originating from the POI. The deliverability metrics include street width and delivery motorcycle ojek access to population centers measured by gravity index. Whereas the pedestrian accessibility to the POI includes gravity indices to traditional markets, shopping malls, hospitals, medical clinics, mosques, churches, elementary schools (*sekolah dasar/SD)*, junior high schools (*sekolah menengah pertama/SMP)*, high schools (*sekolah menengah atas/SMA*), university, and open spaces within 400-meter distance from a street vendor.

Before running any spatial regression, I used linear regression to check for spatial autocorrelation in our model and determine which spatial regression model to use. By using GeoDa and its Python package PySal, I ran an ordinary least squares regression (OLS) analysis to estimate the relationship between the independent variables and dependent variable while generating indicators measuring spatial autocorrelation such as Moran's I, Lagrange multiplier, and robust Lagrange multiplier. From the OLS, I find that the robust Lagrange multiplier results for both the spatial lag model are statistically significant, suggesting that a spatial lag model would be most appropriate. The OLS regression equation is described as follows:

$$Y_i = \alpha + \beta' X_{deliverability} + \gamma' X_{pedestrian\ accessibility} + \varepsilon$$

Where Y is the dependent variable and alpha (α) is the intercept. I have two vectors on the right-hand side. $X_{deliverability}$ is a vector of independent variables that constitute our deliverability metrics and $X_{pedestrian\ accessibility}$ indicates a vector of independent variables describing walkability to the POI. Beta (β) and gamma (γ) are vectors of coefficients that describe the relationship between each independent variable and street vendor presence. Epsilon is the error term in the regression.

The spatial lag model introduces *spatial lag parameter* or rho (ρ) as another coefficient to the OLS regression model. Rho indicates the model's spatial autocorrelation, or the likelihood that street vendor location is correlated to other vendors that have spatial presence nearby, as indicated by the spatial weight matrix. The spatial weight matrix is consistent with the one used to calculate Moran's I in the previous subsection. As discussed in Chapter 3, the neighboring relationship is defined by a 50-meter network distance, which means that two vendors that are located 50-meter away can be considered neighbors.

Therefore, rho can indicate street vendors' clustering preferences. For example, a larger rho in the 2019 analysis would suggest that street vendors' clustering preferences are stronger in 2019. As rho absorbs for spatial autocorrelation, the regression coefficient results (beta and gamma) in the independent variable are no longer confounded by the endogenous clustering effect and the beta and gamma coefficients describe the association between each independent variable and the presence of street vendors in a more accurate way. The spatial lag model is summarized in the following equation:

$$Y_i = \alpha + \rho W_{50} + \beta' X_{deliverability} + \gamma' X_{pedestrian\ accessibility} + \varepsilon$$

Where rho is the spatial lag parameter and W_{50} is the *n* by *n* spatial weight matrix describing the neighbor relationship of *n* number of street vendors using 50-meter as the distance threshold.

I ran separate regressions to describe and compare the phenomenon in 2014 and 2019. They will be distinguished by the dependent variable; one set of regressions uses the street vendor presence in 2014 and the other one uses street vendor presence in 2019. To answer this question, I run the regression on all kinds of street vendor, which includes F&B and non-F&B vendors. I also run the regression on two different sample sizes: the full sample and the randomly-picked equal size sample. The full sample means that I include all surveyed vendors in the data in 2014 and 2019 as the sample. This allows for a different sample size in the two regression models which result would be closer to the real-world perception of location preference but are not comparable. This result is called the result in the absolute term.

Conversely, using randomly-picked equal size sample generate result in the relative term. Equal-size sample eliminates street vendor growth as a confounding variable resulting in comparable regression results between 2014 and 2019. Therefore, the comparison of rho and regression coefficients in the relative term will indicate the change in the importance of clustering, deliverability, and pedestrian access to points of interest which would be a closer estimate of a causal relationship compared to the result in absolute term.

Within the regressions in the relative term, I run 2 sets of regression for all kinds of street vendor and F&B vendors. First, I run spatial regression on 200 randomly selected street vendors of all types in 2014 and 2019 (Figure 19) to answer Question 3. Second, I run the same regression on 150 randomly selected street vendors in 2014 and 2019 that *only* sell food and beverage, which I will uncover in more detail in Question 4 subsection. In either regression, the street vendors are aggregated to the 6,590 street points as the unit of analysis. The results from the former will be used as a benchmark to compare the results from the latter to understand the change in location factor importance specifically for F&B vendors to answer Question 4.

I also ran a parsimonious regression model to generate a more robust result. This means that I ran another round of spatial lag regression where I excluded variables that generated coefficients that are not statistically significant at a 75% confidence interval (CI). In results, I focus on the statistically significant variables that experience a coefficient change larger than 10%, either positive or negative.

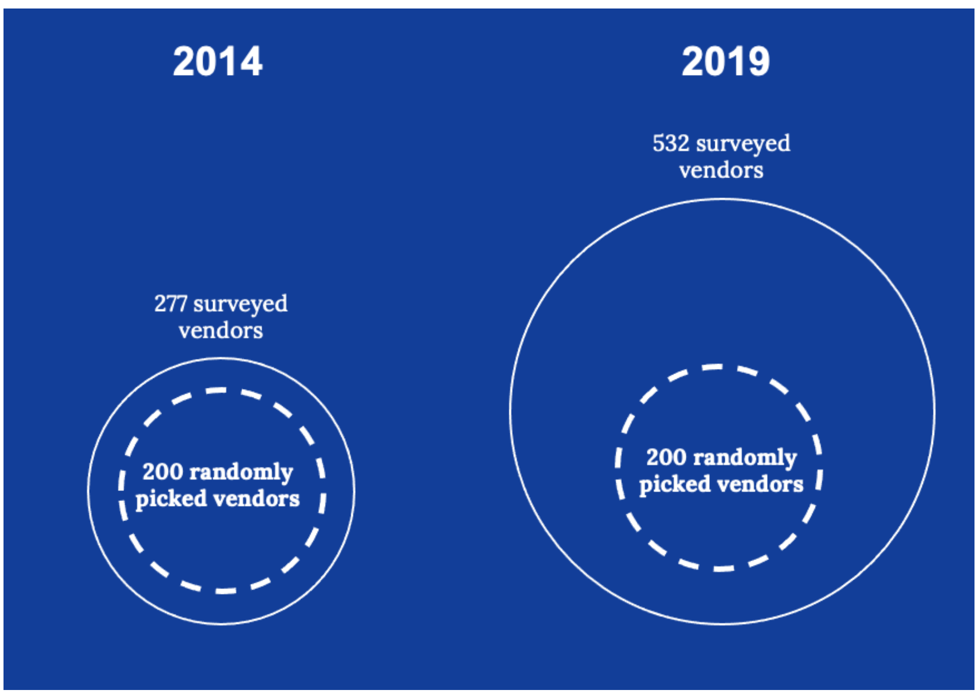


Figure 19. Relationship diagram of the different sets of sample size. Regression result at the absolute term describes regression result using the all of the surveyed vendors while regression result at the relative term describes regression result using the randomly picked sample size, which have equal size in 2014 and 2019.

The result of the regression on street vendors of all types provides a baseline condition to determine if F&B vendors' location preference has changed. It allows me to compare if the magnitude of change in F&B vendors' location preferences is stronger or weaker compared to all kinds of street vendors between 2014 and 2019.

4.4.2 Findings

The data analysis shows that clustering is just as important for all kinds of street vendor in 2019 as it was in 2014. The result from three separate analyses on clustering agreed that the change in clustering indicators is negligible. The UNA clustering analysis shows that the number of clusters has reduced from 11 in 2014 to 9 in 2019 while the average vendor size has increased from 6.2 to 7.5.

While the UNA analysis indicates a decrease in cluster size, statistical analysis shows that the magnitude of change is negligible. Our calculation of Moran's I yields a result of 0.078 in 2014 and 0.077 in 2019, which suggests a decrease of only 1.3%. Additionally, the spatial autocorrelation coefficient generated by the spatial lag regression also yielded a minimal change of 2%, as it decreased from 0.35 in 2014 to 0.34 in 2019 (Table 2). The change suggests that the probability for a street vendor to be adjacent to other street vendors at a 50-meter distance is 35% in 2014 and 34% in 2019. All analyses were done on an equal size randomly picked sample to remove street vendor growth as a confounding variable.

Both Moran's I index and the change in spatial autocorrelation coefficient suggested a very marginal change. Therefore, I conclude that street vendor preferences towards clustering have not changed from 2014 to 2019 among all vendors as a group.

4.5 Question 3: Have location choice preferences changed for street vendors between 2014 and 2019? If so, how?

4.5.1 Methods

The spatial lag regression also generates coefficients explaining the association of individual location choice factor and street vendor presence. As we have equal size sample in both years, we can compare the values of coefficients that are both statistically significant in 2014 and 2019. This comparison will indicate the change of importance in location choice factor in percentage terms. Coefficients that have less than 10% change in positive or negative term can be treated as negligible.

4.5.2 Findings

The result from spatial lag regressions in the absolute term suggests that deliverability metrics and walkability to market became more important factors for the location preferences of all kinds of street vendor in 2019. This sample includes F&B vendors and non-F&B vendors who in theory could use goods delivery services. Yet, the finding indicates that without controlling for street vendor growth, foot traffic remains important for street vendors despite the rise of delivery services and that walkability to market's importance grows concurrently with deliverability. However, variables that generate positive coefficients in the regression with the full sample (Appendix A), produced negative coefficients in the regression with the randomly picked equal size sample (Table 2) suggesting that the growth of street vendor presence indeed confounded the result in the absolute term regression.

When controlling for growth, the relative term regression coefficients of deliverability metrics and walkability to open space became weaker in 2019, while walkability to markets remains stagnant. This relationship indicates that an average street vendor perceives deliverability and walkability to open space to be less important after the rise of delivery apps. Yet, walkability to markets remains as important in 2019 as it was in 2014. The findings from the regression in the relative term reveal the true relationship that is closer to causality while the findings from the regression in absolute term are closer to the real-life perception of location, adjacency, and density.

I also found a few other different results between the regression in the absolute and relative term. In the absolute term, pedestrian access to open space becomes more important as well, however, the coefficients are no longer statistically significant even at a 75% confidence interval. Additionally, pedestrian access to health clinics becomes less important in 2019 in this model and it is statistically significant.

	Randomly picked equal-size sample n = 200		Randomly picked equal-size sample n = 200					
	SL 2014		SL 2019		% Change	Ratio 2014	Ratio 2019	% Change
Vendors of all kinds	Coefficient	t-statistic	Coefficient	t-statistic				
Rho	**0.3463*** **	**13.7543**	**0.3378*** **	**13.2775**	**-2%**	1	1	
Constant	-0.0020	-0.1931	-0.0012	-0.1229		-0.00576	-0.00364	-37%
Population center (Gravity, 3km)	**3.87E-06†**	**1.4854**	**3.31E-06†**	**1.3112**		0.00001	0.0000098	**-12%**
Street width	**0.0013†**	**1.5492**	**0.0011†**	**1.3418**		0.003627	0.003118	**-14%**
Market (Gravity, 400m)	**0.0230*** **	**4.1110**	**0.0209*** **	**3.8545**		0.066447	0.06175	**-7%**
Mall (Gravity, 400m)	-0.0305	-1.1190	0.0219	0.8291		-0.08807	0.064751	-174%
Clinic (Gravity, 400m)	**0.0213***	**1.7339**	-0.0075	-0.6291		0.061469	-0.0221	-136%
Hospital (Gravity, 400m)	**0.0282†**	**1.5701**	-0.0064	-0.3664		0.081317	-0.01881	-123%
Mosque (Gravity, 400m)	**-0.0063†**	**-1.5495**	0.0010	0.2647		-0.01821	0.003083	-117%
Church (Gravity, 400m)	-0.0052	-0.7471	-0.0069	-1.0149		-0.01507	-0.02033	35%
Elementary school (Gravity, 400m)	0.0006	0.1625	**-0.0050†**	**-1.3588**		0.001796	-0.01493	-931%
Middle school (Gravity, 400m)	0.0032	0.4067	**0.0117†**	**1.5428**		0.009203	0.034709	277%
High school (Gravity, 400m)	0.0011	0.1776	0.0049	0.7759		0.003316	0.014386	334%
University (Gravity, 400m)	-0.0105	-0.7457	0.0131	0.9592		-0.03035	0.038761	-228%
Open space (Gravity, 400m)	**0.0016***	**1.7092**	**0.0011†**	**1.1739**		0.004752	0.003236	**-32%**
Mean dependent var	0.0303		0.0303					
SD dependent var	0.1940		0.1876					
R-squared	0.0451		0.0428					
Sigma-square	0.0359		0.0337					
S.E. of regression	0.1895		0.1835					
Log Likelihood	1,579.8500		1,793.8300					
Akaike Informationo Criterion	-3,129.6900		-3,557.6700					
Schwarz	-3,027.7900		-3,455.7700					

Note: Regression is done on the randomly picked equal size sample of street vendors selling all kinds of goods. From all street vendor observations in 2014 and 2019, I picked 200 vendors at random, aggregate them to 6,590 street points as the unit of analysis, and run the regression only on that subset.

Statistical significance:
† : 75% confidence interval; * : 90% confidence interval; ** : 95% confidence interval; *** : 99% confidence interval.

Table 2. Result from the regression with the equal-size randomly drawn street vendor sample of all kinds

4.6 Question 4: Do clustering and location choice preferences differ between food and beverage vendors and vendors selling other goods? If so, how and why?

4.6.1 Methods

Quantitative approach

I subset the vendors who are exclusively selling food and beverage products from the original dataset before running the statistical analyses and spatial lag regression. Similar to the previous questions, I randomly picked equal-size sample of 150 F&B vendors in each year's dataset to control (Figure 20) for the F&B vendor growth and aggregate them to the 6,590 street points as the unit of analysis. This allows me to directly compare the results from Moran's I statistics and spatial lag regression in the relative term. Comparing the Moran's I result and spatial lag parameter (rho) between the two-year datasets will reflect the change of clustering preferences for F&B vendors. While, the comparison of the regression coefficients will reveal the change of location choice factors' importance for F&B vendors. Similar to the previous regression method, I will also run a parsimonious regression for a more robust result. In the end, I will compare the percentage change of clustering and location choice preferences for F&B vendors with street vendors on average and only consider the ones that are larger than 10% in either positive or negative term.

Qualitative interviews

I also interviewed street vendors in Surakarta remotely to discuss how and if food delivery apps affect street vendors' location preferences. The interview findings are complemented by discussions with scholars from Surakarta's Sebelas Maret University Urban Planning department, and a non-profit research body called Rame-Rame Jakarta whose work focuses on Jakarta's urban informality. The street vendor interviews were semi-structured and conducted over phone calls with compensation of Rp50,000 (US$3.1 as of March 2021) per interview. I found the vendors from GoFood's website, the country's leading food delivery service, which discloses the vendors' location and contact number. The interview questions are in Indonesian and revolved around location preferences where vendors can rank the importance of in-person transactions to delivery transactions pre-pandemic and share their rationales behind their vending location (Appendix B).

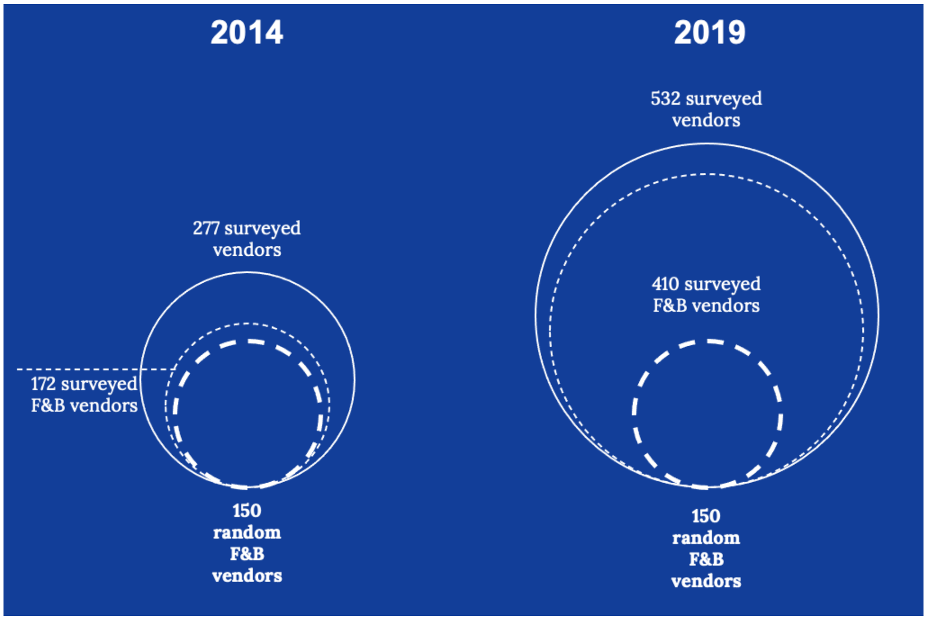


Figure 20. Relationship diagram of the different sets of F&B vendor sample size. Regression result at the absolute term describes regression result using the all of the surveyed vendors while regression result at the relative term describes regression result using the randomly picked sample size, which have equal size in 2014 and 2019.

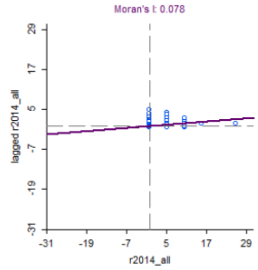
I selected and interviewed 6 street vendors in Surakarta who are registered on the GoFood website based on their level of establishment: less-established, established, very established. I categorized less-established vendors as vendors who only started vending after the emergence of FDA. Established vendors as vendors who have been in the business for a long-term before FDA and have built a regular customer base. Lastly, very well-established vendors are vendors who are not only around for a long time but also enjoyed a loyal customer base and very high popularity. They settle in different parts of the city and selling different kinds of food (Table 3). The limited sample selection suggests bias in the interview, which opens up future opportunities for a more comprehensive interview.

Interviewees	n	Institutions	Location
Less established vendors	2	N/A	Surakarta
Established vendors	3	N/A	Surakarta
Very established vendors	1	N/A	Surakarta
Urban Planning faculty	2	Sebelas Maret University	Surakarta
Researcher	1	Rame-Rame Jakarta	Jakarta

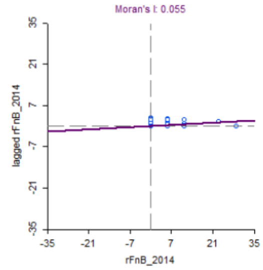
Table 3. Hierarchy of street vendor interviewees

4.6.2 Quantitative Findings

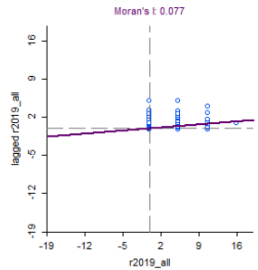
I found a more pronounced change in location and clustering preferences for F&B street vendors compared to street vendors on average (Figure 21 and Table 4). First, F&B vendors' preference towards clustering has weakened more considerably compared to street vendors on average. The Moran's I index for F&B vendors has decreased from 0.055 in 2014 to 0.037 in 2019, indicating a 32.7% decrease. Second, the spatial lag regression of the equal-sized randomly picked F&B vendors also found that the spatial autocorrelation coefficient has decreased from 0.27 in 2014 to 0.20 in 2019, reflecting a 25% drop (Table 4). This result also suggests that the probability for an F&B vendor to be located at a point where all other points contain F&B vendors in a 50m network radius has decreased from 27% to 20% between 2014 and 2019. Third, I also found that in 2019, F&B vendors' preference to be accessible from a traditional market is 24% weaker, while delivery ojek accessibility to population centers within a 3-kilometer network radius is 53% stronger. However, we cannot omit the minimal change in the importance of pedestrian access to open space. Thus, adding a nuance in understanding the change of street vendor presence predictors amidst the rise of FDA.



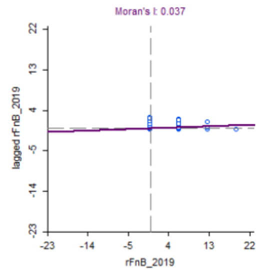
Equal size randomly picked vendors of all kinds in 2014 (n = 200), Spatial Weight = 50m



Equal size randomly picked F&B vendors in 2014 (n = 150), Spatial Weight = 50m



Equal size randomly picked vendors of all kinds in 2019 (n = 200), Spatial Weight = 50m



Equal size randomly picked F&B vendors in 2019 (n = 150), Spatial Weight = 50m

Figure 21. Moran's I comparison between vendors of all kinds and F&B vendors

	Randomly picked equal-size sample n = 150		Randomly picked equal-size sample n = 150					
	SL 2014		SL 2019		% Change	Ratio 2014	Ratio 2019	% Change
Vendors of all kinds	Coefficient	t-statistic	Coefficient	t-statistic				
Rho	**0.2742*** **	**10.0204**	**0.2044*** **	**6.95**	**-25%**	1	1	
Constant	-0.0025	-0.268	0.0005	0.0552		-0.00907	0.002281	-125%
Population center (Gravity, 3km)	**2.8E-06***	**1.7733**	**5.4E-06** **	**2.227**		1.51E-05	2.32E-05	**53%**
Street width	**0.0014** **	**1.9743**	0.0003	0.5139		0.005249	0.001664	-68%
Market (Gravity, 400m)	**0.0193*** **	**3.8461**	**0.011** **	**2.4237**		0.070392	0.053799	**-24%**
Mall (Gravity, 400m)	-0.0065	-0.2671	**0.0274†**	**1.2303**		-0.02384	0.134115	-663%
Clinic (Gravity, 400m)	0.0026	0.2372	**-0.0122†**	**-1.2182**		0.009521	-0.05975	-728%
Hospital (Gravity, 400m)	0.0172	1.0699	-0.0019	-0.1297		0.06281	-0.00928	-115%
Mosque (Gravity, 400m)	**-0.0086** **	**-2.3414**	-0.0012	-0.3711		-0.03128	-0.00603	-81%
Church (Gravity, 400m)	-0.0028	-0.449	**0.0105***	**1.8376**		-0.01027	0.051427	-601%
Elementary school (Gravity, 400m)	0.0018	0.5107	0.0017	0.5309		0.006406	0.008128	27%
Middle school (Gravity, 400m)	0.0049	0.689	-0.0053	-0.8336		0.017693	-0.02613	-248%
High school (Gravity, 400m)	-0.0009	-0.1487	**-0.0065†**	**-1.2372**		-0.00315	-0.03202	916%
University (Gravity, 400m)	**-0.0165†**	**-1.3004**	-0.0009	-0.0748		-0.06009	-0.00422	-93%
Open space (Gravity, 400m)	**0.0011†**	**1.3069**	0.0008	1.0172		0.004119	0.00391	**-5%**
Mean dependent var	0.0228		0.0228					
SD dependent var	0.1727		0.1561					
R-squared	0.0277		0.0144					
Sigma-square	0.029		0.024					
S.E. of regression	0.1703		0.155					
Log Likelihood	2298		2928.32					
Akaike Informationo Criterion	-4566		-5826.63					
Schwarz	-4464.1		-5724.73					

Note: Regression is done on the randomly picked equal size sample of street vendors selling food and beverage. From F&B vendor observations in 2014 and 2019, I picked 150 vendors at random, aggregate them to 6,590 street points as the unit of analysis, and run the regression only on that subset.

Statistical significance:
† : 75% confidence interval; * : 90% confidence interval; ** : 95% confidence interval; *** : 99% confidence interval.

Table 4. Result from the regression with the equal-size randomly drawn F&B vendor sample

4.6.3 Interview Findings

The interview findings suggest a minimal change in clustering and location preference for F&B vendors even after using FDA, which corroborates our quantitative model. As discussed earlier, I categorized the interviewed to 3 levels of hierarchy: less-established, established, and very established (Table 5). I identify less-established vendors for new vendors who only started vending after the birth of FDA, established vendors for vendors who have been operating for a long-term and have built a regular customer base, and very well-established vendors for vendors who are not only around for a long time but also enjoyed a loyal customer base and very high popularity. Their varying level of popularity and customer loyalty impacts how sensitive they are to traditional predictors for vending location choice. Yet, they all agreed that FDA has a negligible effect on their location preference, as the revenue generated from FDA transactions is complementary instead of substitutive of the offline transactions (Table 6).

No	Street vendor hierarchy	Kinds of food and beverage sold	Location
1	Less established vendors	Snack	Near Sebelas Maret University
2	Less established vendors	Coffee	Downtown
3	Established vendors	Substantial meal	Near Sebelas Maret University
4	Established vendors	Snack	Near Sebelas Maret University
5	Established vendors	Snack	Downtown
6	Very established vendors	Substantial meal	Downtown

Table 6. Hierarchy of street vendor interviewees

Less-established vendors found clustering, and walkability to points of interest extremely important for location choice as they rely on incidental purchases that are encouraged by low search cost. In our interview, the less-established vendors are young and well-educated university students who see vending as a path to entrepreneurship. Yet, despite being technologically savvy, most of their transactions are offline. They believe FDA alone is not sufficient to market their goods and build a customer base despite promotions and discounts offered by FDAs for customers ordering from new vendors. This validates that physical presence and foot traffic remain important for new vendors to enter the market.

Interestingly, established vendors are still sensitive to location despite having a regular customer base. I interviewed a few adjacent vendors located within a walking distance from Surakarta's Sebelas Maret University (UNS) campus. Their customer base consists of students who both study in the nearby campus or live in shared-housing facilities with limited kitchen amenities. For this group of vendors, FDA transactions are only significant during inclement weather, when customers find challenges to walk or ride personal motorcycle to dine in. This phenomenon is not limited to vendors who are selling substantial food like rice-based dish, but also vendors who are exclusively selling snacks and light bites. However, FDA transactions on a regular day remain supplementary as their customer base is predominantly cost-sensitive university students who are disincentivized by FDA's delivery fee and vendor's higher price. Vendors mark up the price of products that are sold on FDA to offset the app-imposed service fee of 30% per every online transaction. In the end, vendors prefer to remain walkable and accessible from their customers within the shortest time, as relying on FDA alone might deter their target market.

Very established vendors have a strong reputation and loyal customer base and thus are less sensitive to clustering and walkability to points of interest. The popular vendors in the interview sample have operated for more than three decades and often have a line of customers waiting for a seat. Some of these customers include tourists, as the vendors' food and their traditional vending practice are strongly associated with Surakarta's cultural identity. For this group of vendors, FDA transactions are significant not only during bad weather but also on a regular day as some customers prefer to wait at home for the food to arrive instead of waiting for a seat on the street.

Before the pandemic, the very established vendors have not observed FDA's cannibalization of dine-in customers as they still witness long lines of people. This might suggest that the on-street dining experience remains an attractive quality that is capitalized by this group of F&B vendors. One vendor mentioned that FDA was life-saving during the pandemic as they had to temporarily shut down their vending location and transition into a home-based delivery-only business. Despite this experience, they still prefer to be vending on the street as they realized the marketable cultural value associated with the traditional vending practice. Ultimately, they wish to be operating in a permanent place to expand their dine-in capacity and improve dining experience while retaining the traditional street vending characteristics such as preparing meals in front of the customers using low-tech appliances. Yet, their location preferences remain similar to the pre-FDA times.

Except for the less-established vendors, all vendors have never changed location after the rise of FDA and perceive that their current location is already optimal. While technically street vendors can be itinerant, most F&B vendors stick to a permanent place for logistics and economic reasons. F&B vendors find it easier for customers to associate a vendor with a permanent site location, especially vendors who are strategically located in a walking distance from points of interest. Therefore, most F&B vendors are sensitive to location change, except for extremely popular vendors whose customers include people from different parts of the city and tourists.

No	Question	Vendor #1	Vendor #2	Vendor #3	Vendor #4	Vendor #5	Vendor #6
1	Vendor hierarchy	Less established	Less established	Established	Established	Established	Very well-established
2	What kind of F&B are you selling?	Snack	Coffee	Chicken rice	Snack	Snack	Chicken satay
3	Name the closest location to your vending spot	Sebelas Maret University	Downtown	Sebelas Maret University	Sebelas Maret University	Downtown	Downtown
4	What is your physical typology?	Pushcart	Pushcart	Pushcart, tent	Pushcart	Pushcart, tent	Carrying pole, tent
5	How many employees (including yourself)?	3 (family relatives)	3 (includes co-founders /friends)	2 cooks at home; 2 staff members on site	2 (includes spouse)	3 (includes spouse)	2 (includes spouse)
6	How long have you been on any delivery app?	3 weeks	9 months	2 years	2 years	1 year	2 years
7	How long have you been in your current location?	2 months	9 months	7 years	3 years	9 years	At least 15 years
8	*Have your location criterias changed over the past 5 years?*	N/A	N/A	No	No	No	No
9	*Can you estimate how many of your customers walk to your vending location? (1: Very few of them, 5: Most of them)*	2	2	4	5	2	3

No	Question	Vendor #1	Vendor #2	Vendor #3	Vendor #4	Vendor #5	Vendor #6
10	*Can you estimate how many of your customers ride scooter or drive to your vending location? (1: Very few of them, 5: Most of them)*	4	4	5	4	5	3.5
11	*Can you estimate how many of your customers use delivery apps?*	0	1	5	4	3	4
12	*How important is it for you to be located close to other vendors?*	5	4	4	5	5	3
13	*What other places in the city do you want to be near to your vending location?*	Public space, designated food court	Mosque, places of employment, and iconic destinations.	Satisfied with current location. Wishes to have another branch in downtown area.	Satisfied with current location.	Satisfied with current location. Wishes to have a mosque nearby.	Satisfied with current location
14	*In general, do you think food delivery app has changed vending location choice?*	Not really. Ojek drivers like to cluster around F&B vendors instead	Not really.	Slightly. Knows 1-2 vendors moved to a more strategic point.	Slightly. Customers prefer vendors that are closer in proximity for lower transportation cost/delivery fee.	Not really. Street vendor cluster remains important.	Less popular vendors move to a more strategic point.
15	*If so, how important? (1: Very unimportant, 5: Very important)*	3	3	3	4	3	3

Table 6. Matrix of the answers from 6 interviewed street vendors

The heterogeneous perception towards location preference within F&B vendors is also reflected in a much larger city like Jakarta. The city has more than 10 million inhabitants hailing from different parts of Indonesia, a substantially richer population, extensive urban sprawl, and perpetually congested traffic, which makes the FDA's convenience more attractive to customers (Rame-Rame Jakarta, 2020). Rags-to-riches anecdotes of vendors after joining an FDA are well reported, including a humble banana fritter stall that became a permanent store and the best-selling product on GoFood (Siregar, 2020). Based on our discussion with Rame-Rame Jakarta, a research body focusing on street vending and informal economy, change in street vending location preferences is less likely in space-constrained Jakarta.

A street vendor in Jakarta often needs to have an amicable relationship with local and neighborhood level stakeholders such as local security forces (*satpam*), head of the community (*rukun warga/RW*), and fellow vendors. In highly diverse and densely populated Jakarta, trust-based relationships can be more difficult to forge between people of different demographic groups. Yet, the trust-based relationships are informal mechanisms that are important for vendors to operate safely. Therefore, vendors who already have an amicable relationship with local stakeholders might find relocating costly, except if they are relocating to a permanent structure in which informal relationship is no longer necessary. Moreover, the enormous metropolitan population of 30 million people and heavily-used public transit system means a lot higher foot traffic that is beneficial for street vendors. I have also observed social camaraderie between interviewed vendors in Surakarta, though a more comprehensive research is necessary to understand the strength of personal relationship as a location choice factor.

Despite Surakarta's small size, most vendors noted that FDA penetration within F&B vendors is rather high. One vendor suggested that 80% of F&B vendors in their vending cluster use FDA. However, all vendors agreed that walkability to points of interest and clustering remain important for their business survival. They perceive accessibility by delivery ojek as a benevolent by-product of being located in a strategic location in the first place. Some of our interviewed vendors reported that they know other less-established vendors who relocated to a more suitable location for delivery pickup. However, it is not clear if the vendors move for better delivery accessibility or higher pedestrian visibility, as they are correlated.

Interestingly, few vendors observed that many delivery ojek drivers often rest and set up a basecamp (*pangkalan*) nearby F&B vendor clusters to gamify the FDA's driver-matching algorithm. By being closer to vendor clusters, FDA ojek drivers are more likely to be matched to a food delivery job in that area. This will put the drivers at an advantage to outcompete other delivery couriers, minimize the pick-up effort, shorten task time, and generate higher revenue altogether. Ojek drivers also cluster for social reasons, as many drivers of the same basecamp often have a mutual-aid system that is specific to their basecamp (Qadri, 2021).

Local academics also corroborate the cost-sensitive nature of street vendors' customer base. Urban planning faculty in Sebelas Maret University (UNS), Rufia Andiniputri and Paramita Rahayu, pointed out that most vendors mark up their price to absorb the 30% transaction fee imposed by FDAs. The higher price could alienate their customer base who often turn to F&B vendors for affordable and fulfilling meal. This suggests that any change in location choice preference would be motivated by potentially higher, foot-traffic-driven offline transactions instead of deliverability.

4.7 Methodology limitations

Aside from data collection, there are several limitations on both the quantitative and qualitative methods. As most of our street point observation has zero street vendor presence, our regression coefficient generates a relatively high standard error. I approach this limitation by interviewing stakeholders and Indonesian-based scholars to validate our result. As international travel is limited during the COVID-19 pandemic, the interviews are conducted remotely using WhatsApp call from Massachusetts. This condition limits the number of interviews, as I relied on the GoFood website and information from Google and Google Maps to establish contacts with street vendors. The interview might not be representative of the total street vendor population in Surakarta, which calls for more comprehensive future research.

Chapter 5: Conclusion

While online commerce and delivery services restructure retail and F&B establishments landscape in the United States, street vendors in Surakarta seem to be more resilient. The street vendors' presence in the sample nearly doubled while F&B vendors' presence more than doubled before and after the rise of delivery apps. Yet, interview findings suggest that clustering and pedestrian accessibility remains important despite the introduction of delivery services.

In a rapidly developing and urbanizing region like Surakarta, rural-urban migration soars and street vending provides a low-barrier entry for survival. Even for established vendors with employees, the overhead cost is still low as labor cost is relatively small especially when the employees are related. Moreover, the progressive government attitude and policy towards street vending encourages new street vendors and removes the tension between the state and vendors commonly observed in other parts of the world. Thus, vendors in Surakarta can operate in their perceived optimal location, including places that are walkable from points of interest and existing vendor clusters. Moreover, physical presence and incidental purchases benefit new vendors who only start to build a customer base. Clustering will help this group of vendors as lowers customers' search cost and increase the probability for incidental purchases.

Despite the rise of delivery services, regression results in the relative term suggest that clustering and walkability to points of interest remain as important factors behind location choice for all kinds of street vendor. Interestingly, the deliverability factors such as access to population centers and street width are less important for location preferences in 2019. As this sample includes both F&B and non-F&B vendors who could use goods delivery services at the customers' request, the variety of goods sold in the sample could explain this result. Some vendors might provide goods and services that do not fit in the delivery model. Therefore, there is no strong evidence indicating a change in location preference for street vendors in general.

However, F&B vendors experienced a more pronounced change in the importance of clustering, deliverability, and walkability to the points of interest (Table 7). The quantitative findings of the randomly picked F&B vendor sample show that F&B vendors find clustering less important by 25% after the introduction of FDA. Other highlights include walkability to markets becoming less important by 24%, delivery accessibility to population centers becoming more important by 53%, and walkability to open space which does not change in terms of importance. These findings suggest that vendors prefer to be closer to population centers instead of points of interest, which can facilitate deliverability. However, additional research and evidence are necessary to uncover if FDA has a role in this, as interview findings indicate that FDA has minimal effect on location preference.

	Change of the importance of the independent variable in percentage term between 2014 and 2019					
	Vendors of all kind			**F&B Vendors**		
	(1) Relative term	(2) Absolute term (Spatial Lag)	(3) Absolute term (Reduced Spatial Lag)	(4) Relative term	(5) Absolute term (Spatial Lag)	(6) Absolute term (Reduced Spatial Lag)
Constant	-37%	-927%	-234%	-125%	-81%	-59%
Spatial autocorrelation	**-2%**			**-25%**		
Population center (Gravity, 3km)	**-12%**	**133%**	**168%**	**53%**	**53%**	**84%**
Street width	**-14%**	**17%**	**33%**	-68%	**-20%**	**5%**
Market (Gravity, 400m)	**-7%**	**38%**	**40%**	**-24%**	**-3%**	**1%**
Mall (Gravity, 400m)	-174%	-348%		-663%	-441%	
Clinic (Gravity, 400m)	-136%	**-178%**	-154%	-728%	-317%	
Hospital (Gravity, 400m)	-123%	-164%		-115%	-207%	
Mosque (Gravity, 400m)	-117%	-124%		-81%	-127%	
Church (Gravity, 400m)	35%	-124%		-601%	-252%	
Elementary school (Gravity, 400m)	-931%	-282%		27%	-125%	
Middle school (Gravity, 400m)	277%	-152%		-248%	-250%	
High school (Gravity, 400m)	334%	-24%		916%	-816%	
University (Gravity, 400m)	-228%	-208%		-93%	-177%	
Open space (Gravity, 400m)	**-32%**	44%		**-5%**	**65%**	**45%**
Equal size randomly picked sample	Yes	No	No	Yes	No	No
Reduced covariates	No	No	Yes	No	No	Yes

Table note: The percentage value is generated by comparing the regression coefficient between 2014 and 2019 that has been normalized by the spatial autocorrelation index in each year. The values are in bold when the regression coefficients in both 2014 and 2019 are statistically significant at a 75% confidence level. Values are color-coded in green to indicate positive change and in red to indicate a negative change that is larger than 10%. Columns (1) and (4) show the regression coefficient's change in percentage terms for randomly picked equal size sample, while columns (2), (3), (5), and (6) use the full sample. Columns (3) and (6) show the regression coefficients of a more parsimonious model where I only included covariates that are statistically significant in columns (2) and (5).

Table 7. Comparison of the change of location preference between 2014 and 2019 for all kinds of street vendor and F&B vendors

F&B vendors in the interview agree on the importance of vendor clustering and accessibility to customer base despite the rise of FDA. Those two reduce customers' costs, not only the search cost for customers coming to the vending site in-person but also the delivery cost for customers using delivery services. This is important as all vendors' customer base are cost-sensitive, except for very established vendors.

Therefore, higher delivery cost accrued from longer delivery trips could deter vendors' target market. Additionally, vendors mark up their prices on FDA to absorb the additional 30% commission charge collected by FDA company. Therefore, customers are only willing to pay extra in special circumstances, like extreme weather conditions. Conversely, very established vendors enjoy revenues from FDA orders more consistently as their customer base is more diverse, which often includes groups of people who can afford the extra cost of convenience. For them, however, FDA still do not substitute in-person transactions. This suggests that the search cost that is lowered by FDA is not low enough to substitute transportation cost accrued from in-person transaction. Ultimately, FDA transactions are still more expensive than offline transaction.

These factors could explain vendors perception of FDA as complementary instead of substitutive. Thus, none of the vendors believes that FDA will supplant their offline operation and alter location choice preferences for them. All vendors except for the less-established ones perceive their current location to be optimal for in-person customers and are happy about it. While very established vendors enjoy higher online transactions compared to other groups of vendors, they believe that the street dining experience is a unique value that FDA will never be able to replicate. Interestingly, this view is also shared by governments of developed cities like Tokyo and Singapore who reintroduced traditional vendors to streets as they recreate the cultural experience associated with street vending (Gent, 2019). Similarly, Los Angeles, CA also has a policy to protect and legalize street vendors (WIEGO, 2018). However, all vendors in the sample wish to eventually have a permanent and sheltered stall where customers can enjoy the street vending experience without compromising on comfort.

Interview findings also anecdotally suggest that FDA bears minimum effect on street vendors' location preferences in Surakarta and even in a much larger and wealthier city like Jakarta. Despite the higher number of online transactions compared to Surakarta's, anecdotes hint that street vendors do not relocate to places with better deliverability. This could be correlated with the spatial constraints in larger and denser cities, where space is even more limited and contested compared to Surakarta. Such contestation is associated with a more complex stakeholder and social relationship, which is an important currency that enables informal street vending and hard to replicate. Regardless, quantitative study and interview with larger sample size can confirm the validity of these findings

Instead, our interview suggests delivery drivers maybe locating closer to vendors. The apps' matching algorithm may motivate delivery drivers to cluster or stand-by around food providers as the platform matches delivery jobs to drivers based on spatial proximity from the food provider. This suggests that the high competition within ojek drivers might drive transportation cost for delivery drivers and delivery fee for delivery customers to be low enough so that vendors are not motivated to optimize their location purely for delivery purposes.

Indeed, larger sample size and more comprehensive independent variables will increase the precision of the data analysis, minimize omitted variable bias, and generate a more robust result that could inform future policies. Studying areas with no street vendor presence could also lead to better understanding of vendors' location preferences. As FDA continue to rapidly penetrate street vending and enjoy an amicable relationship with the state, future studies could lead to a significantly different result, especially in larger, wealthier, and more inequal cities. Varying attitude towards vendors across cities in the Global South could also lead to different results.

Despite the potential heterogeneity in cities across the Global South, FDA's hegemony of retailer's data and its proprietary status put city governments at a disadvantage to analyze the FDA effects in their entirety, especially in data-poor contexts. Studies around FDA's cannibalization in the United States and informal laborer-exploiting practice of ride-hailing companies in Indonesia (Rochmyaningsih, 2021; Qadri, 2020) should be a cautionary tale for street vendors' welfare and city government as policymakers. Therefore, authorities should create better data infrastructure either by pursuing data sharing agreements with FDA, partnering with private companies, or investing in an internal data capacity to run better analyses. As the Indonesian decentralized government system allows municipalities to regulate ride-hailing and FDA companies, cities can impose data sharing agreement as a part of the tech companies' obligation before entering the city. Yet, any initiative is only beneficial for the public when city governments acknowledge street vendors and their customers as the city's constituents instead of an out-of-place element.

This calls for city governments in the Global South to not only invest in better street vendor data but also follow Surakarta's lead in street vendor legalization. As online platforms expand amidst rapidly urbanizing population, policymakers are accountable to serve the interests and address the needs of their constituents, including street vendors who aspire for a better quality of life. The democratic institutions and diplomatic relationship between the state and the informal economy put vendors in Surakarta at an advantage, as demonstrated by the peaceful street vendor relocation in the past. A similar participatory framework equipped with better data will advance civic engagement processes to make walkable streets, provide community spaces, activate local economies, and enable pathways for the lower-income population groups to a better livelihood — all through the humble means of street vending.

Yet even through democratic processes, street vendor relocation had limited success in Surakarta as many relocated vendors returned to the streets. As this thesis shows, street vendors continue to grow amidst rapid economic growth, rely on pedestrian customers even in the age of delivery apps, and are still important for cities. As many other cities in Southeast Asia and across the Global South follow Singapore's vendor relocation model, there is a need for future research to envision vendors as an inherent part of the streets through design and policy. Ultimately, this thesis provides the first iteration of evidence that despite the online platforms, the pushcarts are here to stay.

Appendix A

Vendors of all kind	Full sample n = 277 OLS 2014		Full sample n = 532 OLS 2019		Spatial Lag 2014		Spatial Lag 2019		SL 2014 - Ratio	SL 2019 - Ratio	Change in percentage
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic			
Rho					0.4213	**18.4714**	0.4427	**20.0251**	**1**	**1**	0%
Constant	0.0014	0.1362	-0.0061	-0.4463	0.0006	0.0611	-0.0052	-0.396	0.001	-0.0117	-927%
Population center (Gravity, 3km)	0.0000059	**2.315**	0.0000148	**4.3229**	0.0000034	**1.3677**	0.0000083	**2.4923**	**0**	**0**	**133%**
Street width	0.0028	**3.5314**	0.0031	**2.9203**	0.0016	**2.0758**	0.002	**1.9064**	**0.004**	**0.0044**	**17%**
Market (Gravity, 400m)	0.0401	**7.4196**	0.0614	**8.432**	0.024	**4.4988**	0.0347	**4.8503**	**0.057**	**0.0785**	**38%**
Mall (Gravity, 400m)	-0.0227	-0.8526	0.05	**1.3955**	-0.0134	-0.5179	0.0348	1.0053	-0.032	0.0787	-348%
Clinic (Gravity, 400m)	0.0374	**3.1207**	-0.0323	**-1.9996**	0.0233	**2.0014**	-0.0192	**-1.2336**	**0.055**	**-0.0435**	**-178%**
Hospital (Gravity, 400m)	0.0424	**2.426**	-0.0289	**-1.2269**	0.0244	**1.4347**	-0.0165	-0.7263	**0.058**	-0.0374	-164%
Mosque (Gravity, 400m)	-0.0132	**-3.3329**	0.0028	0.5221	-0.0076	**-1.96198**	0.001902	0.368034	**-0.018**	0.0043	-124%
Church (Gravity, 400m)	-0.0145	**-2.1281**	0.003	0.3252	-0.0084	**-1.2686**	0.0021	0.2388	**-0.02**	0.0048	-124%
Elementary school (Gravity, 400m)	0.0018	0.4928	-0.0072	**-1.4358**	0.0015	0.4236	-0.0029	-0.6046	0.004	-0.0067	-282%
Middle school (Gravity, 400m)	0.0055	0.7158	-0.0031	-0.2984	0.0024	0.3229	-0.0013	-0.1327	0.006	-0.003	-152%
High school (Gravity, 400m)	0.0055	0.8666	0.0051	0.5986	0.0028	0.4599	0.0022	0.2724	0.007	0.0051	-24%
University (Gravity, 400m)	-0.0297	**-2.1579**	0.0305	**1.6457**	-0.0172	**-1.2877**	0.0195	1.0864	**-0.041**	0.044	-208%
Open space (Gravity, 400m)	0.0012	**1.3092**	0.0026	**2.0899**	0.0009	0.9742	0.0013	1.0971	0.002	0.003	44%
Mean dependent var	0.0361		0.0681		0.0361		0.0681				
SD dependent var	0.1866		0.252		0.1866		0.252				
R-squared	0.017		0.0213		0.0706		0.0848				
Adjusted R-squared	0.015		0.0194								
F-statistic	8.74	0	11.0055	0							
Log likelihood	1769.66		-196.06		1907.97		-27.3334				
Akaike info criterion	-3511.32		420.12		-3785.94		84.6669				
Schwarz criterion	-3416.22		515.226		-3684.04		186.567				
Likelihood ratio test					276.6152						
		p-value		p-value							
Moran's I	0.0770 / 18.4881	0	0.0883 / 21.1396	0							
Lagrange Multiplier (lag)	247.9713	0	324.3974	0							
Robust LM (lag)	2.5526	0.1101	0.7759	0.3784							
Lagrange Multiplier (error)	245.887	0	323.6414	0							
Robust LM (error)	0.4683	0.4938	0.0199	0.8878							
Lagrange Multiplier (SARMA)	248.4396	0	324.4173	0							

Note: Regression is done on the full sample of all kinds of street vendor.

Appendix A. Result from the regression with the full sample of surveyed all kinds of street vendor

Appendix B

1	Apa Anda menjajakan makanan dan minuman? *Are you a food and beverage vendor?*	Ya/ Yes	Tidak/ No			
2	Apa Anda menggunakan aplikasi pesan antar (GoFood/GrabFood)? *Are you using any delivery app (GoFood/GrabFood)?*	Ya/ Yes	Tidak/ No			
3	Dimana patokan tempat Anda berjualan pada umumnya di tahun 2019? *Can you name the location closest to your vending spot in 2019?*	Jawaban bebas/open ended				
4	Mengapa Anda memilih lokasi tersebut? *Why do you pick that place as your main vending location?*	Jawaban bebas/open ended				
5	Apabila Anda sudah berjualan sejak 2014, dimana patokan tempat Anda berjualan pada umumnya di tahun 2014? *If you've started vending since 2014, can you name the location closest to your vending spot in 2014?*	Jawaban bebas/open ended				
6	Apa saja kriteria pemilihan lokasi berjualan yang penting untuk Anda di tahun 2019? *What are your criterias to pick the vending location in 2019?*	Jawaban bebas/open ended				
7	Apakah kriteria pemilihan lokasi berjualan telah berubah dalam 5 tahun terakhir? *Have the criterias changed over the past 5 years?*	Jawaban bebas/open ended				
8	Kira-kira, berapa banyak pembeli yang berjalan kaki ke lokasi berjualan Anda? (1: Sangat sedikit, 5: Sangat banyak) *Can you estimate how many of your customers walk to your vending location? (1: Very few of them, 5: Most of them)*	1	2	3	4	5
9	Kira-kira, berapa banyak pembeli yang mengendarai motor atau mobil ke lokasi berjualan Anda? (1: Sangat sedikit, 5: Sangat banyak) *Can you estimate how many of your customers ride scooter or drive to your vending location? (1: Very few of them, 5: Most of them)*					
10	Kira-kira, berapa banyak pembeli yang menggunakan aplikasi pesan antar? (1: Sangat sedikit, 5: Sangat banyak) *Can you estimate how many of your customers use delivery apps? (1: Very few of them, 5: Most of them)*					
12	Seberapa penting kedekatan dengan PKL lain penting untuk keberlangsungan usaha Anda? (1: Sangat sedikit, 5: Sangat banyak) *How important is it for you to be located close to other vendors? (1: Very few of them, 5: Most of them)*					
13	Apa saja tempat lain yang Anda inginkan dekat dengan lokasi berjualan Anda? *What other places in the city do you want to be near to your vending location?*	Jawaban bebas/open ended				
14	Menurut Anda, apakah kehadiran aplikasi pesan antar mempengaruhi pemilihan lokasi berjualan untuk PKL pada umumnya? *(Ya/Tidak)* *In general, do you think food delivery app has changed vending location choice?*	Ya/ Yes	Tidak/ No			
15	Apabila iya, seberapa penting? (1: Sangat tidak penting, 5: Sangat penting) *If so, how important? (1: Very unimportant, 5: Very important)*	1	2	3	4	5
16	Apabila iya, seperti apa pengaruhnya? *If so, in what way?*	Jawaban bebas/open ended				

Appendix B. Interview questions to the street vendors in Indonesian and English

Appendix C

Vendors of all kind	Full sample n = 172 OLS 2014 Coefficient	t-statistic	Full sample n = 410 OLS 2019 Coefficient	t-statistic	Spatial Lag 2014 Coefficient	t-statistic	Spatial Lag 2019 Coefficient	t-statistic	SL 2014 - Ratio	SL 2019 - Ratio	Change in percentage
Rho					0.344	**13.636**	0.436	**19.507**	1.000	1.000	0%
Constant	0.000	0.027	0.004	0.331	0.000	-0.001	0.000	0.000	0.000	0.000	-81%
Population center (Gravity, 3km)	0.000	**2.061**	0.000	**3.047**	0.000	**1.387**	0.000	**1.780**	0.000	0.000	**53%**
Street width	0.002	**3.270**	0.002	**1.954**	0.001	**2.197**	0.001	**1.484**	0.004	0.003	**-20%**
Market (Gravity, 400m)	0.026	**5.822**	0.036	**5.443**	0.017	**3.831**	0.021	**3.145**	0.048	0.047	**-3%**
Mall (Gravity, 400m)	-0.010	-0.453	0.033	**1.302**	-0.006	-0.302	0.028	0.865	-0.019	0.063	-441%
Clinic (Gravity, 400m)	0.013	**1.364**	0.015	**-2.792**	0.009	0.945	-0.025	**-1.720**	0.026	-0.057	-317%
Hospital (Gravity, 400m)	0.019	**1.367**	-0.026	**-1.219**	0.012	0.852	-0.016	-0.764	0.034	-0.037	-207%
Mosque (Gravity, 400m)	-0.010	**-3.173**	0.003	0.622	-0.007	**-2.142**	0.002	0.479	-0.020	0.005	-127%
Church (Gravity, 400m)	-0.005	-0.940	0.010	**1.225**	-0.003	-0.582	0.006	0.744	-0.009	0.014	-252%
Elementary school (Gravity, 400m)	0.002	0.603	-0.003	-0.609	0.002	0.517	-0.001	-0.111	0.004	-0.001	-125%
Middle school (Gravity, 400m)	0.003	0.485	-0.004	-0.442	0.001	0.238	-0.003	-0.300	0.004	-0.006	-250%
High school (Gravity, 400m)	0.000	0.039	0.003	0.367	0.000	-0.029	0.001	0.176	0.000	0.003	-816%
University (Gravity, 400m)	-0.024	**-2.187**	0.023	**1.326**	-0.016	**-1.463**	0.016	0.953	-0.047	0.036	-177%
Open space (Gravity, 400m)	0.001	**1.770**	0.004	**3.434**	0.001	**1.362**	0.002	**1.883**	0.003	0.005	**65%**
Mean dependent var	0.023		0.056		0.023		0.056				
SD dependent var	0.151		0.231		0.151		0.231				
R-squared	0.012		0.014		0.044		0.075				
Adjusted R-squared	0.010		0.012								
F-statistic	147.647		345.404								
Log likelihood	0.023		0.053		0.022		0.049				
Akaike info criterion	0.150		0.229		0.147		0.222				
Schwarz criterion	0.022		0.052								
Likelihood ratio test	0.150		0.229								
	6.169	0.000 p-value	6.898	0.000 p-value							
Moran's I	0.0520 / 12.6403	0.000	0.0899 / 21.5122	0.000							
Lagrange Multiplier (lag)	111.926	0.000	332.501	0.000							
Robust LM (lag)	0.0081	0.9285	2.2962	0.1297							
Lagrange Multiplier (error)	112.102	0	335.422	0							
Robust LM (error)	0.1841	0.6679	5.2177	0.0224							
Lagrange Multiplier (SARMA)	112.1101	0	337.7182	0							

Note: Regression is done on the full sample of F&B vendor.

Appendix C. Result from the regression with the full sample of surveyed food and beverage-selling vendor

References

Adama, O. (2020). Abuja is not for the poor: Street vending and the politics of public space. *Geoforum*, *109*, 14–23. https://doi.org/10.1016/j.geoforum.2019.12.012

Ariyadi, E. W., Adishakti, L. T., & Kristiadi, D. (2005). Kajian Terhadap Faktor-faktor Yang Mempengaruhi Tumbuhnya Pedagang Kakilima Pada Suatu Kawasan: Studi Kasus Kawasan Monumen Perjuangan 45 Banjarsari Surakarta (a Study on the Factors Accelerating the Growth of Vendors in a Region: a Case Study). *Journal of People and Environment*, *12*(3), 140–149. https://doi.org/10.22146/jml.18642

Ashraf, A. R., Thongpapanl, N. T., & Auh, S. (2014). The Application of the Technology Acceptance Model under Different Cultural Contexts: The Case of Online Shopping Adoption. *Journal of International Marketing*, *22*(3), 68–93. https://doi.org/10.1509/jim.14.0065

Badan Pusat Statistik. (2014). *Jawa Tengah Dalam Angka / Jawa Tengah in Figures*. https://jateng.bps.go.id/publication/download.html?nrbvfeve=YjBhM2ZlZjdmYTI3ZmZmZGU1MWE2NzBj&xzmn=aHR0cHM6Ly9qYXRlbmcuYnBzLmdvLmlkL3B1YmxpY2F0aW9uLzIwMTQvMTAvMTAvYjBhM2ZlZjdmYTI3ZmZmZGU1MWE2NzBjL2phd2EtdGVuZ2FoLWRhbGFtLWFuZ2thLTIwMTQuaHRtbA%3D%3D&twoadfnoarfeauf=MjAyMS0wNy0yMyAxOTo0NDoyMw%3D%3D

Banerjee, A., & Duflo, E. (2012). *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty* (Reprint ed.). PublicAffairs.

Batréau, Q., & Bonnet, F. (2016). Managed Informality: Regulating Street Vendors in Bangkok. *City & Community*, *15*(1), 29–43. https://doi.org/10.1111/cico.12150

BBC News. (2016, March 22). Jakarta taxi drivers protest against Uber and Grab. *BBC News*. https://www.bbc.com/news/world-asia-35868396

Bhimji, F. (2014). Undocumented Immigrants' Performances and Claims of Urban Citizenship in Los Angeles. *Journal of Intercultural Studies*, *35*(1), 18–33. https://doi.org/10.1080/07256868.2014.864624

Bhowmik, S. (2005). Street Vendors in Asia: A Review. *Economic and Political Weekly*, *40*(22), 2256–2264. https://doi.org/10.2307/4416705

Brata, A. G. (2008). Vulnerability of Urban Informal Sector: Street Vendors in Yogyakarta, Indonesia. *Theoretical and Empirical Researches in Urban Management*, 5(14), 47-58.

Choudhury, S. R. (2019, September 16). Grab says its food business could push the company to profitability. *CNBC*. https://www.cnbc.com/2019/09/16/grab-says-its-food-business-can-steer-the-company-to-profitability.html

Christaller, W. (1966). *Central Places in Southern Germany*. Prentice Hall.

Civic Economics. (2002, December). *Economic Impact Analysis: A Case Study Local Merchants vs. Chain Retailers*. http://nebula.wsimg.com/e4710ded56a36d7de033984b21a7ee02?AccessKeyId=8E410A17553441C49302&disposition=0&alloworigin=1

Collison, J. (2020). *The Impact of Online Food Delivery Services on Restaurant Sales* (Thesis). Stanford University. https://web.stanford.edu/~leinav/teaching/Collison.pdf

Cooley, C. (1894). The Theory of Transportation. *Publications of the American Economic Association*. Published.

De Soto, H. (2003). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else* (Reprint ed.). Basic Books.

Deakin, E. A. (1991). *Jobs, housing and transportation: Theory and evidence on interactions between land use and transportation*. Conference on Transportation, Urban Form, and the Environment, Irvine, California, United States.

Dewan Perwakilan Rakyat. (2015). *Ekonomi Kerakyatan dan Subversi Neokolonialisme* [Slides]. Dewan Perwakilan Rakyat. https://www.dpr.go.id/dokblog/dokumen/F_20150327_8964.pdf

Djumena, E. (2021, March 18). GoFood Ubah Skema Komisi Jadi 20 Persen+Rp 1.000, UMKM Gundah Halaman all - Kompas.com. *KOMPAS.Com*. https://money.kompas.com/read/2021/03/18/113800726/gofood-ubah-skema-komisi-jadi-20-persen-rp-1.000-umkm-gundah?page=all

Eaton, B. C., & Lipsey, R. G. (1975). The Principle of Minimum Differentiation Reconsidered: Some New Developments in the Theory of Spatial Competition. *The Review of Economic Studies*, *42*(1), 27. https://doi.org/10.2307/2296817

Evans, J., O'Brien, J., & Ch Ng, B. (2018). Towards a geography of informal transport: Mobility, infrastructure and urban sustainability from the back of a motorbike. *Transactions of the Institute of British Geographers*, *43*(4), 674–688. https://doi.org/10.1111/tran.12239

Fang, X. (2020, October 27). *Exploring the Impact of E-commerce on Cities and Villages: The Case of Amazon and Alibaba – Practical Visionaries*. Practical Visionaries. http://www.practical-visionaries.org/exploring-the-impact-of-e-commerce-on-cities-and-villages-the-case-of-amazon-and-alibaba/

Freytas-Tamura, K. (2021, March 19). Food Delivery Apps Are Booming. Their Workers Are Often Struggling. *The New York Times*. https://www.nytimes.com/2020/11/30/nyregion/bike-delivery-workers-covid-pandemic.html

Fullilove, M. T., & Merrifield, A. (2020). *Main Street: How a City's Heart Connects Us All*. New Village Press.

Gent, E. (2019). *Why street food is making a comeback in Japan*. BBC Future. https://www.bbc.com/future/article/20191007-the-amazing-innovation-of-japans-traditional-street-food

Gibbings, S. L. (2016). Street Vending as Ethical Citizenship in Urban Indonesia. *Anthropologica*, *58*(1), 77–94. https://doi.org/10.3138/anth.581.a05

Gojek Indonesia [@gojekindonesia]. (2015, December 17). *"Bapak @jokowi telah melindungi ekonomi kerakyatan sebagai fondasi kekuatan bangsa Indonesia. Majulah Indonesia!" - Nadiem Makarim (2)* [Tweet]. Twitter. https://twitter.com/gojekindonesia/status/677711296075296768

Google, Temasek, & Bain. (2019). *e-Conomy SEA 2019 Swipe up and to the right: Southeast Asia's $100 billion Internet economy*. https://www.bain.com/globalassets/noindex/2019/google_temasek_bain_e_conomy_sea_2019_report.pdf

Hack, G. (2013). *Business Performance in Walkable Shopping Areas*. https://activelivingresearch.org/sites/activelivingresearch.sdsc.edu/files/BusinessPerformanceWalkableShoppingAreas_Nov2013.pdf

Haila, A. (2019, November 24). *Urban Land Rent: Singapore as a Property State. – Land&Liberty*. Land & Liberty. https://www.landandliberty.net/urban-land-rent-singapore-as-a-property-state/#:%7E:text=90%25%20of%20land%20in%20Singapore,through%20lease%20to%20private%20enterprise.

Handy, S. L., & Niemeier, D. A. (1997). Measuring Accessibility: An Exploration of Issues and Alternatives. *Environment and Planning A: Economy and Space*, *29*(7), 1175–1194. https://doi.org/10.1068/a291175

Hansen, W. G. (1959). How Accessibility Shapes Land Use. *Journal of the American Institute of Planners*, *25*(2), 73–76. https://doi.org/10.1080/01944365908978307

Hotelling, H. (1929). Stability in Competition. *The Economic Journal*, *39*(153), 41. https://doi.org/10.2307/2224214

Huff, D. L. (1963). A Probabilistic Analysis of Shopping Center Trade Areas. *Land Economics*, *39*(1), 81. https://doi.org/10.2307/3144521

Hussain, B. Z. (2015, March 24). How Lee Kuan Yew engineered Singapore's economic miracle. *BBC News*. https://www.bbc.com/news/business-32028693

International Labour Organization. (2018, April 30). *More than 60 per cent of the world's employed population are in the informal economy* [Press release]. https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_627189/lang--en/index.htm

Isnanto, B. A. (2017, March 16). Go-Jek di Solo Hanya Boleh Layani Go-Food. *DetikNews*. https://news.detik.com/berita/d-3448949/go-jek-di-solo-hanya-boleh-layani-go-food

Jacobs, J. (1992). *The Death and Life of Great American Cities* (Reissue ed.). Vintage.

Jellinek, L. (1979). *The Life of a Jakarta Street Trader*. Amsterdam University Press.

Kohan, S. E. (2021, February 3). Amazon's Net Profit Soars 84% With Sales Hitting $386 Billion. *Forbes*. https://www.forbes.com/sites/shelleykohan/2021/02/02/amazons-net-profit-soars-84-with-sales-hitting-386-billion/

Kurnia, S., Choudrie, J., Mahbubur, R. M., & Alzougool, B. (2015). E-commerce technology adoption: A Malaysian grocery SME retail sector study. *Journal of Business Research*, *68*(9), 1906–1918. https://doi.org/10.1016/j.jbusres.2014.12.010

Kusuma, P. D. (2017). Online Motorcycle Taxi Simulation by Using Multi Agent System. *International Journal of Applied Engineering Research*, *12*(19), 9199–9208.

Lembaga Demografi Universitas Indonesia. (2019, November). *GOJEK's Impact on the Indonesian Economy in 2018*. https://ldfebui.org/wp-content/uploads/2019/11/Lembaga-Demografi-University-of-Indonesia-GOJEK%E2%80%99s-Impact-on-the-Indonesian-Economy-ENG-Nov-2019.pdf

Loayza, N. V. (2016). Informality in the Process of Development and Growth. *The World Economy*, *39*(12), 1856–1916. https://doi.org/10.1111/twec.12480

Loizos, C. (2019, June 28). *A rare glimpse into the sweeping — and potentially troubling — cloud kitchens trend*. TechCrunch. https://techcrunch.com/2019/06/28/a-rare-glimpse-into-the-sweeping-and-potentially-troubling-cloud-kitchens-trend/

Lösch, A. (1954). *The Economics of Location* (2nd Revised ed.). Yale Univ Pr.

Lucas, A. (2020, June 19). DoorDash scores valuation of $16 billion as coronavirus pushes it to top of food-delivery chain. *CNBC*. https://www.cnbc.com/2020/06/19/doordash-scores-16-billion-valuation-now-top-of-food-delivery-chain.html

Majeed, R. (2011). *Defusing a Volatile City, Igniting Reforms: Joko Widodo and Surakarta, Indonesia, 2005–2011*. Princeton University. https://successfulsocieties.princeton.edu/sites/successfulsocieties/files/Indonesia%20Defusing_ToU_1.pdf

Manullang, O. R., & Limbong, N. S. (2019). The Impact of Go-food on Travel Behaviour for The Fulfillment of Consumption Needs in Higher Education Areas. *IOP Conference Series: Earth and Environmental Science*, *396*, 012039. https://doi.org/10.1088/1755-1315/396/1/012039

Mramba, N., Apiola, M., Sutinen, E., Haule, M., Klomsri, T., & Msami, P. (2015). Empowering street vendors through technology: An explorative study in Dar es Salaam, Tanzania. *2015 IEEE International Conference on Engineering, Technology and Innovation/ International Technology Management Conference (ICE/ITMC)*. Published. https://doi.org/10.1109/ice.2015.7438651

Natawidjaja, R. S. (2015). *Inclusive governance of informal markets: the street vendors of Surakarta*. https://pubs.iied.org/sites/default/files/pdfs/migrate/17300IIED.pdf

Noble, A. G., McGee, T. G., & Yeung, Y. M. (1979). Hawkers in Southeast Asian Cities: Planning for the Bazaar Economy. *Geographical Review*, *69*(3), 356. https://doi.org/10.2307/214894

Perdana, E. A. L., Rahayu, P., & Hardiana, A. (2020). Karakteristik pedagang kaki lima dan preferensinya terhadap lokasi kawasan Solo Techno Park. *Region : Jurnal Pembangunan Wilayah Dan Perencanaan Partisipatif*, *15*(2), 172. https://doi.org/10.20961/region.v15i2.24440

Peterson, L. K. (2020, May 19). Column: Our restaurants are failing. Why should food delivery apps thrive? *Los Angeles Times*. https://www.latimes.com/food/story/2020-05-16/food-delivery-app-commissions-ubereats-grubhub-doordash

Pettersson, F., Winslott Hiselius, L., & Koglin, T. (2018). E-commerce and urban planning – comparing knowledge claims in research and planning practice. *Urban, Planning and Transport Research*, *6*(1), 1–21. https://doi.org/10.1080/21650020.2018.1428114

Pipitwanichakarn, T., & Wongtada, N. (2019). Mobile commerce adoption among the bottom of the pyramid: a case of street vendors in Thailand. *Journal of Science and Technology Policy Management*, *10*(1), 193–213. https://doi.org/10.1108/jstpm-12-2017-0074

Popper, N. (2020, November 30). As Diners Flock to Delivery Apps, Restaurants Fear for Their Future. *The New York Times*. https://www.nytimes.com/2020/06/09/technology/delivery-apps-restaurants-fees-virus.html

Qadri, R. (2020, December 28). *Delivery Platform Algorithms Don't Work Without Drivers' Deep Local Knowledge*. Slate Magazine. https://slate.com/technology/2020/12/gojek-grab-indonesia-delivery-platforms-algorithms.html

Qadri, R. (2021). Platform workers as infrastructures of global technologies. *Interactions*, *28*(4), 32–35. https://doi.org/10.1145/3466162

Rahayu, M. J., Andini, I., & Putri, R. A. (2016). Typology of Urban Hawker's Location Preferences. *Procedia - Social and Behavioral Sciences*, *227*, 239–246. https://doi.org/10.1016/j.sbspro.2016.06.067

Rahayu, M. J., Werdiningtyas, R. R., & Musyawaroh, M. (2017). Faktor-faktor yang Mempengaruhi Keberhasilan Penataan PKL sebagai Strategi Penataan Ruang Kota Surakarta. *Region: Jurnal Pembangunan Wilayah Dan Perencanaan Partisipatif*, *7*(2), 109. https://doi.org/10.20961/region.v7i2.11582
Rahayu, R., & Day, J. (2016). E-commerce adoption by SMEs in developing countries: evidence from Indonesia. *Eurasian Business Review*, *7*(1), 25–41. https://doi.org/10.1007/s40821-016-0044-6
Rahman, D. F. (2021, January 28). Indonesia's $3.7b food delivery market largest in region. *The Jakarta Post*. https://www.thejakartapost.com/news/2021/01/28/indonesias-3-7b-food-delivery-market-largest-in-region.html
Rame-Rame Jakarta. (2020). *Accommodating Informal Cities*. https://23851476-ff0b-4c2d-ae44-6ac776f19d84.filesusr.com/ugd/335292_db312490f11448d2b7522cf48bbcf360.pdf
Rochmyaningsih, D. (2021, June 23). *"Only Gojek knows this mystery."* Rest of World. https://restofworld.org/2021/only-gojek-knows-this-mystery/
Roy, A. (2009). Why India Cannot Plan Its Cities: Informality, Insurgence and the Idiom of Urbanization. *Planning Theory*, *8*(1), 76–87. https://doi.org/10.1177/1473095208099299
Roy, A., & Ong, A. (2011). *Worlding Cities: Asian Experiments and the Art of Being Global* (1st ed.). Wiley-Blackwell.
Scott, J. C. (1999). *Seeing like a State: How Certain Schemes to Improve the Human Condition Have Failed* (0 ed.). Yale University Press.
Sevtsuk, A. (2014). Location and Agglomeration. *Journal of Planning Education and Research*, *34*(4), 374–393. https://doi.org/10.1177/0739456x14550401
Sevtsuk, A. (2018). *Urban Network Analysis for Rhinoceros 3D Tools for Modeling Pedestrian and Bicycle Trips in Cities*. Harvard University Graduate School of Design.
Sevtsuk, A. (2020). *Street Commerce: Creating Vibrant Urban Sidewalks (The City in the Twenty-First Century)*. University of Pennsylvania Press.
Sharma, D. (2021, January 22). *The Convenience of Delivery Apps Is Ruining Restaurants*. Eater. https://www.eater.com/22228352/convenience-of-delivery-apps-destroying-restaurants-uber-eats-doordash-postmates
Shen, H., Faklaris, C., Jin, H., Dabbish, L., & Hong, J. I. (2020). "I Can't Even Buy Apples If I Don't Use Mobile Pay?" *Proceedings of the ACM on Human-Computer Interaction*, *4*(CSCW2), 1–26. https://doi.org/10.1145/3415241
Siregar, K. (2020, December 28). *A dash of honey: Jakarta's "burnt" banana fritters a sought-after comfort food*. Channel News Asia. https://www.channelnewsasia.com/news/asia/indonesia-jakarta-burnt-banana-fritter-honey-bu-nanik-13228756
Solo Pos. (2018, April 4). *Solo Magnet PKL, Bertambah 200 Pedagang Per Tahun*. https://www.solopos.com/solo-magnet-pkl-bertambah-200-pedagang-per-tahun-907908
Spivak, J. (2018, July). *Retail Realities | Planning magazine | July 2018*. American Planning Association. https://www.planning.org/planning/2018/jul/retailrealities/
Sudarmo, S. (2008). Governance of Surakarta's Informal Sector: Implications for the Empowerment of Marginalized Stakeholders. *Democracy and Governance for Resourcing the Commons*. Published.
Tam, A. (2019, July 26). *The Past and Future of Hawker Centres.* Urban Redevelopment Agency. https://www.ura.gov.sg/Corporate/Resources/Ideas-and-Trends/Hawker-centres
The Jakarta Post. (2015, December 18). Jokowi defends ride-hailing apps as Transportation Ministry withdraws ban. *The Jakarta Post*. https://www.thejakartapost.com/news/2015/12/18/jokowi-defends-ride-hailing-apps-transportation-ministry-withdraws-ban.html
Taylor, J., & Song, L. (2016). Return to the Streets. *Cityscape, 18*(1), 71-88. Retrieved June 22, 2021, from http://www.jstor.org/stable/26328241
The Jakarta Post. (2019, April 5). Go-Jek becomes Indonesia's first decacorn. *The Jakarta Post*. https://www.thejakartapost.com/news/2019/04/05/go-jek-becomes-indonesias-first-decacorn.html
The Jakarta Post. (2020, August 5). Gojek helps millions of local entrepreneurs digitize in fight for survival amid pandemic. *The Jakarta Post*. https://www.thejakartapost.com/adv-longform/2020/08/05/gojek-helps-millions-of-local-entrepreneurs-digitize-in-fight-for-survival-amid-pandemic.html

Tsai, L. (2020, May 18). *Survey Says 60 Percent of SF Restaurants Are Losing Money With Takeout*. Eater SF. https://sf.eater.com/2020/5/18/21262695/ggra-survey-restaurant-owners-losing-money-takeout

Tung, A. J. (2010, January 30). *Hawker centres | Infopedia*. Singapore Infopedia. https://eresources.nlb.gov.sg/infopedia/articles/SIP_1637_2010-01-31.html

United Cities and Local Government. (2010). *Empowering The Informal Sector: Street Vendor Management*. https://www.uclg-cisdp.org/sites/default/files/observatory/files/2021-06/Surakarta_EN.pdf

Wadud, Z. (2020). The effects of e-ridehailing on motorcycle ownership in an emerging-country megacity. *Transportation Research A: Policy and Practice*, *137*(C), 301–312.

Women in Informal Employment: Globalizing and Organizing (WIEGO). (2018). *Los Angeles, USA Decriminalizes Street Vendors | WIEGO*. WIEGO. https://www.wiego.org/los-angeles-usa-decriminalizes-street-vendors

Yatmo, Y. A. (2008). Street Vendors as 'Out of Place' Urban Elements. *Journal of Urban Design*, *13*(3), 387–402. https://doi.org/10.1080/13574800802320889

Yelp. (2020, September). *Yelp: Local Economic Impact Report*. Yelp Economic Average. https://www.yelpeconomicaverage.com/business-closures-update-sep-2020