

Rhythm analysis of the informal urban economy in the consumption of geographical space

 Alireza Daviran¹ 

¹Department of Geography Education, Farhangian University, P.O. Box 14665-889, Tehran, Iran

 a.daviran@cfu.ac.ir

Abstract

The informal economy encompasses economic activities that operate outside formal institutional frameworks and are shaped by temporal, spatial, and activity-specific factors, particularly in urban contexts. This study investigates the spatiotemporal rhythms of informal economic actors in Zanzan (Iran) addressing the central research question: How is the temporal and spatial organization of the informal urban economy structured, and how does space consumption relate to activity type? Employing a qualitative phenomenological approach grounded in rhythm analysis, data were collected through continuous observation and semi-structured interviews and analyzed through descriptive and interpretive methods. Findings indicate that informal activities are spatially clustered across central, intermediate, and peripheral urban zones according to pedestrian flows, market density, accessibility, and product type, while temporal rhythms vary daily, weekly, and seasonally under the influence of environmental conditions and regulatory enforcement. The activity content primarily involves the provision of subsistence-oriented goods of medium to low quality. The study highlights that rhythm analysis provides a robust framework for understanding the dynamic spatial and temporal patterns of informal economies, offering practical insights for data-informed urban planning and policy-making.

Keywords

Space consumption,
Rhythm,
Time geography,
Informal economy,
Zanzan

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Highlights for public administration, management and planning:

- Informal economic activities are structured and coordinated in space and time, requiring urban policies that integrate these actors into planning processes.
- Temporal rhythms and spatial patterns of activities align with market flows, pedestrian movement, and regulatory conditions, highlighting the need to consider daily and seasonal variations in urban management.
- Identifying activity zones (central, intermediate, peripheral) and vendor types enables optimal allocation of urban spaces and reduces congestion.
- Collaboration and coordination among informal vendors suggest that strengthening collective management and communication can improve efficiency, environmental hygiene, and social cohesion.

1 Introduction

1.1 Research rationale and goals

Business location selection is a core concern in economic and urban geography, focusing on why and how businesses choose specific locations and the factors influencing these decisions (Adler & Florida 2022). Among urban economic phenom-

ena, the informal economy represents a critical spatial problem. It encompasses unregulated economic activities (such as street vending, mobile sales, small-scale retail, and periodic markets) that occupy public spaces, often without formal permission, and shape urban spatial patterns (Shokouei 2004; Khademzadeh Yeganeh et al. 2021). These activities, while vital for livelihoods and local con-

sumption, frequently interact with formal urban structures, creating challenges related to spatial organization, accessibility, and infrastructure use (Daviran 2024; Veisian et al. 2015).

Globally, informal economic activities constitute a substantial share of urban employment, particularly in developing countries. The International Labour Organization (ILO) reports that 61% of the global workforce participates in informal activities, excluding agriculture nearly half of employed individuals work informally, with regional shares reaching 85.8% in Africa, 68.2% in Asia and the Pacific, and 25.1% in Europe and Central Asia (ILO 2018). In Iran, over 55% of employed individuals engage in informal jobs, with urban sectors particularly concentrated in services (Statistical Center Iran 2024). Despite its economic significance, research has often addressed informal economies in general terms—focusing on employment statistics or regulatory challenges—without systematically analyzing their spatiotemporal patterns or the rhythms through which informal actors occupy and consume urban space.

Time and rhythm are essential for understanding the informal economy as a spatial problem. Time geography conceptualizes economic actors' movements as space-time paths within space-time prisms, reflecting the potential locations accessible under temporal and mobility constraints (Corbett 2006). Applying rhythm analysis allows for the identification of recurring temporal and spatial patterns, revealing how informal actors strategically use urban space according to activity type, demand flows, and regulatory conditions (Lefebvre 2002; Judson 2011). This perspective moves beyond static maps of vendor locations, emphasizing dynamic interactions among time, space, and human behavior in shaping the informal urban economy.

Despite its relevance, existing research rarely integrates the temporal dimension with spatial analysis, leaving gaps in understanding how informal economic activities rhythmically structure urban space and how different activity types consume and transform it. This study addresses this gap by investigating the spatiotemporal organization of informal economic actors and the patterns of urban space consumption they produce. This study aims to examine the rhythmic structure influenced by time geography in the informal urban economy and, by identifying patterns of production and consumption of urban space within this sector, model its spatial and temporal functional diversity. The novelty of this research lies in recognizing and explicating the rhythmicity of the informal economy in urban space, thereby elucidating the spatial consumption

profile of its actors. Accordingly, the central research question is: How is the spatial and temporal structure of the informal economy in the urban space of Zanjan city (in Iran Country) organized, and how does space consumption relate to the type of activity?

1.2 Theoretical departures

Time, place, and human space are considered three fundamental components in the formation of geographical relationships and the spatial organization of human activities (Daviran 2023). In geography, time is understood not merely as a linear framework but as a dynamic dimension within which spatial phenomena emerge, transform, and persist or decline through interaction with social and economic structures (Moghimi 2001). Accordingly, the time-geography approach, introduced by Torsten Hägerstrand, demonstrates that human activities are always organized within spatiotemporal constraints, access opportunities, and social interactions, and that everyday life patterns are shaped through the simultaneous linkage of these two dimensions (Shokouei 2004). This perspective emphasizes that understanding human behavior and spatial phenomena without simultaneously considering time and space remains incomplete, as human lived experience continuously unfolds within spatiotemporal rhythms (Moghimi 2001).

One of the domains where this spatiotemporal linkage becomes particularly evident is the urban informal economy. This sector is commonly characterized by features such as irregular income, lack of legal protection, absence of job security, and temporal flexibility in activities (Shokouei 1985). Economists generally define it as encompassing unregistered economic activities which, despite operating outside formal regulatory frameworks Hart, still influence economic cycles and even gross domestic product (Schneider & Enste 2000; Frey & Pommeroy 1984). Such activities often take the form of small-scale production or services that emerge in response to limitations in formal labor markets and function as livelihood mechanisms for vulnerable groups (Alderslade et al. 2006).

However, reducing the informal economy to a purely economic phenomenon overlooks its spatial and social complexities. Research indicates that this sector is closely linked to urban poverty, structural inequalities, and restricted access to formal opportunities (Chen 2016), while entry into it may result either from deliberate choice for greater flexibility or from structural compulsion (Günther & Launov 2012). In Iran, indicators such as lack of social insurance, absence of formal contracts, and depri-

vation of occupational benefits are considered primary criteria for identifying informal employment (Zarouki et al. 2020), and economic poverty is recognized as one of the major drivers of entry into this sector (Nazier & Ramadan 2015).

The expansion of the informal economy in cities is directly associated with broader processes of urbanization, migration, and resource concentration. The concentration of economic opportunities in large cities, combined with the inability of formal economies to absorb migrant labor, has created conditions conducive to the growth of informal activities (Damayanti et al. 2018). From this perspective, some scholars consider the informal economy an inseparable component of the economic structure of cities in the Global South (Auerbach et al. 2018). Nevertheless, the spatial consequences of this phenomenon—including occupation of public spaces, physical disorder, and pressure on urban infrastructure—require urban planning and policy intervention (Kamete 2012). Therefore, managing and regulating the informal economy is increasingly viewed not as eliminating it but as intelligently integrating it into the urban system (Daviran 2024).

At the micro-urban level, one of the principal manifestations of the informal economy is informal retail, including street vending, mobile selling, and temporary markets. Beyond providing livelihoods, these activities play a role in regulating prices within formal markets; however, they may simultaneously generate spatial tensions, unequal competition, and managerial interventions (Daviran 2024). Location studies indicate that the choice of activity location plays a decisive role in the economic success of informal vendors, as spatial clustering can foster commercial agglomerations and attract more customers (Akalın et al. 2013). Consequently, the manner in which these activities occupy and consume urban space has become a key issue in urban planning (Moradi & Mirzaei 2024).

In this context, the rhythmanalysis approach provides a deeper analytical lens for examining the relationship between time, space, and human activities. This concept, initially proposed by Lefebvre, is based on the premise that urban space is the product of interactions among diverse human, social, and natural rhythms, formed through repetition, movement, and lived experience (Lefebvre 2002). Rhythms may be linear or cyclical and emerge from the interaction of temporal flows with space and human action (Azami et al. 2022). From this perspective, analyzing spatial rhythms contributes to understanding how urban space is produced, reproduced, and consumed (Judson 2011; Daviran 2023). The interdisciplinary nature of this approach has led to its

broad application in urban geography, urban design, sociology, and everyday-life studies (Daviran 2024). Empirical studies of the informal economy have also illuminated various dimensions of this phenomenon, yet most have focused primarily on economic, social, or managerial factors. For instance, Mo-taghi Dastnaei et al. (2021) demonstrated the role of socio-economic variables in the tendency toward informal cross-border activities. Sadeghi et al. (2020) examined the spatial organization of street vendors in Tehran and highlighted the importance of economic factors. Bahrami (2023) emphasized the necessity of supportive policymaking and avoiding coercive approaches. Additionally, Daviran (2024), in a study of Zanjan's night-time economy, pointed to the interaction among spatial quality, citizen presence, and informal activities.

At the international level, studies have shown the role of the informal economy in mitigating employment crises (Williams & Windebank 1998), its complex relationship with urbanization (Elgin & Oyvat 2024), the need for gradual formalization to achieve urban justice (Skinner & Chen 2021), the importance of social interactions in integrating informal activities (Jason 2008), and its linkage with welfare policies and spatial rights (Martinez & Estrada 2017; Brown 2015). Despite these contributions, relatively few studies have simultaneously analyzed the temporal and spatial patterns of these activities and the rhythms of urban space consumption.

A review of the existing literature thus reveals two largely separate research streams: first, informal economy studies that predominantly focus on economic, social, or policy dimensions while paying limited attention to spatiotemporal organization; second, urban rhythm studies that analyze space consumption and everyday life but rarely consider the informal economy explicitly. This disconnection constitutes a clear research gap, as the informal economy should be understood not only as an economic sector but also as a spatiotemporal process manifested through specific rhythms of urban space consumption. Accordingly, the present study seeks to bridge this gap by integrating time geography, informal economy studies, and urban rhythm analysis to explain the spatiotemporal organization of informal activities and their patterns of urban space consumption. By explicitly linking temporal rhythms with spatial practices in the informal economy, this research aims to provide a more comprehensive understanding of urban functional diversity, inform urban planning strategies, and contribute to theoretical development in studies of the urban informal economy.

2 Methods

This study employs a qualitative, exploratory research design, with its core framework grounded in rhythmanalysis as a phenomenological approach. Rhythmanalysis focuses on the lived experience of time and space, aiming to identify and interpret temporal and spatial rhythms as they are perceived and enacted by actors in urban environments. The target population (200 vendors) consists of mobile street vendors and produce sellers operating within the spatial and structural characteristics of the informal urban economy in Zanjan (in Iran). Data were collected through continuous field observation and unstructured case interviews (35 Persons). Continuous observation involved longitudinal monitoring of vendors' activities across different urban spaces, recording their timing, location, and type of activity throughout days, weeks, and months. Unstructured case interviews consisted of open-ended conversations with vendors to understand their ex-

periences, spatial practices, and activity patterns without a predefined framework. Over the course of one year, the research team combined longitudinal observation and case-based interviews to identify temporal patterns, types of activity, and spatial positioning of vendors. Data were analyzed using qualitative summary tables and interpretive techniques, and the results were presented in the form of rhythmic charts and tables. The coefficient of determination (R^2) was used to assess the explanatory power of variables in relation to temporal consumption patterns, with values approaching 1 indicating a high level of correspondence between observed patterns and the rhythmanalysis framework. The indicators were further validated ex ante by a panel of 18 academic and professional experts in geography, urban planning, sociology, psychology, architecture, and economics before the commencement of fieldwork and data collection, confirming strong content validity. The final framework comprises three main dimensions: spatial con-

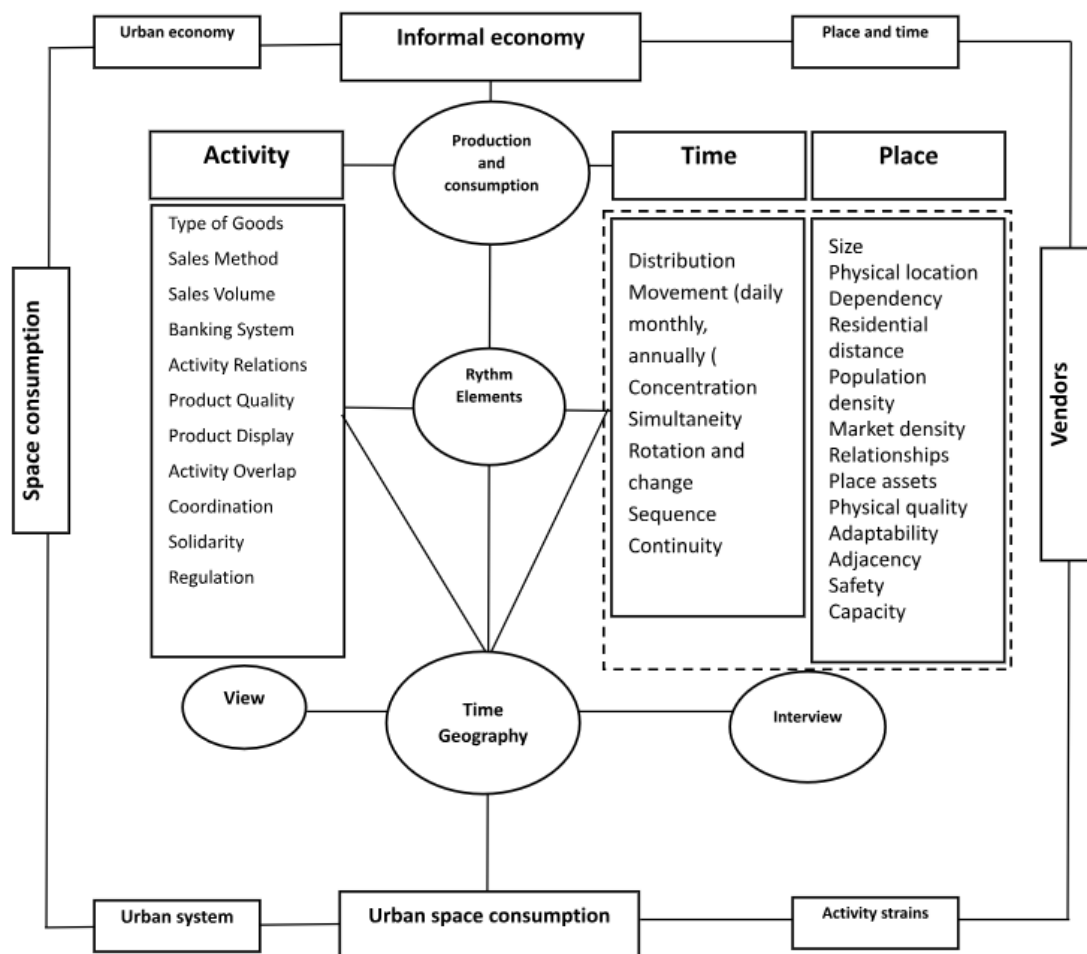


Fig. 1 Conceptual-Operational model of the study

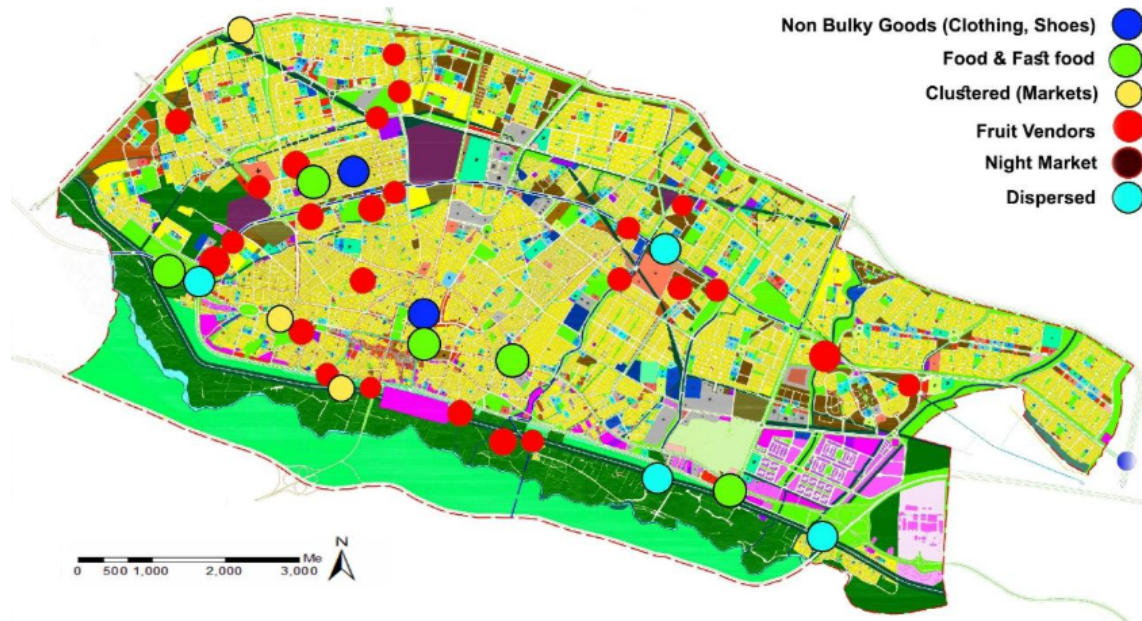


Fig. 2 Spatial distribution of the location of informal economy in Zanjan city (Iran)

tent, activity content, and temporal content, encompassing a total of 39 items. Based on this framework, a conceptual-operational model of urban space consumption by the informal economy was developed, capturing both the structural-spatial patterns and phenomenological rhythms of informal economic activity in urban space (Fig. 1).

3 Results

Zanjan, with a population of approximately 450000 and an area exceeding 7000 hectares, is classified as a mid-sized city in northwestern Iran. Its street network, organized around three concentric rings, accommodates a mix of residential and commercial activities and provides a context for informal economic activity. Field observations indicate that more than 1500 mobile or semi-fixed retail units operate in Zanjan's public spaces, primarily concentrated in the central urban core, intermediate commercial corridors, and peripheral zones. Spatial clustering varies by type of micro-enterprise—for example, clothing and footwear vendors in central areas, produce vendors along main arterial roads, and weekly market or bulky-goods sellers in designated locations. Rhythmanalysis reveals that informal activities follow a cyclical pattern, with spatial, temporal, and activity dimensions operating in an integrated manner. To capture these rhythms, continuous field observations and semi-structured interviews were conducted over one year, and activities were classified into six

typologies based on product type, operational logic, and locational behavior (see Fig. 2 and Fig. 3).

3.1 Spatial rhythm of place content

The spatial dimension of informal economic activities encompasses a set of physical and environmental attributes that collectively shape and attract economic presence. These attributes include form, location, size, dependency, proximity, density, spatial assets, environmental quality, safety, accessibility, capacity, compatibility, and adjacency. This study employed continuous field observation combined with case-based interviews to systematically investigate these spatial characteristics. Spatial analysis in Zanjan demonstrates that informal economic actors do not select locations randomly or solely based on physical features; rather, they strategically locate according to pedestrian flows, visual corridors, and commercial pathways, establishing a reciprocal relationship whereby the nature of place shapes the type of activity and vice versa. This interdependence underscores the significance of spatial context for the sustainability and strategic functioning of informal economic actors.

Six distinct spatial types characterize the distribution of informal economic activities. Vendors of non-bulky goods (such as clothing, footwear, and accessories) are predominantly concentrated in dense commercial districts, primarily within the central urban fabric along Saadi, Emam, and Madani Streets in Eslamabad. In contrast, hot food vendors (including kebab stands, fast-food carts, and mobile

supermarkets) tend to cluster near the city's eastern and western gateways, notably Basij and Jihad Squares, as well as along major tourist corridors such as Kavazang, Hassan Abdal, and Zanjanrud. This pattern indicates that the nature of the activity and type of goods directly inform spatial placement, rather than proximity to vendors' residences or individual characteristics.

Clustered informal markets, often organized by municipal authorities, occupy peripheral zones with linear or zonal spatial arrangements. Key examples include weekly markets operating on Mondays, Thursdays, and Fridays, specifically the Friday Market in the northwest, the Thursday Market in Mazar-e Paeen, and the Khayyam poultry market in the southern district. Mobile fruit vendors display wider spatial dispersion and typically locate along arterial roads servicing residential neighborhoods to intercept commuter flows. These vendors often

operate from semi-fixed sites that have gradually evolved into self-organized fixed points. Night markets primarily situate within the city center and extend into high-traffic squares characterized by formal nocturnal commercial activity, such as clusters of food vendors near the eastern city entrance and Azadi Square. These locations benefit from enhanced safety measures, substantial pedestrian traffic, and a vibrant nighttime economy. In contrast, dispersed vendors exhibit no consistent spatial pattern; their activities are ephemeral (lasting one to three hours) and characterized by frequent relocation. This highlights the dynamic, adaptive nature of informal spatial practices and the challenges posed for urban management and planning. Analysis of spatial content indicates that in types with a defined spatial identity (Types 1–5), the scale of occupied space is primarily determined by activity density, resulting in the fusion of place and func-

Row	Types	Location of Activity	Observational Examples
1	Non-bulky goods (e.g., clothing, shoes)	Central urban fabric – Saadi and Emam Streets; Peripheral areas – Shahid Madani Street, Eslamabad	
2	Food and fast food	Tourist entry points and major intersections – Basij Square, Kavazang, Jihad Square, Moqaddam Crossroads, Azadi and Enghelab Squares	
3	Clustered (market-based)	Weekly markets – Friday Market (Kuy-e Farhang), Thursday Market (Mazār-e Pāeen), Khayyam Poultry Market	
4	Fruit vendors	Along major arterial roads throughout the city	
5	Night market	Central urban areas	
6	Dispersed	Primarily at highway entry and exit points – 22 Bahman and Khayyam Highways	

Fig. 3 Types of informal economy activities

Attribute	1 – Non-bulky Goods (Clothing, Shoes)	2 – Food Fast Food	3 – Clustered (Markets)	4 – Fruit Vendors	5 – Night Market	6 – Dispersed
Spatial Occupation	Linear (3–5 m)	Linear (10–30 m)	Areal (5–10 m limit)	5–15 m	5–10 m	20–30 m
Density Type	Dense	Point-linear, semi-dispersed	Very dense	Point-linear, dispersed	Linear, dense	Point-based
Location	City center – commercial corridors	Periphery – tourist routes	Weekly markets – city edge	Citywide – main roads	City center – active squares	Undefined – mainly along 22 Bahman & Khayyam highways
Functional Attachment	Relative – customary	Relative – customary	Relative – customary	Relative – customary	Potentially variable	Constant relocation
Residential Distance	Distant	Distant	Distant	Near residence	Distant	Distant
Population Density	High	Low	Very high	Relatively high	Moderate	None
Activity Density	Very high	Moderate	Very high	Moderate	Moderate	None
Spatial Consumption	High	Moderate	Very high	Moderate	Low	None
Service Infrastructure	Adequate	Relatively inadequate	Inadequate	Severely inadequate	Adequate	Lacking
Physical Quality	Suitable	Moderate	Unsuitable	Very poor	Suitable	Variable
Adjacency	Commercial fabric	Tourist-transit zones	Residential fabric	Residential fabric	Commercial fabric	Variable
Compatibility	Fully compatible	Compatible	Relatively incompatible	Incompatible	Fully compatible	Incompatible
Safety	Suitable	Relatively suitable	Relatively suitable	Unsuitable	Suitable	Highly unsuitable
Capacity	Very dense – no capacity	Relative – expandable	Very dense – no capacity	Inadequate	Relative – expandable	Inadequate

Table 1 Spatial attributes of informal economy activity types

tion and contributing to the spatial stabilization of informal economic activities. Proximity to vendors' residences does not emerge as a decisive factor; rather, market density and sales potential predominantly shape spatial identity. The co-location of formal and informal activities, alongside the benefits of agglomeration economies, exerts a substantial influence on location selection.

Types 1 and 5 concentrate in dense commercial zones, operating at a smaller spatial scale while prioritizing environmental quality and pedestrian visibility. In contrast, Types 2 and 4 favor more spacious, low-density areas that accommodate extensive product display and facilitate vehicular access. These differences demonstrate that spatial choice in the informal economy is not merely a matter of physical space but is contingent on activity type and operational requirements. Recognizing such distinctions is essential for urban planning aimed at balancing accessibility, density, and environmental quality (Fig. 3).

3.2 Temporal rhythm structure of informal economic activities

Time constitutes a fundamental element in rhythm-analysis, serving as the medium through which activities unfold within space and influence it. The temporal dimension governs when and where activities occur, rendering spatial practices inseparable from temporal processes and closely linked to both physical transformations and social contexts (Tohjiwa 2022, p. 2). As Shokouei (2004) notes, all geographical phenomena are inherently time-bound, with their evolution and transformation conditioned by temporal factors. Similarly, (Moghim 2001, p. 334) emphasizes that time mediates the generation, development, and eventual decline of geographical phenomena.

Within the informal economy, temporal characteristics encompass the initiation and cessation of activities, distribution patterns (daily, monthly, seasonal), relocation cycles, temporal density and concentration, simultaneity, sequence, and continuity. Our analysis in Zanjan demonstrates that tempo-

Attribute		1 - Non-bulky Goods	2 - Food & Fast Food	3 - Clustered (Markets)	4 - Fruit Vendors	5 - Night Market	6 - Dispersed
Daily start	spring and summer	09:00	20:00	08:00	10:00	20:00	11(a.m) 17(p.m)
	Autumn and winter	11:00	17:00	09:00	22:00	23:00	11(a.m) 16(p.m)
End	spring and summer	21:00	24:00	21:00	22:00	23:00	13(a.m) 19(p.m)
	Autumn and winter	18:00	23:00	17:00	20:00	21:00	13(a.m) 17(p.m)
Density	spring and summer	18:00-20:00	20:00-22:00	17:00-19:00	12:00-14:00	19:00-21:00	11-13 17-19
	Autumn and winter	17:00-18:00	19:00-21:00	11:00-15:00	11:00-14:00	18:00-20:00	12-14 15-17
Average activity duration per day	spring and summer	11 hrs	5 hrs	11 hrs	10 hrs	4 hrs	2 hrs
	Autumn and winter	9 hrs	6 hrs	9 hrs	10 hrs	3 hrs	2 hrs
Interference with the formal economy		Yes	No	No	No	No	No
Daily work sequence		Continuous	Continuous	Continuous	Continuous	Continuous	Discontinuous
Continuity and annual continuity		Permanent	Permanent	Permanent	Permanent	Semi-permanent	Impermanent and lacking continuity
Time limit - closure		Climate & holidays	Climate -dependent	Climate -dependent	Climate -dependent	Climate -dependen	Dependent on climate

Table 2 Temporal characteristics of informal economy types

ral rhythms are neither uniform nor random; instead, they are strategically aligned with market dynamics, consumer flows, and environmental conditions, reflecting the adaptive capacity of informal economic actors.

Vendors of non-bulky goods in the city center (Type 1) synchronize their daily operations with formal market hours, generally starting between 9:00 and 10:00 a.m. and continuing until 9:00 p.m. in summer and 7:00 p.m. in winter. Night

markets (Type 5) operate after the closure of formal retail spaces, running until midnight in summer and 10:00 p.m. in winter. Food and fast-food vendors (Type 2) typically commence just before sunset and continue into early morning hours, whereas mobile fruit vendors (Type 4) maintain continuous operations from 9:00 a.m. to 9:00 p.m., occasionally extending to 10:00 p.m. during summer. Clustered markets, including Friday and Thursday bazaars (Type 3), function from 9:00 a.m. until

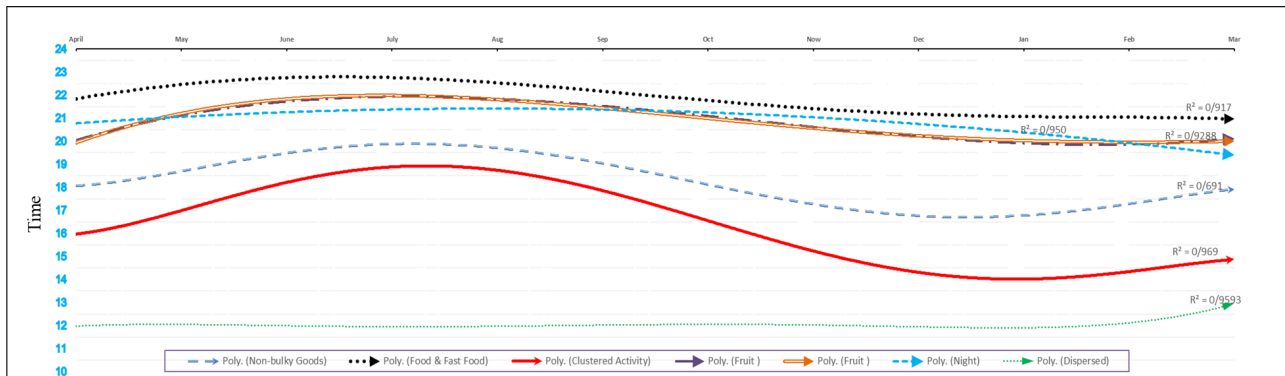


Fig. 4 Monthly distribution of maximum daily strain density

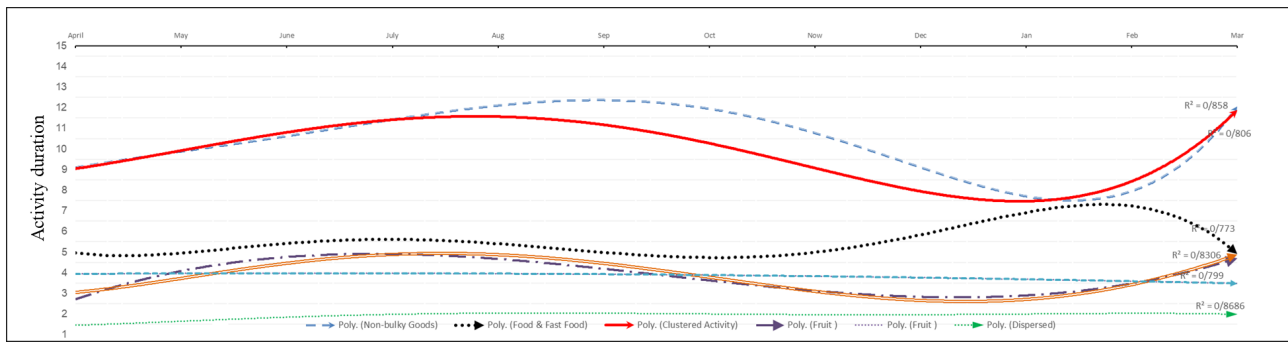


Fig. 5 Monthly distribution of strain activity duration

sunset. Dispersed vendors (Type 6), however, exhibit irregular temporal patterns; their activities are short-lived (one to three hours), opportunistic, and highly responsive to enforcement measures and immediate spatial opportunities. These findings illustrate that temporal strategies are intrinsically linked to activity type, goods sold, and environmental constraints, providing insight into operational decision-making within the informal economy.

Temporal continuity analysis reveals that all types, except Type 6, operate year-round, though activity levels decline during colder seasons and precipitation events. The most pronounced seasonal reductions occur among Types 1, 3, and 5, while Types 2 and 4 display greater resilience. Daily temporal densities also vary: Type 1 vendors peak in the afternoon (16:00–21:00 in summer; 15:00–19:00 in winter), Type 2 primarily operates between 21:00–23:00, Type 3 maintains consistent activity throughout market hours, Type 4 exhibits bimodal peaks (12:00–14:00 and 18:00–20:00) aligned with commuter flows, Type 5 peaks between 19:00–23:00 and Type 6 demonstrates sporadic appearances around midday and dusk.

Temporal overlap among types is generally minimal, with distinct operating windows reducing direct competition. Nonetheless, high-demand zones experience convergence during peak hours, resulting in temporary intermingling of activities. Seasonal rhythm analysis further reveals high sensitivity to climatic and daylight variations, distinguishing informal vendors from formal market schedules. Activity peaks are observed in spring and summer, particularly in September and March, corresponding to the academic calendar and Nowruz shopping periods, while declines occur in autumn and winter. Overall, these temporal patterns highlight the adaptive, heterogeneous, and strategically mediated rhythms of informal economic actors, offering critical insight for urban planners and policymakers aiming to manage temporal-spatial in-

teractions in urban environments. Finally, the coefficient of determination (R^2) across all types exceeds the average threshold, confirming a robust fit of the observed temporal patterns within the rhythm-analytical framework, and validating the methodological approach for capturing the nuanced dynamics of informal economic rhythms (Table 2, Figure 4 and Figure 5).

3.3 Rhythmic structure of activity content

The activity content of informal economic types in Zanjan reflects an integrated socio-economic system rather than a set of isolated vending practices. This system encompasses product structure, sales methods and volume, financial transaction mechanisms, accounting practices, product quality, pricing strategies, spatial arrangement of goods, activity overlap, spatial adjacency, vendor coordination, sales interdependence, and regulatory dynamics. Field observations and interviews indicate that, except for Types 3 and 6, most vendors supply new goods, suggesting a shared adaptive strategy aimed at maintaining affordability and steady demand rather than specializing in second-hand markets. The relatively consistent average net daily income ($\approx 800,000$ Iranian rials, with only minor variation across types) further points to structurally similar economic constraints despite functional diversity. Financial practices also demonstrate hybrid adaptation: widespread use of POS devices and mobile banking coexists with cash transactions, indicating partial integration into formal financial infrastructures without full institutional incorporation.

Spatial dynamics intensify these economic relationships. Peak-hour congestion, driven by pedestrian flow and vendor density (particularly in zones of overlapping activity) creates operational challenges such as traffic disruption, pressure on formal businesses, and environmental hygiene con-

cerns. However, evidence suggests that these conditions simultaneously foster cooperative spatial practices, including coordinated product display, logistical support, and informal regulation among vendors. This duality highlights congestion not merely as a constraint but as a catalyst for collective adaptive strategies. Limited or inconsistent municipal intervention has reinforced self-organization mechanisms, with authorities alternating between neglect, coercive removal, and provision of inadequately serviced rental market spaces. Consequently, informal governance structures have emerged, enabling vendors to stabilize economic activity through shared norms, mutual support, and collective risk management. Overall, the findings indicate that Zanjan's informal economy operates as a structured socio-economic network characterized by internal coordination, inter-type interaction, and resilience rooted in economic solidarity, rather than as fragmented individual survival activities.

4 Discussion

The findings of this study provide novel insights into the spatiotemporal dynamics of the informal urban economy, illustrating how economic actors navigate and utilize urban spaces under multiple constraints. By employing a time-geography perspective, this research emphasizes the critical role of temporal rhythms and space-time accessibility in shaping informal economic practices. The observed patterns indicate that informal economy actors operate within well-defined space-time frameworks, structured by their physical capacities, the necessity for co-presence, and institutional regulations governing access to specific urban locations. A key contribution of this study lies in delineating how the distribution and intensity of informal economic activities are organized across daily, weekly, and seasonal rhythms. These rhythms are not merely the product of individual agency; they are also conditioned by broader socio-economic and spatial systems, including transport infrastructure, regulatory frameworks, and the spatial distribution of demand. The dynamic interplay between these rhythms and structural constraints promotes adaptive strategies among actors, including flexible working hours, spatial relocation, and multi-site operations.

The rhythm analytical examination of Zanjan's informal economy reveals a sector deeply embedded within the city's socio-spatial fabric. Informal vendors strategically position themselves in high-footfall, accessible urban areas, and their spatial

clustering is influenced by product type, visibility, and safety considerations. Temporally, their activities align with environmental rhythms and daily solar cycles, with typology-specific operating hours that complement, rather than directly compete with, the formal market. Despite its economic significance, the informal economy remains predominantly subsistence-based and vulnerable to external shocks, including inflation and political instability. Operational practices are largely traditional, constrained by limited financial infrastructure and sub-optimal physical conditions. Nevertheless, strong social cohesion among vendors ensures the continuity of this sector despite infrastructural and regulatory challenges.

Field observations indicate that vendors operate within self-organized activity clusters, forming informal networks grounded in shared economic conditions and social class. This cooperation is driven by mutual understanding, economic empathy, and collective vulnerability, fostering a culture of solidarity and mutual support. Spatial analysis reveals that site selection is not solely determined by physical attributes but is also contingent on activity type, market density, proximity to other vendors, and the co-location of formal and informal markets, which together shape spatial identity and economic productivity.

Temporal analysis further highlights typology-specific patterns. Certain types, such as small-goods vendors, clustered markets, and night markets, exhibit high sensitivity to seasonal and environmental variations, whereas other types, including fruit and food vendors, demonstrate greater temporal flexibility. Temporal overlap among typologies is generally limited, though peak hours in high-demand areas induce transient interactions. Overall, the informal economy in Zanjan operates as a complex spatiotemporal system, whereby daily, weekly, and seasonal rhythms structure activity patterns and intensity, reflecting the strategic, adaptive, and context-sensitive nature of informal economic practices.

Collectively, these findings underscore that the informal economy is not merely an economic phenomenon but a deeply embedded spatiotemporal process that interacts dynamically with urban structures and daily rhythms. This highlights the imperative for nuanced urban policies that recognize informal economies as integral components of urban livelihoods, prioritize adaptive regulatory frameworks, and account for seasonal and diurnal variations in activity. Such policies must also acknowledge the sector's critical role in meeting localized consumer demands and sustaining the livelihoods

Types	1 Non-bulky Goods	2 Food Fast Food	3 Clustered Markets	4 Fruit Vendors	5 Night Market	6 Dispersed
Type of Goods	Clothing, shoes, cosmetics, small items	Kebab, falafel, potatoes, beans, corn, fire-brewed tea	Highly diverse: textiles, second-hand, fruit, tools, plastics	Seasonal fruits with longer shelf life	Clothing, shoes, toys, imported cosmetics	Mostly bulky goods: carpets, tents, toys
Supply Source	Wholesalers in Zanjan, Tehran, Kurdistan	Zanjan food market, wholesale suppliers	Highly diverse: Zanjan, Hamedan, Kurdistan, Turkey, Tehran, Azerbaijan	Central fruit markets, direct from farmers, group purchases	Wholesalers in Zanjan, Tehran, Kurdistan, Azerbaijan	Outside province: Tehran, Azerbaijan, Kurdistan, Isfahan, western/northern borders
Packaging System	Inadequate packaging	Lacks hygienic packaging	Mostly bulk	Bulk, unpackaged	Inadequate packaging	Inadequate packaging
Daily Income (thousand IRR)	700	800	850	850	800	550
Product Quality	Medium to low	Medium	Medium to low	Medium, shelf-life dependent	Medium	Medium
Banking System	POS-enabled account	POS-enabled account	POS-enabled account	POS-enabled account	POS-enabled account	POS-enabled account
Display Method	Ground, stools, makeshift stands	Stools and stands	Vehicle, tents, stands	Vehicle, ground	Ground	Vehicle and ground
Product Shelf Life	Non-perishable	Perishable	Mixed, mostly non-perishable	Perishable	Non-perishable	Non-perishable
Overlap with Formal Economy	Environmental overlap, occasional tension	None	None	None	None	None
Residential Overlap	None	None	Present	Present	None	Partial
Inter-activity Solidarity	Strong	Strong	Strong	Strong	Moderate	Unknown
Work Coordination	Strong	Strong	Strong	Strong	Moderate	Unknown
Environmental Organization	Relatively adequate	Relatively inadequate	Inadequate	Very inadequate	Relatively adequate	Very inadequate
Environmental Control	Relatively adequate	Relatively inadequate	Inadequate	Very inadequate	Relatively adequate	Very inadequate
Product Diversity	Diverse	Limited	Highly diverse	Mostly seasonal fruit	Moderately diverse	Limited
Virtual Sales	None	None	Occasional	None	Occasional (phone/social media)	None / occasional phone
Vendor Residence	Local	Local	Local non-local	Local	Local non-local	Mostly non-local
Sales Method	Cash	Cash	Cash, occasional credit/check	Cash	Cash	Cash, credit
Customer Demographics	Families	Youth	Families	Heads of households, mostly men	Families	Mostly men

Table 3 Rhythmic attributes of informal economy activity content

of a substantial segment of Zanjan's urban population.

This study acknowledges several limitations that warrant consideration. First, the reliance on cross-sectional field observations in Zanjan constrains the ability to capture longitudinal dynamics and causal relationships over extended periods. Second, while the rhythm-analytical approach effectively reveals spatiotemporal patterns, it does not fully account for individual-level decision-making processes or the psychological dimensions of vendor behavior. Third, the study's focus on a single mid-sized city limits the generalizability of findings to other urban contexts with different socioeconomic and regulatory environments. To reduce these uncertainties, future research should incorporate longitudinal tracking methods, in-depth ethnographic interviews, and comparative multicity analyses. Additionally, integrating quantitative data on household economics and digital transaction records could provide more robust insights into the financial vulnerabilities and adaptive capacities of informal economy actors.

5 Conclusion

This study demonstrates that the informal economy in Zanjan constitutes a systematically organized and adaptive urban subsystem, rather than a peripheral or chaotic activity. By applying rhythm-analysis within a time-geography framework, it reveals how temporal rhythms and spatial constraints jointly shape the strategies of informal actors, allowing them to optimize accessibility, visibility, and economic returns while responding to environmental, seasonal, and regulatory pressures. These findings indicate that informality is not merely a survival mechanism, but a socially coordinated and spatially embedded economic phenomenon.

Theoretical contributions are twofold. First, the research validates time geography as a lens for understanding urban informality, linking temporal cycles, activity content, and spatial positioning in a coherent framework. Second, it reframes informal economies as structured and contextually adaptive, challenging traditional views that consider informality as marginal or purely opportunistic. This perspective highlights the interplay between individual agency and structural conditions—such as transport infrastructure, market density, and institutional regulations—in producing distinctive spatial-temporal patterns.

From a policy and urban governance standpoint, the findings underscore the necessity of context-sensitive, data-informed interventions. Urban au-

thorities should recognize informal actors as integral to urban livelihoods and design regulatory frameworks that preserve adaptive capacities. Specific policy implications include: Implementing flexible spatial regulations that accommodate seasonal and diurnal variations in activity. Supporting vendor coordination networks to enhance collective management of space, reduce congestion, and improve environmental hygiene. Integrating informal economy data into urban planning and infrastructure development, ensuring public spaces balance economic activity with mobility, safety, and social interaction. Prioritizing participatory governance approaches that involve informal actors in decision-making, rather than relying solely on coercive enforcement.

In sum, the study emphasizes that informal economies are core components of urban socioeconomic systems, with rhythms and patterns that can inform both theoretical understanding and practical governance. Ignoring these dynamics risks inefficient policies, social tension, and underutilization of urban space, whereas acknowledging them enables more resilient, inclusive, and sustainable urban development strategies. Future research should explore comparative, longitudinal, and micro-temporal analyses to refine policy recommendations and extend insights to other urban contexts.

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