Impact of the pandemic on urban mobility: exploratory factor analysis of evidence from students at MRSP Fatecs

ABSTRACT
The Covid-19 pandemic has drastically altered urban mobility. With the end of restrictions on circulation, urban mobility can return to normal, although this normal appears to be considerably different from what was previously the case. To understand these changes, a survey was actualized with Fatec students at the Metropolitan Region of São Paulo (MRSP) to verify changes in moving options before and after the pandemic. There are considerable changes in the use of digital media for accessing banks and shopping in general, as well as a tendency to prefer home-office, but not e-learning. The Exploratory Factor Analysis (EFA) results have demonstrated that there are strong correlations between behavior before and after the pandemic. The results highlight the need to reorganize urban mobility in the post-pandemic period, considering aspects of changes in consumption patterns and providing valuable information for planning transport policies and strategies that meet new moving needs.

Keywords: exploratory factor analysis, urban mobility, urban planning, MRSP, Covid-19.
resultados destacam a necessidade de reorganizar a mobilidade urbana no período pós-pandemia, considerando aspectos de mudanças nos padrões de consumo e fornecendo informações valiosas para o planejamento de políticas e estratégias de transporte que atendam às novas necessidades de deslocamento.

**Palavras-chave:** análise fatorial exploratória, mobilidade urbana, planejamento urbano, MRSP, Covid-19.

1 INTRODUCTION

Mobility ranges from everyday mobility to social, residential, and work mobility, as well as mobility related to migration and commuting leisure mobility accrued from tourism (Balbim, 2016). In urban environments, mobility ends up having a strong correlation with the definitions of transport which, according to Morlok (1978), refer to “an act, process or instance of transport or being transported”, with the verb transport meaning “to transfer or transmit from one place to another.”

Therefore, it can be said that mobility comes to be configured as an inherent need of human beings in the search for food, work, fun and knowledge. According to Bruton (1979), people travel mainly to meet their needs for going to work, shopping, health, leisure, education and, in the end, returning home.

Despite issues of mobility and the inherent need for human beings to move, at the end of 2019 the WHO received the first alert about a new variant of the Human Coronavirus, responsible for the disease called COVID-19 (PAHO, 2021). In Brazil, the first case was confirmed in February 2020, in São Paulo (UNASUS, 2021) and on March 11, 2020, the WHO declared a global pandemic (WHO, 2021). The State of São Paulo entered a quarantine situation on March 23, 2020 (São Paulo, 2021a and São Paulo, 2021b).

This fact imposed a sudden change in the mobility logic of all societies, some with stricter rules and others with more lenient ones, but everyone had to isolate themselves and interrupt social contact and daily travel in one way or another. This fact changed the entire social dynamics of going to work, shopping, leisure, studying and other daily activities.

Thus, the objective of this research was to check with students from the São Paulo State Technology Colleges (Fatecs) located in the municipalities of the MRSP, how they performed certain daily activities, such as travel to work, leisure, shopping and going to school and how
they believe they will do them post-pandemic. The analysis of the before and post-Pandemic perspectives was conducted here.

2 THE PANDEMIC AND URBAN MOBILITY

The impacts of the Covid-19 pandemic were felt in all corners of the world, impacting not only global economic relations but also the local economy of each country and region. While in 2020 the Eurozone GDP plummeted by 7.5% and the average global GDP fell by 4.5% According to OECD (2020), Brazilian GDP fell by 4.1% (IBGE, 2022).

Moreover, the impact on GDP, the pandemic greatly affected everyone's daily lives, impacting how people move in urban areas, public transport felt a large part of the impact of social distancing, sanitary hygiene rules and the fear of contagion, which significantly hinders transport capacity and affects the financial forecasts of operators and public transport systems (ITF, 2021).

Some examples of travel reduction can be seen in several works published in 2020 and 2021, such as the one exposed by Arellana et al. (2020) who found an increase in goings to pharmacies and supermarkets and a drop in travels for all other purchases in general during the pandemic period in Colombia and in the work of Vieira et all (2021) who found a reduction in passengers in public transports in Rio Grande do Sul. Another impact, anticipated by Covid-19, on demand in urban public transport is the option for distance working, which grew timidly until 2020, but was boosted by the Pandemic, mainly for low-income classes (Teixeira and Lopes, 2020).

Another important fact, which can impact the number of travels, is the change in the pattern and form of consumption, especially in large urban centers, where there is, for example, a reduction in the number of bank branches, with the closure of 5274 agencies between 2013 and 2021 (BCB, 2022a), closing of hypermarkets and migration of consumption to grocery stores (Sebrae, 2014), with an increase of 45 thousand establishments between 2013 and 2021 (Sebrae, 2022), in addition to the change in the form of access to money and financial transactions, PIX by itself handled more than 891 million in almost 1.9 billion transactions in May 2022 (BCB, 2022b) and the growth of online commerce with an increase of 162% from 2017 to May 2022 (Neotrust, 2022).
The ITF (2021) reports that the main challenges for reorganizing mobility during and after the pandemic would be: the financial factor, with balancing the accounts of transport companies; the reestablishment of the use of transport with health safety; the road safety factor, ensuring the safety of users; and the factor of changing the form of transport, with the maintenance of alternative forms of transport. Furthermore, they report the main solutions found or proposed: providing financial support for transport financing; minimize risks when promoting public transport, adjusting supply and demand; maintain the reorganization of cities and the public environment; and promote intermodality to help limit car use, diversifying urban mobility.

3 METHODOLOGY
3.1 STUDY LOCATION AND SAMPLE DEFINITION

The locations defined for the application of the questionnaire were the São Paulo State Technology Colleges (Fatecs) in cities that make up the Metropolitan Region of São Paulo (MRSP). The Fatecs are technological college education units bounded to the Paula Souza Center (CPS), an agency linked to the Secretariat of Science, Technology and Innovation of the State of São Paulo, which operates in technological college education, with 75 units throughout the State of São Paulo, with more of 90,000 students (CPS, 2022). Figure 1 shows the location of the 23 Fatec of the MRSP.

![Figure 1 – Fatec units in MRSP and its localization in São Paulo State and in Brazil](image)

Source: Adapted from Daroncho et al, 2023
The option to apply field research in Fatecs was due to the plurality of the public, as it serves technological college education, with an audience made up of 45.90% of people between 18 and 23 years old, 22.17% of people between 24 and 28 years old, and 31.93% by people over the age of 28 (CPS, 2022), which shows good stratification and population representation. MRSP Schools were selected owing to it being the area with the largest presence of all modes of public transport, in addition to the abundance of data and information from the various public transport management companies.

These Fatecs have an approximate number of 33,000 students, this number may vary throughout the semester for distinct reasons, such as closures. A sample (n) of 1,034 student respondents was calculated, considering an accuracy level of 95%, which corresponds to a deviation from the average value (Z) equal to 1.96, margin of error (e) of 3% and proportion expected (p) of 50%.

3.2 SURVEY QUESTIONNAIRE

The research effected at the end of the 2021 second semester, still during the remote class period. The instrument adopted for the research was a structured questionnaire applied to interviewees online, using Microsoft Forms, linked to the Microsoft Teams platform, used by Fatecs for remote classes during the Covid-19 pandemic period. The questionnaire contained questions about the movement habits of Fatecs students regarding carrying out some basic activities, such as going to the supermarket, the bank, leisure activities, work, school, and shopping in general.

The diagnosis included questions that sought to map three scenarios: firstly, the scenario that existed prior to the pandemic; secondly, the scenario experienced during the pandemic; and finally, the scenario imagined for the post-pandemic. The survey was sent to all students of the 23 Fatecs based in the municipalities that make up the MRSP, with 1,100 students responding to the survey, which exceeded the calculated minimum sample of 1,034 students.

The questionnaire was structured into four blocks of questions. The first block was intended to characterize the sample, including age group, vehicle ownership and income. The second block evaluated the travels before the pandemic. The third block investigated the movement during the pandemic. And, finally, the fourth block aimed to analyze the prospects for post-pandemic movements.
For this work, questions regarding the purchase of electronics, purchases in general, supermarket purchases, banking services, questions regarding the means of access, questions related to access to religious temples, entertainment, school and work in the periods before and after the pandemic, as, due to health restrictions, the responses in the during the pandemic block ended up focusing on the option of remote access or not carrying out the aforementioned activity.

The answers to the questions regarding the form of access were classified into 4 categories: “I am not the one who makes or will make this type of purchase in my home”; “I would and will make this type of purchase in person”; “I was and will be divided between online and in-person”; and, “I was already doing and will continue doing this type of action online”. The answers are related to the means of access were divided into remote access, on foot, by bicycle, by car, by public transport and “I did not or will not do that activity”.

3.3 DATA ANALYSIS

For this work, two analyzes were actualized. The first was an analysis using simple data comparison, where the data was plotted in bar charts to be able to verify the behavior before the pandemic and the trend, or expectation, for the post-pandemic period.

The second analysis conducted was the Exploratory Factor Analysis (EFA). According to Hair et al (2009), EFA is a statistical technique used to identify the underlying patterns (factors) present in a set of observed variables with the goal of reducing the size of the data, in other words, summarizing a set of variables into a few latent factors that better capture data variability. These factors are constructed in such a way that each original variable has a stronger relationship with a given factor than others. It involves several steps, including selecting the variables to be included in the analysis, defining the number of factors to be extracted, choosing the factor extraction method, rotating the factors to facilitate interpretation and interpretation of the results.

According to Vieira et al (2021), the model's standardized variables \( X_i, \ldots, X_p \) can be described by Equation 1:

\[
X_i = a_{i1}F_1 + a_{i2}F_2 + \cdots + a_{im}F_m + \epsilon_i \quad (i = 1, 2, \ldots, p)
\]  

(1)

Where:
\[ a_{im} \] are the factor loadings that measure the degree of correlation between the original variables \( i \) and the common factors \( F_m \) and \( \varepsilon_i \) are the relative errors of the specific factors.

The factors \( (F_1, F_2, \ldots, F_m) \) are estimated by the linear combination between the original variables \( X_i \) and the coefficients of the factor scores \( b_{ji} \) as shown in Equation 2:

\[
F_i = b_{j1}X_1 + b_{j2}X_2 + \cdots + b_{ji}X_i \quad (i = 1, 2, \ldots, p)
\] (2)

To identify the significant components, maximum likelihood extraction with \textit{Oblimin} rotation (oblique – which allows correlation between factors) was used and the number of latent factors to be used was determined using parallel analysis of principal components. To check whether the data were coherent for the EFA, \textit{Bartlett's} sphericity test (p-value < 0.50) was carried out, which verifies a sufficient correlation between the items, and the \textit{Kaiser-Meyer-Olkin} sampling adequacy test (KMO > 0.50), the factor loading, which indicates the relationship between the variable and the factor, was defined as must be greater than 0.30 and was used to replace the communality test, due to the characteristics of the data (Law et al, 2017; Hair et al, 2009; Tabachnick and Fidell, 2019).

Furthermore, the internal consistency of the factors was assessed using Cronbach's \( \alpha \) and McDonald's \( \omega \). Values of \( \alpha \) and \( \omega \) between 0.35 and 0.70 are considered moderately reliable (Guilford, 1965; McDonald, 1999). According to Bradley (1994), the adequate consistency indicator increases with the number of items in the Factor, and for a three-item scale a value of 0.50 can already be considered adequate.

4. RESULTS AND DISCUSSIONS

4.1 BASIC DATA ANALYSIS

We can see (Figure 2) that 38.7\% of students don’t have a vehicle, and 46.6\% have a vehicle or use a family’s vehicle (self-propelled or not). Therefore, we can expect that this proportion will be maintained without depend on if the use of the vehicle transportation is for public transport or daily trips, although having a vehicle does not specifically define the use of it for everyday activities.
The chart in Figure 3 shows the behavior of students in the period before the Covid-19 pandemic and the perspective of behavior for the period after it in terms of access to the banking system, purchasing in supermarkets, purchasing general items, and purchasing of electronics.

It can be seen that there is a growing trend in the use of remote options, in the 4 items surveyed there was an increase in the percentage of students saying they intend to use this option more, the smallest growth occurred in access to online banks (2.4% growth or 2.3 percentage points), followed by the online purchasing of electronics (17.8% growth or 10.9 percentage points), followed by access to general purchases online (28.9% growth or 16.1 percentage points). Nonetheless, the biggest growth occurred in access to online supermarkets (159.5% growth or 5.9 percentage points). Many of these students are already in the job market, either as permanent employees or interns, others will soon enter the job market, so it is very possible that...
we will notice a general change in the face-to-face consumption relationship in cities, which could affect companies established based on face-to-face commerce.

The chart in Figure 4 shows the behavior of students in the period before the Covid-19 pandemic and its perspective for the period after the Covid-19 pandemic in terms of access to work, school, entertainment, and religious temples.

![Figure 4](image)

We can see that when accessing a religious temple there is a very significant increase in the option of not going to the temple (from 11.1% to 45.0%, an increase of more than 300%) or of going on foot (from 1.8% to 16.0%, an increase of more than 780%). As for entertainment, the biggest growth occurred in the option of not doing it (from 11.1% to 28.7%), an increase of more than 150%, while the use of public transport reduced by more than 200% (from 30.6% to 9.6%). Concerning school, the remote class option grows by almost 50% (from 12.1% to 18.0%) and about work, there is a growth of almost 250% in the work option remote (from 4.7% to 16.1%), apparently the option should be to work more remotely.

The AFE made it possible to define factors and identify which of these factors are related to pre- and post-Covid-19 pandemic activities. The following variables were used: Ele_pre for the way electronics were purchased before the pandemic; Ele_pos for how to purchase electronics after the pandemic; Ger_pre for the form of general purchases before the pandemic; Ger_pos for general purchasing methods after the pandemic; Sup_pre for the shopping way in supermarkets before the pandemic; Sup_pos for how to purchase in supermarkets after the pandemic; Ban_pre for how to access banking services before the pandemic; Ban_pos for how to access banking...
services after the pandemic; Div_pre for how to access fun before the pandemic; Div_pos for how to access fun after the pandemic; Rel_pre_trp for the way of accessing the religious temple before the pandemic; Rel_pos_trp for how to access religious temples after the pandemic; Div_pre_trp for access to fun before the pandemic; Div_pos_trp for the fun access mode after the pandemic; Ele_pre_trp for the way to access school before the pandemic; Ele_pos_trp for the way to access school after the pandemic; Rel_pre_trp for the way of accessing the religious temple before the pandemic; Rel_pos_trp for how to access religious temples after the pandemic; Div_pre_trp for access to fun before the pandemic; Div_pos_trp for the fun access mode after the pandemic; Esc_pre_trp for the way to access school before the pandemic; Esc_pos_trp for the way to access school after the pandemic; Tra_pre_trp for the way to access work before the pandemic, and; Tra_pos_trp for the way to access work after the pandemic.

As can be seen in Table 1, there are 8 factors that generate, or group, the proposed variables, 7 of them represent the relationship between the before and after of the same activities, another factor represents the relationship, both in terms of form and mode of access to entertainment options. Factor 1 for purchases in general (Ger_pre and Ger_pos), factor 2 for the purchase of electronics (Ele_pre and Ele_pos), factor 3 for the mode of access to the religious temple (Rel_pre_trp and Rel_pos_trp), factor 4 groups both were of access regarding the mode of access to entertainment (Div_pre and Div_pos, Div_pre_trp and Div_pos_trp), factor 5 for purchasing in supermarkets (Sup_pre and Sup_pos), factor 6 for the mode of access to school (Esc_pre_trp and Esc_pos_trp), the factor 7 for the work access mode (Tra_pre_trp and Tra_pos_trp), and; factor 8 for access to banking services (Ban_pre and Ban_pos).
Table 1 – Factors and factor loadings

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<tr>
<th>Variables</th>
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<td>Ger_pos</td>
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<td>Ger_pre</td>
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<td>Ele_pre</td>
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Source: Authors

The result of Bartlett's sphericity test ($\chi^2 = 2952; gl = 153; p < .001$) shows that there is a high correlation in the data matrix, that is, it is suitable for EFA. The KMO sampling adequacy measurement test resulted in values greater than 0.50 for all variables, which represents a good fit to the model. The global KMO of the model was 0.617, corroborating the good fit of the EFA to the data model. The $\alpha$ Cronbach's overall was 0.520 and the $\omega$ McDonald's overall was 0.570, indicating adequate internal consistency and reliability and the total variance explained was 48.17%.

5 FINAL CONSIDERATIONS

The Covid-19 pandemic brought forward many concepts and many actions that were designed for periods of 10-20 years, such as remote working (Home office), for example, as well as expanding investments and the use of online commerce (e-commerce) and, because of this, it may end up generating a reduction in the number of trips in urban areas.

Analyzing the research accomplished, there is a tendency to change transport and consumption habits, although this change, in some cases, is not as significant as one might think. Although public transport suffered a lot during the pandemic, with restrictions on movement,
passengers are gradually recovering, just as traffic in urban areas is gradually returning, both to levels lower than the period before the pandemic, or in other words, perhaps we are experiencing a reorganization of the logic of travel in urban areas, but it is still too early to say anything about this and this requires specific research on the topic.

The majority of those surveyed no longer used the procedure of going to bank branches, doing everything over the internet (website and applications) and seem to intend to no longer use the banking system in person, preferring digital banks, that is, the reduction in bank branches seems to be consistent with people's intention not to go to branches.

In terms of purchases (supermarkets, general and electronics), very few seem to have the intention of buying online supermarkets, while in relation to general purchases, the vast majority intend to use the internet and intend to continue purchasing electronics online, without going to stores, which corroborates the growth of digital commerce.

Concerning access to work and education, although few intend to continue remotely, this option has grown in relation to the pre-pandemic, as well as the use of cars and public transport, which shows that the use of public transport must resume and in congestion on urban roads. Regarding access to education, few intend to pursue education remotely (although this option has grown) and that car use tends to increase and public transport to fall, even if in lesser amounts.

Furthermore, the EFA proved to be useful in grouping the variables referring to the use before and after the same item, showing that there are strong relationships between the answers to specific questions before and after the same activity.

This shows that the planning, management, and reorganization of public transport systems in urban areas may experience turbulence during this period, as after the atypical scenario of the pandemic there is a scenario of changes and uncertainties, making daily monitoring necessary of flows, as done by CET-SP, which began monitoring, from June 2020 to the present, both the volume of vehicles and the slowness on streets and avenues, as well as the bus fleet and its occupancy. This provides more data for planning and management to ensure better urban mobility.
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