TEMPERATURE VARIATIONS AND THEIR EFFECTS ON THE DEMAND AND OPERATING COSTS OF MOTORCYCLE TAXI DRIVERS IN PATOS, PARAÍBA

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Ayrlla Caetano do Nascimento[1], Echiley Alves da Silva[2], Lícia Isadora Pereira de Medeiros[3], Maria Vitória Oliveira Duarte[4], Raoni Gabriel da Silva[5], Maria Victoria da Silva Pereira[6], Gabriel Carvalho Gomes[7] and Evadio Pereira Filho[8]

ABSTRACT

This study sought to analyze the impacts of temperature on the demand and operating costs of motorcycle taxi drivers in Patos, Paraíba, a city with a semi-arid climate and intense temperatures. Data collection took place at two motorcycle taxi ranks, observing the mileage traveled, temperature variations and consumer behavior. In Praça A, associated with the street market, demand decreased with the increase in temperature, but grew on commemorative dates, reflecting a cost-benefit logic. In Praça B, close to air-conditioned areas, demand remained more constant, although there was a reduction in mild temperatures. The operating costs of motorcycle taxi drivers varied significantly, with increases of up to 60% in periods of low demand. The survey pointed out that the temperature directly influences the choice of means of transport, such as motorcycle taxis, being an essential factor for comfort in urban mobility. Therefore, the study suggests the need for public policies aimed at motorcycle taxi drivers, which consider regional climatic conditions and the profile of users, aiming to optimize operations and improve the working conditions of service providers.

Keywords: Temperature. Motorcycle taxis. Demand. Operating Costs. Urban Mobility.

[1]Undergraduate student in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[2]Undergraduate student in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[3]Undergraduate student in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[4]Undergraduate student in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[5]Graduating in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[6]Undergraduate student in Civil Engineering
Federal Institute of Paraíba - Patos campus
[7]Graduating in Civil Engineering
Federal Institute of Paraíba - Patos Campus
[8] Dr. in Business Administration
Federal University of Rio Grande do Norte - UFRN

INTRODUCTION

The municipality Urban transport influences the quality of life of a society, as urban mobility enables the performance of economic, educational and social activities, which are intrinsically linked to the maintenance and development of cities (Ferraz and Torres, 2004).

In this perspective, motorcycles are the main means of transport in countries such as Vietnam (Siebert et al., 2021), widely used for urban transport, based on the offer of personalized travel services that generate income for professionals through monetary collection due to the route requested by users, highlighting motorcycle taxis, which provides an affordable transportation alternative in cities (Cruz, 2014; Pontes et al., 2023).

Thermal oscillation in urban areas, especially in cities with a semi-arid climate such as Patos-PB, has been shown to be an increasingly relevant factor for understanding urban mobility patterns. With the increase in the flows of people moving daily, this population will tend to require better comfort in terms of their commute (Queiroga, 2019). It is assertive to state that temperature variance is correlated with regard to comfort in urban mobility in the city, thus being a factor that directly influences the choice of car or services such as motorcycle taxi to make the journey.

However, changes in global temperature, intensified by anthropogenic actions, impact society in several areas, especially activities related to the displacement of people (Schaeffer et al., 2012).

From this, with the growth of the city of Patos-PB and the consequent change in the temperature of this urban center, individuals choose the means of transport that they consider will best meet this need for locomotion (Queiroga, 2019).

In addition, thermal discomforts can cause changes with regard to human activities (Queiroga, 2019). Thus, it can, for example, impact the services provided by motorcycle taxi drivers to the population.

Therefore, this work aims to analyze the influence of temperature conditions, focusing on the periods of increasing and decreasing temperature, on the flow of motorcycle taxi rides in two squares located in Patos, Paraíba. In addition, the study seeks to highlight variations in operating mileage, costs per kilometer traveled and consumer behavior, understanding how temperature fluctuations impact both demand and operating costs.

THEORETICAL FRAMEWORK

URBAN MOBILITY

Urban mobility is defined by the Ministry of Cities as an "attribute of cities, related to the movement of people and goods in the urban space using vehicles, roads and all urban infrastructure" (ANTP, 2007, p. 16). Through urban mobility, the individual is guaranteed the right to freedom, individuality, to inhabit and to appropriate space. In general terms, urban mobility guarantees the right to the city (Léfèbvre, 2001).

Motorcycle taxi

The service known as motorcycle taxi is an activity provided from the use of motorcycles, which are easy to park, which aims to move people, thus consisting of a means of transport for individual use in which the contractors of these services can choose the places for their boarding and disembarking (Abreu, 2012).

CLIMATE CHANGE

The Earth's climate is not linear, since natural causes result in changes in it, in addition to the fact that these changes are intensified by human activities that emit greenhouse gases, causing an increase in the temperature of the Earth's atmosphere (Oliveira and Vecchia, 2009).

Climate change affects several areas, and can impact the economy and the activities of society. In addition, the greater the warming, there may be changes in aspects that may be unalterable (Marengo and Souza Júnior, 2018).

ELASTICITY OF DEMAND

The elasticity of demand for a good or service can be defined by the way demand responds to variations in the factors that influence it, and is essential to support producers' decisions, as it is intrinsically linked to the revenue generated by the sale of the good or the provision of services (Etulain, 2019; Iunes, 1998).

When analyzing the elasticity in the motorcycle taxi service, it can be seen that the temperature variation significantly influences the demand, reflecting in the total kilometers traveled. Using the formula (1), it is observed that, on hotter days, the demand for the service tends to increase, as customers seek greater comfort and speed in travel. On the other hand, in milder or colder temperatures, demand may decrease.

$$E = \frac{Km}{Tm} \qquad (1)$$

where:

E= elasticity of demand

Km= total km traveled

Tm = average temperature

OPERATING COSTS

Operating costs correspond to the financial resources employed in the production of goods or services within a company (Neto, 2008). Applying this approach to the service provided by motorcycle taxi drivers, operating costs correspond to expenses directly linked to the execution of the activity. These costs are recognized at the time when essential resources, such as gasoline used in passenger transport, are consumed for the provision of customer service. This work was dedicated to the analysis of the operating cost, considering the relationship between the price of regular gasoline and the total mileage traveled, according to the formula (2).

$$Co = \frac{5.96}{Km} \qquad (2)$$

where:

Co = Operating Cost

5.96 = average price of gasoline Km = total km traveled

CONSUMER BEHAVIOR

"Purchasing behavior translates into the processes that a consumer goes through to make purchasing decisions, as well as to use and dispose of goods and services (Lamb et al., 2004, p.126)". As portrayed by Ramos (2014), this behavior described by Lamb is equally influenced by social factors, as well as by reference groups.

Psychological, social, cultural, and structural factors of individuals are intermediate and preponderant factors in decisions to use a service (SILVA, 2021). Therefore, the importance of understanding these customs of local consumers is reaffirmed, aiming to maximize the financial profitability of service providers.

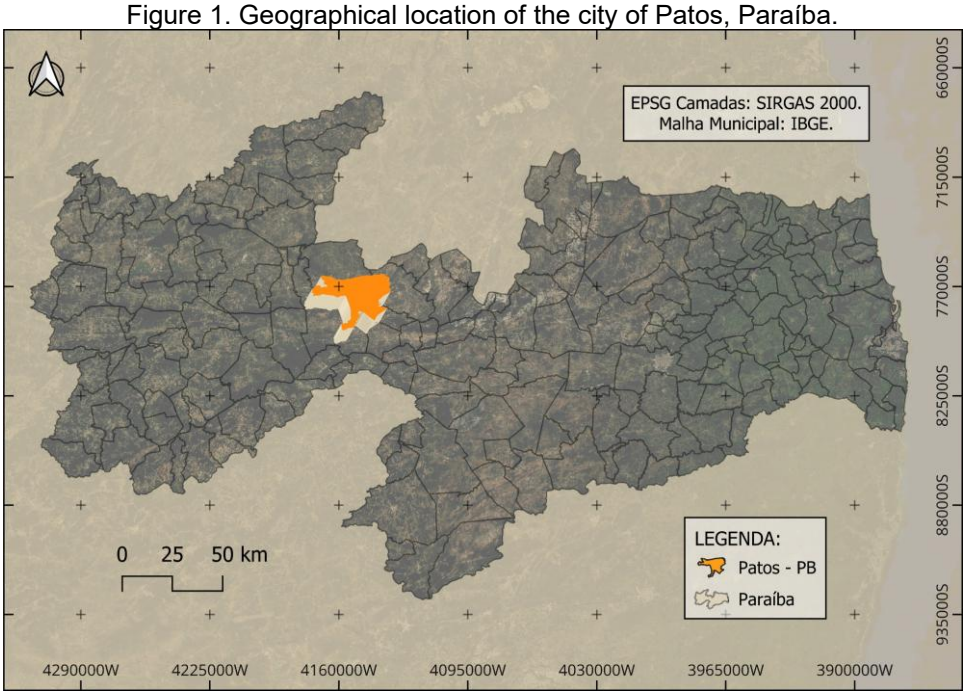
METHODOLOGY

PLACE OF STUDY

The present study was carried out in the city of Patos, Paraíba, known as "Morada do Sol", located in the semi-arid region of the Sertão Paraíba. According to the Brazilian Institute of Geography and Statistics (IBGE, 2023), Patos has approximately 103,165 inhabitants, and its territory covers 472,892 km², standing out as an important urban center in the Paraíba network, as shown in figure 1.

The choice of Patos as a study area is justified by its extreme climatic conditions, with temperatures often exceeding 37°C, especially during the hottest periods of the year, which occur in the last three months of the year (Weatherspark, 2024). These characteristics make the city an ideal setting to investigate the impacts of temperature changes on urban transport services, especially motorcycle taxis.

Figure 1. Geographical location of the city of Patos, Paraíba.

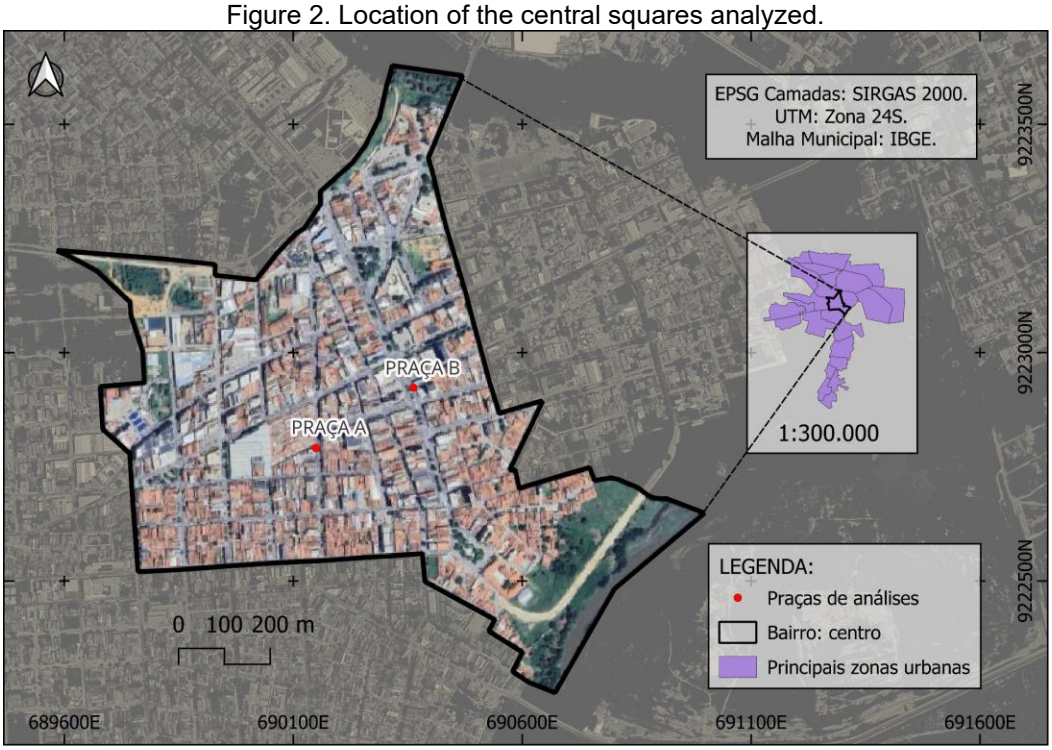


Source: Prepared by the authors, 2024.

Two motorcycle taxi ranks were selected for analysis, due to their strategic location in the center of the city of Patos/PB, where the highest concentration of transport flows and users occurs. Square A is located close to fairs and public markets, making it a point of great movement, especially on days of intense commerce. Square B is located near the city hall, post office and banking institutions, configuring itself as an important administrative and financial center of Patos. These places have greater movements during the hours of greater urban activity, due to their proximity to shops and public services, in addition to being traditional points for boarding and disembarking motorcycle taxis. The selection was

based on direct observation carried out by the researchers during the data collection period. The spatial delimitation of the squares and their surroundings was carried out with the aid of the Qgis software, which allowed the creation of maps for the geographical visualization of the areas studied, as illustrated in figure 2.

Figure 2. Location of the central squares analyzed.



Source: Prepared by the authors, 2024.

DATA COLLECTION

Data collection was conducted over four consecutive weeks in November 2024. This interstice was chosen because it is the one where high temperatures are recorded. The collections occurred weekly, at two different times of the day: during the moments of increasing and decreasing temperature, allowing to capture significant variations and their impact on the operation of motorcycle taxis.

The data were recorded using the observer researcher method, through on-site visits to motorcycle taxi ranks. Variables such as mileage traveled by drivers and demand patterns were recorded in a manual spreadsheet developed specifically for this study, as described in the layout presented in figure 3. This approach ensured the systematization of the information collected and the treatment of the data in an effective manner.

Figure 3. Layout used to record the data collected in the field.

PRAÇA:		OBSERVADORES:	
DIA DA SEMANA:			
HORÁRIO DE CHEGADA:		HORÁRIO DE SAÍDA:	
ANÁLISE (HORÁRIO DE ANÁLISE):			
QUANTIDADE (MOTORISTA NA PRAÇA)	DEMANDA DE SERVIÇO (CORRIDAS/HORA)	TEMPERATURA (°C)	OBSERVAÇÕES
ANÁLISE (HORÁRIO DE ANÁLISE):			
QUANTIDADE (MOTORISTA NA PRAÇA)	DEMANDA DE SERVIÇO (CORRIDAS/HORA)	TEMPERATURA (°C)	OBSERVAÇÕES

Source: Prepared by the authors, 2024.

Based on the temperature records, the researchers defined two main categories: increasing temperature and decreasing temperature. The first covers values between 31°C and 35°C, while the second refers to temperatures between 36°C and 34°C. These intervals were defined based on the patterns identified during the days of data collection. For the analysis, meteorological data were extracted from regional and global climate databases, and later correlated with information collected in the field.

This integrated methodology enabled a comprehensive analysis of how extreme temperature conditions affected the operation and demand for motorcycle taxi services in the central urban area of the city of Patos.

RESULTS AND DISCUSSIONS

The data collection carried out in the two motorcycle taxi plazas in the center of the city of Patos/PB, made it possible to analyze the values of the mileages traveled during certain times of the day, being evaluated together with the temperature variation. Seeking to understand the demand according to the increase and decrease of the high temperature and the consumer behavior through these variations in the context of the study, it was thus possible to calculate the minimum operating costs of motorcycle taxi drivers from the local mobility flows.

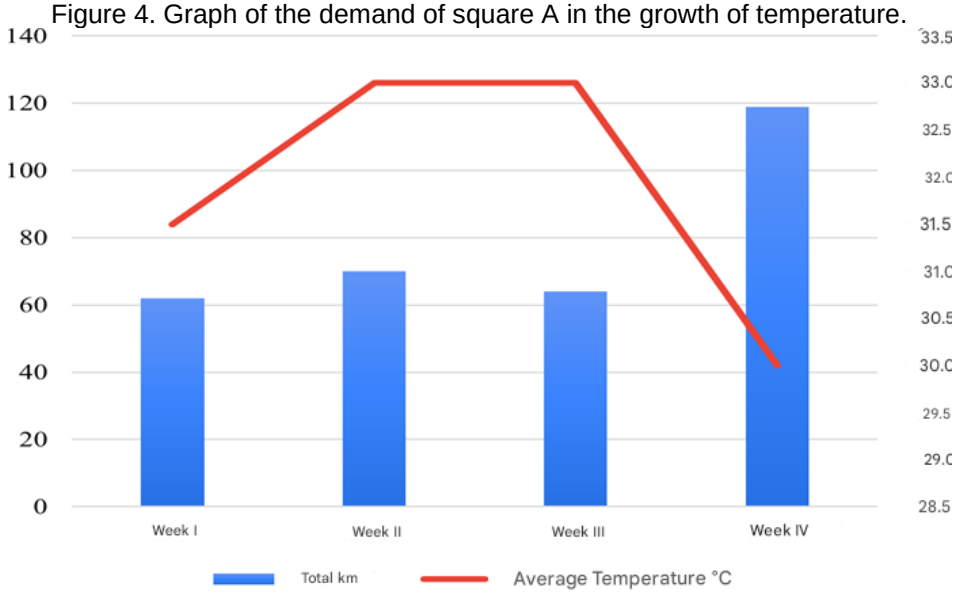
Thus, the data were organized and separated into two categories: I - increasing temperature and II - decreasing temperature. The separation and organization of the collected data helped to understand the two squares in a different way, helping to understand the influence of the flow of races on the climate, resulting in the study of the elasticity of demand from squares A and B in the two categories.

Still with regard to the total mileage traveled in each analysis, it is possible to understand the operating cost with the average value of regular gasoline over mileage, understanding which category has the highest volume of rides. During data collection, the average value of 5.96 reais per liter was used, the average price released by PROCON in Patos after analysis at 24 gas stations in October 2024 (Oliveira, 2024).

The concentration of people who use square A is mostly customers who attend public fairs and there was an oscillation in demand. This justifies the times of concentration of the activities of the fairgrounds, with the number of people being higher in the early hours of the morning, as well as the gradual increase in temperature, this flow decreases, with the demands of the square being around 60 km to 80 km in the first three analyses. On warmer days, demand is likely to gradually decrease after the peak period, especially as thermal discomfort reduces the time people stay in these open environments.

On the day referring to week IV of square A, in category I, there was a greater demand, even with the reduction of 3°C, from 33°C to 30°C, being a separate case, which can be explained by being close to commemorative dates and people populated the shopping center more, thus demanding a greater requirement from motorcycle taxi drivers for immediate displacement. There was a displacement from 80 km to approximately 120 km, as shown in graph 1.

Figure 4. Graph of the demand of square A in the growth of temperature.

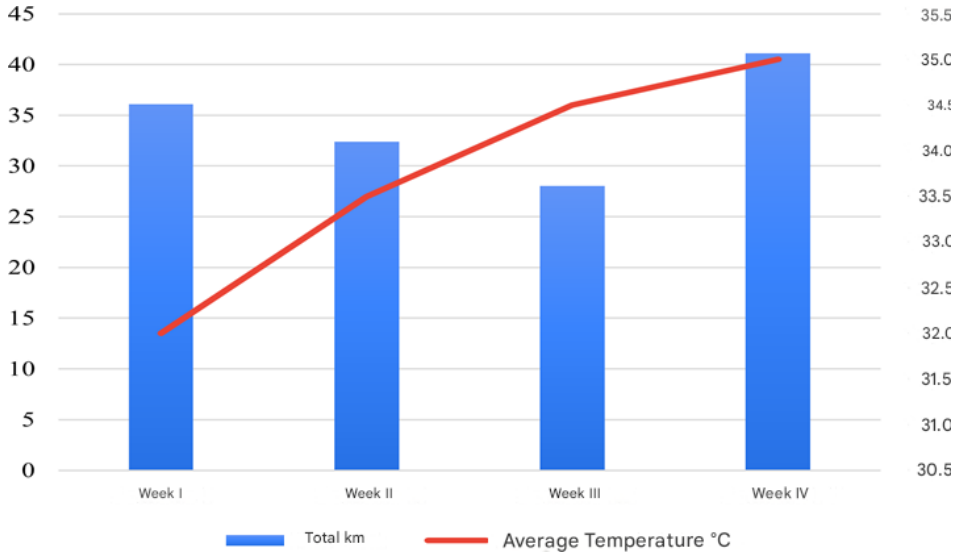


Source: Prepared by the authors, 2024.

In square B, because there is an intense commercial and administrative area, mostly properly air-conditioned, the flow of people remains constant in the urban centralization of the municipality. This characteristic makes the demand less susceptible to climatic

variations, since users are often in transit between air-conditioned environments, allowing for a gradual increase in mileage due to the rise in temperature. Therefore, in these locations, people may prefer short and quick trips between establishments, increasing the demand for transport services in the region at high temperatures, as shown in graph 2,

Figure 5. Graph of the demand of square B in the growth of temperature.



Source: Prepared by the authors, 2024.

Compared to square A where demand is decreased as the temperature rises, despite the mileage being higher than that of square B, the dynamics reflected in the temperature is seen as a means of negative impact. The elasticity of demand varied from 1.93 to 3.96. While operating costs did not reach 10% as shown in table 1, showing to be quite efficient.

Table 1. Operational analysis of square A at increasing temperature.

Weeks	Total km	Average Temperature °C	Elasticity of the demand	Operating Costs
Week I	62,00	31,5	1,9683	0,0961
Week II	70,00	33,0	2,1212	0,0851
Week III	64,00	33,0	1,9394	0,0931
Week IV	118,80	30,0	3,9600	0,0502

Source: Prepared by the authors, 2024.

However, in square B at the increasing temperature there is still demand and an almost constant flow, according to the data on the elasticity of demand, there is a variation of around 0.81 to 1.17 throughout the study, while the average temperature is different and operating costs reach around 21%, precisely in week III that there was a significant drop in the workflow of motorcycle taxi drivers as noted in table 2. Which observes a need to increase the working hours in another shift to meet the operating costs of the day.

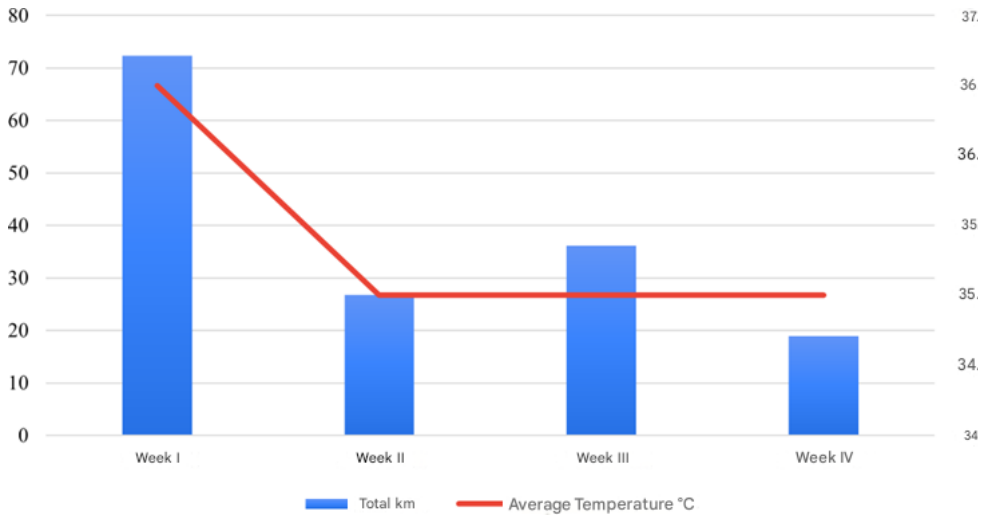
Table 2. Operational analysis of square B at increasing temperature.

Weeks	Total km	Average Temperature °C	Elasticity of demand	Operating Costs
Week I	36,10	32,0	1,1281	0,1651
Week II	32,40	33,5	0,9672	0,1840
Week III	28,00	34,5	0,8116	0,2129
Week IV	41,10	35,0	1,1743	0,1450

Source: Prepared by the authors, 2024.

In category II, the observations and data collection were carried out on the same days of analysis, but at a time when the temperature is decreasing. Making it possible to understand how consumers behave, based on the climate, in the direct demand of motorcycle taxi drivers in a milder climate. Thus, it was observed that in square A, as the temperature decreased, there was an even greater reduction in the use of motorcycle taxi drivers for locomotion, as shown in graph 3, which reinforces the idea that while decreasing temperatures and a less hectic routine at fairs, consumers may prefer alternative options for commuting, such as walking, bicycles or informal carpooling.

Figure 6. Graph of the demand of square A in the decrease in temperature.



Source: Prepared by the authors, 2024.

Compared to the volume of category A in category I, there was a significant reduction in the volume of mileage traveled in category II in the same square, thus generating less elasticity of demand. This reinforces the need for motorcycle taxi drivers in that square to intensify their working hours in the hottest shift to meet operating costs. According to table 3, costs start at 8% in the first week, reaching 31% in the fourth week.

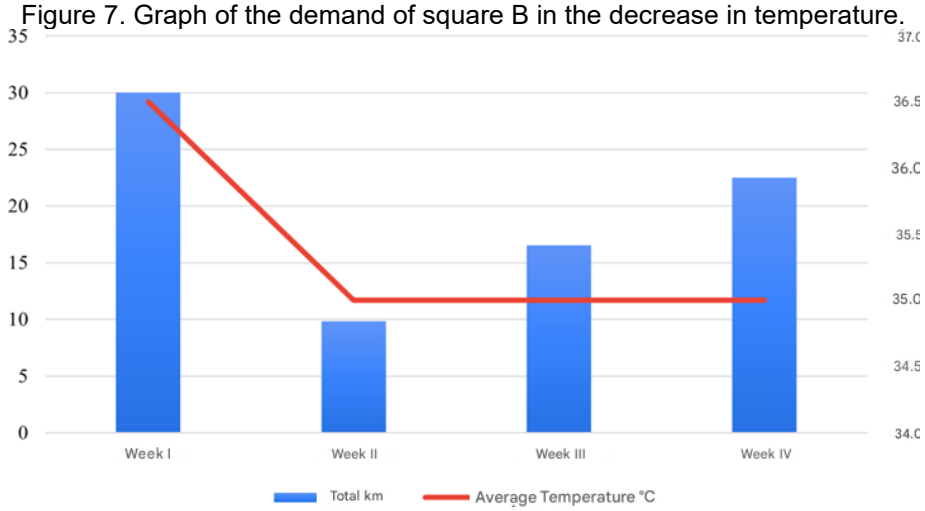
Table 3. Operational analysis of square A at decreasing temperature.

Weeks	Total km	Average Temperature °C	Elasticity of demand	Custos Operación
Week I	72,30	36,5	1,9808	0,0824
Week II	26,80	35,0	0,7657	0,2224
Week III	36,10	35,0	1,0314	0,1651
Week IV	18,90	35,0	0,5400	0,3153

Source: Prepared by the authors, 2024.

Square B, as shown in graph 4, represented a decrease in the flow, with a sharp variation in demand and a practically linear climate in the last three analyses. However, the total mileage analyzed went from 30 km in the first week, reaching approximately 10 km in the second and returning in the fourth week, a flow of less than 25 km. Thus representing the low use of motorcycle taxi drivers at milder times, even in the most accentuated location.

Figure 7. Graph of the demand of square B in the decrease in temperature.



Source: Prepared by the authors, 2024.

In square B, in shifts where there is a decrease in temperature, the operating costs for motorcycle taxi drivers reached 60% in the second week of analysis, which implies a huge loss, since the demand in that week did not reach 30% of what was expected, as can be seen in table 4. Which makes us analyze, on the other hand, the possibility of an increase in gasoline prices over the months after this study. Which will cause operating costs to grow significantly.

Table 4. Operational analysis of square B at decreasing temperature.

Weeks	Total km	Average Temperature °C	Elasticity of demand	Operating Costs
Week I	30,00	36,5	0,8219	0,1987
Week II	9,80	35,0	0,2800	0,6082
Week III	16,50	35,0	0,4714	0,3612
Week IV	22,50	35,0	0,6429	0,2649

Source: Prepared by the authors, 2024.

In both contexts, squares A and B, the reduction in average temperature over the weeks is accompanied by a decrease in the total mileage traveled. This indicates that temperature has a direct impact on the behavior of users and, consequently, on the economic issues of motorcycle taxi drivers.

This behavior of users as a consequence of thermal sensitivity manifests itself in different ways in the two squares, being directed by different contexts and logical profiles of users, as can be seen in Chart 01.

Table 01. Consumer behavior.

USER ASPECTS	SQUARE A	SQUARE B
User Profile	Attendees of public fairs	Users of air-conditioned areas such as commercial and administrative
Busy hours	Early morning (peak fair time)	Constant movement throughout the day (business hours)
Influence of temperature	Rising temperatures reduce the flow of people	The rise in temperature does not decrease the flow, on the contrary, it increases the demand
Observed behavior	Oscillation in demand with a drop in mileage throughout the day	Demand stability, with mileage growth throughout the day
Justification	Unfavorable thermal conditions cause people to spend less time in outdoor areas.	Short trips in air-conditioned locations make motorcycle taxis a convenient option on hot days
Sensitivity to the weather	High temperatures with strongly influenced demands	Low temperatures with more constant demand, even with climatic variations

Source: Prepared by the authors, 2024.

In Praça A, the cost-benefit logic prevails, demand drops significantly on warmer days, there is an oscillation throughout the day and it interdepends on the flow at the fair, requiring observation by motorcycle taxi drivers to maximize profits based on these shifts of greater demand with the commercialization of the public fair.

While in Praça B, whose users prioritize immediate needs, there is a constancy in the use of the service according to the hottest times of the day. In the in situ observations, it was noted that most users came from air-conditioned environments and resorted to motorcycle taxi drivers because they were close to these places. Thus, the elasticity of demand in shifts that marked high temperatures was justified.

CONCLUSION

The present study aimed to evaluate the influence of temperature variation on the demand of motorcycle taxi drivers in two central squares of the municipality of Patos-PB.

Based on the data studied, the relationship between temperature, elasticity of demand and operating costs in regions such as Patos, predominantly hot climate, in increasing temperatures, the feeling of thermal discomfort influences the increase in demand for motorcycle taxis, as people tend to avoid traveling on foot or by other non-motorized means

Consumer behavior is sensitive to temperature, but it is also greatly influenced by the characteristics of the environments near each motorcycle taxi station. Therefore, public policies aimed at motorcycle taxi drivers need to go beyond general economic factors and take into account the profile of users in each zone, seeking strategies that help ensure more efficiency and better working conditions, even in the face of the climatic variations prevailing in the region.

In decreasing temperatures with reduced thermal discomfort, it leads users to opt for transport alternatives that minimize their additional costs per trip. In this way, to minimize costs and maximize profits, motorcycle taxi drivers can adapt their shifts according to the local temperature.

In addition, it is important to note that the analysis of demand variation as a function of temperature and its effects on the operating costs of transport services is still a scarce field, but this type of research contributes to a better understanding of the needs and behaviors of users, which can lead to improvements in service and greater efficiency in the management of available resources.

Further studies could investigate the impact of different temperature ranges, at different times of the year, in addition to evaluating the relationship between demand behavior and socioeconomic factors, such as income and frequency of use of motorized transport. It would also be interesting to carry out a more detailed analysis of the behavior of specific groups, such as workers, students and the elderly, who may present different demand patterns.

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