



# Market System and Proximity of Food Vendors: A Spatial Analysis That Improves Household Behavior

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## Suggested Citation

Pona, Y., Kone, D. & Mohomodou, W. (2023). Market System and Proximity of Food Vendors: A Spatial Analysis That Improves Household Behavior. *European Journal of Theoretical and Applied Sciences*, 1(5), 848-856.  
DOI: [10.59324/ejtas.2023.1\(5\).71](https://doi.org/10.59324/ejtas.2023.1(5).71)

## Abstract:

A study of the market system and the proximity of food vendors, the aim of which is to install food vendors to ensure food security (availability, accessibility, quality and cost of foodstuffs in local markets). The objective is to identify the proximity of food vendors to ensure the food distribution system for the urban populations of Bamako. Thus, we address an estimation method adapted to these spatial specifications. Our exhaustive sampling includes 201 sales outlets in the “Bankoni and Sablibougou” neighborhood of the Bamako district. Special modeling allows vendors to make projections on food access. The results of the

analysis show that the distance is more important in relation to the position of the vendor installed in the neighborhood, whatever the price charged to the customer ( $\gamma < 0.05$ ). Moreover, when the probability is lower, the sellers are so far from the customers, they go out of the limits of the radius of 1000 put. The sensitivity of the market to a change in price, customers are somehow not loyal, regardless of the value of elasticity is greater, and therefore profits are smaller. Conclusion: In a symmetric equilibrium with a finite market boundary, profits are greater when prices are high, and therefore when the elasticity of demand is low. The lower the density of marginal consumers, the lower the elasticity.

**Keywords:** *food, proximity, spatial analysis, distance, accessibility*

## Introduction

The food environment was initiated to address food security (availability, accessibility, quality and cost of food on local and global markets. It indirectly influences income management and determines social structures as well as environmental changes FAO (2018) et Bendhaou (2021)

In sub-Saharan Africa, food insecurity remains a major concern. have predicted that 46 million

more people will be affected by hunger in Africa in 2020. Around one in five people (21% of the population) faced hunger in Africa in 2020, Bendhaou (2021). The burden of food insecurity and malnutrition remains a global challenge, and despite global progress in reducing global food insecurity, 690 million people are severely hungry and chronically undernourished. It has been shown that the cost of a healthy diet in West Africa was 3.45 USD in 2020, and that 337.1 million people in the region, around



79.2%, could not afford this high market cost Fao (2022).

to deteriorate progressively due to the immediate effects of multi-faceted conflict and violence Pona et al. (2023). Added to these shocks are the natural constraints of climate change (droughts, floods, etc.). COVID-19, with its biotic and abiotic impacts, affects all basic social sectors and the protection of people's livelihoods. Protection incidents 35% have been recorded in the Mopti region OCHA (2021). However, the displacement of a large part of the population, which was estimated at 311,193 in October 2020, will increase to 358,212 in 2021 OCHA (2021). Households are registered in this fear of seeking the most accessible food and close to the population. Out of a population of 20,537,000 in 2020 INSTAT (2022).

Analysis of the spatial evolution of the city of Bamako relates to political, economic and territorial factors. Cartographic analysis on a micro-local scale has enabled us to track the evolution of development and spatial transformations in the port area and has provided some pointers to links with other scales Pona, Mohomodou, et al. (2023). Geographical approaches clearly highlight the multi-scalar issues facing port cities, which represent major challenges for ports in developing countries Ba et al. (2013).

Spatial analysis is the study of the configuration and properties of the space produced and experienced by human societies. It encompasses a range of theories and methods for analyzing and measuring the effects of geographical location. This has led us to question the management policies implemented to date within the space occupied by vendors. The food environment is one of the most important aspects of consumer dietary diversity. As defined by the FAO (1997), a food environment is the perimeter within which individuals can find all the variety of available and accessible foodstuffs they need daily. This availability reflects a multitude of processes that take place around farmers. Agricultural production has a direct influence on the food environment, resulting in food security (availability, accessibility, quality

and cost of foodstuffs on local and world markets Pona, Traore, et al. (2023). It indirectly influences income management and determines social structures and environmental changes.

According to FAO (1997) et Turner et al. (2018), food environments are places where food is acquired or consumed. Today, it seems necessary to rethink these market equipment projects by integrating them into a more global reflection on food systems. The location of the villages' center of gravity in the center of the study area, and its slight displacement around it, reveal the influence of the original small households on the spatial diffusion of vegetable and fruit vendors Cheneau-Loquay (1997). Spatial diffusion plays an important role in the formation, stability and transformation of spatial structures. It has two dimensions: spatial and temporal, which are very closely linked, since from a phenomenological point of view, space and time appear as a continuum. What changes do distribution systems need to make to better meet the food and social challenges of cities? The aim is to identify the proximity of food product sales to ensure different food distribution system for the urban population of Bamako. We therefore propose an estimation method adapted to these spatial specifications.

## Materials and Methods

### Study Area

All of data collection was undertaken as part of the final year studies of the third cycle of the University of Bamako. Data collection was also supervised by a PhD student from the same university during the month from May to June 2022. We chose two starting points, one on the left bank and the second on the right bank of Bamako. The vendors, who represent varying levels of sales outlets, can be in various places, at varying distances from the urban area. Both districts have specific characteristics in terms of demography, openness to the national market and strong demographic and economic growth, fueled by their position as regional commercial centers.

## Data and Survey Method

We conducted a participatory rural survey in which we identified 201 vendors, all located in our study area. All sales outlets and other forms of food supply, including public spaces and street vendors located within 1000 m of the starting point, were interviewed. By systematically walking all along the streets and alleys of the district until the whole area was observed. Included were vendors in the vicinity of public markets but selling food or covered halls owned by municipalities, small neighborhood grocery stores, and street vendors referring to traditional distribution. Thus, in each selected neighborhood, the main public elementary school was taken as the starting point. Everyone taken at random in each space has a propensity to behave like any other individual in the same space.

## Economic Model

In the Spatial Econometrics work of Le Gallo (2002) on spatial autocorrelation in linear regression models, the economist is often confronted with the use of localized data. The processing of observations of a variable measured in different locations distributed in space. Special modelling allows sellers to make projections on the access of foodstuffs to the last household that has access to the product to ensure its food consumption. Data were collected from ONA collection then processed on STATA for empirical analyses using a distance-based econometric model will be performed. The multinomial logistic regression model will be used for analyses that aim to explain that a binary variable of interest that takes “zero or one” Jérôme (2019). The explanatory variables introduced into the model can be quantitative or qualitative.

We must also add independence between geographical observations and spatial heterogeneity to the differentiation of variables and behaviors in space. To determine the role of proximity and spatial-temporal dependence in the propagation of a phenomenon, we often resort to splitting the data into a series of fixed period views, as in the work of Bocquet et Jakobi (1998) who use the show test to check

hypotheses and compare coefficient estimates over two or more sub-periods.

In fact, the distance between the house and the grocery store located at a very close distance is accessible to people without access to a motorized vehicle or a well-developed public transport network in their area Bonnafous (1991). This same distance has also been used in studies by Vacher (2014). The simple formula for calculating the distance is used to evaluate the average distance:

$$D = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2} \quad (1)$$

The coordinates of the points are given by the geographical coordinates of the points of sale.  $A(x_A; y_B)$  et  $B(x_A; y_B; \dots; x_{Aij}; y_{Bij})$ . A is the starting point, and B is each sales point. However, the distance between point A and point B between these two points is given by the geographic coordinates collected for each salesperson within a radius of 1000 meter, i.e., a diameter of 2 kilometer. Note that for all distances less than 1000 meter, the coefficient is adjusted to a value of 1. The higher the k coefficient, the more the attraction decreases, so widespread shops will have higher k coefficients than shopkeepers. Within the same trade category, the coefficient can also vary considerably according to the size of the outlet, its shelf space, its choice of products and the size of its parking lot. Thus, we noted that income level should be considered as an element influencing customer potential. We'll be testing the influence of a strong residential presence on the correlation between the model and female customers.

## Modeling Human Behavior

An interesting problem in Hotelling's model is that of store choice. It's hard to imagine consumers choosing their stores in such a Manichean way, based solely on price and distance. Let's take a brief look at economists' methods of modeling human behavior Basaille-Gahitte et Mathieu-Nicot (1991) et Nava, Matteo, et Aste (2018). A model commonly used

by economists is the ordinal logit model. This model is very appealing because it is very close to statistical physics. The probability of consumer J choosing store S over other stores is given by the regression between total dwellings and sales outlets, showing the safe areas and areas where vegetable or food vendors are present to ensure household consumption. Let's consider again a two-dimensional model. Consumers are distributed continuously and uniformly over a square of length L, centered at (0, 0). According to the logit model, the probability  $\delta_{j,s}$  that consumer J will buy his product from store S is:

$$\delta_{j,s} = \frac{\exp(k_{j,s}/\mu)}{\sum_{s'} \exp(k_{j,s'}/\mu)} \quad (2)$$

where  $k_{s,j}$ , is the part of the utility that writes price and distance and  $\mu$  is a positive real parameter that quantifies the importance of the irrational aspect of consumers. When  $\mu = 0$ , the consumer chooses exactly the two outlets with the highest utility and when  $\mu \rightarrow +\infty$  then it doesn't matter what the price and distance are since the two outlets are identically chosen, where S and S' can take the values 1 and 2 and the demands D1 and D2 of the first and second outlets are written as follows:

$$\int_{-L/2}^{L/2} dx \int_{-L/2}^{L/2} dx \frac{1}{1 + e^{\{p_1 - p_2 + \alpha[|j-s_1|^2 - |j-s_2|^2]\}/\mu}} \quad (3)$$

and

**Table 1. Outlet Repartition**

Name of outlet	BANCONI			SABALIBOUGOU			All LOCATIONS		
	Obs	Mean	Std. dev.	Obs	Mean	Std. dev.	Obs	Mean	Std. dev.
Staple foods	30	.34	.47	34	.30	.46	64	.31	.46
Dark leafy vegetables	10	.11	.31	24	.21	.41	34	.16	.37
vegetables	83	.94	.23	106	.93	.24	189	.94	.23
Fruits	26	.29	.45	32	.28	.45	58	.28	.45
Meat	8	.09	.28	15	.13	.34	23	.11	.31
Poultry	7	.07	.27	3	.02	.16	10	.04	.21

$$D_2 = L^2 - D_1 \quad (4)$$

where  $J = (j_x, j_y)$  is the vector corresponding to the position of store i. The total demand D1+D2 is effectively equal to the sum of the consumers, because they are all forced to buy one and only one product, and this sum is equal to the area of the square, because the distribution of consumers is uniform:

$$\frac{\partial D_2}{\partial p_2} = \frac{\partial D_1}{\partial p_1} = -\frac{\partial D_2}{\partial p_1} = -\frac{\partial D_1}{\partial p_2} \equiv -I, \quad D_1 + D_2 = L^2 \quad (5)$$

A high elasticity corresponds to a situation where a store's profit falls significantly for a small variation in its selling price. I is called elasticity and we define the elementary elasticity  $i(j)$  at position j as one-dimensional and  $f(j)$  as the density of consumers in j as:

$$i(j) = \frac{\partial \delta_i(j)}{\partial p_i} = \frac{L}{4T} \frac{f(j)}{\cosh^2(\gamma \sigma j)} \quad (6)$$

$$I = \int_{-A}^A i(j) dj \quad (7)$$

## Results

Table 1 show the outlet repartition on the locality. In the data collection package, Fish seafood and small protein were not available from vendors. As a result, households will have to go to the market to buy these two products.

Eggs	25	.28	.45	28	.24	.43	53	.26	.44
Milk & products	20	.22	.42	20	.17	.38	40	.19	.41
Pulses	17	.19	.39	12	.11	.31	29	.14	.35
Red palm oil	-	-	-	3	.02	.16	3	.01	.12
Oils & fats	18	.20	.41	11	.09	.29	29	.14	.35
Sugar	29	.32	.47	24	.21	.41	53	.26	.44
Sweets & snacks	31	.35	.48	26	.23	.42	57	.28	.45
Sugar drinks	23	.26	.44	19	.16	.37	42	.21	.41
Miscellaneous	31	.35	.48	21	.18	.39	52	.25	.43
Condiments	22	.25	.43	29	.25	.43	51	.25	.43
Onion	22	.25	.43	39	.34	.47	61	.31	.46
Tomato	22	.25	.43	41	.36	.48	63	.31	.46
Chili pepper	22	.25	.43	41	.36	.48	63	.31	.46
Amaranth	13	.14	.35	16	.14	.35	29	.14	.35
Jute mallow	19	.21	.41	35	.31	.46	54	.26	.44
Okra	6	.06	.25	14	.12	.33	20	.09	.31

**Source:** Authors

There is enough time or travel a long distance to acquire a good or service. The farthest distance is 56.61 meter from the starting point. All other things being equal, some vendors are obliged to set up shop in a fixed location, where buyers are obliged to find them on the spot, such as various stores and food stores.

Among vendors occupying spaces for basic consumable foodstuffs (condiments), the average height is around 1.44 meters, and can reach up to 17 meters depending on vendor specialization. Spatial analysis of the clientele shows that 84% of customers live very close to the vendors.

The interviewee sells several varieties to enhance the food basket. Processed and unprocessed products account for 63% of the food in the locality of the starting center and are located at an average distance of 6 meters from the customers. However, very few vendors are interested in direct sales of condiments (around 11%). This can be explained by the fact that households opt for group buying of condiments to have a family stock. All vegetables Fresh produce and leafy vegetables are available from vendors, while minimizing distance travelled and ensuring access to food quality.

Certainly, these results reveal spatial proximity as the main channel of distribution, particularly in the center and end of the radius of the study area. Elementary products are also closer to the average, with staples having a high access rate (32% of sellers), but generally being further from the consumer, as are poultry (5% of sellers) and meat (11% of sellers). We seeing in figure 1 the distribution of products on either side of the moving average.

These small production units have focused on Mali's productive sectors, emphasizing diversification, accessibility, and the processing of agricultural products. This has created a ripple effect in the management of territories in the social vendor integration dimension, which is a source of job creation, small business development and wealth creation within the territory. However, it must be recognized that there is a favorable environment for interaction between a salesperson and his or her potential customer.

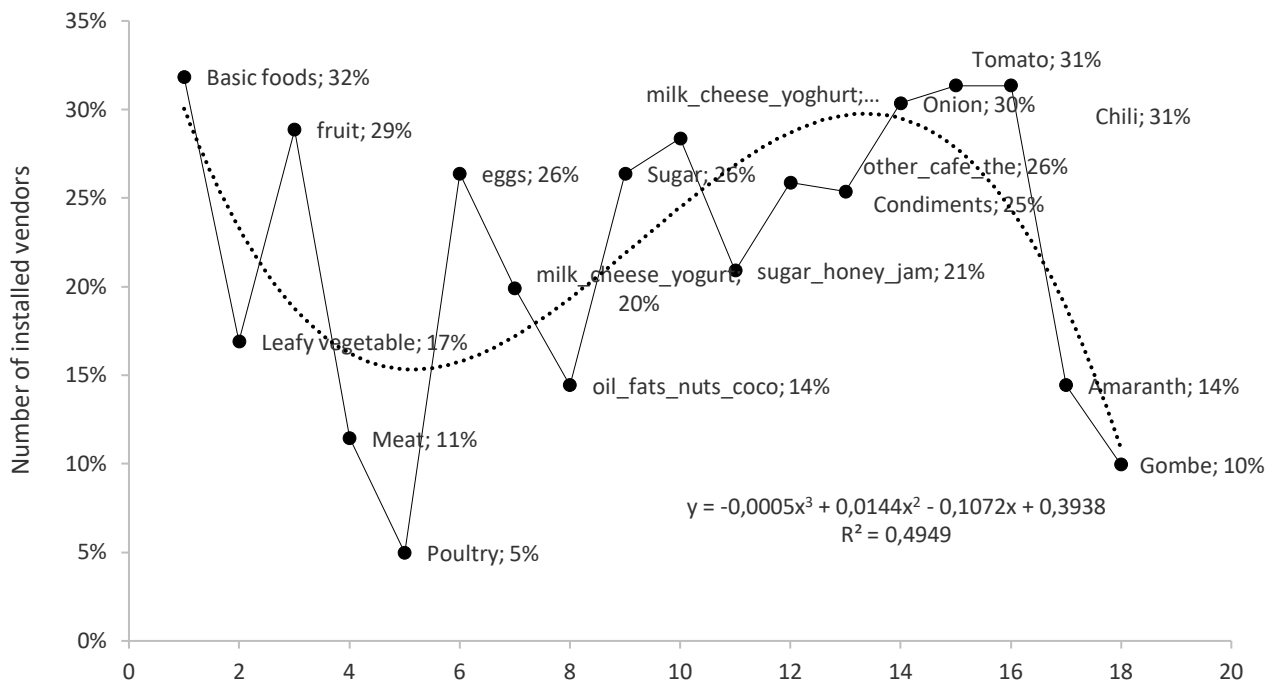


Figure 1. Potential Numbers of Products

In the regression model, statistically significant relationships were found at 5% for the food groups (leafy vegetables and condiments), then at 10% for the food group (milk, cheese, yoghurt, and oil, fats, coconut). The space occupied by vendors, cultural adaptation and dietary diversification of collection areas have positive and significant effects at 5% on the distance a customer has to travel to buy vegetables and various store products. Adjustments made by vendors have variable effects on their sales. However, the results of the regression model indicate that only the accessibility system and the diversification of

sundries sold have what could be considered significant effects on the vendor's profit.

Reading the table shows that the regression model has expected effects on producers adopting the simplest or most complex of possible adaptation strategies to satisfy the community's desire to appreciate their level of profit. We note that the proximity feeding of customers has a positive impact on vendors' income levels. With this in mind, we will test the influence of a strong housing presence on the vendors available in the vicinity.

Table 2. Spatial-Temporal Proximity Estimate

Distance par rapport au point de départ	Coeff	Error Standard	$\gamma$	$P > \gamma$
Staple foods	.1160876	.3327538	0.35	0.727
Leafy vegetables	-.9444183	.3636432	-2.60	0.009
Fruit	.1757472	.3016546	0.58	0.560
Meat	-.5917613	.4078248	-1.45	0.147
Eggs	.2032604	.3441709	0.59	0.555
Milk, cheese, yogurt	.9830098	.5334472	1.84	0.065

Fish captain carp	.5952564	.43278	1.38	0.169
Oil, fats, coconut	.8503888	.476271	1.79	0.074
Sugar, honey, jam	-.1428376	.5069136	-0.28	0.778
Others, ketchup, coffee, tea	-.5748844	.5163825	-1.11	0.266
Condiments	-1.164065	.3845127	-3.03	0.002

**Source:** Authors

The sensitivity of the market to a price change is greater, and customers are somehow not retained, regardless of the value of the elasticity, so profits are smaller.

In the study on the problem of the spatiality of vendors, vendors are a decisive element in the response to the problem of social integration and reducing difficulties of access to food. The low rate of spatial-temporal proximity of several foods remains a major challenge for customers. This has also enabled us to understand that each vendor wants to dissociate himself from a situation of voluntary unemployment (in other words, classic unemployment) to launch an income-generating activity (small business).

## Discussion

The special competition has allowed to locate that the walking areas that the Temporal Installation of space represents 94.5% and the rest is reserved general food and miscellaneous store around 4.5%. As for the average size of the space occupied by the vendors, 4.23 meters for a maximum of 2630 cm. The average distance from the starting point to each sales outlet is estimated at  $5.68 \pm 931m$ . Hotelling's law (1929) provides an insight into the competitive interactions between retail outlets. These small production units will focus on Mali's productive sectors, with an emphasis on the processing of agricultural and livestock products, given the importance of these sectors to Mali's economic development. This will have a knock-on effect in other regions, with

The minimum distance would be 0.37 m or almost install side by side. This distance is explained by the fact that sellers want to get closer to their customers, so households won't provide. The differentiation of eating habits is

characterized for some by an increase in dietary diversity, which is notably characterized by a strong demand for fruit and vegetables and dairy products. Gergely et Csibra (1997) et Pona, Traore, et al. (2023). More recently, studies on the supply of towns in Zaire and Côte d'Ivoire have been inspired by this Goossens, Minten, et Tollens (1994) ; Pirotte et Poncet (2002).

The regression result shows that for a sufficiently large value of  $\mu$ , distance is therefore more important than the position of the salesperson setting up in the neighborhood.

Whatever the price charged to the customer ( $\gamma < 0.05$ ), the only possible Nash equilibrium in position is achieved when the two salespersons are set up-side by side. However, for lower values of  $\mu$ , i.e., where product quality makes the difference, another Nash equilibrium exists where the sellers are spatially separated. What's more, when the probability is lower, sellers are so far away from customers that they fall outside the limits of the 1,000-meter radius. The contribution of Von Thünen's writings is twofold. There is an identical optimal location for all agricultural activities around the market town. Moreover, the supply of land is relatively scarce, otherwise there would be no competition between agricultural activities. This analysis was taken up by (William et Dunn 1954) to study the evolution of agricultural areas. Polèse (2005) While these reflections refer to agricultural space, many notions were taken up by the models of household location and urban space structuring initiated by Alonso: the notion of center, the influence of transport costs on land rent and competition between activities for space allocation.

## Conclusion

This article shows that the implementation of a certain number of structural measures could have a positive impact on the social integration difficulties of neighborhood vendors. This, through the development of individual small businesses on all blocks. Vendors had been criticized for making their food environment healthier and more attractive, enabling customers to have access to quality food to improve their diet without having to travel long distances to acquire it. Several factors may explain the proximity of vendors to customers, the most decisive of which appear to be easy access and distribution of food products, the imbalances created by consumer choice in access to food resources, and the economic factors of customers. Elementary products are also closer to the average, with staples having a high access rate (32% of sellers), but generally being further from the consumer, as are poultry (5% of sellers) and meat (11% of sellers). The proximity of customers' food supplies has a positive impact on vendors' income levels. Elementary products are also closer to the average, with the staple product having a high rate of access for vendors, but generally being further away from the consumer, as are poultry and meat vendors.

Based on the methodology adopted, we arrived at results that enabled us not only to identify the stakes, characterize the effect of proximity and their interactions within the community. In a symmetrical equilibrium with a market of finite boundaries, profits are higher when prices are high, i.e., when demand elasticity is low. The lower the density of marginal consumers, the lower the elasticity. So, if consumer consumption is uniform, elasticity is minimal when the corresponding hyperplane has a minimal area. Since the strategic space is a hypercube, this hyperplane is parallel to one of the faces, implying that differentiation occurs in one dimension only.

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