Market Day Coordination, Market Size, and Rural Development*

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Abstract

Market days are the pulse of rural, economic and social life in many parts of the world and millions of people rely for their daily sustenance on weekly markets. They are also a complex coordination problem between sellers and buyers that determines who participates where and when in market exchange. I study the role of this long-standing institution in shaping agglomeration and present-day local trade patterns. I identify a natural experiment in Western Kenya in which market schedules over the past century were set quasi-randomly, inducing exogenous variation in markets competing over participants with their neighbors on the same day of the week. I find that market schedule coordination causally and lastingly affected market attendance, driven by cross-attendance from other villages, as well as present-day population and nighttime luminosity as a proxy for economic activity.

Keywords: Market days, coordination, rural development, spatial patterns of economic activity, persistence.

JEL Classification: O12, O18, Q13, R11, R12

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1 Introduction

The periodic "pulsation of economic activity" that market days spark (Hill, 1966) has been described as "one of the basic life rhythms in all traditional agrarian societies" (Skinner, 1964). At their economic core, they constitute a solution to a complex coordination problem: Bringing buyers and sellers together in the same place at same time. Rural periodic markets[1] are also the final link in the food supply chain for millions of people. Market days are the site of myriad matching problems and the livelihoods of vulnerable market participants on both sides of the transaction depend on reliably finding someone to trade with at a predictable price. This process is challenging in thin markets with few buyers and sellers and can be eased through market integration that increases market attendance. An age-old, very straightforward, and essentially costless way of increasing the attendance to weekly markets, which I study in this paper, is to schedule market days in such a way that they do not clash between neighboring villages, thus allowing buyers and sellers to cross-attend. I investigate whether this strategy meaningfully increases market attendance and how it might have influenced present-day local trade patterns and agglomeration. To do so, I identify a natural experiment in how market schedules were set in Western Kenya over the past century, which allows me to show that better schedule coordination in the distant past raises market attendance and makes a market more likely to become a commercial center today.

I first formalize a notion of market schedule coordination proposed in the geography literature. A simple regression analysis that relates outcomes of interest to such a measure of coordination quality would not identify the causal effect of schedule coordination on these outcomes. There may be other factors such as geographic fundamentals or initial conditions (e.g. in population density) that both induce some markets to synchronize their schedule more with their surroundings while simultaneously affecting the outcomes we are interested in. I provide evidence of this threat in Section 5.3. My goal in this study is to resolve this omitted variable bias.

An in-depth literature review in anthropology, sociology, geography, history, and economics, as well as over 1400 detailed and extensive key informant interviews with village elders and market administrators in the study area allow me to reconstruct the market scheduling process for all 165 weekly markets in my study area. Market day scheduling was a function of the distance to existing markets at the time, region-wide weekday preferences, as well as idiosyncratic preference shocks. Using the method proposed in Borusyak and Hull (2023), I leverage this contextual knowledge to separate the observed variation in coordination quality into a component that was to be expected given the known geography and scheduling process, and a component of quasi-random deviations from this expectation which are the culmination of a cascade of idiosyncratic weekday preference shocks. In the analysis that follows, I use this latter component to identify the causal effect of coordination quality and frictions on various outcomes of interest.

To measure how well market schedules are coordinated, I construct a measure of the area that each market controls, which I define as the area within which the market in question is the closest

[1] Periodic markets are markets that either operate on a non-daily, typically weekly, schedule or on a daily schedule with substantially higher attendance on designated market days.

one to reach on its main market day. I find that indeed distance to existing markets predicts market day scheduling decisions and that simulations from the resulting coordination model can be used to purge out omitted variable bias in observed market area. The quasi-random component of the scheduling decision model is then used in the remainder of the analysis. I show that the coordination of market days causally impacts market attendance by both buyers and sellers and that this is driven by outsiders cross-attending from other towns. I also show that market towns that are endowed with a larger market area than the coordination model would have us expect have a larger population today and are brighter in nighttime satellite imagery, a proxy for economic activity.

Food markets in many developing countries are thin (Fafchamps, 1992) and thin markets are volatile (Desmet and Parente, 2010): With few buyers and sellers on either end of the transaction, supply, demand, and prices are likely to fluctuate as match rates are low. This makes it difficult for both buyers and sellers to reap the full potential of market participation. Market integration can improve the performance of price systems and the reliability of markets to all participants (Barrett, 2005; Jensen, 2007; Svensson and Yanagizawa, 2009; Casaburi et al., 2013; Faber, 2014; Donaldson, 2015, and others) and ease matching (Akbarpour et al., 2020). In this paper, I study a straightforward means of market integration aimed at increasing market attendance to periodic markets: Coordinating market day schedules with the goal of allowing buyers and sellers to cross-attend several markets is a widely recognized phenomenon in anthropology, sociology, geography, and history (Schurtz, 1900; Thomas, 1924; Fröhlich, 1941; Hill, 1966; Hodder, 1961; Fagerlund and Smith, 1970; Good, 1973; Wood, 1974b; Bromley et al., 1975; Scott, 1978; Smith, 1979, 1980; Geertz, 2000). Interest for them in the social sciences peaked in the 1970s, before the availability of modern GIS and satellite data, detailed maps of virtually every corner of the Earth, or the computing power required for many recent GIS and statistical methods. These earlier papers tend to be small-n case studies focusing on origins rather than impacts of market days. Despite their importance, periodic market days have not attracted broad attention from economists. I revive and build on this rich literature, bringing to bear newly available data and methods, while also departing from the purely descriptive and explanatory scope of earlier work with an attempt at assessing the impacts of periodic market schedules.

Two fascinating papers by von Carnap (2022, 2023) are closely related to mine. Using an innovative remote sensing methodology, he attempts to detect weekly markets across sixteen Kenyan counties. He relates their location to historical records of marketplaces compiled by Wood (1973b). The natural experiment I describe was largely completed and market schedules established at that time.[2] Reassuringly – and using fundamentally different methodologies and data sources –, our two

[2] For about two thirds of these historical markets, von Carnap (2023) does not find activity that would be detectable in present-day satellite imagery, which I attribute to the remote sensing methodology being better suited to detect larger markets. Having a data collection team on the ground allows me to be somewhat more confident in having obtained a complete market census than either of these papers and in the counties where we overlap I find over twice times as many weekly markets as von Carnap (2023), including almost all of the 1970s markets (though some of them are small daily trading centers without a market day). The discrepancy lies mostly in the smaller markets being undetectable on satellite data.

studies align closely on the finding that historic market centers are highly predictive of present-day population density. I demonstrate that this link is causal.

A number of creative and insightful studies in economics have addressed agricultural markets. Fafchamps and Hill (2005) investigate the role of transport costs for coffee farmers in Uganda in deciding whether to travel to and sell at wholesale markets themselves or whether to accept the lower prices offered by aggregators who come to their farm gate. Jensen (2007) is the classic reference for market integration through information sharing using mobile phone technology and insightful progress has been made since (Svensson and Yanagizawa, 2009; Aker, 2010; Goyal, 2010; Jensen and Miller, 2018). In a study of the road infrastructure connecting the major agricultural markets in Sierra Leone, Casaburi et al. (2013) study market integration through the reduction in travel times and what its effect on crop prices reveals about the competitive structure in these markets. In a creative study on Kenyan markets, Bergquist and Dinerstein (2020) investigate the competitive structure of sellers and intermediaries by exogenously inducing firm entry. Burke et al. (2019) discuss the ability of a well-timed microcredit intervention to support farmers to smooth out seasonal price variation. Throughout, market integration has been shown to have meaningful effects on people's lives and livelihoods. While large gains in market integration will certainly be reaped from modern information technology, physical infrastructure, and microcredit, it should be noted that none of these have existed nearly as long as the simple act of synchronizing schedules, which limits our ability to assess their effects in the very long run, and that the latter, if timed at the inception of a new market, can be done essentially costlessly. It should also be noted that the cited studies have focused on markets that tend to be around an order of magnitude larger than the ones I discuss in this paper. While these larger wholesale markets are crucial for the functioning of country-wide food security, the smaller, last-mile markets are the direct touch point of millions of people around the world with the food supply chain, either as consumers who rely on them for their daily sustenance, or as smallholder farmers in an early stage of graduating from subsistence agriculture to marketization – or in fact as both simultaneously (Smith, 1980). These smaller markets outnumber the large wholesale markets many dozen if not hundreds to one.[3] Market periodicity and schedule frictions have not, to my knowledge, been discussed in the economics literature.

This paper proceeds as follows. Section 2 reviews the literature about periodic markets in general and in Western Kenya in particular. This section makes the case for the study context being a suitable natural experiment. In section 3 I introduce the data collection exercise, describe the various outcomes of interest, and provide descriptive evidence to support the literature review. Section 4 describes the identification argument and empirical strategy in more detail. Section 5 discusses results and section 6 concludes.

[3] Of the several hundred market places I sampled in Siaya County, only Ramba Market in Siaya Town would be considered a wholesale market and it in turn is substantially smaller than any of the markets for which Burke et al. (2019) present seasonal crop price fluctuation data.

2 Background

2.1 Markets in Western Kenya

Western Kenya, which is the focus of this paper, did not have periodic markets until the early twentieth century. The region was "on the whole [...] outside of the major nineteenth century trade routes"and economic exchange was limited to sporadic barter trade that was sparked by encounters between pastoralist (Luo) and farming tribes (Luhya), dictated by specialization and seasonal fluctuations in livelihoods (Hay, 1975). Around the turn of the century, not merely weekly markets, but *the concept of a "week" itself* was introduced to the region (Wood, 1973a). The local tribes did not traditionally have an intermediary unit of timekeeping between the solar day and the lunar month. It was imposed jointly by a coalition of Christian missionaries and the British colonial administration[4] (Dietler and Herbich, 1993). In order to organize Christian worship, the missionaries wanted the local population to adopt the seven-day week in order for them to know what day of the week church service was to be attended. The British colonial administration had known periodic rural market days both in Europe and in their colonies in West Africa, where periodic markets were substantially more common than in East Africa (Good, 1973) and where periodicities other than the seven-day week had emerged long before colonialism[5]. The colonial administration's goal of marketization was to encourage division of labor and specialization to lift the local population out of subsistence agriculture and livestock rearing, turn them into more affluent trade partners, and to concentrate the resulting trade in a specific place and time in order to levy taxes. Only Central and Western Kenya appear to have had sufficient population density and economic activity to sustain markets (Wood, 1974a).

There is important path dependence in economic activity, trade patterns and locational economic trajectories (Bleakley and Lin, 2012; Faber, 2014; Storeygard, 2016; Jedwab and Moradi, 2016; Donaldson, 2018). Wahl (2016) documents a strong role for medieval trade centers in the emergence of modern European cities. Market days are no exception when it comes to persistence (Bromley et al., 1975) and I document that over the past century market schedules in my study area remained mostly unchanged (cf. Table 5). Both markets and their periodicity were thus introduced about a century ago by outside forces, thus marking an approximate start date for this natural experiment and their schedules were persistent, constituting an opportunity for studying

[4]Present-day Kenya was allocated to the British Empire in the Berlin Conference of 1885. It was declared a British Protectorate in 1895 and the Uganda Railway, which allowed the White settlers to make inroads into Western Kenya, was completed in 1901. It connected Mombasa, an important stopover port for Indian Ocean trade routes and the location of the first Christian Mission since 1844, with Kisumu, the regional capital of Western Kenya on the shore of Lake Victoria and already a major settlement at the time. Kenya was declared a British Colony in 1920 and gained independence on 12 December 1963.

[5]The seven-day week appears to be of Babylonian origin and, after entering Judaism through the book of Bereshit/Genesis, it was spread around the world by the more expansionary abrahamic religions of Christianity and Islam. West Africa on the other hand had and to some extent still has weeks of other periodicities. In contrast to Western Kenya, where the religiously motivated seven-day week dictates market periodicities, the week in West Africa is conjectured to be itself a product of the need to structure trade periodicities (Schurtz, 1900; Thomas, 1924). The outside impetus for market creation and the introduction of a previously unknown weekly periodicity in Western Kenya is crucial for my research design.

their role in economic development.

3 Data

3.1 Market mapping, history, and attendance

Markets are not presently well mapped in Kenya, especially when it comes to smaller markets. As part of my data collection, my implementing partner REMIT conducted a census of all markets in Siaya and Busia County in Western Kenya[6]. From scoping activities, it became apparent that the most knowledgeable key informants on market and village history tend to be Village Elders, Market Chairpersons, and Market Incharges. Their informational advantage is increasingly recognized in the economics literature (Basurto et al., 2020; Balan et al., 2022) and their role has found renewed appreciation across the continent post-independence (Baldwin, 2016). The initial sampling frame comes from triangulating two listing exercises: Villages are part of two parallel administrative structures. Each village is part of a sublocation with an Assistant Chief, which is part of a location with a Chief, which is part of a subcounty with a Deputy Commissioner who reports to the County Commissioner. At the same time each village is part of a ward which has ward administrators and the wards are in turn part of the same subcounties. The location-sublocation structure is determined by Kenya's central government and structures executive power. Finding markets this way avoids missing small markets, but risks duplication if several villages share the same market. The ward structure is determined by the county government and structures taxation and public service delivery. Conducting a census of markets through this structure may miss small markets where no fees are being collected, but is unambiguous when it comes to uniquely identifying markets. Starting from the top of these two parallel hierarchies, we obtained contacts for every subcounty Deputy Commissioner from the County Commissioner. From those we worked our way down to the location Chiefs and from them to the sublocation Assistant Chiefs who gave us the contacts of Village Elders in each village in their sublocation. Starting from the County Revenue Inspector, we went to the Subcounty Revenue Inspectors who referred us to the Ward Market Incharges who shared contacts for Market Incharges and Market Chairpersons. The majority of our key informants are from these groups, although occasionally, we were referred on to other village members who offered additional insights.

Geolocations for each market were obtained from Google Maps or Open Street Map (OSM) where available and otherwise an enumerator would visit the village and geocode it. Throughout, whenever we found markets that were not yet mapped, we documented them on OSM, while Google Maps appears to be automatically ingesting our OSM contributions, thus making this public good

[6] The quality of the results of any study suffers when data are missing. This study measures coordination quality of every market as a function of the schedules of all of its neighbors. Measurement error in one market therefore spills over into measurement error for all markets. Missing a market that clashes with a neighbor schedule makes surrounding markets appear better coordinated than they really are. Missing a market that does not clash with any neighbors but where two other neighbors clash with each other makes it look like there would have been a way to avoid a clash that was not being used. It is therefore critical to not just obtain a sample but a full census of markets in an area.

available much more broadly. In phone surveys, we collected key dates in each market's history, most importantly when it was started and on what day of the week it is being held. If markets operate on several days of the week, we ask whether there is a main market day. I document very strong persistence in week days to the present day, even for markets that have been around for a century. I also obtain an estimate of present-day market attendance as well as how this attendance is decomposed into sellers and buyers (cf. Figure 3). If a respondent or the enumerator indicates that they are at least somewhat uncertain about the indicated data, this will prompt the surveying of a second informant for the same market for triangulation. In order to guard the data collection against missing some markets entirely, every informant is also asked to list other markets in their area and to provide the contacts of knowledgeable informants. As Table 1 illustrates, the majority of respondents received their information either first-hand as they were alive at the time the market was started or second hand and only for very few markets does my analysis rely on information that was passed through more than one social network link. Village Elders spend years in the company of previous elders, preparing for their role and learning about the local history of their town. Written records are rare in this context. In collecting these data, we thus also contribute to the preservation of the oral history of Western Kenya. These data form the basis for the empirical strategy described in sections 4.1 to 4.5.

Table 1: Source of information

	Count
I was alive at the time the market started	59
From a village elder who **was** "	22
From a village elder who **was not** "	1
From another village member who **was** "	33
From another village member who **was not** "	10
From a family member who **was** "	37
From a family member who **was not** "	1
From a written record	2
Total	165

This table describes how close respondents are to the source of information about the process of market scheduling. Most respondents either experienced the start of their market first hand or learned about it from someone who did. Only a small share of responses relies on data that is more than one network link remote. Written records are rare.

3.2 Outcome data

Ultimately, this study is interested in how scheduling frictions affected rural economic development. Outcomes of interest for my study include village population size and night lights as a proxy for local economic activity. Appendix Table 11 provides more details. These data form the final stage of analysis, described in section 4.6.

3.3 Pre-treatment controls

Pre-colonial Western Kenya did not have a formalized administration that would have recorded social or economic data in writing. Pre-treatment controls are therefore restricted to geographic controls (agricultural suitability, terrain ruggedness, proximity to Lake Victoria, proximity to the regional capital Kisumu, see footnote 4) as well as an estimation by the key informant of the village population in 1920.

3.4 Descriptive evidence

Markets may be open every day of the week, but they tend to be substantially larger on market days (Fröhlich, 1941). In my study area, the majority of markets operate every day, though over half have a dedicated market day, as shown in Table 2. The first map in Figure 1 shows all markets in the study area along with the days on which they operate, while the second map shows only those markets with a main market day, which are studied in this paper. Market days are distributed across days of the week and there appears to be some preference for some days over others (2). A model of market scheduling should therefore allow for week-day fixed effects.

Markets in my sample sport more sellers than the hosting village has households. Buyers outnumber sellers almost three to one. These averages mask important heterogeneity. Markets that have a market day are much larger than those that do not (Table 2) and market attendance is substantially higher on market days than on non-market days (Figure 3). The figure illustrates the pulsation that Polly Hill (1966) described: While attendance by locals to their own market roughly doubles or triples on market day, some markets see a five, ten, or even twenty-fold increase in outside attendees.

Table 2: Market attendance

	Average	Count
Number of sellers	306	203
” in markets with main market day	371	163
” in markets without main market day	44	40
Number of buyers	634	203
” in markets with main market day	751	163
” in markets without main market day	159	40
Population (HHs) around 1920	4	620
Population (HHs) when market was first started	87	689
Population (HHs) today	222	736

This table describes the market attendance and the population size of the towns in/near which they operate. Markets with market days are substantially larger than those without. The left column describes sample averages and the right column the number of markets over which the averages are formed.

Anecdotally, from the conducted surveys and scoping interviews, market participants link lower attendance at their own market to the emergence of nearby markets on the same day of the week.

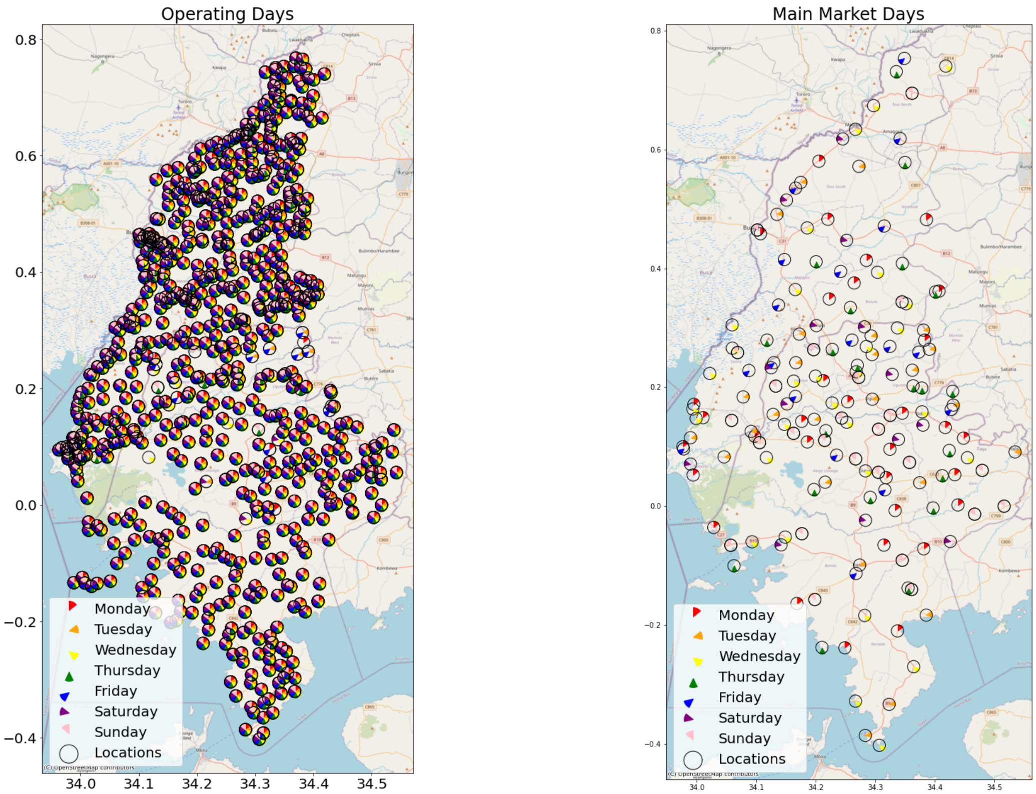

Figure 1: **Map** of markets in Siaya County. The left panel shows all markets along with the days on which they operate (often daily), while the right panel shows only those markets with a main market day.

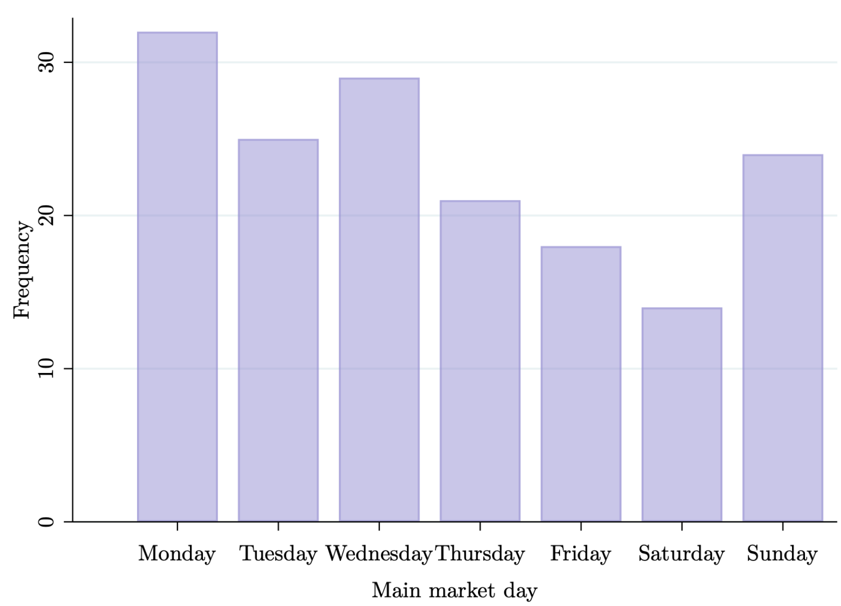

Figure 2: **Market days** across the different week days.

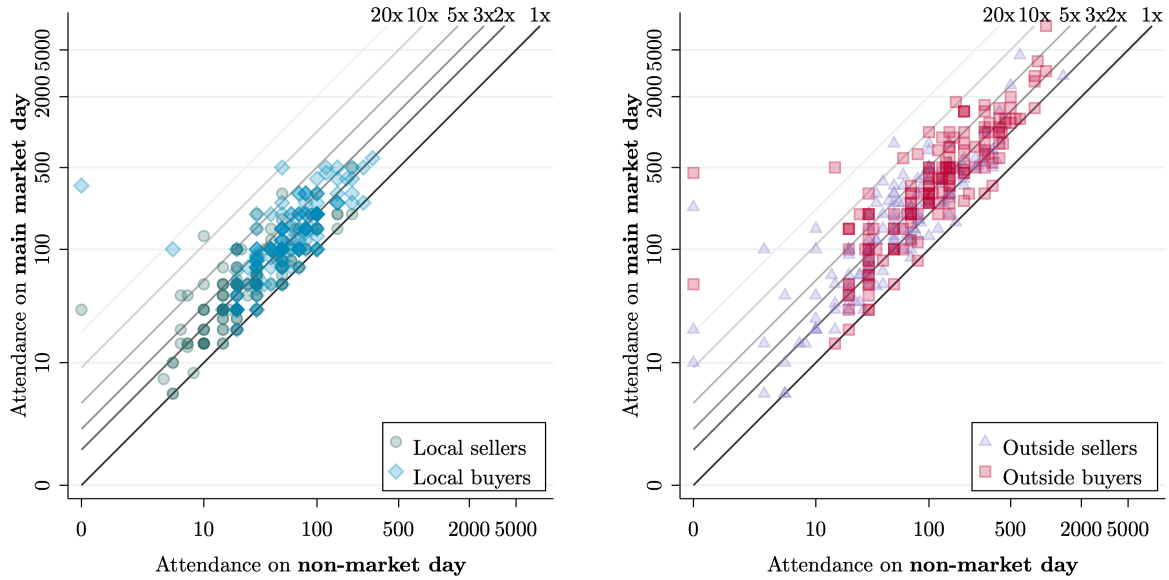

Figure 3: **Market attendance**, shown here on a $\log(x+1)$ scale by market, broken down by attendant category, is substantially higher on market day than on other days of the week, especially among participants from outside the town or village (right panel). But even local attendance is higher on market day.

I therefore inquire about the scheduling process for these market days. Historical sources suggest that while the Europeans pushed for the introduction of markets following a seven-day periodicity (Wood, 1973a), they left the precise scheduling to local authorities – a fact I confirm for the study area. Market days were initially set by the Village Elders, local authorities, and local stakeholders (Table 3) with a *coordination motive* and with knowledge of already existing nearby markets, though in some cases local idiosyncrasies led to the adoption of particular days or they emerged organically (Table 4). There is no evidence that higher levels of government, the church, or another social planner-type actor held any sway over the schedule. We can therefore think of the coordination process as decentralized, which introduces the possibility of inefficiencies.

Once set, market schedules and activities have been remarkably persistent. Only a small share of markets have ever seen a change to their schedule. When asked what they would do if holding a market on their current market day were no longer possible, a non-negligible share of market stakeholders indicate that shifting their market day would have such adverse effects on market attendance that they might as well close the market altogether. Survey respondents also indicate that few if any markets have ever been interrupted in their activities for any meaningful amount of time, especially for reasons other than the COVID-19 pandemic.

Markets were first started in the colonial period with an acceleration around Kenyan Independence in 1963. Most markets since around 1975 are smaller markets without main market days (cf. Figure 4). In evaluating the effects of scheduling frictions, this study thus takes a long-term view of the cumulative effects over the past century, where the regional market schedule was mostly set

Table 3: Decision makers

	Percent
Village elder(s)	21.8
Local council	32.1
Traders from the village	66.7
Traders from outside the village	46.2
Emerged organically	11.5
Sublocation chief	1.9
Location chief	3.2
County government	10.6
Central government	0.0
Colonial government	4.5
Don't know	3.8
Other	0.0
Observations	162

This table describes who was (and who wasn't) involved in the schedule setting of the main market day. It highlights that market scheduling was a decentralized coordination process that was not implemented by a social planner.

over half a century ago. Over the same period, the average distance from points in the study area to the nearest market fell sharply and stabilized over the past half century.

4 Identification and empirical strategy

The goal of this paper is to estimate the causal effect of scheduling frictions over the past century on market attendance and, in turn, on rural economic development today. If the area over which a market is the nearest operating one on its market day is larger, how many more sellers and buyers can it attract? If by contrast, two nearby markets are splitting their surrounding area between each other on market day, how much does this hurt their attendance? Are other measures of economic development affected by this? I will argue that scheduling frictions are at least in part the product of chance. Yet, simply regressing outcomes of interest on some measure of how well market schedules are coordinated would be biased if for example new markets coordinated better with existing larger markets than with existing smaller markets and market size in the past is predictive of market size (or other outcomes of interest) today. Evidence for that would be an imbalance in pre-treatment controls (such as population size a century ago or geographic fundamentals) with respect to coordination quality, which I present in Section 5.3.

The following model illustrates how the bias arrises. It relates coordination quality CQ_l in a location l to some outcome Y_l where ε_l is an error term that contains other factors such as geography

Table 4: Coordination motive

	Percent
Scheduling motives	
To not clash with the schedule of another market	66.0
Sellers preferred this day	37.2
Buyers preferred this day	19.9
Outside traders visited regularly on this day	23.7
To align with the church schedule	9.0
Don't know	7.7
Other	4.5
Obervations	157
Distance (in km) to nearest market with	
Any market day	3.1
Same market day	8.8
Observations	165
Hypothetical coordination	
New markets that would coordinate	87.3
Mention idiosyncratic day preference	11.8
Observations	323

This table describes what factors determined schedule setting of the main market day. It highlights that market scheduling was driven by a coordination motive as well as local idiosyncratic preferences over week days. The middle panel shows the average distance to the nearest market with any market day and to the nearest market with the same market day. The bottom panel shows that the majority of towns without a market but that entertain the possibility of starting one also mention the need for schedule coordination. These data are manually coded from open-ended answers.

Table 5: Market persistence

	Percent
Market schedule never changed	93.0
Rather close than change market day	38.2
Market never interrupted	79.4
Interrupted: COVID	17.6
Interrupted: Other reason	3.0
Observations	165

This table describes the persistence of markets and their schedules.

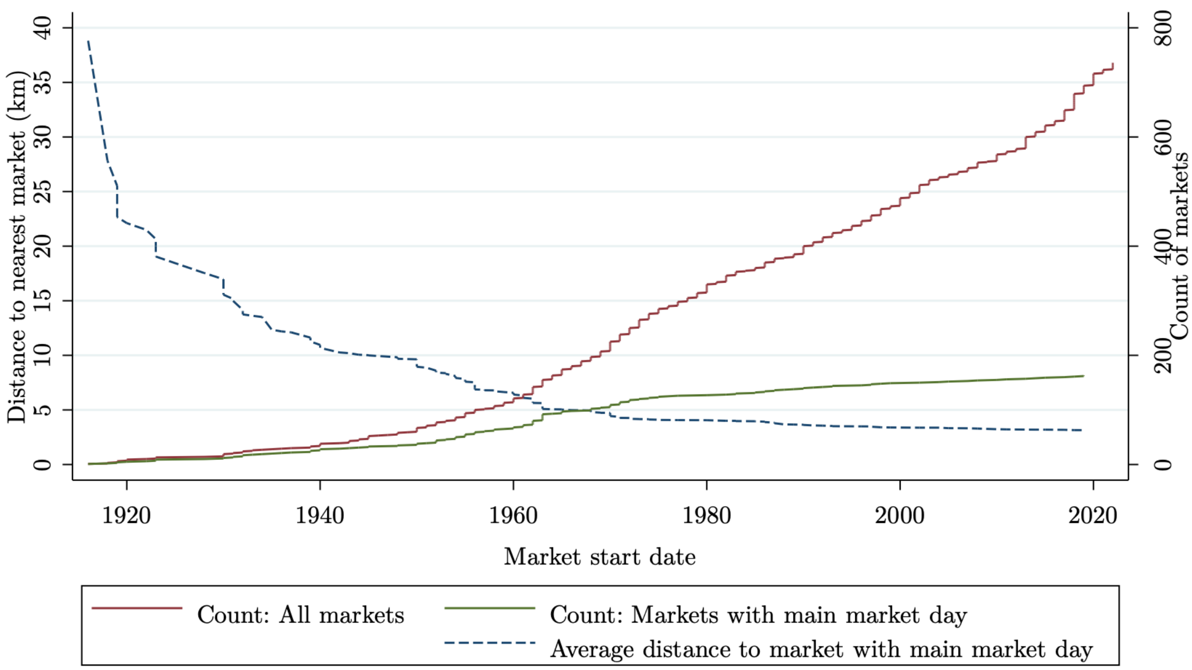

Figure 4: **Markets were first started** in the colonial period with an acceleration around Kenyan Independence in 1963 (left axis). Most markets since around 1975 are smaller markets without main market days (left axis). The average distance to a market with a main market day similarly fell rapidly until around 1975 (right axis).

or lagged values of Y_l that are potentially correlated with CQ_l:

$$Y_l = \beta_0 + \beta_{\text{CQ}}\text{CQ}_l + \varepsilon_l, \qquad \text{where } \mathbb{E}\left[\sum_l \text{CQ}_l \; \varepsilon_l\right] \neq 0. \tag{1}$$

The coefficient β_{CQ}, which I seek to estimate, is the causal effect of scheduling frictions on outcomes of interest. Estimating equation (1) with simple OLS would yield a bias because of the omitted variables in ε_l that are correlated with coordination quality.

The contextual insights from the key informant interviews and literature review in anthropology, sociology, history, and geography allow for a design-based approach to resolving this causal inference challenge in which I separate the schedule assignment process into its endogenous, fixed-by-design, as well as its exogenous, quasi-random component. As evidenced in Table 4, market scheduling was a function of the relative distance to already existing markets as well as some local idiosyncratic preferences by market stakeholders. This makes coordination quality CQ_l a function of randomly distributed preference shocks over weekdays ξ and the known geography $\mathit{\Delta}$.

$$\text{CQ}_l = f_l(\xi, \mathit{\Delta})$$

The following three assumptions allow me to exploit the scheduling process as a natural experiment for causal identification of the effects of scheduling frictions:

Assumption A1: I assume that preferences over weekdays ξ are independent of other factors contained in ε and therefore affect outcomes of interest only through the coordination quality that results from them: $\xi \perp\!\!\!\perp \varepsilon$. Concretely, I parameterize idiosyncratic weekday preferences as iid draws from a Type-1 Extreme Value distribution (one for each market and weekday): $\xi_l = (\xi_l^{\text{Monday}}, ..., \xi_l^{\text{Sunday}}) \overset{\text{iid}}{\sim} \text{T1EV}^7$

Assumption A2: Market scheduling decisions were made without foresight over the entry or scheduling choices of future entrants. In other words, scheduling choices are optimal relative to the geography $\mathit{\Delta}_t$ that existed at the time $t(l)$ at which market l was started.

Assumption A3: Market entry order is fixed and does not depend on the schedule of existing ones. Suppose we label markets $l = 1, ..., L$ in the order in which we observe them start in the data, i.e. $t(1) < ... < t(L)$. **A3** says that $(t(1), ..., t(L)) \perp\!\!\!\perp (\xi, \mathit{\Delta})$. In a counterfactual world in which market day scheduling may have played out differently, the order of entry would have been the same.[7]

[7] Assumption **A3** deserves particular discussion. It describes a decision process in which a town decides that it wants to start a market without anticipating the scheduling problem. This is not an innocuous assumption. There are a few reasons to believe that it might still be a reasonable approximation to the truth. First, the assumption is likely plausible early on in the process when markets are few and far between and only starts to be become implausible as the map gets more crowded, which would explain the pattern in Figure 4 that most markets with market days were started prior to 1975 and very few since. Second, the assumption becomes more palatable, the more uncertainty there is around the success of any particular weekday as a market day. Third, Hodder (1965) conjectures that population pressure is the main driver of the decision to start a market, in which case market viability would depend first and

Taken together, these assumptions produce the following decision problem: Taking market start dates as exogenously given (**A3**), every market chooses one of seven possible week days to hold its market. The choice depends on distance to other existing markets that are already happening on the same day (but no foresight over the identity or actions of potential future entrants, **A2**) and on idiosyncratic local preferences (**A1**). Concretely, a town l chooses a day $d_l \in \{1, ..., 7\}$ at time t with idiosyncratic location-day-specific preference ξ_l^d (**A1**) and distance to the closest existing market on a given day d, $\Delta_{ldt(l)} \equiv \min \text{distance}_{ldt(l)}$ in kilometers and weighted by some utility weight δ_Δ. The term δ_d allows the T1EV distributions to have different means, should particular weekdays be overall more popular than others. The time subscript captures the fact that entry order matters and the establishment of new markets changes the distances and schedule clashes considered by later markets. Entrant markets maximize the utility from each day d_l

$$U_{lt(l)}(d_l) = \delta_d + \delta_\Delta \Delta_{ldt(l)} + \xi_{ldt(l)}$$

and coordination quality CQ_l is computed from the resulting schedule $\{\arg\max_{d_l} U_{lt(l)}(d_l)\}_{l=1}^{L}$.

Borusyak and Hull (2023) show that knowledge of $f(\xi_l, \Delta_l)$ suffices to decompose $\text{CQ}_l = \mathbb{E}[\text{CQ}_l] + \widetilde{\text{CQ}}_l$ in such a way that the expected coordination quality has the exact same correlation with the error term ε_l as CQ_l:

$$\mathbb{E}\left[\sum_l \mathbb{E}[\text{CQ}_l]\ \varepsilon_l\right] = \mathbb{E}\left[\sum_l \text{CQ}_l\ \varepsilon_l\right]$$

This powerful result implies that adding $\mathbb{E}[\text{CQ}_l]$ to equation (1) resolves the omitted variable bias.

Figure 5 builds intuition for the identification strategy in this natural experiment. Suppose eight villages, depicted by nodes, start markets sequentially ($t = 1, ..., 8$) and decide on what day of the week (indicated by colors) to hold their market day. In the top four panels, we observe the first seven villages choosing their market days in a certain way and the eighth village finds it optimal to host its market on Wednesday, since it is relatively further away from the next Wednesday market than from any other market. In a world where attendees from surrounding villages attend their closest market, the eighth market would capture the attendees from most of the other villages on its Wednesday market day. The shading indicates the market area of each market. In the bottom four panels, the same coordination process unfolds with one small deviation: Village 5 chooses Wednesday instead of Tuesday, perhaps because the local chief was traditionally holding a village gathering on this day, and village 8 therefore subsequently finds it optimal to host its market on a Tuesday. The resulting cross-attendance patterns on Wednesdays look very different in this counterfactual world. In this paper, I leverage variation in trade patterns caused by small and arguably quasi-random perturbations like this and I provide evidence of their role in scheduling in Table 4. If most counterfactual coordination outcomes look more like the bottom panel, then under the realized coordination pattern in the top panel, a place like village 4 suffers more strongly under

foremost on local attendance. In this view, locals need to first form a critical mass of attendance to then attract outsiders on a particular day.

the spatial competition from village 8 than the fundamentals of geography and the coordination process would have us expect. This difference between how favorable we would have expected the neighboring market schedules to be for cross-attendance versus how favorable they turned out to be is the treatment in this natural experiment. The effects of that should then be detectable in market attendance and other measures of rural economic development.

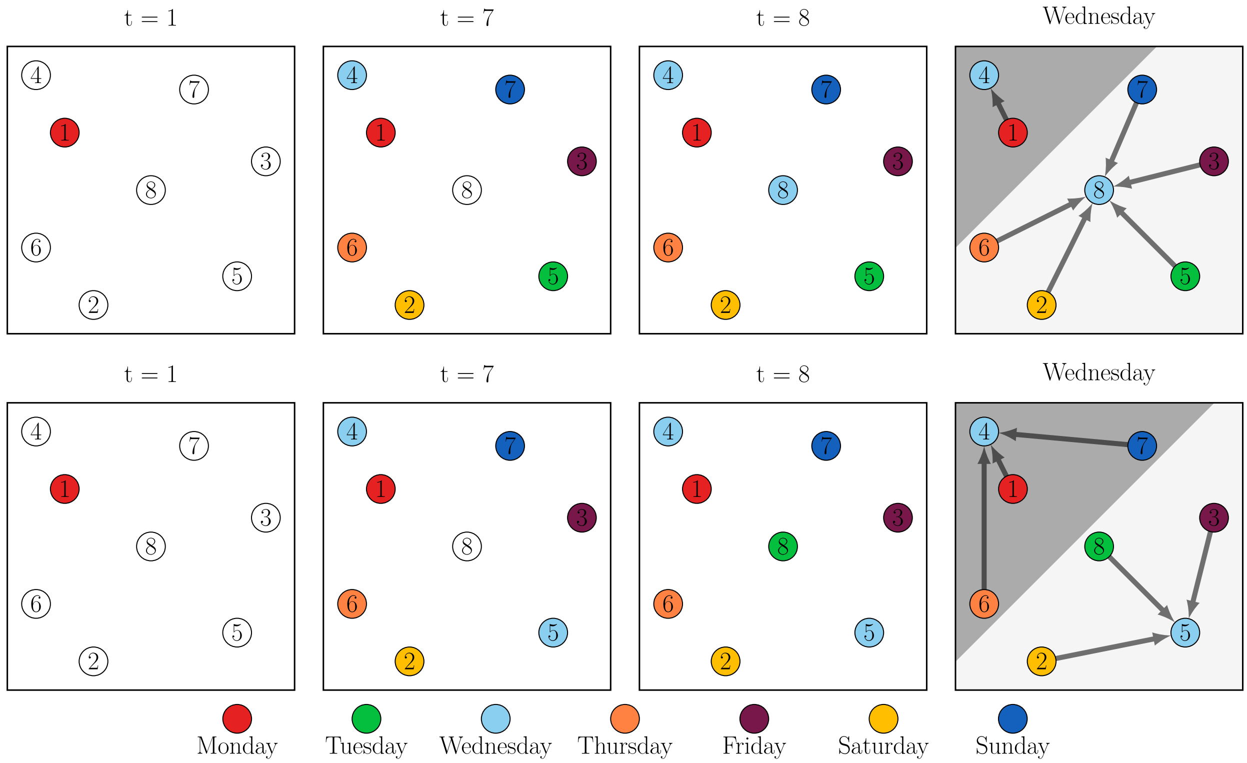

Figure 5: **Counterfactual coordination**: Each node is a town. They sequentially choose market days in the order of their numbering ($t = 1, \ldots, 8$). In the top four panels the last town to pick a market chooses to host its market on a Wednesday in order to avoid clashing with its close neighbors. This makes it the closest Wednesday market for the majority of towns. The bottom four panels show that a small local deviation in the scheduling process (town 5 choosing Wednesday over Tuesday) changes the market cross-attendance pattern. Simulating many such small perturbations in the scheduling process can give us a sense of the potential for market cross-attendance for each market, indicated by arrows. The shading indicates each market's area which I use as the measure of coordination quality.

My empirical strategy proceeds in six steps, described in more detail below:

1. Measure present-day market coordination quality.
2. Reconstruct the decision problem that each market town faced when starting its market (Figure 5, top).
3. Simulate many counterfactual coordination processes and measure their coordination quality (Figure 5, bottom).

4. Following Borusyak and Hull (2023), partial out from each market's observed coordination quality the one we would have expected for it. The residual becomes the treatment assignment, which depends on how ties between similarly attractive scheduling choices were broken plausibly randomly.

5. As a first result, estimate the effects of coordination quality on present-day market attendance after controlling for expected coordination quality.

6. As a second result, estimate the effect of these same scheduling frictions on rural development more broadly.

4.1 Measure coordination quality

To assess coordination, I formalize what the geography literature calls market area (Skinner, 1964; Hodder, 1965; Wood, 1974a,b). I compute the area of the map for which a particular market is the closest market *on the weekday on which this market holds its market day.* This can be thought of as a geographic measure of market potential. Formally, call Q the set that contains all points q_k in the two-dimensional plane that constitutes the study area. The set $P_d \subset Q$ contains the locations of all market places p_{ld} that have their main market day on day d. A market area R_l is defined as the set of points q_k that are closer to p_{ld} in Euclidean distance than to any other market p_{dm} that holds its market day on the same day d:

$$R_l = \{q_k \in Q \mid d(q_k, p_{ld}) \leq d(q_k, p_{dm}) \,\forall\, p_{dm} \in P_d, m \neq l\}$$

My measure of how well a market l is coordinated with its neighboring markets, CQ_l is then the area covered by R_l. In practice, it is calculated as a day-specific Voronoi tesselation, up to a distance of 20km, and removing the area covered by Lake Victoria.[8]

4.2 Reconstruct coordination process

Following the distributional assumption in **A1**, I implement the decision problem of maximizing the above utility as a logit across the seven days of the week, accounting for alternative-specific characteristics (distance to other markets vary by the day of the week). The day-specific intercept allows for the possibility that some days of the week might be inherently more appealing for markets than others. I estimate seven parameters: Six day-specific intercepts $\hat{\delta}_d$ (relative to the seventh) as well as $\hat{\delta}_\Delta$ which translates distance to a competing market on the same day relative to those on other days into utils. Only markets within a travel distance of 20km are taken into consideration here.[9] While in some contexts, the logit model's property of proportional substitution

[8] A better measure of the potential share of trade activity that a market can capture would arguably be a measure of area augmented by population density, but there are no reliable estimates of population density prior to market establishment that would be granular enough for this exercise and present-day population density patterns may themselves be a product of the treatment I am studying, so I prefer this area measure.

[9] Otherwise, as the map of markets grows unboundedly, very distant market schedules (which would be highly leveraged in this estimation) would have arbitrary sway on the estimated relationship.

is unrealistic, it does not appear to be unreasonable in my context to assume that if e.g. Mondays did not exist, the Monday markets would instead distribute across other days roughly according to relative preference over those days.

4.3 Simulate counterfactual coordination outcomes

Using the parameters $\hat{\delta}_d$ and $\hat{\delta}_\Delta$ backed out above, I simulate how towns *could have coordinated*, by redrawing iid Type-1 EV preference shocks (**A1**) for each town and facing them in their same order (**A3**) with their respective decision problems under the new idiosyncratic shocks. After each decision τ, the distance measures $\Delta_{ldt(l)}$ for all future entrants l for which $t(l) > \tau$ are updated based on the last decision. Decisions take the current distances as given without foresight of future entrants or their scheduling decisions (**A2**). When all market days are assigned I calculate the coordination measure from section 4.1. I repeat this process 1,000 times.

4.4 Recentered coordination treatment assignment, counterfactual validity, and baseline balance

Following Borusyak and Hull (2023), I average the coordination quality I obtain across the 1,000 simulations described in section 4.3 at the market level. These can be interpreted as the expected coordination quality for each market $\mathbb{E}[\text{CQ}_l]$. Borusyak and Hull (2023) suggest that under a correctly specified shock assignment process, the slope of a regression of CQ_l on $\mathbb{E}[\text{CQ}_l]$ should be close to 1 and the intercept close to 0, which I confirm. In order to scrutinize whether the residual CQ_l is indeed quasi-random conditional on $\mathbb{E}[\text{CQ}_l]$, I further check baseline balance of pre-treatment control variables, discussed in section 3.3, using the below OLS specification:

$$X_l = \theta_0 + \theta_{\text{CQ}}\text{CQ}_l + \theta_E \mathbb{E}[\text{CQ}_l] + \varepsilon_l$$

4.5 Analysis 1: Effect of coordination on market attendance

In this first step, I am interested in the effect of coordination quality on market attendance. Simply regressing market attendance on the coordination quality calculated in section 4.1 is potentially confounded. It is possible to find a positive correlation between coordination quality and attendance for other reasons, for example if new markets are more likely to avoid clashes with bigger markets than with smaller markets. Still following Borusyak and Hull (2023), I control for the expected coordination quality at each market, thus recentering the observed coordination quality by the coordination quality that the coordination model would have led us to expect. The below equation (2) illustrates this approach: After controlling for the expected coordination quality $\mathbb{E}[\text{CQ}_l]$ and pre-treatment control variables $\mathbf{X}$, the coefficient γ_{CQ} captures the effect of only the random component of observed coordination quality in how the market scheduling actually played out on our outcome of interest.

It is not *ex ante* clear which side of the market, if any, is affected more by scheduling conflicts. If seller attendance falls more than buyer attendance (for example because sellers are more mobile and markets draw mainly local buyers), we would expect sellers to overall benefit from more fractured markets as more buyers are locked in with fewer competing sellers or vice versa, so I regress seller and buyer attendance separately on coordination quality.

$$\begin{aligned} \text{Seller attendance}_l &= \gamma_0^s + \gamma_{\text{CQ}}^s \text{CQ}_l + \gamma_E^s \mathbb{E}[\text{CQ}_l] + \varepsilon_l^s \\ \text{Buyer attendance}_l &= \gamma_0^b + \gamma_{\text{CQ}}^b \text{CQ}_l + \gamma_E^b \mathbb{E}[\text{CQ}_l] + \varepsilon_l^b \end{aligned} \tag{2}$$

Conditional on $\mathbb{E}[\text{CQ}_l]$, the treatment in this natural experiment is assigned at the market level, so I will not cluster standard errors (Abadie et al., 2017). The concern of outcomes being spatially correlated instead suggests the use of Conley (1999) standard errors.[10]

4.6 Analysis 2: Effect of attendance on economic development

I then explore the effect of scheduling on several broader outcomes relevant to economic development. The regression equation is presented below and the outcomes Y_l defined in section 3.2 replace the attendance measures.

$$Y_l = \beta_0 + \beta_{\text{CQ}} \text{CQ}_l + \beta_E \mathbb{E}[\text{CQ}_l] + \varepsilon_l \tag{3}$$

5 Results

5.1 Reconstructing the scheduling process

Non-parametric, descriptive evidence of the coordination motive is presented in the binscatter in Figure 6. Weekday clashes are less likely in the near vicinity than at longer distances.

Table 6 presents the results from the discrete choice scheduling problem in Section 4.2, where markets decide on their market day based on the distance to other already existing markets at the time they start their own markets, as well as day fixed effects. The distance parameter enters significantly positively, indicating that markets are more likely to be scheduled on a particular day of the week if the nearest existing market with the same market day is further away. At the sample-wide average distance between two markets happening on the same day of 8.8km (Table 4), the probability of two markets that are exactly this far apart to share the same market day is 14.3% (Figure 6).[11] The estimated coefficient on distance $\hat{\delta}_\Delta$ implies that halving the distance between the two markets would reduce that probability to 10%. The coefficients on the weekday fixed effects mirror Figure 2.

[10] Conley (1999) standard error adjustments follow the code implementation by Hsiang (2010).

[11] For reference, under completely random weekday assignment we would expect the probability of a clash at any distance to be about $1/7 = 14.3\%$.

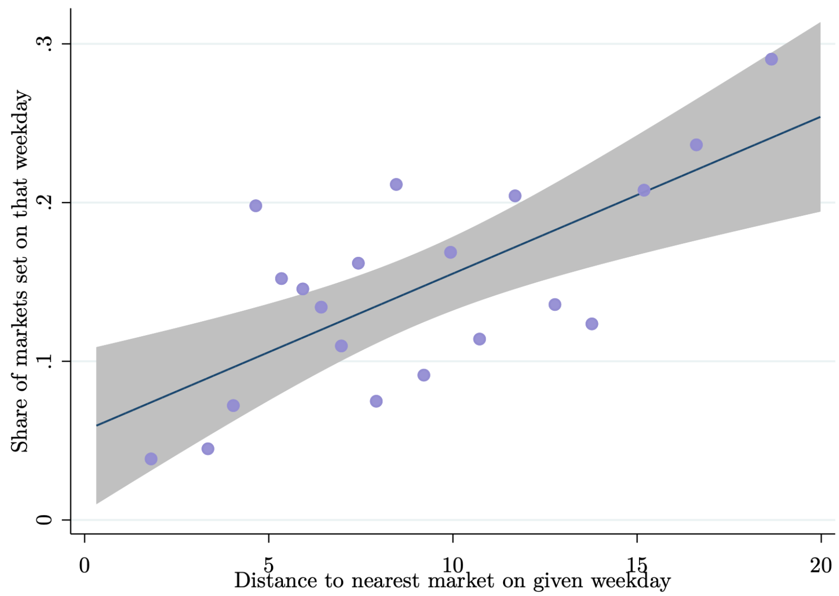

Figure 6: **Binscatter** of the share of markets with clashing weekday schedules at different distances.

Table 6: Scheduling

	(1) Scheduling conflicts
Distance	.09367***
	(.02348)
Day FEs	
Tuesday	-.2039
	(.2911)
Wednesday	-.3157
	(.2963)
Thursday	-.619*
	(.3161)
Friday	-.6152*
	(.3243)
Saturday	-1.231***
	(.4095)
Sunday	-.4001
	(.3027)
Observations	817

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2 Expected coordination

After parameterizing the coordination process in Table 6, I simulate 1,000 new runs of it under different Type-1 EV draws. Borusyak and Hull (2023) suggest that under a correctly specified shock assignment process, the slope of a regression of CQ_l on $\mathbb{E}[\text{CQ}_l]$ should be close to 1 and the intercept close to 0. I provide evidence of this in the top panel of Figure 7. The bottom panel shows the distribution of residualized market area, which will be useful in interpreting the results. Holding geography and market entry order (and therefore the expected market area) fixed and moving a village from the 10^{th} to the 50^{th} percentile of the realized market area distribution (which can be thought of as preventing unnecessary schedule clashes) coincides with adding about 92 km^2 of market area and from the 50^{th} to the 90^{th} percentile (akin to assigning a market a spatio-temporal monopoly) about an additional 182 km^2. For comparison, Paris inside the Boulevard Périphérique measures about 87 km^2 and the District of Columbia is about 158 km^2. Reassuringly, the simulations match other moments of the observed data well. For example, similar to the finding in Table 4, I find an average distance to the nearest market with a clashing market day of 9.06 km.

5.3 Balance

With market schedule coordination quality as the treatment in this natural experiment, I now proceed to testing for baseline balance on the pre-treatment control variables I described in section 3.3. Column (1) of Table 7 shows mild imbalances in the pre-determined control variables with respect to the market area. Markets further away from the regional capital Lake Victoria appear to have larger market areas, while those in more rugged regions have smaller market areas. In a regression in which all of the controls are used to predict market area, however, I marginally reject the hypothesis that the controls are irrelevant. Imbalances in the treatment would indicate that estimated effects are not causal and potentially systematically biased, confounding the effect of market coordination with that of the imbalanced pre-determined variables and geographic fundamentals. The Borusyak and Hull (2023) methodology provides a solution to this problem: By purging out the non-random component of market coordination, it allows me to obtain market coordination deviations from the expectation that are driven purely by random idiosyncratic weekday preference. Under my model, controlling for the expectation of market schedule coordination quality purges out potential omitted variable bias, not only of the variables presented in the sample balance analysis but any other unobservable variable as well. I provide evidence that the sample imbalance is indeed ameliorated after accounting for expected coordination quality in column (2) of Table 7.

5.4 Attendance, population and night lights

I estimate equation (2) for analyzing the effects of scheduling frictions on seller and buyer attendance in Tables 8 and 9. An additional square kilometer of market area (above and beyond what the reconstructed coordination process would have us expect) induces the market size to increase by

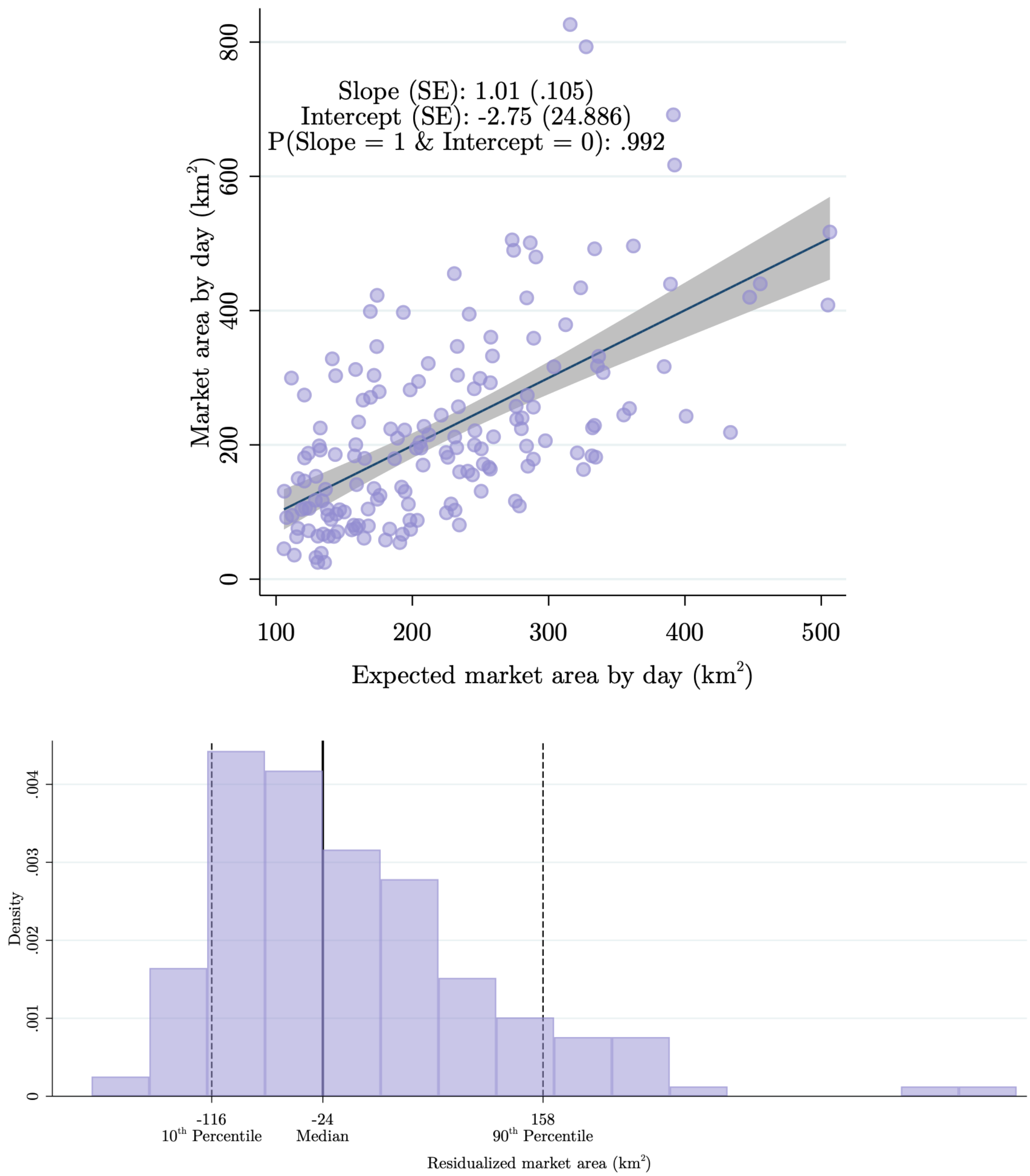

Figure 7: **Expected market area** predicts realized area per market.

Table 7: Sample balance

	(1) Mean (SD)	(2) Market area	(3) Recentered Market area
Population 1920 (HHs)	3.5	-.002926	.008629
	(9.5)	(.005755)	(.007073)
Agricultural suitability	-125.6	.2984	.4157
	(1,347.8)	(.73)	(.9172)
Ruggedness	24,848.5	-36.43**	-28.42
	(30,286.7)	(16.16)	(20.28)
Distance: Lake Victoria	26,395.4	22.9***	5.017
	(16,455.2)	(8.735)	(10.73)
Distance: Kisumu	69,166.9	1.835	3.022
	(17,211.9)	(9.326)	(11.72)
Observations		165	165
F		2.02	0.81
$p(F = 0)$		.079*	.55

This table describes the sample balance of the measure of market area with respect to several pre-determined variables. The main panel reports the sample means and coefficients of the area measure in a regression predicting each control variable. At the bottom of the table, an F statistic is reported for a regression in which all controls jointly predict the treatment. The first column shows sample means and standard deviations. In the second column, the coordination measure is used at face value while in the third column I partial out the expectation of the coordination measure. Standard errors are reported in parentheses. Significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

about .7153 sellers and 1.106 buyers. Moving a village from the 10^{th} to the 50^{th} percentile of the market area distribution translates into an increased market attendance of 66 sellers and 102 buyers and moving it from the 50^{th} to the 90^{th} percentile leads to an additional 130 sellers and 201 buyers respectively, relative to an average main market day attendance of 371 sellers and 751 buyers (after accounting for rounding precision loss). Decomposing attendance in local and outside attendance, both seem to mainly be driven by cross-attendees from outside, although both increase significantly in the case of buyers. All of these results are robust to including baseline controls into the regression.

Table 8: Market attendance: Sellers

	Seller attendance			Seller attendance (local)			Seller attendance (outside)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market area	0.719***	0.715**	0.700**	0.0586	0.0444	0.0461	0.644***	0.669**	0.659**
	(0.244)	(0.344)	(0.348)	(0.0448)	(0.0616)	(0.0606)	(0.218)	(0.305)	(0.313)
$\mathbb{E}$[Market area]		0.0104	0.0117		0.0396	0.0540		-0.0691	-0.0927
		(0.528)	(0.619)		(0.0714)	(0.0682)		(0.489)	(0.590)
Baseline controls	×	×	✓	×	×	✓	×	×	✓
Observations	163	163	163	160	160	160	160	160	160

This table describes the effects of market area induced by scheduling on the outcome variable indicated at the top. Columns (1), (4), and (7) describe the results of the naive OLS regression of the outcome on market area, while columns (2), (5), and (8) remove omitted variable bias by controling for the expected market area. Columns (3), (6), and (9) add baseline controls to the regression. Conley (1999) standard errors with a distance cutoff of 5km are reported in parentheses. Significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Market attendance: Buyers

	Buyer attendance			Buyer attendance (local)			Buyer attendance (outside)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market area	1.165***	1.105*	1.033*	0.201**	0.141	0.143	0.929**	0.951*	0.873*
	(0.421)	(0.574)	(0.571)	(0.0790)	(0.101)	(0.102)	(0.364)	(0.501)	(0.497)
$\mathbb{E}$[Market area]		0.165	0.226		0.166	0.182		-0.0613	-0.0174
		(0.897)	(0.968)		(0.143)	(0.144)		(0.802)	(0.885)
Baseline controls	×	×	✓	×	×	✓	×	×	✓
Observations	163	163	163	160	160	160	160	160	160

This table describes the effects of market area induced by scheduling on the outcome variable indicated at the top. Columns (1), (4), and (7) describe the results of the naive OLS regression of the outcome on market area, while columns (2), (5), and (8) remove omitted variable bias by controling for the expected market area. Columns (3), (6), and (9) add baseline controls to the regression. Conley (1999) standard errors with a distance cutoff of 5km are reported in parentheses. Significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Economic development

	Population (HHs)			Nightlights			Log nightlights		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market area	0.315**	0.404*	0.336	0.183**	0.251*	0.262*	0.0124**	0.0155**	0.0169**
	(0.147)	(0.228)	(0.208)	(0.0809)	(0.142)	(0.144)	(0.00507)	(0.00682)	(0.00693)
$\mathbb{E}$[Market area]		-0.248	-0.130		-0.189	-0.250		-0.00883	-0.0124
		(0.386)	(0.403)		(0.251)	(0.264)		(0.0132)	(0.0136)
Baseline controls	×	×	✓	×	×	✓	×	×	✓
Observations	164	164	164	165	165	165	165	165	165

This table describes the effects of market area induced by scheduling on the outcome variable indicated at the top. Columns (1), (4), and (7) describe the results of the naive OLS regression of the outcome on market area, while columns (2), (5), and (8) remove omitted variable bias by controling for the expected market area. Columns (3), (6), and (9) add baseline controls to the regression. Conley (1999) standard errors with a distance cutoff of 5km are reported in parentheses. Significance is denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.5 Economic development

I estimate equation (3) for the outcomes discussed in Section 3.2 in Table 10. Even after adjusting for its expectation, market area has an effect on present-day population of the villages that host markets. An additional square kilometer of market area (relative to its expectation) induces a population increase in the hosting village of about .4044 households. Moving a village from the 10^{th} to the 50^{th} percentile of the market area distribution translates into an effect size of 37 additional households and moving it from the 50^{th} to the 90^{th} percentile leads to 74 additional households respectively, relative to an average village size of 222 households. Assuming an average household size of 7 people, this corresponds to headcount increases of 260 and 515, respectively (after accounting for rounding precision loss). Note that this is not a purely mechanical result, as the outcome variable in question is not the population of the market area, but that of the village hosting the market in its center. Even after adjusting for its expectation, market area has an effect on present-day nighttime luminosity, as Table 10 shows. This suggests that market day scheduling has impacts not just on market attendance but more broadly on economic activity in the area. All of these results are robust to including baseline controls into the regression.

6 Conclusion

In this paper, I have described and evaluated a natural experiment in how markets in Western Kenya scheduled their market days. I found that while a simple regression analysis of outcomes of interest on a measure of market area that is observed today may be biased, this bias can be purged out by leveraging contextual knowledge of the coordination process. Doing so allows me to conclude that scheduling indeed had a sizable and lasting causal impact on market attendance, particularly cross-attendance from other towns and that it can also partly explain the population size and night time luminosity of the towns that host the market. These are important results both in the pursuit of market integration and for understanding how today's trade and economic centers came to be.

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Appendix

Table 11: Outcome Variables

Name	Definition	Source	Spatial resolution	Temporal resolution	Citation
Attendance	Attendance estimates of sellers and buyers on the main market day	Phone survey	Market	2023	This paper
Population	Number of households presently living in the village	Phone survey	Market	2023	This paper
Nighttime lights	Lunar-adjusted top of atmosphere radiance	NASA BlackMarble	∼500m	January 2023 (composite)	Román et al. (2018)

Note: This table summarizes the outcome data sources used in this paper, alongside with definitions, sources, applicable resolution and useful citations.