TRANSPORT GLOBAL PRACTICE

BUENOS AIRES TRANSPORT DEMAND ASSESSMENT:

LEVERAGING *BIG DATA* TO UNDERSTAND THE CHANGING MOBILITY PATTERNS

WORLD BANK GROUP

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The study was prepared by a team led by Aiga Stokenberga (Senior Transport Economist, ILCT1) and Javier Morales Sarriera (Economist, ILCT1), with extensive inputs provided by Andres Gartner (Consultant, ILCT1) and Javier Rodrigo Pena Bastidas (Consultant, ILCT1). Overall guidance was provided by Jordan Schwartz (Country Director, LCC7C), Franz Drees-Gross (Regional Director, ILCDR), and Nicolas Peltier (Practice Manager, ILCT1). Administrative assistance was provided by Patricia De la Caridad Marrero (Team Assistant, ILCT1).

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Abbreviations and acronyms

AMBA	Metropolitan Area Buenos Aires (Área Metropolitana de Buenos Aires)
ANSES	National Social Security Administration (Administración Nacional de la Seguridad Social)
ATM	Metropolitan Transport Agency (Agencia Metropolitana de Tránsito)
BRT	Bus rapid transit
CABA	Autonomous City of Buenos Aires (Ciudad Autónoma de Buenos Aires)
CACE	Argentina's Chamber of Electronic Commerce (Cámara Argentina de Comercio Electrónico)
CATI	Computer Assisted Telephone Interviewing
CBD	Central Business District
CDR	Call detail record
CGP	Management and Participation Center (Centro de Gestión y Participación)
CNRT	National Transportation Regulatory Commission (Comisión Nacional de Regulación del Transporte)
DNRPA	National Directorate of the Registry of Motor Vehicles and Pledged Credits (Dirección Nacional de Registro del Automotor y Créditos Prendarios)
ENMODO	Household Travel Survey (Encuesta de Movilidad Domiciliaria)
EPH	Permanent Household Survey (Encuesta Permanente de Hogares)
GBA	Greater Buenos Aires
GCBA	Government of the City of Buenos Aires
GDP	Gross Domestic Product
GHG	Greenhouse gas
INDEC	National Institute of Statistics and Census of Argentina (Instituto Nacional de Estadística y Censos)
km	kilometer
MaaS	Mobility as a Service
MJ	municipal jurisdiction
MNL	Multinomial logit
NJ	National jurisdiction
NMT	Non-motorized transport
OD	Origin-destination
PAMI	Comprehensive Medical Attention Program (Programa de Atención Médica Integral)
PBA	Province of Buenos Aires
PJ	Provincial jurisdiction
p-km	Passenger-kilometer
pp	Percentage point
RMBA	Buenos Aires Metropolitan Region (Región Metropolitana de Buenos Aires)
SOFSE	Sociedad Operadora Ferroviaria Sociedad Del Estado
STPB	Public Bicycle Transport System (Sistema de transporte público en Bicicleta)
TOD	Transit oriented development
v-km	Vehicle-kilometer

Executive Summary

The COVID-19 pandemic and the lockdown measures implemented in 2020 had a significant impact on mobility in the Metropolitan Area of Buenos Aires (AMBA), adding new constraints to the travel behaviors of the residents and businesses. The Government of Argentina implemented a strict quarantine in AMBA in March 2020 until November 2020. The capacity of buses and trains was limited to seated passengers only, and the use was restricted to "essential" employees while operators were required to maintain their usual schedules to ensure social distancing among users. In addition, transport fares were frozen. Further policy responses followed to "catch up" with the changing mobility landscape; however, these were implemented in absence of adequate data that would allow understanding exactly how travel patterns in the metropolitan area have changed since March 2020, what have been their drivers, and how persistent the changes might be going forward. This study was conducted with the objective of generating new insights on the extent to which the various developments associated with the pandemic have affected urban mobility trends in AMBA, by drawing on "big data", historical mobility data, and new survey data collected on the ground.

Two types of trends shaped mobility in AMBA prior to the pandemic…

Overall, the historical trends in urban mobility patterns in AMBA have been driven either (1) by a specific policy looking to achieve mobility goals or (2) by a wider economic policy or external circumstances that in turn impacted mobility.

Trends driven by policies looking to achieve specific mobility objectives

Despite the lower absolute ridership figures, subway was the only public transport mode that saw a relatively consistent increase in the last twenty years before the pandemic. In 2019, subway ridership was 35 percent above the 2000 level and also quite significantly above the 2010 level. The subway is the only public transport subsystem that has increased fares substantially while also not seeing a fall in demand. The suburban rail system, similarly, has shown improvements in service levels as a result of increased investments made after the accident at the Once train station, and these have been associated with demand growth or at least preservation. Over the past decade, bus ridership in AMBA has been supported by the development and implementation of the Metrobus corridors, with segregated bus lanes that were first implemented in the Autonomous City of Buenos Aires (CABA) and then in Greater Buenos Aires (GBA). Productivity gains have been significant in the corridors in which these have been implemented, with travel times declining by between 29 and 35 percent. Between 2000 and 2020, an estimated US$7.08 billion was invested in the rail system (41 percent of total transport investment in AMBA), US$5.26 billion in infrastructure and rolling stock of the bus system (31 percent), and US$3.70 billion in the subway system (22 percent).

In addition to the significant investment that has taken place, the change in relative prices in favor of public transport, too, likely played a role in preserving the share of trips in public transport in relation to trips in private transport, although this has been more successful in the case of subway and, less so, rail ridership than bus ridership (Figure 1). Since 2011, the rate of increase in subway fares has greatly exceeded that of the rest of the modes, and the current fare levels are double those of DF buses (circulating within CABA). The average rail fare has declined the most in relative terms, and stands at approximately half of the average subway fare (and 70 percent of the bus). In 2016-2021, the nominal cost of public transport in AMBA increased to a much lesser extent than the expenses associated with private motorized transport, especially in 2020-2021, considering all vehicle purchase and maintenance costs. The incidence of public transport expenditure in the Minimum Salary of AMBA has fallen sharply since 2002, and currently the share of minimum income that would have to be allocated to pay for 40 trips by public transport each month is approximately 4 percent, compared to 16 percent at the beginning of the 2000s. In constant prices, fares are currently at around one-third of their 2001 level.

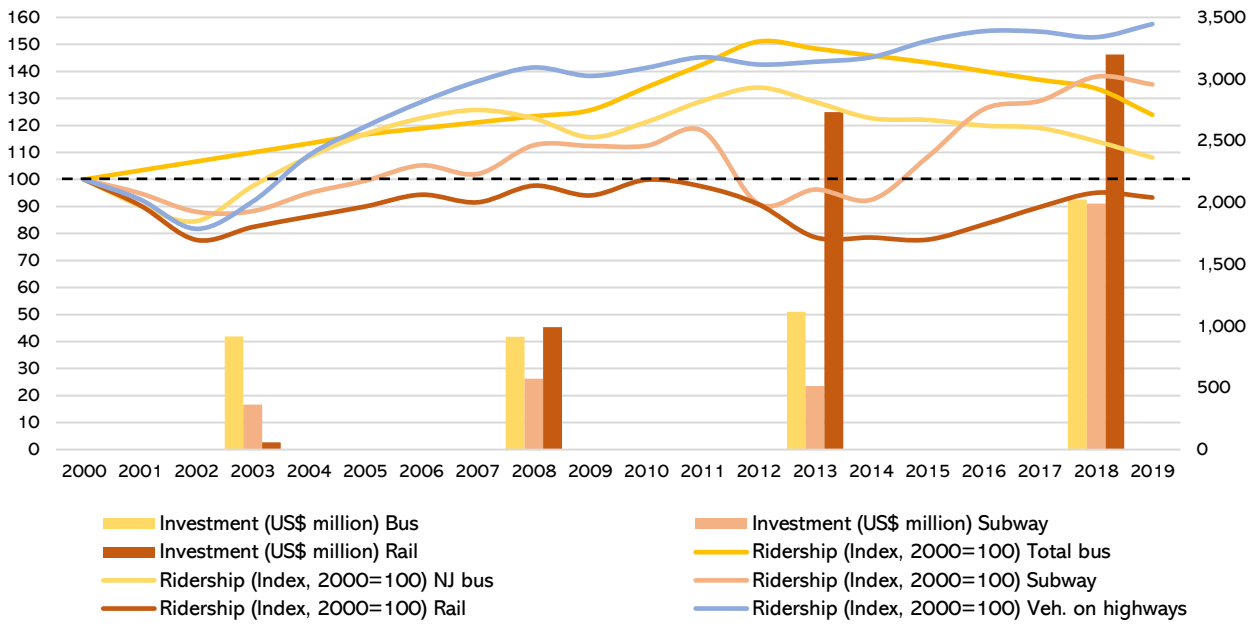
Finally, the strong growth in cycling in the last decade – at least in CABA – appears to be closely linked to the targeted development of infrastructure and the network effect generated by the increase in

the available kilometers of bicycle lanes; the public bicycle system gained further momentum as the available stations increased.

Trends mostly driven by wider economic policies or circumstances

Despite the policies and investments aimed at supporting public transport ridership and cycling (in CABA), the overall modal share of private motorized transport in AMBA appears to have grown steeply since 2009 when the ENMODO survey estimated it at 32 percent of all trips. According to the Call Detail Record (CDR)-based analysis conducted as part of the current study, private motorized modes in 2019 accounted for about 53 percent of all trips on weekdays. Nearly all of the gain in private motorized mode share was at the expense of public transport, which in 2019 was estimated to serve about 23 percent of all weekday trips, compared to 39 percent in 2009, although it has to be noted that the methodologies used in the two years are different.

Figure 1: Transport use, by mode, 2000-2019 (2000=100) and investment in public transport (US$ million, 5-year total)



Source: Estimated using data from CNRT, INDEC, and Dirección General de Estadística y Censos

The drivers of private motorization in the past decades are many, including growing incomes and increasing land values in CABA and the resulting suburban expansion, which was further fostered by the expansion of access road infrastructure that was part of the wider strategy for infrastructure modernization in the 1990s.

In the last decade, there has been a progressive shift to trips that are more local in nature, in contrast to the more radial trips between CABA and GBA, which has led to a consolidation of the role of the bus compared to other public modes and, within the bus sector, to a greater share of trips in municipal and provincial lines despite significant investment benefiting national jurisdiction (NJ) bus services. The trend towards shorter trips was driven, among others, by the decentralization of public service provision and structural changes in the job market, with non-registered jobs and self-employment gaining share in recent years. Moreover, over time there has been an increase in jobs in "non-defined destinations", including remote work and highly irregular work.

Since the steep decline in March 2020, overall mobility appears to be recovering

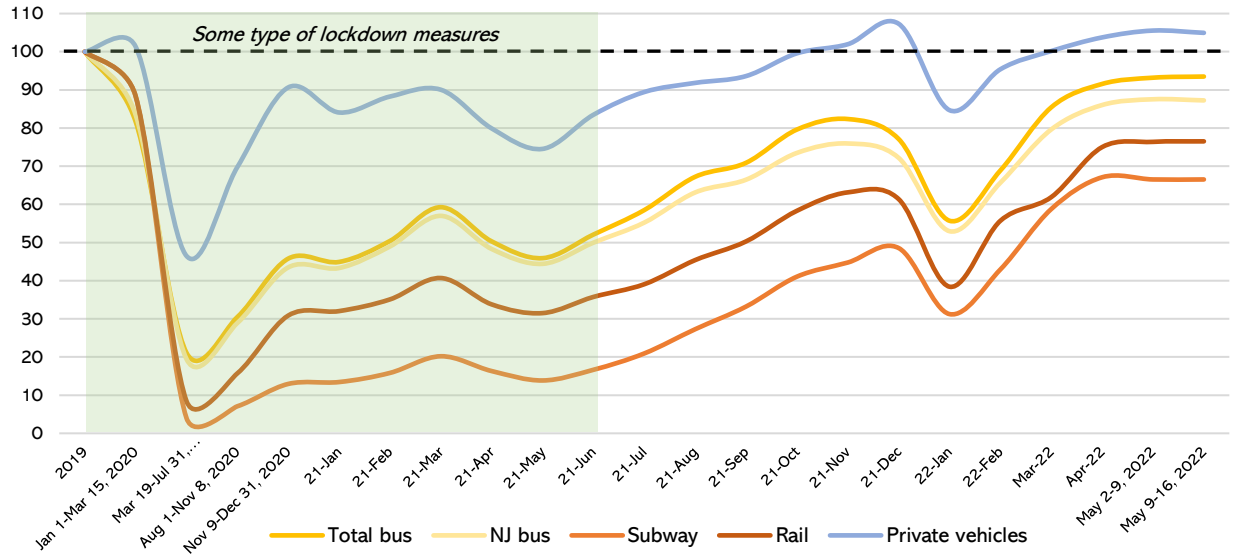
Using CDR data, the current study analyzed several key mobility indicators at the scale of AMBA for the pre-pandemic (October 2019), pandemic (October 2020), and "new normal" (October 2021) periods.

Overall, the total number of trips made in AMBA on an average weekday was found to be still over 11 percent lower in 2021 than in 2019. The overall hourly trip pattern in the pre-pandemic and the "new normal" periods was similar, with the highest peak at around 5-6 pm and a second one at 7-8 am. However, while the overall hourly trip distribution appears to not have changed much, the intensity of the highs and the lows has. The morning, mid-day, and evening rush hour peaks in 2021 were lower than in 2019, accounted for by the lower share of people commuting to in-person jobs, among other factors: for example, in 2021, there were nearly 11 percent less trips starting at 7am or at 6 pm compared to 2019. Consistent with the still-recovering trips to workplaces, trip generation rates per person in 2021 were still below the 2019 level in CABA and the first ring of GBA, while in the peripheral parts of AMBA they had recovered more. Trips spanning between 1 km and 2.5 km continued to account for the largest individual share of trips both pre-pandemic and in 2021 (approximately 30-31 percent) although their absolute number declined the most of any distance category.

… while public transport ridership is still significantly below the pre-pandemic level

Already on the decline or stagnant prior to the pandemic, public transport ridership was hit heavily by the pandemic and the associated lockdowns and changes in passenger preferences. Public transport ridership in AMBA declined sharply in March 2020 and has not yet recovered despite picking up after the end of the lockdown measures (Figure 2). In mid-May 2022, public transport ridership still stood at only 79 percent of the level of the same month of 2019. The average work week transactions in public transport were at only 61 percent of the 2019 level in the case of the subway, 79 percent in the case of rail, and 93 percent in the case of buses. According to the large scale survey implemented as part of the current study, roughly 11-13 percent of the current car and motorcycle users in AMBA shifted to the motorized mode only since the start of the pandemic, and the vast majority of them previously relied on public transport.

Figure 2: Change in SUBE transactions and private vehicle flows on AMBA's motorways, 2020-2022 (2019=100)



Source: Buenos Aires Observatory of Mobility and Road Safety

Public transport trips taking place *within* CABA decreased their share even further during the pandemic (from 27.5 percent of all AMBA trips in 2019 to 21 percent in 2020), accelerating a historical trend, while the share of trips between GBA *partidos* increased significantly. Accordingly, as of May 2022, the municipal and provincial bus lines had recovered ridership to a greater extent than the national lines (serving CABA-GBA and within-CABA trips).

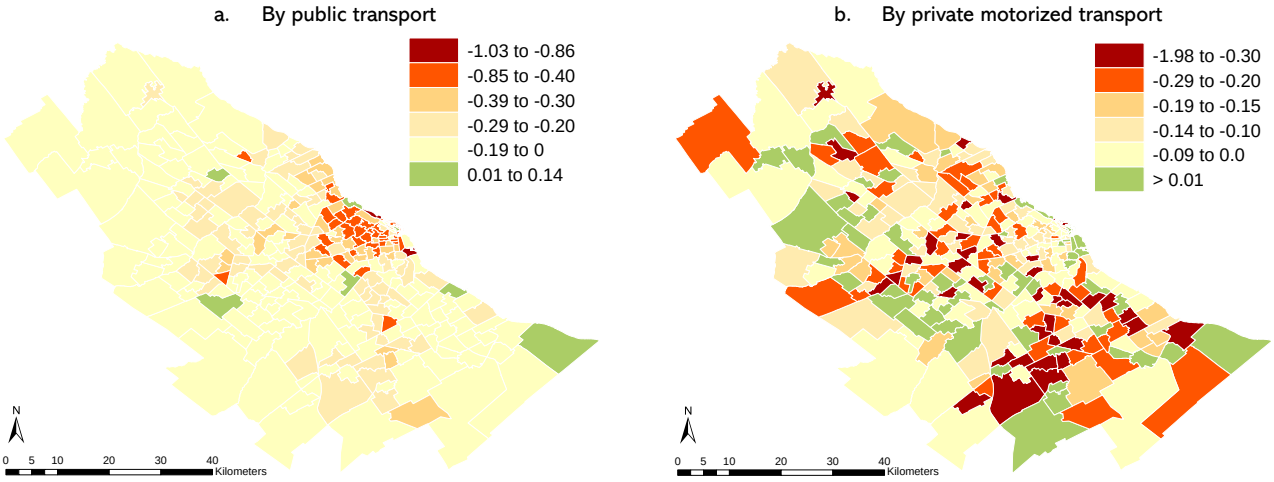
Demand recovery has so far been the weakest in the subway system, which can be explained by its spatial coverage (serving CABA only) and is consistent with the much lower recovery of trips to workplaces in CABA as opposed to the rest of AMBA. As of the last week of March 2022, subway Line E was the only one where demand had recovered to over two-thirds the 2019 level. Across the individual suburban rail lines, ridership in 2021 – as compared to 2019 – was still the most suppressed on the Mitre, Urquiza, and Sarmiento lines, which tend to travel through areas in AMBA characterized by a high density of services sector jobs.

… compensated by increased private motorized mobility and cycling (in CABA)

Private motorized mobility saw an immediate drop of about 90 percent at the very beginning of the pandemic; however, within a year it had more or less fully recovered. As of mid-May 2022, the volume of private vehicle flows on AMBA's highways was at 107 percent the level of an average work week in 2019. According to the CDR-based analysis, while most macrozones in AMBA in October 2021 were still seeing significantly less trips by public transport compared to October 2019, trip generation rates by private motorized transport already exceeded the pre-pandemic level in a large number of areas although not CABA (Figure 3).

Ridership in CABA's shared bicycle system has increased steadily since it was first put in place over a decade ago, and even in 2020 and, especially, 2021, ridership continued its upward long-term trend despite an initial drop in March-July from a record high in 2019. The mode share of bicycles increased from 4 percent to 10 percent of all trips in the City of Buenos Aires, the highest ever observed.

Figure 3: Change in the trip generation rates per person, a workday in October 2019 vs. October 2021



Source: Analysis by study team based on CDR data from Claro Argentina

The pandemic accelerated e-commerce and telework, although tapering off in 2021…

Teleworking grew significantly during the pandemic, with the number of people working from home tripling from pre-pandemic levels, from 6 percent to 17 percent, and it is estimated that 18 to 29 percent of the jobs in Argentina can be conducted remotely, albeit concentrated in high-wage sectors. In the last week of March 2022, the volume of trips to workplaces in AMBA overall was still 8-9 percent below the pre-pandemic level, with the remaining gap at least in part be due to a continuation of remote/hybrid work arrangements. The initial drop in trips to workplaces was lower in GBA than in CABA, and, if in the last week of March 2022 the volume of trips to workplaces in CABA overall was still below the pre-pandemic level, in most GBA partidos it was at least 15 percent *above* it.

Already having grown significantly in the last few years, e-shopping and food delivery have boomed even more during the pandemic, with more than doubling in e-sales in Argentina overall in the first

half of 2020 compared to the first half of 2019. The share of online shoppers who selected the goods to be delivered to their home (as opposed to picking them up or arranging for a different option) increased to 80 percent, up from 62 percent in 2018. That said, by late 2021, the overall boom in online shopping had slowed somewhat compared to 2020, with annual growth of 68 percent, as people returned to eating out more and shopping in person. AMBA's share in the country's overall e-sales grew slightly in 2019-2021, from 37 percent to 39 percent. Trips to grocery stores and pharmacies in CABA in early June 2022 were already about 20-30 percent above the March 2020 level, having initially fallen by half.

How will urban mobility in AMBA evolve in the coming years in the context of the past and recent trends?

The two types of long-term trends identified above will continue to shape mobility in AMBA over the coming years, albeit with some modifications introduced by the COVID-19 pandemic. The "new normal" mobility environment in AMBA appears to be characterized by less public transport ridership than prior to the pandemic which may persist for some time. The pandemic has also strengthened some previous trends that were already taking shape over the last decade – such as increased use of non-motorized transport (NMT) – that are likely to further consolidate.

As of late Spring 2022, the effects of the pandemic and the lockdowns on transit ridership had tapered significantly but not nearly fully. Having seen the most consistent growth in the decade before the pandemic, subway was hit the hardest by the pandemic and has recovered the least, while the opposite has been the case for the bus system. Among others, the ability of the bus system to attract new users and increasing its share of public transport trips will depend on whether the suburban rail system is perceived as a convenient mode for shorter commutes as the trend towards trips between GBA's *partidos*, which accelerated during the pandemic, strengthens.

Despite considerable investment in efficient bus systems over the past decades and associated reductions in travel times, for the foreseeable future, plans for Metrobus expansion are limited to CABA, and, given the congestion already above the pre-pandemic levels during certain times of the day as captured by data from Waze for Cities, commercial speeds for buses in GBA may start to decline on the non-segregated bus corridors, impacting service quality and ability to attract the passengers lost during the last two years.

The increase in cycling observed during the pandemic – at least in CABA – is likely to continue, given that Buenos Aires has the necessary characteristics to promote non-motorized modes. There do not appear to be any direct threats to the sustainability of this public policy in the next few years.

During the pandemic, there was a significant population relocation to gated communities in GBA, as telecommuting allowed to stay at home without the need to spend time commuting. Families that already had a house in a gated community opted for staying there as restrictive measures on personal movement were enforced, and there was a surge in property prices as more people decided to move to these communities. As a result, plans for new housing developments continued to consolidate through GBA, and new gated communities are being built, especially in the western and southern areas.

That being said, the level of service of private motorized transport connecting these communities to central Buenos Aires will likely see a decline as there is limited room for expanding access roads, either from a fiscal or land availability perspective. Therefore, travel times are expected to grow for a fraction of commuters that live in gated communities in the second and third Ring, but also for poorer commuters living in GBA using motorized modes. The increasing congestion in AMBA over time, driven by the continuing rise in motorization and the limits to road expansion, is likely to impact the modal split to at least some extent. As suggested by the results of the stated preference choice survey implemented as part of this study, if private motorized travel times for the travelers' typical origin-destination pairs were to increase by at least 15 minutes, nearly 31 percent of the current car and motorcycle users would potentially switch to public transport, and another 5.5 percent and 4.5 percent would switch to NMT modes and taxi/remis, respectively.

The rather structural trend seen over the past decades towards decentralization and more local trips (especially within GBA) will probably not change significantly also going forward. If telecommuting grows over time, it might primarily affect internal CABA trips, as these types of work schemes mostly benefit higher-income people living in CABA working in or around Microcentro. However, the territorial distribution of jobs and schools will not change very fast even if the trends that were boosted by the pandemic – such as increased propensity to work from home in certain sectors – continue. As rents continue to increase in CABA, also more vulnerable populations can be expected to continue moving into GBA to be able to access the housing market, especially to the Southern and Western corridors, thus further boosting within-GBA trips at the expense of within-CABA and CABA-GBA ones.

How can policy and planning tools shape the future trends?

The transport planning authorities in AMBA can influence which transport behaviors remain more permanent in the post-pandemic world. Infrastructure investments can be crucial for building trust in public and active transport. On the other hand, pricing and regulatory policies can help – at least to some extent – incentivize less energy-intensive transport behaviors. Finally, as demonstrated by CABA's experience with cycling, public behavior change campaigns can work under the right conditions.

Public transport and NMT expansion and reorganization

During the last decade, price signals favored public transport. In order to be successful, however, price-based incentives have to be combined with infrastructure supply and improvement. As shown by the results of the demand elasticity analysis conducted as part of this study, ridership in most public transport sub-systems and routes in AMBA has historically significantly responded to changes in the vehicle-kilometers of service supplied and improvements in punctuality. Similarly, the stated preferences of the surveyed current car and motorcycle users indicate that improvements in the public transport *performance* could incentivize a significant modal shift from private to public transport. In fact, the results of the survey suggest that travel time savings of just 5 minutes by public transport compared to the current times by private modes would be sufficient for 56 percent of the current private mode users to shift from private to public transport. In other words, public transport would have to offer travel times that are on par with or slightly better than those offered by private motorized modes to be able to attract significantly more riders. The patterns of private versus public transport use appear to be relatively set in the most well-off localities in AMBA where nearly half of the households own a vehicle. Increasing these residents' use of buses or trains will likely require changing their perception of these modes by improving the safety and security, comfort, and the objective aspects of journey time and frequency. As suggested by the results of the stated preference survey, 36 percent of those current private motorized vehicle users who are not sensitive to price signals – i.e., would not switch to another mode even at a doubling in the price of gas – *would* switch to public transport if it offered even 5 minutes of travel time savings as compared to the current travel time by private modes.

Opportunities for mode shift towards public transport are likely the greatest in AMBA's middle-income localities, located along the axes formed by motorways and public transport lines, where in the past improvements in public transport supply have led to increased public transport use and decreased private car use. Thus, in considering which rail improvement works should be prioritized in order to encourage sustainable mode shift or at least prevent a shift to private mobility, it is likely that investments in the Belgrano Norte or San Martin lines serving middle-income neighborhoods would have a bigger impact. On the other hand, considering rail improvements that will increase accessibility to jobs and services for low-income populations and encourage mode shift from bus transport, it is likely that rail investments in the Belgrano Sur line would have a larger impact. Furthermore, given that in GBA in particular there has been a shift towards more local trips, investments in, for example, the Haedo–Temperley branch of the Roca rail line, connecting localities in GBA, could be an effective policy response, especially if well-integrated with the NMT infrastructure.

The spatial analysis of the national jurisdiction (NJ) bus lines indicates a high degree of overlap, with 99 lines sharing more than half of their route with

another line and 17 sharing more than 80 percent of the route. The overlaps are particularly concentrated in the Centro corridor, the Southwest, and the South. In areas – such as large parts of CABA – where demand is lower than pre-COVID, an on-demand bus service could be introduced to replace some of the underperforming NJ bus routes, keeping transit available to those citizens while shifting the underutilized buses to support higher demand areas. Similarly, the municipal jurisdiction bus routes could be reorganized to make trips to rail stations more direct and efficient, and the services could be operationally better integrated with rail services, such as in terms of the alignment of arrival times and dedicated transfer infrastructure.

The city administration and transit operators will need to work together in implementing regulations to create a safe public transport environment. As shown by the study's car and motorcycle user surveys, safety concerns and fear of contracting COVID-19 rank very highly among the mode choice factors among those who became users of private motorized modes only since the start of the pandemic.

In addition, to prevent a shift to private motorized mobility going forward – in the post-COVID context where an increasing share of the population may be considering moving to lower density environments but do not necessarily want to live in gated communities that lack sustainable connectivity options – public transport supply must be accompanied by a proactive land use policy. The rail infrastructure provides a good opportunity to engage in transit-oriented development (TOD) projects to densify areas around train stations, especially in Rings 1 and 2 and attract middle-income households to move into these areas and avoid the connectivity limitations associated with living in the more segregated gated communities. TOD near rail could foster multimodality by expanding the effective rail coverage area, especially if rail services were better integrated with municipal bus lines and newly developed NMT infrastructure. As the expansion of gated communities in GBA continues, public policies can also be oriented toward the generation of new mixed-use centralities, thus helping avoid long commuting trips from GBA into CABA.

In the context of the accelerating trend towards shorter trips, especially within GBA, a policy aimed at promoting non-motorized travel could attract users throughout the metropolitan area and could gain increasing traction in the post-COVID context of heightened aversion to enclosed public spaces/vehicles. Moreover, as shown by the CDR data analysis comparing the pre-pandemic period with the "new normal" (October 2021), trips between 1 and 2.5 km still dominate AMBA's mobility, corresponding to trips that could feasibly be made by walking or cycling. Also as suggested by the results of the stated preference choice survey, the share of the current private motorized mode users who would be willing to switch to cycling for their typical trip if a ciclovia were available to them is by far the highest among those whose typical trips take place within GBA (40 percent). However, even among the respondents who typically commute between CABA and GBA, over 15 percent would consider this mode. Among the current car/motorcycle users, women are much more likely than men to state that they would consider biking if a ciclovías /safe bike route were available for them. Finally, while there are no current comprehensive data on how many rail, subway or Metrobus stations are physically integrated with NMT modes, it is clear that there is also an untapped opportunity to deploy NMT infrastructure prioritizing rail and subway stations as the hubs for trip attraction in GBA in order to improve public transport ridership. The recently created Metropolitan Transport Agency can play a cross-cutting coordinating role in these efforts.

More selective road infrastructure investment

In order to reduce the incentives for private motorized mobility, authorities could limit further expanding the radial access road capacity while increasing investment in road safety and improving the connectivity between the access highways and public transit infrastructure – for example, the connection between the Belgrano Norte rail line and the Pilar branch of the Acceso Norte – thus fostering multimodal integration. Additional road space could also be allocated to public transport corridors, such as following the example of the Metrobus segregated corridor on the 25 de Mayo highway in CABA.

Pricing tools

The decline in public transport ridership over the past two years has further worsened the financial

unsustainability of the transit system and poses some challenging questions for its future. Even in a context of recovering ridership in 2021 and 2022, the lag in fare increases, combined with recognition of higher public transport service operators' costs, means that the "new normal" for the public transit system in AMBA will be characterized by very low cost recovery. Analysis conducted as part of the current study of the longer-term response of public transport ridership to changes in real fares suggests that there is certainly room for increasing fares on most bus and rail routes without jeopardizing ridership. The elasticity of demand with respect to fares is either statistically non-significant or marginally significant and low in magnitude on most of the bus lines (except individual lines that are mostly concentrated in northern and western AMBA), and there appears to be a small demand response to fare changes on either of the rail lines.

An important aspect for the development of an integrated system is the deepening of the price signals in terms of road pricing, gas taxes, tolls, and licenses for Uber-type services. An increase in the price of gas, such as through increased taxes, would likely have at least some impact on mode choices in AMBA, as suggested by the findings of the stated preference survey implemented by the study team. At a 50-percent increase in the price of gas, it could be expected that approximately 40 percent of the current car/motorcycle users would shift to public transport, and an additional 7 percent would shift to non-motorized modes. Certainly, such an increase is rather large and also somewhat difficult to interpret in a high-inflation context; increases of such magnitude are much more likely to result from external factors such as logistics bottlenecks and global supply limitations.

In terms of other pricing tools, some level of cross-subsidization could be implemented via the Metropolitan Transport Agency to support public transport. For example, a small surcharge on road tolls could fund infrastructure that would improve the level of service for public transport, following a similar model as was implemented in 2002 whereby subsidies for public transport started to be funded by a surcharge on diesel fuel.

Data alliances for mobility planning

The proliferation of mobile devices, the widespread adoption of geolocation technologies and the increasing digitization of mobility have given rise to new data sources with enormous potential to complement, enrich or even replace data sources traditionally used for mobility analysis and transport planning. Many of these new data sources are in the hands of private entities, so it is of interest to explore the establishment of data partnerships from which cities, the private sector, and society as a whole can benefit. There are several opportunities to improve the mobility information available in Buenos Aires through access agreements to non-public data and better use of public data, in particular: (i) using cell phone data to periodically update AMBA's origin-destination matrices, perhaps complemented by brief and targeted household travel surveys that can provide more detailed socio-economic data on the travelers; (ii) leveraging SUBE public transport smart card data for a better characterization of public transport demand; (iii) making use of Waze for Cities data for transportation planning, beyond just traffic management; and (iv) partnering with the providers of different mobility services to help mitigate the existing mobility information gaps, such as on new mobility services (ride hailing, shared mobility) and freight mobility.

1. Introduction

The COVID-19 pandemic and the lockdown measures implemented in 2020 that lasted throughout 2020 and part of 2021 had a significant impact on mobility in the Metropolitan Area of Buenos Aires (Área Metropolitana de Buenos Aires, or AMBA),[1] adding new constraints to the travel behaviors of the city's residents and businesses. The COVID-19 crisis caused by the novel coronavirus disrupted nations and economies around the world. Major manufacturing companies stopped producing goods; shipping activities came to a halt due to the imposed quarantine policies impacting global supply chains; and work patterns shifted towards more home-based modalities in many sectors. Pandemic control strategies in many Latin American countries, including Argentina, also included restrictions on transportation such as limits to public transport vehicle occupancy. On March 20, 2020, Argentina entered a nation-wide lockdown, and the imposed restrictive measures have considerably impacted transport demand and supply. The implementation of the lockdown resulted in a steep decline in demand for bus services, of around 85 percent initially. After 6 months, demand was still 70 percent below the pre-pandemic levels, and COVID-19 restrictions on demand resulted in buses operating with an average of only 7 passengers per bus trip, falling to 4 passengers per bus trip in some corridors. On the other hand, private transport demand appeared to have recovered faster. Even after 20 months of the implementation of the initial restrictive measures, overall mobility demand (a composite index[2] for all modes – public and private – in AMBA) still stood at less than 90 percent of the demand before the initial lockdown was implemented, likely due to changes in personal mobility preferences.

A number of policy responses have been made since the start of the pandemic in order to accommodate the "new normal". The City of Buenos Aires (Ciudad Autónoma de Buenos Aires, or CABA) implemented pop-up bike lanes with higher capacity in two major corridors previously dominated by cars (Corrientes and Cordoba), and four other corridors are being planned to be increasingly dedicated to non-motorized modes. There are also plans to implement a Demand Responsive Transport scheme in the northwestern part of the city. All three governments with jurisdiction over transport in AMBA (the national government, the government of the Province of Buenos Aires (PBA), and the government of CABA), through the Metropolitan Transport Agency (ATM), have agreed to work on innovative ways to move towards a more demand-responsive approach, such as by reducing public transport services on routes that overlap and where ridership is low. However, the data readily available to AMBA's transport planners has been inadequate to understand exactly how travel patterns in the metropolitan area have changed since March 2020, what have been their drivers, and how persistent the changes might be going forward. The existing four-step transport models may still provide a good starting point, but their assignment is no longer representative, for example, due to the changes in non-commuting trips and trips during off-peak hours.

This study was conducted with the objective of generating new, comprehensive data and insights on the extent to which the various developments associated with the pandemic have affected urban mobility in AMBA. The study does so by drawing on several sources of "big data", historical mobility data (covering the last two decades), and new survey data collected on the ground over the past five months, in order to better understand the drivers of the mobility changes and their likely persistence going forward in the context of the historical trends. In doing so, it provides empirical evidence that will allow optimizing and adapting the transport services and infrastructure supply in AMBA to meet the changing demand requirements and to be able to better plan for the future mobility needs in a more sustainable manner.

[1] The terms "RMBA" (Buenos Aires Metropolitan Region) and "AMBA" might be used indistinctly throughout the report in reference to the same geographical area, i.e., the Metropolitan Region of Buenos Aires. The term "CABA" is used in reference to the Autonomous City of Buenos Aires, and "GBA" in reference to Greater Buenos Aires, that is, the part of the AMBA located in the territory of the Province of Buenos Aires.

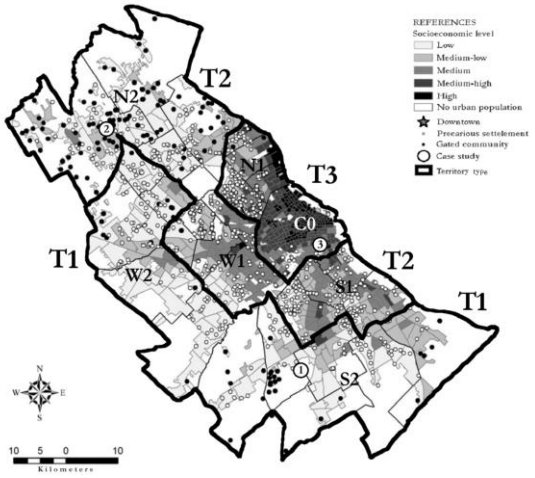
[2] Includes bus, rail, and subway (Subte), calculated using the following weights: buses (CABA): 0.5, rail: 0.3, Subte: 0.5, private transport: 1.4.

2. Long-term urban mobility patterns in AMBA and their drivers

Historically, the demand for transport services in AMBA has been driven by its economic weight – with around a third of the country's firms located in the metropolitan area – and population growth, accompanied by a low-density expansion pattern in the peri-urban area. AMBA accounts for 40 percent of Argentina's population and 50 percent of its gross domestic product (GDP). In more recent decades, urban mobility has been increasingly affected by trends in technology, land use, consumer behavior, and teleworking, among many other changes that are shaping the way people work and play. Some of the trends hold great promise for moving towards a more sustainable mobility ecosystem, with increased use of active modes of transport such as walking and biking, reduced need for commuting and shopping trips, new vehicle sharing systems, and mobility solutions such as electric passenger and freight transport. Other trends – including urban sprawl, increasing motorization rates, and stagnating or declining demand for public transport over the last decades – are having the opposite effect. Importantly, some of these longer-term drivers of urban mobility in AMBA may have seen a shift in their importance as a result of the pandemic.

2.1. Overall mobility patterns: an increasing role for local travel and a rise in private motorization and "active" modes

Figure 4: Socioeconomic zones within the AMBA (2009)



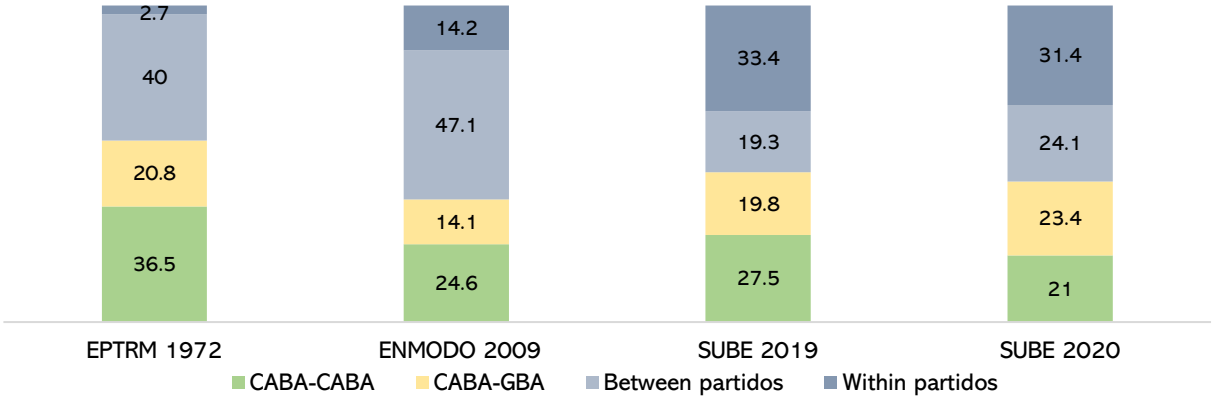
Source: Blanco & Apaolaza

In 2009, around 55-60 percent of the trips took place between GBA's municipalities, 25 percent within CABA, and 17 percent were interjurisdictional (CABA-GBA) (Mendiola et al. 2021). CABA was the main destination for ¾ of the trips starting in CABA itself (Szenkman 2015). Ring 1 was the single most important origin of trips to work (41 percent), while CABA – the main destination (41 percent). The highest level of *immobility*, the share of the population not making trips, was in zone S2 in southern AMBA (37.2 percent), a zone that is characterized by diversity of incomes. Immobility in this zone was higher than among all the lowest income quintile households in AMBA overall (36.6 percent), as it may have been expected. Similarly, the most advantaged zones in terms of transport infrastructure, C0 and N1, have higher mobility rates than the two highest income quintiles in AMBA overall (Blanco and Apaolaza 2018).

Although the data sources cover different sets of modes,[3] analysis over time suggests that, **between 1972 and 2019, the share of internal trips within CABA decreased, while trips within GBA *partido* trips grew**, driving the growth of demand on municipal bus lines which are only authorized to operate within a specific *partido*. In 2019, according to the Permanent Household Survey, 47 percent of the people employed in CABA traveled from GBA, and 24 percent of the GBA employed population worked in CABA. Out of the 1.6 million people who traveled to CABA daily, 1.3 million did so for work reasons (Anapolsky 2020).

[3] ENMODO refers to all modes, while SUBE transactions are specific to public transport

Figure 5: Travel between macrozones, 1972-2020 (percent of trips)



Source: EPTRM 1972, ENMODO[4] 2009, SUBE 2019, SUBE 2020

Relatively short-distance travel now appears to be common in AMBA. According to SUBE records, the average distance for the interjurisdictional trips (CABA-GBA) is 21 km, train trips being longer, on average, than subway or bus trips. In contrast, across all trips (within and inter-jurisdictional), the average distance traveled falls to 9.6 km (Anapolsky 2020). Relatively short trips are especially common to lower-income groups for the purposes of shopping, studying, and recreation (Blanco and Apaloaza 2018).

In 2009, about 70 percent of the interjurisdictional trips were by public transport (Anapolsky 2020). However, private cars were the preferred mode in northern AMBA (N1/N2), which has several highways and households from the upper and second highest income quintiles. The main corridors used for private motorized mobility were Ave. General Paz, Route 4, and the Northern Access, jointly representing 12 percent of all private motorized trips. On the other hand, on the southern corridor (S1/S2), buses were dominant (Bussi et al. 2020), while in the Central zone (C0), where traffic jams are common, public transport – subway (*subte*) and NJ buses primarily – were used because it has good coverage. The main bus corridors were Route 4, Rivadavia Ave., Autopista 25 de Mayo, and Ave. Gral. Paz, while the rail lines with the highest demand were Roca (35 percent of rail passengers), Sarmiento (18 percent) and Belgrano Norte (10 percent). However, the three highest-demand rail lines combined represented barely 5 percent of the total AMBA public transport demand. Subway lines with the greatest share of demand were the D and B lines, with 30 percent and 29 percent of the subway demand, respectively, and a combined share of 5 percent of all passengers in AMBA's public transport network (Szenkman 2015). Around 30 percent of the commutes within Ring 1 and within Ring 2 were made on foot and by bike, compared to 17 percent within CABA. The higher share of NMT trips within Rings 1 and 2 is likely mostly driven by the lower incomes rather than by supportive infrastructure (Mendiola and Gonzalez 2021).

Table 1: Single-stage commutes by origin, destination, and mode in 2009 (% of each origin-destination subtotal)

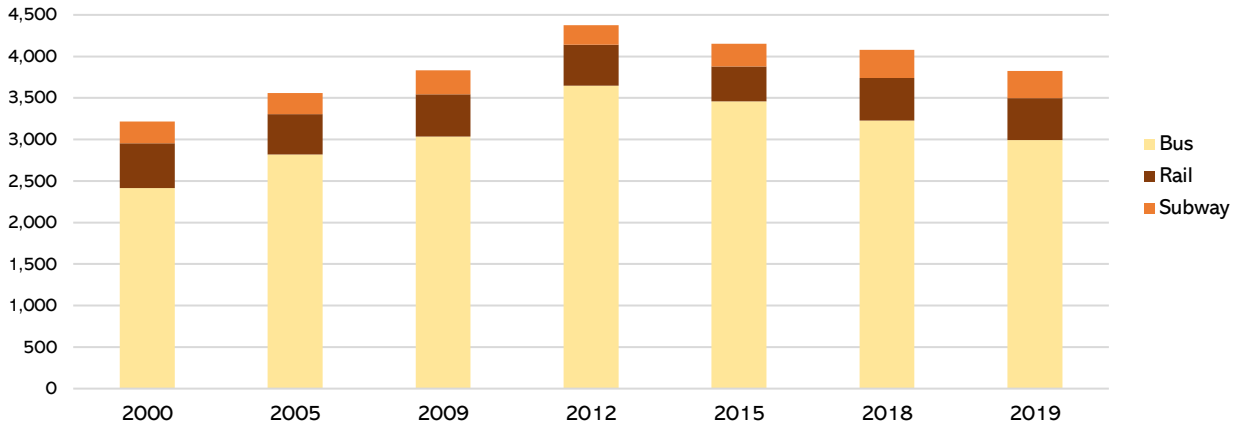
Origin	Transport mode	Destination			
		CABA	**Ring 1**	**Ring 2**	**Outside AMBA**
CABA	Private transport	25%	65%	73%	56%
	Public transport	58%	3.4%	27%	37%
	Bicycle / Walk	17%	1%	0%	7%
Ring 1	Private transport	43%	37%	56%	60%
	Public transport	56%	37%	36%	21%
	Bicycle / Walk	1%	26%	8%	19%

[4] Encuesta de Movilidad Domiciliaria (Household Travel Survey)

Origin	Transport mode	Destination			
		CABA	**Ring 1**	**Ring 2**	**Outside AMBA**
Ring 2	Private transport	53%	41%	32%	63%
	Public transport	46%	56%	35%	32%
	Bicycle / Walk	1%	3%	33%	5%

Source: Mendiola and González (2021)

Figure 6: Demand in the public transport system, 2000-2019 (million)



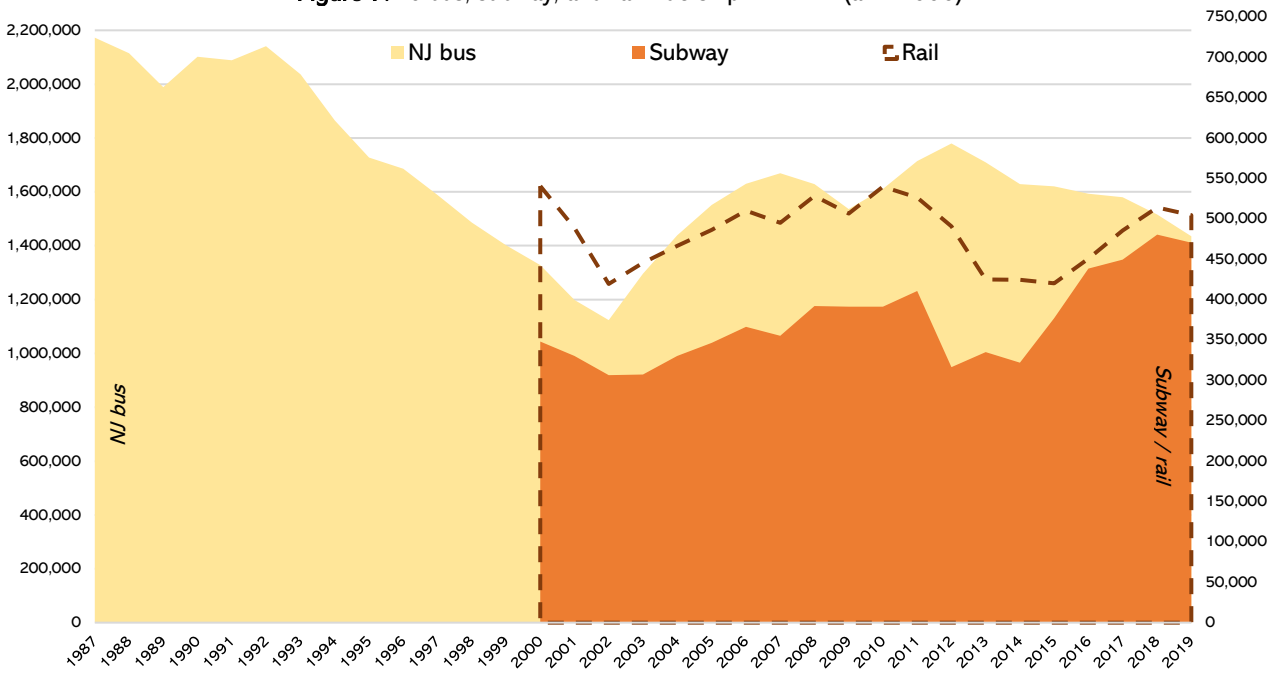
Source: INDEC, CNRT and Alzaga et al. (2021). Figures for provincial and municipal jurisdiction buses are estimated for 2000-2012

Throughout the last decades, bus trips continued to represent around 80 percent of public transit trips in AMBA. The share of bus trips grew between 2000 and 2012, after which it slightly fell (Figure 6). This might be due to various reasons, including a recovery in the level of service of rail and subway and the low economic activity which might unfavorably impact bus demand (which serves a demand that is more local in nature). This may reflect an improved data collection on demand on the other public transport systems compared to the bus.

Demand in the national jurisdiction (NJ) bus sub-system – serving trips between GBA and CABA and within CABA – has decreased significantly in the last three decades, although not continuously, and in 2019 represented 47 percent of all bus trips in AMBA (Figure 7). The total number of passengers carried declined from 2.173 billion in 1987 to 1.454 billion in 2018 (33-percent drop). While demand grew somewhat between 2002 and 2012, the system again lost passengers in recent years, and in 2019 demand was about 10 percent below the 2016 level. Spatially, the steepest decline in the share of overall transport demand occurred on the NJ lines in the North of AMBA, possibly due to the high purchasing power of urbanizations in the North corridor, higher private motorization levels, and increasing preference for cycling. The highest growth in NJ bus share in total mobility in 2000-2019 occurred on the Western corridor.

In contrast to the decline in demand on the NJ lines, the total passengers carried on the municipal (MJ) and provincial jurisdiction (PJ) lines serving within-*partido* and inter-*partido* trips in GBA, respectively, grew by 45 percent in 2000-2019. In contrast to the NJ services, which after the 2001 economic crisis grew mostly as a result of the recovery in the economic activity, the growth in the demand on the PJ and MJ routes, instead, was driven by the emergence of new urbanizations and new lines. As a result, while in 2000 the NJ system accounted for 55 percent of bus system demand (PJ 29 percent and MJ 16 percent), in 2019 its share had declined to 47 percent (PJ 32 percent and MJ 21 percent), implying a shift to more within-GBA travel (Alzaga et al. 2021). By corridor, the Transversal, Southeast, and South corridors saw growth in demand in recent pre-pandemic years (2014-18), while the Southwest, Northwest, and West corridors lost demand. Demand on the North corridor remained approximately the same.

Figure 7: NJ bus, subway, and rail ridership in AMBA (all in '000)



Sources: CNRT, SUBE, and Dirección General de Estadísticas y Censos de la Ciudad de Buenos Aires

The number of subway passengers increased significantly since the system was privatized in 1995, reaching nearly 500 million in 2019. However, during this period, there were two "breaks" in the general trend. The first was a result of the economic crisis in 2001-2002, and the second during 2012-2014, when the regulation of subway was transferred from the National Government to the City Government (in 2012 the system did not operate for around 10 days due to a strike against the transfer). The demand levels in the subway are similar to those of the surface railway, even though its size and geographic scope is much smaller, as the subway system covers areas with a higher population density.

In absolute terms, ridership is highest on subway lines B and D, reaching around 104 million passengers each in 2019. These are among the longest lines in terms of kilometers of service, passing through higher income (line D) and middle-to-high income neighborhoods in northwestern CABA and, in the case of line D, concentrating a high density of jobs in their immediate vicinity. On the other hand, ridership growth in the decade prior to the pandemic was highest on the lines crossing lower and mixed-income neighborhoods: A, E, and the recently opened H line. Ridership declined on line C located in downtown CABA.

Rail ridership grew during the second half of the 1990s[5] until – as with the other modes – the crisis of 2001-2002. Demand began to recover in 2003, with an upward phase until 2010, after which it declined and reached its lowest level in 2013.[6] In 2013-19, demand grew again and reached the 2007-2008 levels, albeit below the values recorded in the 1990s. The fall in demand in 2010-2015, although significant, could be considered temporary, responding to falling service levels - e.g., less security at the stations, fewer services on the Mitre and Sarmiento lines, and the temporary closure of stations due to improvement works. Nonetheless, the demand has not exceeded 500 million passengers per year despite the significant investments in the system after the Once crash, compared to over 540 million passengers carried annually in 1998-2000.

[5] Due to, among other factors, better level of service provided by the concessions.

[6] The high proportion of unpaid passengers - which in some lines reaches 50 percent - could be amplifying this apparent drop.

Figure 8: *Subte* lines and job density

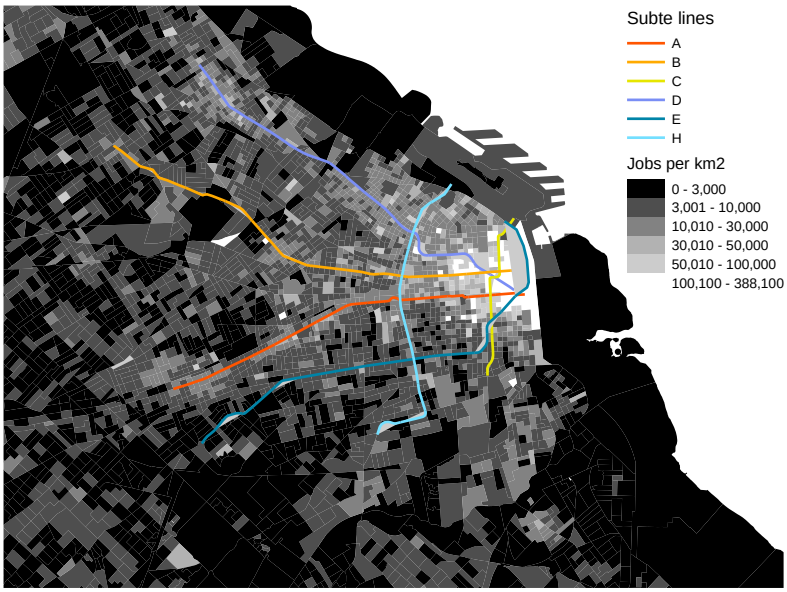
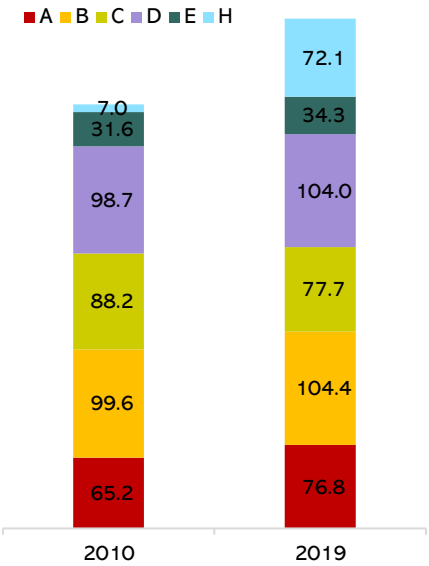


Figure 9: Total *Subte* ridership by line, 2010 vs. 2019 (million)



Source: DataBuenosAires.gob.ar; Dirección General de Estadística y Censos, base don CNRT data

Figure 10: Railway lines and population density (2020)

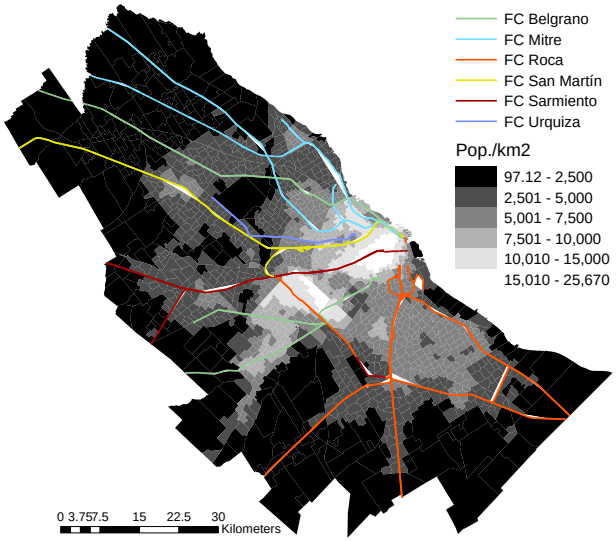
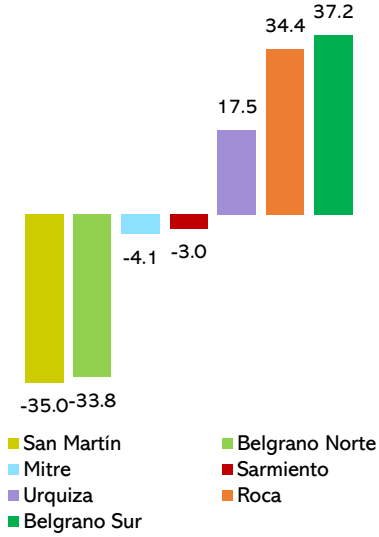


Figure 11: Change in total rail ridership in 2010-2019, by line (%)



Source: WorlPop.org Population data, CNRT demand data; Note: paid passengers only

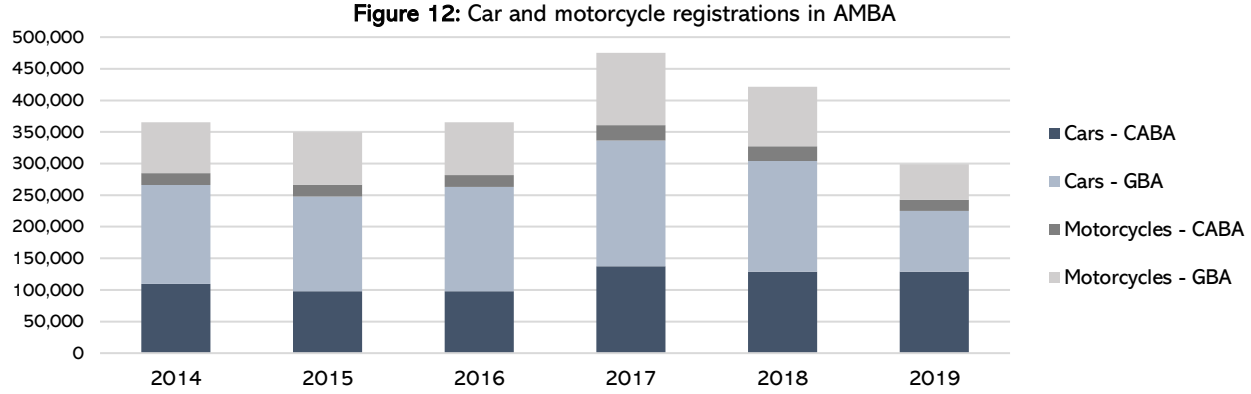
In the rail system, demand in the last 15 years has grown the most on the Roca and Belgrano Sur lines, covering the South/South-West of AMBA but declined on those serving the North/North-West (Figures 10-11). On the Roca line, demand has grown since 2011 and in 2019 was 34 percent higher than in 2010. Roca is the most important line of the system in terms of spatial scope and has seen the greatest boost in modernization in the last two decades – incorporation of new rolling stock and branch electrification leading to improved level of service. Its share of total rail demand in 2019 was 40.3 percent, compared to 31.2 percent in 2010. Meanwhile, demand on Belgrano Sur grew rapidly between 2016 and 2019. In contrast, the San Martin line lost all the demand that it had gained since 2005, due to the construction of the viaduct and the resulting impact on the service. In 2019, total ridership on the San Martin line

was 35 percent lower than in 2010, and a similar decline in demand was observed on the Belgrano Norte line. Sarmiento and Mitre, meanwhile, only recovered their 2005 demand towards 2019, after the sharp drop suffered by both lines after the Once accident.[7]

Rail occupancy levels fell significantly throughout the period of analysis. Since 2005, occupancy (load factor) has fallen on all lines, especially Sarmiento and Mitre. In 2019, occupancy was highest on Urquiza (54 percent) and Belgrano Norte (48 percent), and lowest on Belgrano Sur (21 percent). However, because occupancy is calculated considering paid passengers only, these figures could be underestimating the real load factors during some periods.

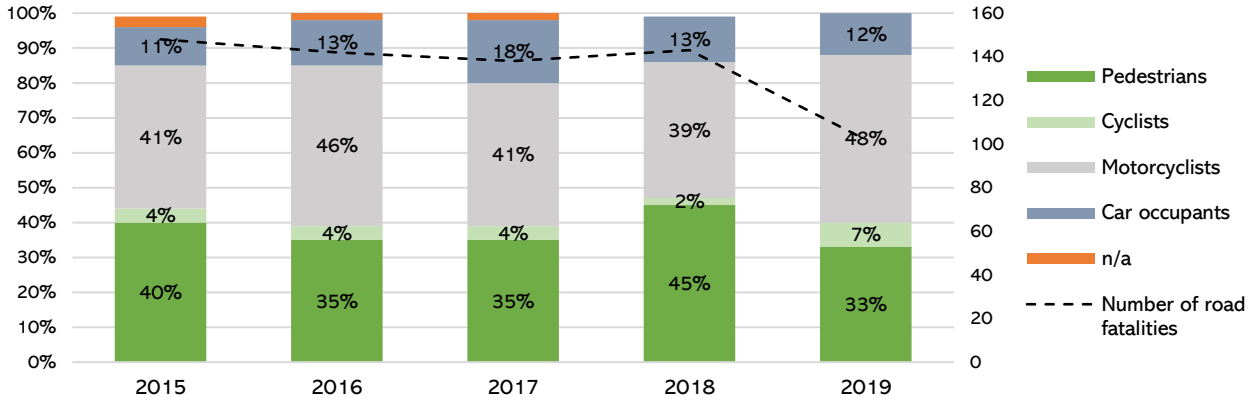
In the last decade, AMBA's private vehicle fleet increased, and new vehicle registrations have only declined since 2018 (period of economic stagnation). In 2009, only 35 percent of the households in AMBA had a private car, according to the ENMODO survey. In 2010-19, private motorization grew by 2.5 percent per year in CABA and by 5 percent in GBA (Anapolsky 2020). New car registrations accelerated after 2014, reaching approximately 250,000 to 300,000 vehicles per year (Figure 12). Over the same period, motorcycle ownership also grew steadily: according to the National Directorate of the Registry of Motor Vehicles and Pledged Credits, (DNRPA), in 2014-2019, in GBA, a motorcycle was registered for each two cars sold, while in CABA the ratio was closer to 1:5.

Figure 12: Car and motorcycle registrations in AMBA



Source: Own estimate based on DNRPA data

Figure 13: Road fatalities in CABA, per type of user (2015-2019)



Source: Undersecretary for Mobility Planning

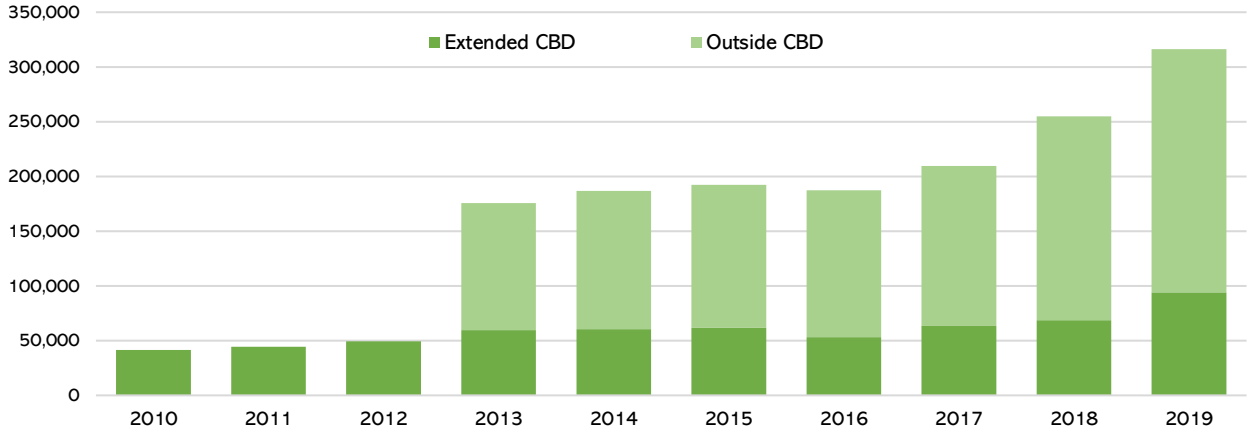
[7] These figures are specific to paid passengers, and, as the level of fare evasion differs across lines, the trends over time in *total* ridership could be different. For example, in 2019, fare evasion was estimated to vary from 4 percent on the Roca line to 40 percent on Belgrano Norte. Mitre and Sarmiento were operated by *Trenes de Buenos Aires*, from which the operation was taken after the accident at Once train station. As they operated the same types of trains as the one involved in the Once accident, many services on those lines were cancelled until the new rolling stock was put in operation after 2014.

Increased motorcycle ownership was observed despite the motorcycle users representing an increasing share of road fatalities over time (see Figure 13 for CABA). The increased private motorization took place in a context in which fare levels clearly favored the use of public transport, with explicit policies in place to lower the relative cost of these modes compared to private transport.[8]

Between 1998 and 2019 the number of vehicle trips via highways into CABA grew by approximately 70 percent, with nearly all the increase occurring between 2002 and 2008 and then plateauing. This translates into approximately 350,000 vehicles currently traveling on CABA's highways per day, compared to 200,000/250,000 in the late 1990s. In 2010, 63 percent of the traffic in CABA were vehicles coming from GBA. There is no data available to compare these figures over time, as there are no records on internal vehicle flows within AMBA. Vehicle counts on General Paz, the first ring road around CABA, show that traffic in the most used road segment grew from 245,000 daily vehicles in 2006 to around 270,000 in 2014, to fall again to 250,000 in 2019.

According to ENMODO 2009/10, public transport accounted for 39 percent of all trips, followed by private motorized modes (32 percent), NMT modes (25 percent), and "other" (4 percent). According to ENMODO 2018, between 2009 and 2018, the overall modal share of private motorized transport in AMBA appears to have decreased, with an increase in the share of public transport and non-motorized transport (NMT) – biking and walking. However, it is known from individual public transport sub-system demand data that, although the number of trips in public modes increased until 2012, since then it has remained relatively constant (approx. 4 billion trips per year). Moreover, the ENMODO 2018 data – which is still not officially published[9] – may fail to reflect some of the trends that are known to have occurred between 2009 and 2018, such as the improvement of the subway level of service, reaching new areas served via branch extensions in high-density corridors, and the significant increase in the number of private vehicles in circulation. Similarly, ENMODO 2018 suggest that the share of trips in "remis" has remained constant, even when new competing options have emerged, such as Cabify/Uber.

Figure 14: Evolution of bicycle trips in CABA 2010-2019



Source: Secretaría de Transporte y Obras Públicas (2021)

At the same time, the increasing role of NMT modes suggested by the ENMODO 2018 survey is also confirmed in other mobility data that is being tracked by the City. In 2013-2019, the total number of daily trips by bicycle in CABA increased from about 170,000 to over 320,000, with nearly 70 percent of riders commuting to/from work. According to the systematic counts conducted by the CABA Government, which allow characterizing the evolution in the number of cyclists in the City in a representative way, between 2013 and 2019, cycling increased every year, a trend not observed for any other public

[8] Public transport fares and their effects are analyzed in detail in section 2.3.

[9] There is some dispute on the results from the survey, and several government offices are working on its reprocessing.

mode (at least not at similar rates). The counts were complemented with user surveys, with the results indicating that the average distance traveled is 3 km.

Demand is the highest on cycle lanes in the North corridor and in the Center, possibly due to the preference for cycling among higher income users. However, Blanco and Alaolaza (2018) suggest that bicycle ownership and use is more common among lower income groups needing to have a low-cost means of transport: 42 percent and 24 percent of the lowest income quintile (Q1) and highest quintile (Q5) households, respectively, have at least one bicycle. Despite the fact that the vast majority of cyclists are men (over three-quarters of the total), the participation of women has increased steadily (Secretaría de Transporte y Obras Públicas 2021). Between 2013 and 2018, there was no significant change in the main reason for travel (Work). However, there has been a slight increase in cycling for "Study" purposes (12 percent), replacing "Recreation" as the second most important motive. Women are much more likely to report "Health" as a motivation compared to men.

Although data over time is not available from officially published surveys, the modal distribution in AMBA is closely related to the socioeconomic profile of people. Public transport is the most widely used mode among all income groups, but there are differences: as per data from ENMODO 2009/10 and when considering single-stage commutes from home to work, buses are used by 46 percent of low-income commuters and 39 percent of high-income commuters, while the subway use ranges from 2 percent (low income) to 9 percent (high income). Public transport is the most widely used mode among unskilled workers, while employers / entrepreneurs and professionals tend to use private transport more. The use of NMT is most common among unskilled workers (Mendiola and Gonzalez 2021). Private motorized and NMT trips account for 25 percent and 18 percent, respectively, of all trips conducted by the upper income quintile travelers, while the opposite is the case for the lowest quintile travelers who use private motorized transport for 12 percent of trips and NMT for 40 percent of trips (Blanco and Apaloaza 2018).

ENMODO 2009/10 data reveal clear differences in the modal choices of men versus women. For example, 28 percent of men use private cars for commuting compared to only 8 percent of women. Women travel more by public transport (50 percent vs. 37 percent of men's trips) and on foot (16 percent vs. 10 percent) (Mendiola and Gonzalez 2021). The average travel distance for women is only 4.77 km compared to 6.72 km for men (Quiros et al. 2014). As already noted, the 2018 ENMODO results are not considered reliable, so it is not possible to ascertain how these patterns have changed over time.

Despite being more dependent on it due to their spatial remoteness, women in more vulnerable neighborhoods are constrained in their use of public transportation because of security issues. A recent study on women's mobility barriers show that in neighborhoods such as Villa 31 and Ejercito de los Andes, security issues influence women's selection of public transport modes and time to travel, which lead to longer travels (World Bank 2018). Their safety and security fears include the segments they have to walk to reach the stops, the period they waited at stops as well as the entire ride in the vehicle. Unlike men, women preferred traveling at off-peak hours when they had the opportunity to do so, particularly in mid-morning. Very early or late hours are perceived as unsafe due to poor street lighting and having to walk across deserted areas, especially in low accessibility areas far from the city center.

2.2. Demand-side drivers of long-term mobility patterns

2.2.1. Land use change and land values

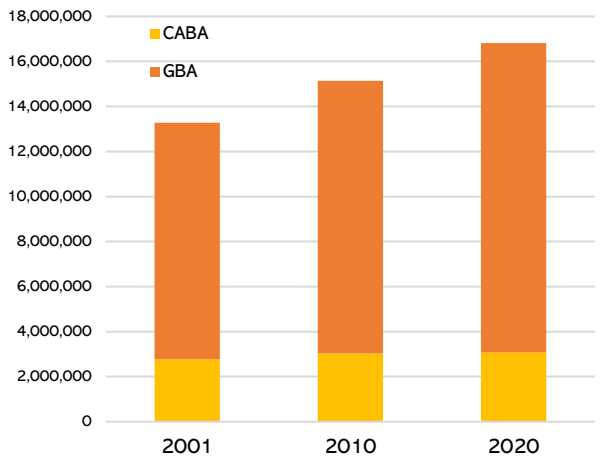
Many cities in Latin America have experienced recent acceleration of urban sprawl, resulting in longer travel distances (Pardo et al. 2021). AMBA is the third-largest city in Latin America after Mexico City and São Paulo, concentrating about 16.8 million people in 2020, of which only about 18 percent live within the boundaries of the City of Buenos Aires. Its growing population has been mostly accommodated by expansion of the peri-urban areas, resulting in a sizeable population living in relatively new, low-

density neighborhoods. This has made it expensive to extend public infrastructure and services.

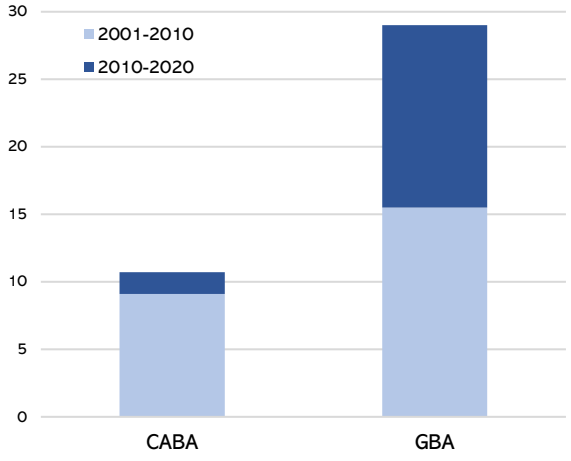
The population of AMBA increased by about 27 percent between 2000 and 2020, and the vast majority of it was contributed by growth in GBA (Figure 15). The skewed spatial distribution of population growth can at least partly be attributed to the rising land and property values in CABA. There are very few indices that track land value over time and the ones that exist are just for CABA or Zona Norte/AMBA and do not compare across different areas. The available information suggests that over the last three decades, real estate prices per square meter have experienced periods of fast acceleration, mainly between 2002-2012 and 2015-2018, and periods of significant decline, in particular during economic crisis in 2001 and 2020. In CABA's Zona Norte, even with an average of about 1.5 million square meters of construction completed annually, the price of real estate in the area doubled between 2000 and 2015 (Cruces 2016).

Figure 15: Population growth in CABA vs. GBA (2001-2020)

a. Total population in CABA vs. GBA in 2001, 2010, and 2020



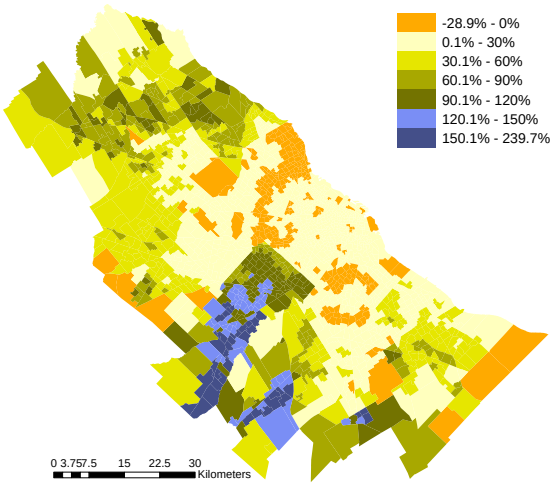
b. Population growth since 2001 (percentage points by decade)



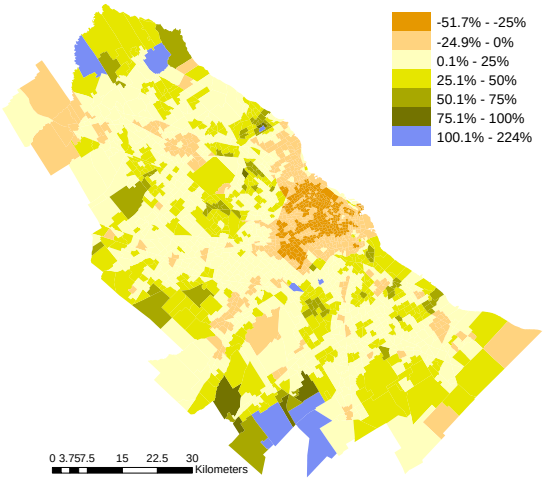
Source: INDEC. Figures for 2020 are estimates

Figure 16: Population growth and economic activity change in AMBA over time

a. Population growth (2000-2020)



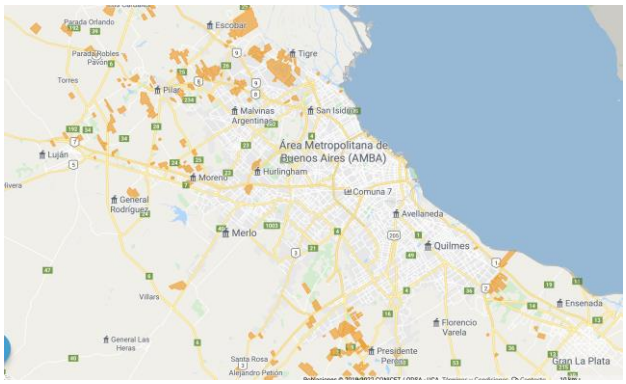
b. Change in average nighttime light intensity (2012-2019)



Sources: WorldPop.org and Earth Observation Group

Population growth and urban development in GBA over the past two decades has been characterized by low population density, sprawl, and the rise of housing developments (gated communities) for high-income groups.[10] About 60 percent of the gated communities were built between 1993 and 2000 and 30 percent during 2001-2015. Most of these communities are located in the north and southwest AMBA, next to the highways connecting GBA to CABA (Figure 17), suggesting that the construction of the highway infrastructure directly facilitated their development by reducing commuting times by private modes and, consequently, the trade-off usually present between transport cost/time and available housing space. Also in the northern zone of CABA, municipalities such as San Isidro and Vicente Lopez were occupied by the upper class following the development of the motorways in the 1990s (Buenos Aires Ciudad 2019). Current data shows the consolidation of this trend with most gated communities situated next to the main roads in AMBA.

Figure 17: Gated communities in AMBA in 2018



Source: https://mapa.poblaciones.org

The growth of the Nordelta development in northern AMBA is an example of how the expansion of gated communities favored the use of private transport. Founded in 2000, it now hosts a population of around 35,000. Although it covers an area of 16 km^2, public transport was not allowed in the area until 2019, when protests were made public as workers had no proper means to enter and travel within the community. Also currently the public transport service is limited, operating only in certain time periods on a specific road.

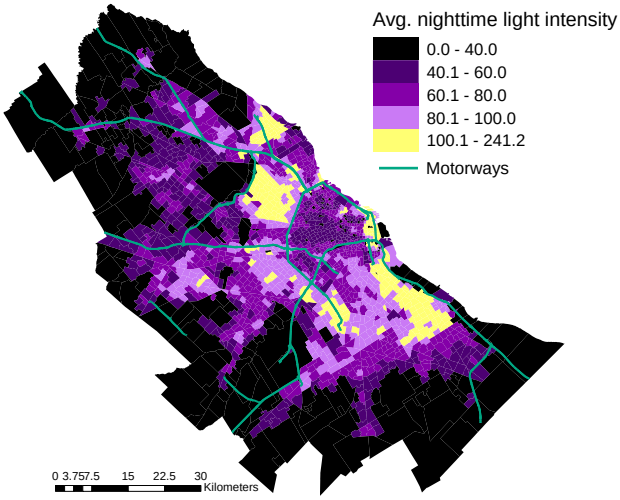
At the same time, also the number of slums and informal settlements[11]**have grown steadily, especially in GBA**, from 496 in 1991 to 796 in 2006 and an estimated 1,340 currently, according to the National Registry of Popular Neighborhoods. In AMBA overall, 8.2 percent of the population today live in slums or informal settlements, compared to about 4 percent in the early 1980s. The overall poverty rate in CABA is 11.2 percent, compared to nearly three times the level in the municipalities that constitute the metropolitan area (World Bank 2019). On the other hand, CABA, La Matanza, and General Sarmiento have the largest absolute number of households with unmet basic needs (World Bank 2020). Vulnerable settlements show a more dispersed territorial footprint, not necessarily in the vicinity to the highway network.

Today, the spatial dispersion of different socio-economic groups in AMBA is quite distinct (Mendiola and Gonzalez 2021); the high-income households live mostly in CABA and in the peripheral areas close to the highway network; the middle-income households mostly inhabiting areas along the axes formed by motorways and public transport lines; and the low-income households living in peripheral areas with little access to the main thoroughfares.

[10] The lack of Census data since 2010 makes it difficult to precisely quantify the rate of expansion of gated communities. According to some sources, the population living in these communities grew from 100,000 in 2000 to 220,000 in 2015. (https://www.perfil.com/noticias/sociedad/se-duplico-en-quince-anos-la-superficie-que-los-countries-ocupaban-en-la-decada-del-90-20141129-0028.phtml).

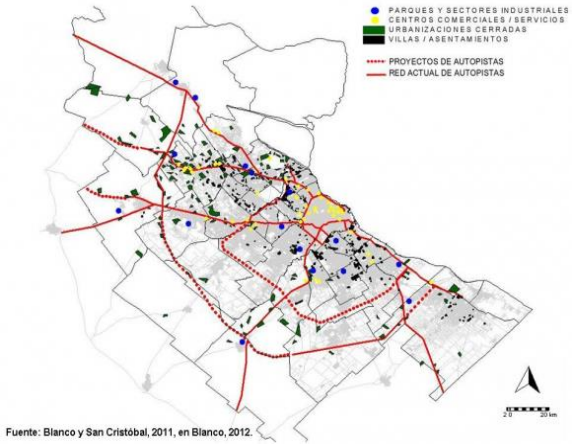
[11] This refers to *Barrios Populares,* defined by the Government as at least 8 families grouped, where more than half of the population does not have the land title or regular access to two or more basic services (water network, electrical network with meter and/or sewerage network).

Figure 18: Nighttime lights intensity and motorways (2019)



Source: Earth Observation Group, OSM

Figure 19: Industrial parks and commercial areas along access roads (2012)



Source: Blanco (2012)

Overall, the relationship between land use patterns and mobility in AMBA has worked in both ways, with the former affecting the latter at least to some extent. The improvement in the availability of car-oriented infrastructure – the radial highways connecting GBA to CABA – have promoted the development of industrial parks in these areas (Figures 18-19), as it provided the required infrastructure for improved connectivity with markets in the rest of the country. Traditional industrial areas located in the south of CABA and in Ring 1 of GBA have relocated next to the highways and to industrial parks (Blanco 2021). However, at the same time, the relocation of industries has further boosted the demand for transport services and motorized mobility for the workforce.

Overall, the most notable urbanization trend that has impacted the distribution of trips within AMBA has been the decrease in the share of trips taking place strictly within CABA, while the opposite trend occurred for trips among GBA *partidos* and, especially, the within them. As a consequence, most trips in AMBA today take place within GBA. Moreover, the growth in the number of private developments – increasing by nearly 40 km^2 between 2000 and 2010 – impacted overall mobility patterns, as most of the residents of gated communities are high income people that have a higher auto usage than the rest of the population.

There has been a trend towards decentralization of public services, with services that were previously provided by national or provincial government agencies at central locations[12] now being provided by local municipal governments in GBA or through the opening of decentralized branches from national agencies (e.g., ANSES,[13] Ministry of the Interior, PAMI[14]) in most municipalities. While this has strongly impacted GBA-CABA trips, as previous needs can now be solved within one's home municipality, some CABA-CABA trips have also been eliminated, after CGPs (Centros de Gestión y Participación) were opened in each Commune.

2.2.2. Economic structure and employment

Services dominate AMBA's GDP and employment, and non-tradable sectors have a high overall share. In 2017, services contributed 50.4 percent of national GDP, and AMBA has lower employment in tradeable sectors compared with the average for both direct and best-practice comparator cities (World Bank 2020). The main sectors among the non-tradables are consumer services and public

[12] Universities, ID issue offices, registering for subsidies, motor vehicles registries, etc.
[13] Administración Nacional de la Seguridad Social - National Social Security Administration
[14] Programa de Atención Médica Integral - Comprehensive Medical Attention Program, a public health insurance agency

services. The tradeable sector is dominated by financial and business services, transport and communications, and industry (Muzzini et al. 2016).

AMBA's overall transport demand is also significantly affected by the major freight hubs located in the area, with the Port of Buenos Aires Port Complex handling 83 percent of Argentina's containers and with 91 percent of all air freight passing through Ezeiza International Airport in Buenos Aires. The Buenos Aires Port Complex has historically represented an important hub in the flow of tradable goods, including for the country overall, which has presented challenges for AMBA's mobility patterns and congestion given that the Port is located in a densely built-up area and only about 1 percent of the container traffic that reaches the Port comes by rail.

The share of non-registered workers in AMBA's overall employment has remained high, at 35-40 percent throughout 2011-2019 in GBA.[15] This mainly affected women, with the share of non-registered female wage earners growing both in CABA and GBA in all types of activities with the exception of domestic workers. Growth in non-registered work among men has been stronger in GBA.[16] Moreover, the bulk of newly created jobs over the past ten years appears to be less sophisticated, concentrated in low qualified public jobs – characterized by being self-employed (*monotributistas)* and supported by social aid – such as delivery workers, commercial establishment workers, or service staff in gated communities (gardeners, cleaning staff, security personnel, etc.), which is mostly catered for by local labor.[17]

Activities such as, for example, small-scale construction, waste collection recovery, clothing manufacturing at home, and informal transport services, have growth in importance as AMBA has undergone significant overall deindustrialization since the 1970s, resulting in a general reduction of formal employment in the manufacturing industry. In relation to commercial, recreational and service activities, new centralities emerged in the recent decades, contributing to a gradual dispersion of economic activities and slow but persistent reduction in the concentration of jobs in CABA. "Local" mobility emerged, corresponding to trips that have an origin and a destination in the same district.

Jobs in Argentina and AMBA specifically have also become more amenable to home-based work during the last two decades, enabled by cheaper and more widespread digital connectivity, especially so in the high-skilled, formal, public sector jobs, in sectors such as finance and public administration. These trends, too, have started to impact transport mobility within AMBA. In 2003-2019, data from the Permanent Household Survey (EPH)18 indicates that, while in 2003, 38 percent of jobs were located in CABA, this fell to 35.2 percent in 2019. The share of jobs in GBA remained almost constant at around 58 percent, and **the participation of jobs in non-defined destinations grew from 4 percent to 6.5 percent, probably depicting a combination of irregular work and remote work, associated with less certain mobility behaviors.** Overall, the share of employed people living in CABA and working in CABA or living in CABA and working in GBA fell. On the other hand, there was an increase in the share of people living in GBA and working in non-defined destinations, which grew from 2.9 percent to 5.1 percent of all employed people.

Growth in online (e-) shopping over time has had the effect of reducing commuting and shopping trips while increasing leisure travel and freight trips, modifying temporal demand patterns and modal choices. According to data tracked over time by Argentina's Chamber of Electronic Commerce (CACE), there has been a steady growth in the proportion of Internet users in Argentina making purchases online: from approximately 12 percent in 2001 to 32 percent in 2010. By 2019, nearly 18.8 million Argentines were shopping online, and the share of shoppers who purchased something online at least

[15] Non registered employment represents the share of wage earners without social security benefits. Source: Observatorio del Conurbano Bonaerense, http://observatorioconurbano.ungs.edu.ar/?page_id=8328

[16] Source: Observatorio del Conurbano Bonaerense

[17] The deterioration of the labor market -a phenomenon starting in the 1990s- for the RMBA and Argentina as a whole has been extensively analyzed in various research papers, e.g., Balza (2020), Cappannini (2016), Maurizio (2011).

[18] These figures reflect the trips of employed people (40-45% of the total population of AMBA). It doesn't take into consideration unemployed, non-active, and children below 10 years of age, all of whom might show even a more local mobility behavior.

once a month reached 66 percent, up from 46 percent just two years earlier.

E-commerce sales in the country overall increased from just 80 million pesos in 2001 to 7.8 billion in 2010,[19] of which over two-thirds were concentrated in AMBA, but with an increasing dispersion into other parts of the country. About 92 percent of the e-commerce volume was in business to consumer (B2C) transactions and the rest in consumer-to-consumer (C2C) transactions; more than 28 percent of SMEs in Argentina overall were selling or buying online, compared to only a few dozen companies in 2001. By 2016, the total e-sales in AMBA had reached 45.6 billion pesos, and data showed that three-quarters of the e-shoppers were women and 42 percent were Millennials. Many online shoppers make frequent small purchases (tickets, books, music, ring-tones, etc.), while some make large purchases of airline tickets or electronics. The most common e-commerce purchases in AMBA are tickets for events and performances, tourism related purchases, and clothing.

Importantly, approximately one-third of all e-commerce purchases in 2019 in AMBA were picked up in person by the buyers themselves or someone sent on their behalf, rather than home delivered. Thus, only part of the e-commerce volume led to avoided trips or trips that are more rationally planned (as a result of trip chaining by the delivery firm, for example).

2.3. Supply-side drivers of long-term mobility patterns

The institutional landscape for mobility planning in AMBA is fragmented, and there is a need for a stronger coordination at the metropolitan level, which has been absent for most of the period under analysis. The National government regulates a significant portion of the bus system (the national jurisdiction lines, which represent about 50 percent of the total system), controls the entire surface rail system and operates six of the lines, and manages the concession contracts of some of the access roads from GBA to CABA. The City government, on the other hand, governs the concession contract under which the subway is operated by a private concessionaire, plans and deploys the NMT infrastructure in CABA, and operates several internal CABA highways via the public company AUSA. The City government has also built several Metrobus corridors although it has no jurisdiction over the bus network. Finally, the provincial government manages the provincial bus lines and operates, through a public company (AUBASA), one of the access roads to the CABA. All the municipalities comprising AMBA have the ability to regulate their own municipal bus networks, and as they have jurisdiction over their road networks, are responsible for developing NMT policies and allocating road space for these modes.

Along with changes in the institutional setup in 2000-2020,[20] there have been several shifts in the focus of the federal government's public policy with respect to mobility in AMBA. Before 2010, the focus was on subsidy implementation to keep the levels of commercial fares low after the economic crisis of 2001-2002. After 2012, attention shifted to investments in rail infrastructure and equipment. Finally, in 2016, as a new administration came into office, the construction of segregated bus corridors increased. However, the federal government is only one of four that have regulatory and implementing responsibilities for mobility planning and investment in AMBA (Table 2).

As a significant milestone, the Metropolitan Transportation Agency (ATM) was created in 2014 (decree 1359/14), with the mission of developing coordinated public policies among the National Government, the Province of Buenos Aires and the City of Buenos Aires, in order to improve mobility in the Metropolitan Area. The ATM was tasked with promoting a comprehensive transportation network and promoting physical, operational and tariff integration. One of the results of the creation of the

[19] This online sales figure represents just over 12 percent of the total ICT market in Argentina (63.2 billion pesos in 2010).

[20] In 2000-2012, the responsible entity for transport public policies at the national government was the Secretary of Transport (initially as part of the Ministry of Economy and then of the Ministry of Federal Planning). In 2012, the Ministry of Transport was created. Since 2016, policy is a responsibility of the Ministry of Transport.

ATM was the publication of the ATM Transportation Master Plan in 2018 (Agencia de Transporte Metropolitano 2018). The Plan incorporates a series of objectives and a compendium of projects to be carried out throughout AMBA. However, its preparation did not benefit from a robust analytical process and consultations with the various relevant planning authorities, and the Plan is therefore not considered in the current day-to-day planning process.

Table 2: Administrative setup of AMBA's transport planning

Jurisdiction	Responsibilities
Federal Government	• Bus lines 1 to 199 (DF, SGI, SGII groups) • Surface railways (Roca, Mitre, Sarmiento, San Martin, Belgrano Norte, Belgrano Sur, Urquiza lines). SOFSE and ADIf are part of the National Ministry of Transport • Access Highways: Panamericana (Acceso Norte) & General Paz; Richieri; Acceso Oeste
PBA	• Bus lines 200 to 499 (UPA, UPAM groups) • Access Highway: La Plata – Buenos Aires highway
CABA	• Subway (lines A, B, C, D, E, H, Premetro)[21]. SBASE is part of the CABA Secretary of Transport • Non-motorized transport (infrastructure, public policy and bike sharing system) • Highways internal to the City: Lugones/ Illia; Dellepiane; 9 de julio sur; 25 de mayo/Perito Moreno
GBA Municipalities	• Bus lines 500 to 700 (UMA1 and UMA2 groups) • Non-motorized transport (systems and infrastructure)

The City of Buenos Aires published its Climate Action Plan 2050 in December of 2020. The Plan recognizes the important role of the transport sector in the city's overall carbon emissions, accounting for 30 percent in 2017, of which only 1 percentage point is due to trains and subway and the rest – road transportation. The Plan proposes an "acceleration in climate action" with the objective of cutting overall carbon emissions in half by 2030, including through the achievement of several transport sector targets: (i) 75 percent of the population using public transport and NMT rather than private motorized transport,[22] (ii) 50 percent of the bus fleet being zero-emissions, and (iii) 30 percent of private vehicle fleet consisting of low-emission vehicles. By 2050, the Plan sets targets for the same indicators at 80 percent, 100 percent, and 100 percent, respectively.

CABA's overall urban mobility objectives are set out in the Sustainable Mobility Plan of 2010. According to this plan, the City's priorities focus on: (i) encouraging the use of public transportation; (ii) promoting healthy mobility (pedestrian and bicycle mobility); (iii) improving traffic management and road safety; and (iv) developing an Intelligent Transit System, which includes new instruments to improve traffic management and facilitate circulation.

2.3.1. Large investment in major access roads, with lasting impacts

During the 1990s in particular, significant investment was made in adding road capacity. In 1970-2006, the bulk of the investment in AMBA's transport system went to road infrastructure (US$4.4 billion), in particular the access highways leading from GBA to CABA, compared to US$730 million to the railway and US$1.22 billion to the subway (Szenkman 2015). The management of the main roads in terms of traffic flows was handed over to private companies under concession schemes. These included all the access roads into CABA, which were transformed into highways. The improved level of service meant reduced congestion and travel times, which made it more attractive for people to relocate

[21] Until 2012, the subway was under jurisdiction of the Federal Government.

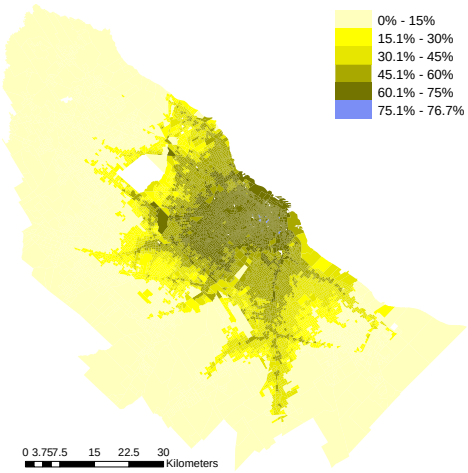
[22] For example, the Plan envisions an increase in cycling to reach 1 million daily trips already in 2023; expansion of ciclovias in the lower-income neighborhoods and at the Metropolitan scale; improvement in the inter-modality between cycling and public transport; and other actions.

to Ring 1 and 2 in GBA and commute daily to CABA. This led to the rapid development of gated communities targeted at medium and high-income people living in CABA, and subsequent car-oriented changes in land use in AMBA. After 2006, further investment was made into other road works, including the construction of the 4th lane on General Paz Avenue, a 3rd lane on Tigre Access, shifting of the Aeroparque boundaries to allow the extension of the Illia Highway, and the construction of the Highway on Route 4. Overall, between 2000 and 2020, approximately US$1.1 billion was invested in road works that primarily benefit private vehicle traffic in AMBA (excluding provincial and municipal roads and dual carriageways). By increasing the relative advantages of private mobility,[23] especially for travel from GBA to CABA, these investments contributed to the steady private motorization growth described earlier. As investments in public transport systems failed to meet the growing demand for urban mobility, the use of private vehicles became more widespread (Goytia and Cristini 2017).

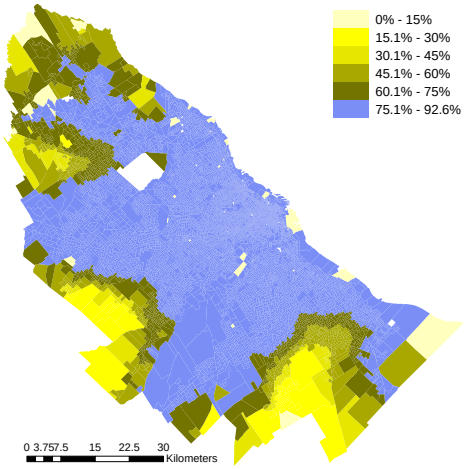
Thus, Buenos Aires has been densifying largely in the periphery, where the existing transport system offers worse overall accessibility and worse transit accessibility in relation to private vehicle based accessibility. The estimation of accessibility (calculated as the amount of employment opportunities that are within a 60-minute threshold of a specific origin) for AMBA shows that the center city has the highest levels of relative accessibility by public transport and the lowest discrepancy between accessibility by public transport vs. private cars (Quirós and Mehndiratta 2015). The growth rate of motorized vehicles, especially in GBA's peri-urban areas, has increased much faster than the population growth rate.

Figure 20: Share of all AMBA jobs accessible in an hour by public transport vs. car

a. By public transport



b. By car (free flow)



Source: Quirós and Mehndiratta (2015)

2.3.2. Public transport supply and its impacts on accessibility

AMBA is characterized by a complex and dense public transport network and multiplicity of services. It operates one of the most comprehensive formal bus networks in the world, with more than 11 million passengers per day and 1,500 routes. Rail services and 75 percent of bus lines serve interjurisdictional traffic. Since 2012, the state-owned Sociedad Operadora Ferroviaria Sociedad Del Estado (SOFSE) has managed five suburban lines in AMBA (Roca, San Martín, Belgrano Sur, Sarmiento, Mitre) that serve 85 percent of the demand for passenger rail services in

[23] Increased private transport speed and reduced travelling times was an objective of authorities when deciding to move forward with the infrastructure works, e.g.: https://www.argentina.gob.ar/noticias/hubo-34-ofertas-para-las-obras-de-ampliacion-del-acceso-oeste-0

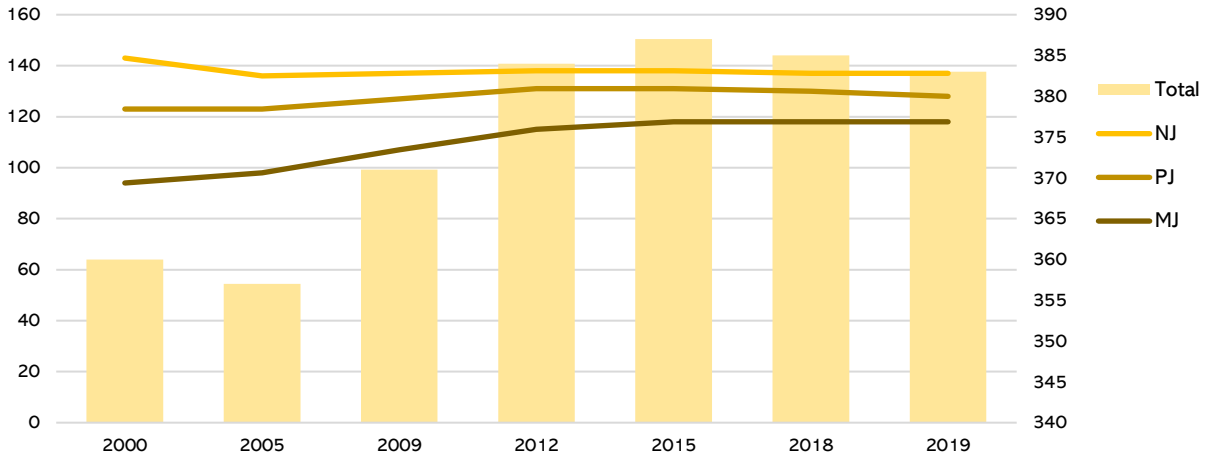
the metropolitan area. The privately managed Urquiza and Belgrano Norte Lines account for the remaining 15 percent (World Bank, 2021a).

Mobility in the city has been shaped by longer-term public transport policies, such as the development of the bus rapid transit (BRT) network and the implementation of the integrated fare system. Public transport investment in AMBA has focused on the modernization of rail transport, the expansion of BRT infrastructure and urban road improvement aimed at providing more efficient service, safety, and quality for users (World Bank 2021b). New investments in public transport in AMBA over the last decade have increased the quality and the accessibility of mass rapid transit, thus helping maintain the historically high mode share of public transport, of about 40 percent in 2014. Metrobus, a BRT system, opened in CABA in 2011. Since then, the system has been extended to the metropolitan region and is currently 93.3 km long, operating on most of the lines in CABA and a few in GBA. Certain BRT lines are said to have reduced travel times by more than 50 percent for their users (ITF 2021). However, the BRT system in Buenos Aires differs from BRT networks in other cities like Bogota or Mexico City, as the BRT network is a series of corridors in which buses have exclusive lanes and priority, but there is no single specific service with different type of vehicles that uses the corridor. Instead, regular buses are able to enter and exit the corridor as part of their route (Arias 2018). The Argentina Metropolitan Areas Urban Transport Project financed by the World Bank (closed in December 2019) included the construction of La Matanza BRT corridor, leading to a decrease in the generalized cost of travel by a third.

Overall, between 2000 and 2020, approximately US$5.3 billion was invested in AMBA's bus system - including both road infrastructure that specifically benefits the bus routes as well as rolling stock. This represents approximately 31 percent of overall transport sector investment during this period, only second to rail. This figure excludes investment in areas such as transshipment centers, improvement of stops, etc.

However, the overall NJ bus operations fell during the early 2000s, and, after some recovery, again since 2011. By 2018, the number of vehicle-kilometers (v-km) of service supplied in NJ lines was approximately 10 percent less than in 2010. Meanwhile, the number of lines increased in the rest of AMBA, especially MJ lines, reflecting the response by the authorities and operators to new travel poles such as gated communities, shopping centers, hospitals, etc. As the number of gated communities grew through the GBA, several services sectors developed in their vicinity. A share of the people employed in these developments were people living in the same or nearby municipalities, driving the need for new municipal and provincial bus services. The supply on MJ and PJ lines over the recent pre-pandemic years remained stable, with MJ providing about 220 million v-km annually and PJ about 400 million v-km.

Figure 21: Evolution of the number of bus lines by jurisdiction, 2000-2019



Source: Alzaga et al. (2021)

Despite reduced demand and a slightly smaller number of operational lines, the number of vehicles in operation in the NJ sub-system today is similar to that 35 years ago, approximately 9,500. The need to keep the same number of buses and preserve a relatively similar level of service in a context of falling demand meant that the use of the fleet declined (Alzaga et al. 2021).[24] Between 2000 and 2012, vehicles in service on MJ and PJ lines increased by approximately 36 percent and 22 percent, respectively. After the Resolution 422/2012 was issued, establishing the freezing of the fleet for which a subsidy was recognized for MJ and PJ operations, the number of vehicles in operation at the provincial and municipal levels has remained stable.

The NJ system has seen a sustained fall in kilometers traveled per vehicle, from 80,000 in 2005 to 64,000 in 2019, with a similar trend observed in the PJ and MJ subsystems (Alzaga et al. 2021). The estimated average load factor for the entire AMBA remained unchanged at around 27 percent during 2008-2018, as a result of the decline in demand in parallel with the decrease in the kilometers supplied. NJ lines had higher load factors, while MJ had the lowest. However, many of the MJ lines cover low density neighborhoods, where demand is not sufficient to justify a service but is needed on social grounds. On NJ lines, where the number of passengers per vehicle was 28 percent lower in 2018 compared to 1992, the drop in productivity occurred even though infrastructure was improved to make the system more efficient: priority of public transport on certain avenues in CABA, such as Las Heras, Jujuy-Pueyrredón, and Santa Fe; construction of 9 Metrobus corridors (and a transfer center in La Matanza); and better infrastructure in 10 trunk avenues through on which public transport operates and the paving of more than 400 km of corridors and dirt roads in GBA. In other words, the development of dedicated infrastructure did not result in a systemic impact by improving productivity levels, even though the service level on specific lines that travel on the improved transport corridors benefited.

During the past few decades, the number of bus companies fell and their average size increased. Although the market is not concentrated, there is a clear trend towards concentration, facilitated by the centralization of capital ownership in some companies and the established regulatory scheme that imposes strict economic conditions for entry and exit, setting prices of services and operating parameters by the regulatory authority, types of vehicles, etc. Of the 383 bus lines in RMBA, only 40 are operated by "Monoline" companies (single line operators), with the share of such lines falling significantly since 2000. Between 2000 and 2019, the ten largest bus companies increased their share of demand from 26 percent to 47 percent, with the average number of passengers carried per company more than doubling (Alzaga et al. 2021).

There is no consolidated data that allows identifying a trend in AMBA's bus service performance over time. In 2019, a performance indicator per line was constructed with data from 2018, as a simple average of three dimensions, namely: a quality indicator, an economic indicator, and an operational indicator.[25] The results showed a significant disparity: the score of the "best" lines was about 35 times higher than that of the "worst" lines. Geographically, the worst performer routes are in the Southeast, followed by the Northwest, Southwest, and West corridors (Ministry of Transport 2019). While no time-series data is available to confirm how performance changed over time, it is clear that during the last few decades targeted policies have been implemented to improve the level of service to users, at least in the NJ system. These include: (i) implementation of ticket sales through vending machines (1994) and through digital systems (SUBE) (2009-2013); (ii) incorporation of automatic gearbox, rear engine, air suspension (1990s); (iii) introduction of low-floor units with ramps for access people with disabilities (since 1997); (iv) Metrobus corridor construction (since 2011); and (v) introduction of air conditioning and heating (since 2013).

[24] Reducing the number of buses would mean reducing the number of staff as well, which tends to be an inflexible factor. Also, through part of the period under study subsidies were allocated on supply parameters, the number of vehicles being one of those. This was an incentive to maintain a given number of buses in operation.

[25] The quality indicator is a composite measure of three indicators: fleet average age, vehicle technology and passenger complaints; the economic indicator is built as an aggregate measure of: fare collection per kilometer, fare collection per vehicle and demand variations; the operational indicator is a composite measure of three other indicators: occupancy factor, kilometers per vehicle and passenger-kilometer index.

The subway system has benefited from extensive planning efforts, including several plans and laws, which the City Government and SBASE (the public company managing the system) commissioned. However, some of the plans have seen significant implementation delays. For example, Law 317/1999 commissioned the construction of line H; however, the line became fully operational only in 2019. Similarly, while Law 670 of 2001 authorized the construction of lines F, G, I, as of 2022, the bidding processes to contract the construction of these lines have not yet started. Moreover, none of the plans for the subway include extension beyond CABA boundaries.

Nevertheless, in the last two decades, the subway system did expand, mainly through extensions of existing lines. Between 2000 and 2020, an estimated US$3.7 billion was invested in the subway system (not counting investment in repowering, signaling, parking garages), equivalent to 22 percent of overall transport investment in AMBA during this period. Investment particularly ramped up after 2013, which is also reflected in increasing ridership.

The length of the subway network increased by 46 percent in 1995-2020 (from 43.9 km to 64.2 km). Growth since 2000 has been uneven across the different lines: of the 17 km that were incorporated into the network since 2000, almost half were accounted for by line H. Lines A, B and D expanded further into Caballito, Villa Urquiza and Belgrano, respectively, areas of high (albeit properly planned) population density and high share of upper socioeconomic strata. Line H, on the other hand, was the first line to connect the more vulnerable areas in the southern part of the city (Parque Patricios) to the wealthiest neighborhood in the north (Recoleta). Line H is not only the first subway line to expand to a low-income and low-density area in recent years but has also benefited from government actions to proactively adjust land use (creation of the Technological District in Parque Patricios, relocation of government offices to the City's southernmost districts). Preliminary analysis[26] suggests that the implementation of the H line and the complementary land use policies contributed to the densification of the corridor: in the seven years prior to the opening of the line (2000-2007), population in the 500-meter radius around the future line grew by a total of only 0.86 percent, compared to a total of 2.57 percent in the seven years after the line opened. In comparison, the respective figures for CABA overall were 2.77 percent and 2.26 percent, suggesting that population growth in CABA slowed while increasing specifically in the line H vicinity.

The frequency recorded in most subway lines did not change much in recent pre-pandemic years (2016-2019), with the exception of line H which significantly improved its level of service since 2016. However, commercial speeds across all subway lines are low, due to several factors, including some lines' outdated rolling stock, the short distance between stations, and congestion on several lines, forcing vehicles in some stations to wait longer than 30 seconds (Buenos Aires Ciudad 2015).

Table 3: Administrative milestones in the railway system, 1994-2020

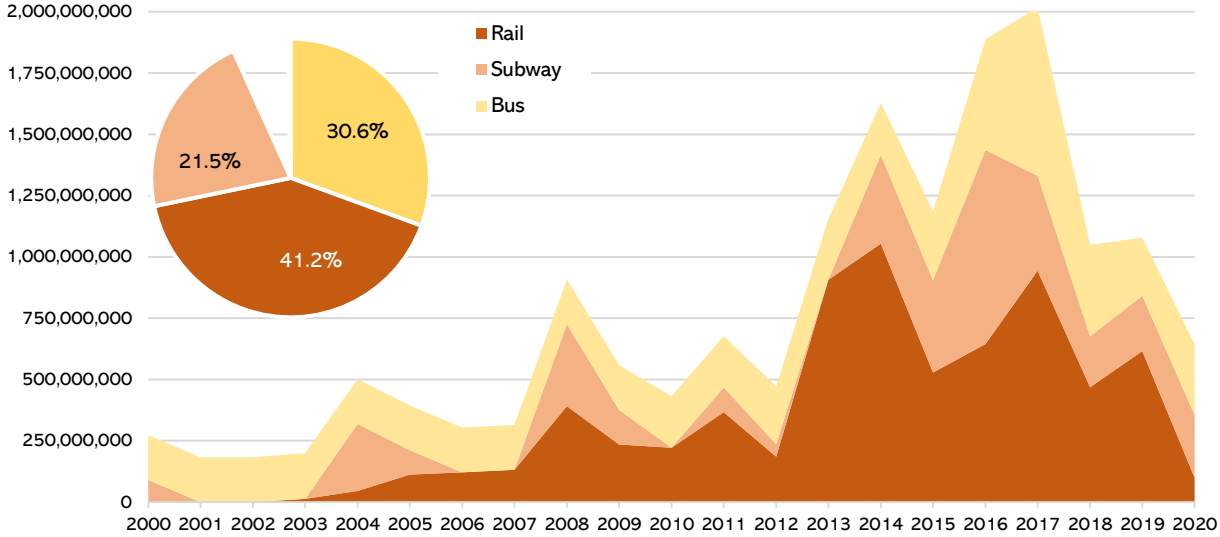
1994/95	Rail service concessions begin to operate
1997	First contracts renegotiations take place
2002	Railway Emergency is declared
2004	Termination of the FC San Martín operating contract
2005	UGOFE takes over the FC San Martín operation
2007	Termination of the FC Roca operating contract. UGOFE takes over the FC Roca / Belgrano operation
2008	Creation of ADIF and SOFSE
2012	Crash at Once FC Sarmiento station; termination of the TBA operating contract; creation of UGOMS
2013	SOFSE takes over the FC Sarmiento operation
2014	COFESA and Argentren are created
2015.	SOFSE takes over the FC Mitre, San Martín, Roca, Belgrano Sur operation
2017/19/20	Contract extensions for FC Urquiza (Metrovías) and Belgrano Norte (Ferrovías) are awarded

[26] Team's analysis based on high-resolution population distribution data for 2000-2014 from WorldPop.org

In the railway sector, the administrative organization and the operators and organizations that compose it has undergone important changes. In the last 25 years, the sector has migrated from completely private operation of the lines to a scheme under which the state operating company is in charge of more than 90 percent of the network (Table 3).

A total of approximately US$7.1 billion was invested in the rail system over 2000-2020, most of it in the latter decade, accounting for about **41 percent of total transport investment in the metropolitan area, or the single largest category** (Figure 22). The rail system currently has 24 branches that are grouped into 8 lines, with a total length of 940 km (258 km electrified). The supply levels closely mirror the demand patterns over the last two decades, with a decline in the number of train-kilometers supplied from 2009 to 2015 and subsequent growth until 2019. However, the apparent response of demand to service quality improvements might be due to either passengers returning to railway as their preferred mode of transport and/or authorities more actively implementing enforcement measures to reduce fare evasion, which would translate into higher formally recorded ridership numbers. The supply in electrified branches increased significantly starting from 2015, mostly attributable to the Roca line.

Figure 22: Investment in public transport in AMBA (US$ and share of total transport investment), 2000-2020



Source: Data assembled by study team from various sources

Rail system investment in the 2000-2020 period underwent two distinct stages. **Prior to the crash at the Once station, investment was not sufficient to sustain and expand operations; the highest share of resources was allocated to funding operating subsidies that allowed to maintain low fares.**[27] It was estimated that an investment of no less than US$450 million per year was needed just t o replace the worn-out parts, while, on average, investment only reached around US$50 million annually between 2003 and 2010, and the investment plans announced by the national government were only partially implemented.

The crash at the Once station of the Sarmiento line in 2012 changed the priorities of the authorities and boosted investment in the sector and marked a break in the overall supply and demand trend over time. Even when the subsidy levels continued growing, investment levels increased significantly, reflected in several works and large purchases: construction of viaducts on the Mitre and San Martin lines; construction of several underpasses; electrification of La Plata and Roca branches; and purchase of rolling stock on almost all electrified branches, including Roca, Sarmiento, and Mitre. Investment plans were also announcements for projects that have not yet

[27] Some of the main costs of providing rail service in AMBA experienced explosive growth. For example, labor came to make up almost three-quarters of the total operating cost: wages increased, and the number of employees practically doubled (largely because it absorbed previously outsourced jobs).

been completed, such as the electrification of the San Martín line, tunnelling of the Sarmiento line, extension of the Belgrano Sur viaduct to Constitución, and renovation of Belgrano Norte.

Regularity of the overall system, defined as services on time as a share of services operated, is currently below the level of the 2000s, with an increasing divergence across the lines. In 2019, regularity was highest on the Roca line (92 percent) and lowest on Sarmiento, Mitre, and San Martin (80 percent). Despite the infrastructure investments that have been made, commercial speeds fell between 2005 and 2019, mainly due to the reduction in the approach speeds of the trains to the terminal stations on the Sarmiento and Mitre lines in response to measures taken after the Once accident. The CNRT compiles a comfort indicator[28] which, although limited, indicates whether the travel experience improved or worsened from one year to the next (not whether the subjective passenger experience was positive or negative). From 2005 to 2013, the annual comfort indicator tended to be mostly positive, while in 2014-2019 it was quite significantly negative every year. By line, the comfort indicator has since 2005 been the most consistently negative for the Sarmiento line and, more recently, the Mitre and Urquiza lines.

The introduction of the integrated ticket in 2017 appears to have slightly increased the share of multi-leg trips, from 26 percent in 2009 to 29 percent in 2019. Travelling by rail appears to involve more multimodal integration compared to subway: while only 5 percent of public transport trips in 2019 were single-stage rail trips, rail represented 13 percent of all public transport trip legs that year; for subway the corresponding figures were 8 percent and 10 percent. The share of single-stage bus trips in overall public transport trips has decreased over time (66 percent in 2009 but 58 percent in 2019) (Anapolsky 2020).

The extent to which each mode is used is partly explained by its availability. For example, in 2009, while bus journeys were evenly distributed throughout AMBA, the localities in Ring 2 that are not served by rail services had difficulties accessing CABA. The flexibility of the bus system has allowed the supply to adapt to changes in demand, as exemplified by the PJ and MJ systems deploying new services during the last decade.

2.3.3. Consistent support to NMT modes

Between 2008 and 2010 the CABA Government designed and began to implement the Sustainable Mobility Plan, with the objective of improving the quality of life of the people commuting daily through CABA (the geographical scope of the plan is limited only to the City). The Sustainable Mobility Plan sought to privilege pedestrians, NMT modes, and public transport. In support of the City's climate and walkability objectives, five priority areas have been turned into pedestrian priority areas in the last few years: Tribunales, Retiro, Casco Histórico, Once, and Microcentro. In addition, the section of Corrientes Avenue between Carlos Pellegrini and Florida Streets was transformed in 2019, reducing vehicle lanes, leveling crosswalks and widening sidewalks to create more pedestrian sidewalks to create more pedestrian space. An estimated US$64 million was invested in the expansion of the cycleway network between 2010 and 2020.

The Sustainable Mobility Plan is the only mobility plan in AMBA that was defined based on a specific diagnosis, structured along specific axes/guidelines, and fully implemented according to the initial objectives. Public policy was developed based on the notion of cultural change, including programs for children, subsidies for healthy mobility, a free rental system, parking at public shows, reduced rates in garages, implementation of bicycle racks in the city, activities at schools, and personal loans at a subsidized rate, among others.

The City of Buenos Aires has actively promoted the expansion of bicycle-based mobility, with the first initiatives launched over a decade ago. The implementation of the network of protected bicycle lanes began in 2009 and the network reaching more than 265 km in CABA in 2020[29] and a gradual

[28] Trains Run: 20%; Compliance with Schedule: 10%; Passengers by Car: 50%; Trade Speed: 10%; Absolute regularity: 10%. The formula is as follows: 0.20x (TC) + 0.10x (CD) - 0.50x (PxC) + 0.10x (VC) + 0.10x (RA). All operating indicators are added and Passengers per Car is subtracted since an increase in this indicator would present a worsening in travel comfort.

[29] Even though there are other bicycle lanes in the rest of AMBA, and some municipalities have active policies to

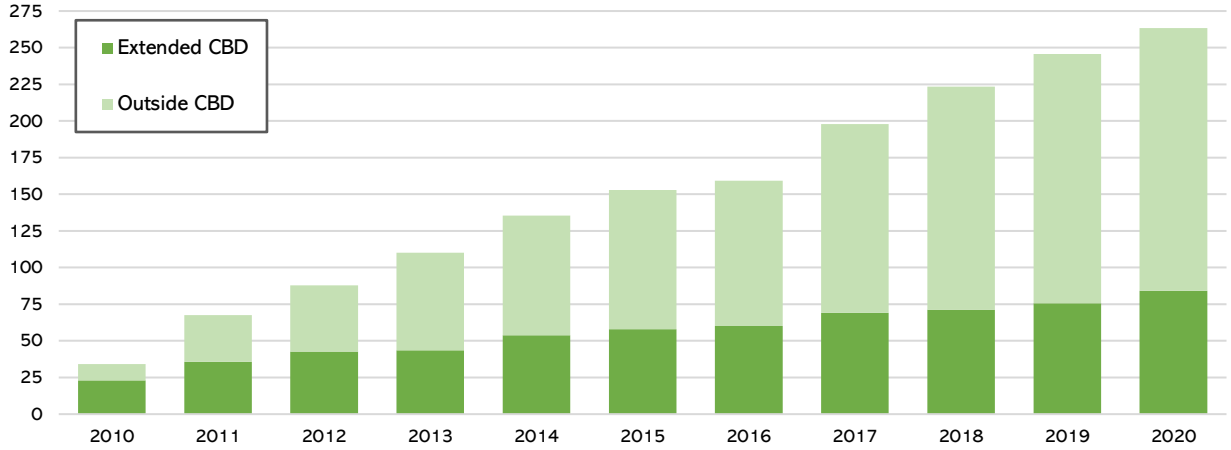
expansion from the center to the periphery. With the sole exception of 2016, when only 6 km were built, during the rest of the period the annual growth was of at least 18 km.

Figure 23: Bicycle lane network in CABA, 2010-20

Source: Secretaría de Transporte y Obras Públicas (2021)

Trips began to grow significantly only from 2016, coinciding with the time when the cycle network exceeded 150 km, possibly suggesting a "network effect" in attracting users. As of 2020, exclusive lanes for cyclists started to be built on the city's main avenues, including Córdoba, Corrientes, and Forest. The Government of CABA also plans to implement exclusive lanes along the entire length of Avenida Del Libertador.

Figure 24: Evolution of total km of bicycle lanes in CABA, 2010-2020



Source: Secretaría de Transporte y Obras Públicas (2021)

An important part of the strategy to promote the use of bicycles in CABA was the deployment of the Public Bicycle Transport System (STPB). At the end of 2010, the system was piloted with 3 stations and 72 bicycles. Currently, the system has 270 stations and 2,500 bikes available. The growth in the number of stations brought an exponential increase in trips, accelerating further in 2016, when the system began to introduce automatic stations.[30] The station network has wide coverage throughout the City, and the number of registered users also increased in recent years as the system expanded. While 40,267 users were registered in 2015, in 2019 the figure reached 81,418.

The number of road fatalities affecting cyclists has decreased in recent years, from 0.1 fatalities per million trips in 2015 to 0.03 in 2020 (Secretaría de Transporte y Obras Públicas 2021), encouraging even more users – and more diverse users – to join the network. The deployment of the system on Av. Corrientes and Av. Córdoba resulted in an increase in female cyclists, suggesting that the new infrastructure provides a greater perception of safety.

promote non-motorized modes, the information regarding this availability is not systematized.

[30] The system allows take up to 4 free trips per day of 30 minutes on weekdays. Options that require user payment are also available, including monthly, annual, single-trip, weekend passes, and tourist passes.

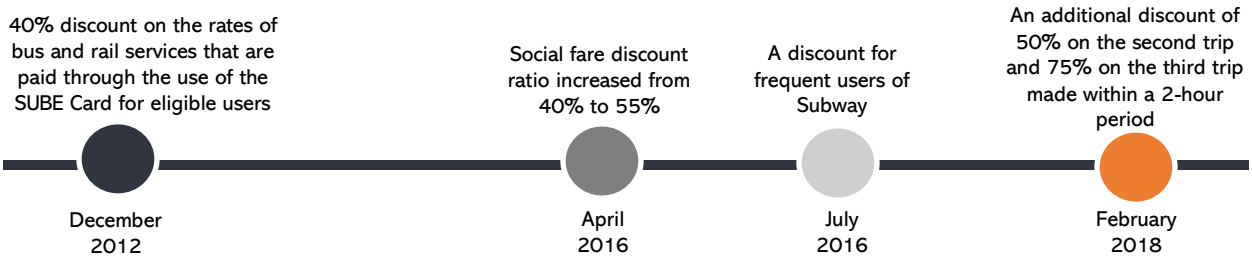
2.3.4. Transport affordability

Perhaps the most significant change that AMBA's bus system underwent during the last decades is the implementation of a fare compensation system and a diesel quota regime at a differential price for bus operators as of 2002. Until then, income from ticket sales made it possible to cover the costs necessary to maintain the system operation. Since then, the original scheme has undergone various modifications, especially in terms of subsidy distribution (Alzaga et al. 2021). Between and 2002 and 2012, the distribution was based on a participation coefficient for each line according to certain parameters (passengers, income, km-traveled); the said coefficient was then applied to the amount to be distributed. Starting from 2012, a part of the total amount was distributed according to the participation coefficients of the lines (based on the supply parameters) and another part corresponded directly to the specific demand of each line (for example, the compensation discount by social attribute). Finally, since May 2019, only the criteria associated with demand are applied.

Certainly, the integrated fare system SUBE has had a direct impact on promoting modal and fare integration among different public transport modes in AMBA, resulting in an overall reduction of passengers' travel cost, by providing a 50-percent discount on the second public transport trip and a 75-percent discount on further trips, mainly benefiting the poorest users who undertake longer trips with more transfers (IEG 2020).

The introduction of the social fare in 2012, updated in 2016, provided fare discounts for eligible users. Demand-side subsidies are provided through social fares, which grant a 55 percent discount per trip to some categories of users, which include: beneficiaries of cash transfer programs such as Universal Child Allowance and the Universal Pregnancy Allowance, beneficiaries of social inclusion programs such as Progresar (students) and Hacemos Futuro (employment), retirees and pensioners, seniors, persons with disabilities, mothers of 7 or more children, war veterans, domestic workers, and small contributors to the social security. Eligibility was expanded in 2016 and the fare discount increased. As a result of these reforms, from 2015 to 2019 the number of trips paid with social fare in the bus system increased from 14 percent to 33 percent. In addition, for all students in the public education system, public transport is free of charge in their first four trips of the day. In addition, there are also fare discounts for transfers in multi-stage trips taking place within two hours, a scheme that was initially designed in 2018 to benefit vulnerable users living in the urban periphery. The expansion in the fare discounts certainly played a role in maintaining some users in the public transport system and attracting others.

Figure 25: Major milestones in implementation of fare benefits for public transport users



There has also been a significant change in the relative prices of public modes compared to one another, **especially since 2011**. Before 2010, the structure of relative prices between modes remained stable. Since 2011, the rate of increase in subway fares greatly exceeded that of the rest of the modes, and the current fare levels are double those of DF buses (circulating within CABA). The average rail fare has declined the most in relative terms, and stands at approximately half of the average subway fare (and 70 percent of the bus).

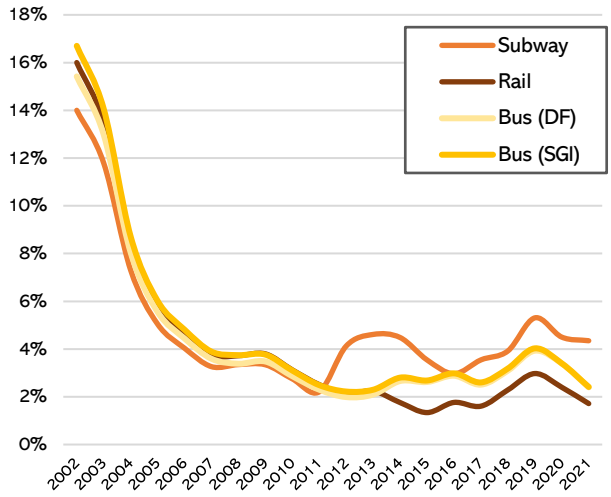
In 2016-2021, the nominal cost of public transport in AMBA increased to a much lesser extent than the expenses associated with private motorized transport, especially in 2020-2021, considering all vehicle purchase and maintenance costs. By October 2021, the price of private vehicle purchase had

increased more than 7.3 times compared to December 2016, and the cost of private vehicle maintenance was about 4.4 times higher (roughly in line with the overall Price Index). Meanwhile, the public transport prices in October of 2021 were about 2.9 times the level in December 2016. Gas prices saw increasing trend exceeding that of public transport fares (Figure 27).[31]

Over the past years, not only did the relative prices of modes change, but they also fell in relation to the population's income. The incidence of public transport expenditure in the Minimum Salary of AMBA has fallen sharply since 2002 (Figure 26). Currently, the share of minimum income that would have to be allocated to pay for 40 trips by public transport each month is approximately 4 percent, while in the beginning of the 2000s a minimum wage earner would have to allocate up to 16 percent.

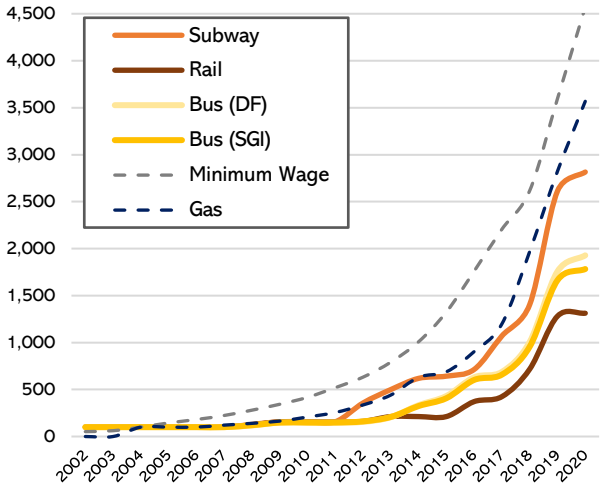
Historically, public transport fares in AMBA have not increased at the same pace as inflation. In constant prices, fares are currently 55 percent of their 2001 level (World bank 2021b). However, fare hikes have been more frequent since 2012. In nominal terms, fares roughly doubled in March 2016 and tripled from January 2018 to April 2019. Since then, there has been no fare adjustment and due to high inflation, the March 2021 level of fares in constant prices is equivalent to the levels of January 2018.

Figure 26: 40 tickets /minimum wage ratio



Source: CNRT, INDEC and Secretaria de Energia

Figure 27: Average annual public transport fares, minimum wage, and gas price in nominal prices (2004=100)



Source: CNRT, INDEC and Secretaria de Energia

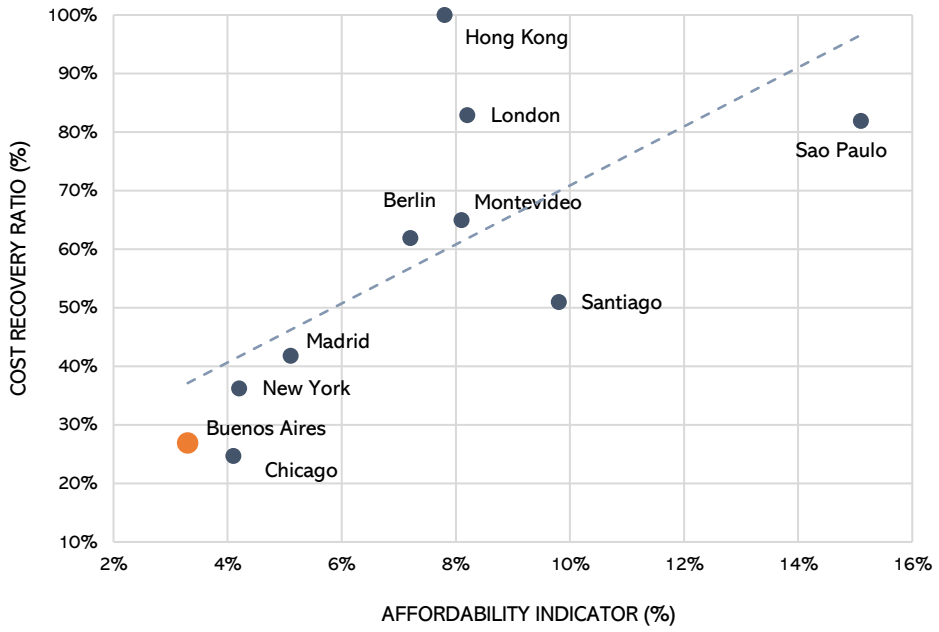
In 2019, subsidies to the public transport system in AMBA amounted to US$2.6 billion, which corresponds to 0.57 percent of GDP (World Bank 2021b). In comparison, investment in public transport infrastructure in AMBA by the national Ministry of Transport the same year amounted to 0.18 percent of GDP. In 2019, subsidies represented 1.8 percent of the current expenditures of the national government, 2.5 percent of the provincial government, and 3.8 percent of the Government of CABA. Subsidy per passenger-trip amounted to US$0.48 for bus and subway transport and US$2.13 for suburban rail. The subsidy per passenger-km (p-km) is similar in all three modes due to longer trip lengths on suburban rail, from US$0.07 for bus to US$0.10 for suburban rail. Evidence suggests that transit subsidies in AMBA disproportionately benefit the middle income class rather than the poor (Bondorevsky 2007).

Also comparison with international benchmarks suggests that public transport in AMBA is very affordable at the expense of low-cost recovery. Affordability and cost recovery levels in AMBA were compared with other public transport systems from ten megacities around the world with 2019 data. The results show that AMBA has the lowest cost to users relative to minimum wage and the second to last cost

[31] As a reference, the market price for one liter of *Super* type of gas was considered, sold at YPF retailers in CABA.

recovery ratio. The cost of 40 trips in AMBA amounted to 3.3 percent of the minimum wage, while the average for the other ten cities is 7.3 percent. The cost recovery ratio in AMBA in 2019 was 27 percent, while the average for the other cities was 57 percent. While there are no cases in which cost recovery and affordability are equally high, the cities of Singapore, Berlin, Montevideo, London and Hong Kong appear to be the most successful, with high levels of cost recovery, and average levels of affordability. There is significant heterogeneity when comparing cost recovery by mode of transport, but the conclusions for AMBA remain the same when looking at bus transport, suburban rail or subway individually.

Figure 28: Benchmarking of AMBA against global cities in terms of public transport affordability[32] and cost recovery



❖ Elasticity analysis for bus ridership

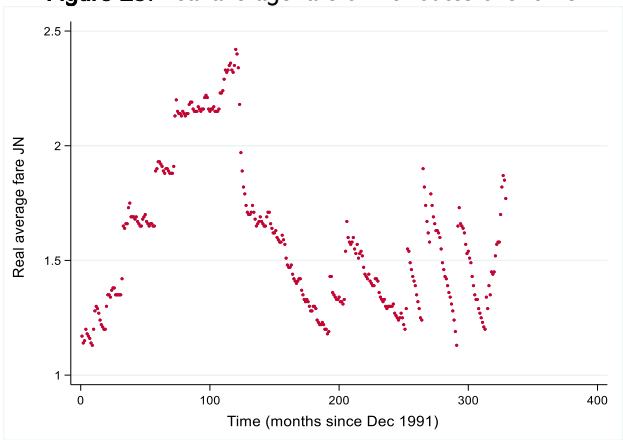
In 2012 and 2014, there were two fare increases per year,[33] while in 2018 the bus fare was increased six times. Even though fare levels increased less than inflation, the cost of operating private vehicles, or the minimum wage, the trend of persistent increases may have influenced the users' perception with respect to an increasingly expensive service.

The study analyzed[34] the relationship between monthly ridership in buses in AMBA, covering the period between January 1992 and December 2019, and the average fares in constant terms,[35] as well as other factors that may affect ridership in public transport, namely the monthly total vehicle-km of service offered, gas prices (in constant terms) to account for the price of the substitute, private transport, employment activity in the metropolitan area[36] to account for economic activity, and monthly seasonal dummy variables. Ridership data in all bus lines combined (national, provincial, and municipal jurisdiction) is only available starting from 2014; for NJ it is available for the whole period.

[32] The cost of 40 trips by public transport as a share of minimum wage.
[33] These increases apply to the NJ system, but, due to fare coordination across AMBA, the increases were replicated by provincial and municipal systems.
[34] The analysis used the ARIMA regression model, which is commonly applied to data characterized by time dependency. It fits univariate models with time-dependent disturbances, where the disturbances are allowed to follow a linear autoregressive moving-average (ARMA) specification.
[35] To check the robustness of the results, analysis was also performed considering nominal fares, using the same set of models. The results are very comparable, as shown in Tables 1.1.-1.4 in Annex 1.
[36] Measured as the number of registered private sector jobs in CABA and Province of Buenos Aires, thousands (SIPA).

The association between bus ridership and the bus fare appears to be quantitatively small and statistically not significant. On the other hand, the results suggest a strong, positive association between ridership and economic activity (jobs), especially the activity in CABA, and, to some extent, the v-km of service supplied. Also adding a control for AMBA's population size does not change this result, nor does adding the average fare for the minimum regular fare (fare to cover the shortest trip distance). Across the different models, the real average gas price does not appear to have a strong association with bus ridership (Table 4).

Figure 29: Real average fare on NJ routes over time



The same analysis is then applied to the dataset specific to NJ bus lines that operate on routes within CABA and between CABA and GBA. Without considering any other factors, the association between the average real fare and NJ bus ridership is statistically significant although modest (elasticity of -0.176). When controlling for the other factors affecting mobility decisions, however, the average fare elasticity becomes statistically non-significant.

Across all the models – and in contrast to the overall bus ridership analyzed earlier – NJ bus ridership appears to be strongly positively associated with the v-km of NJ bus service supplied, while the association with the private sector economic activity (jobs) in either AMBA overall or specifically in CABA is much smaller and not statistically significant (Table 5).

Table 4: Estimated elasticities of ridership in all bus lines with respect to real average fare and other variables, while controlling for time dependency in data (auto-correlation)

	(1)	*(2)*	*(3)*	*(4)*
Real average fare	-0.133	-0.126	-0.087	-0.088
Vehicle-km of service supplied	0.098 *	0.096	0.094 *	0.067
Real average gas price		-0.076	0.044	0.021
Registered private sector jobs in AMBA			4.002 **	
Registered private sector jobs in CABA				4.042 ***
T	71	71	71	71

Note: *** and ** denote statistically significant results, * denotes marginally statistically significant results. T denotes the total number of time periods. The ARIMA model was estimated with 2 lags auto-correlations and differenced 1 time, following Dickey Fuller and Philips Perron test for unit root, and the autocorrelation and partial autocorrelation functions.

Table 5: Estimated elasticities of ridership in NJ bus lines with respect to real average fare and other variables, while controlling for time dependency in data (auto-correlation)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Real average fare	-0.176 ***	-0.138 **	-0.139 **	-0.126 **	-0.121
Vehicle-km of service supplied	0.831 ***	0.548 ***	0.545 ***	0.528 ***	0.528 ***

Real average gas price			0.006	0.043	0.043
Registered private sector jobs in AMBA				1.316	1.326
Minimum fare					-0.004
T	328	76	76	76	76

Note: *** and ** denote statistically significant results, * denotes marginally statistically significant results. T denotes the total number of time periods. Regression (1) has data from 1992-2019. Regressions (2) to (5) has data from 2013-2019 due to data availability. The ARIMA model was estimated with 2 lags auto-correlations and differenced 1 time, following Dickey Fuller and Philips Perron test for unit root, and the autocorrelation and partial autocorrelation functions.

Table 6: Estimated elasticities of ridership in NJ bus lines with respect to real average fare and other variables for different periods of time, while controlling for time dependency in data (auto-correlation)

	(1) 1992-1999	*(2)* 2000-2009	*(3)* 2010-2019
Real average fare	-0.262 ***	-0.349 ***	-0.151 ***
Vehicle-km of service supplied	0.922 ***	1.419 ***	0.640 ***
T	95	120	113

Note: *** and ** denote statistically significant results, * denotes marginally statistically significant results, T denotes the total number of time periods. The ARIMA model was estimated with 2 lags auto-correlations and differenced 1 time, following Dickey Fuller and Philips Perron test for unit root, and the autocorrelation and partial autocorrelation functions.

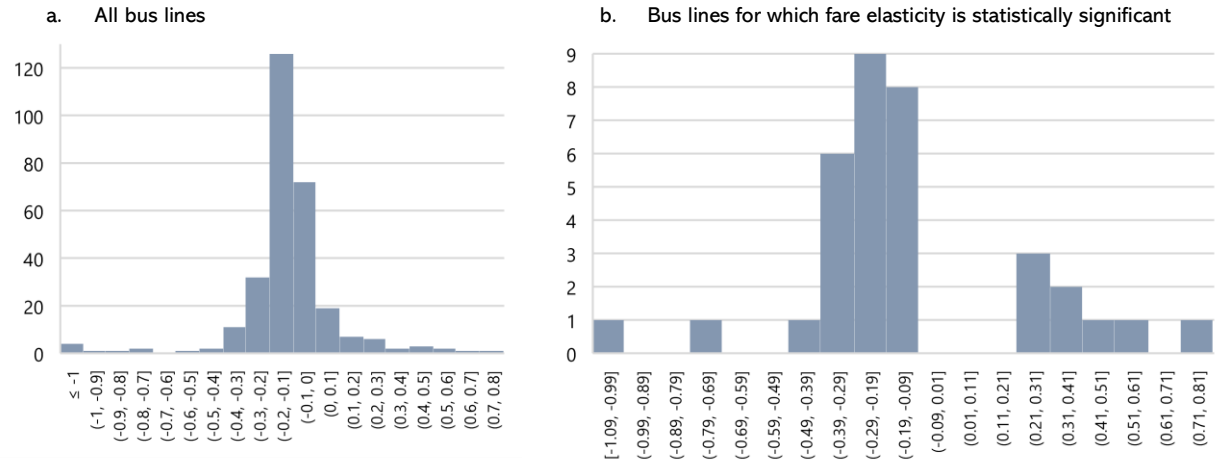
There is evidence that fare elasticities in AMBA have declined over time. For NJ bus lines jurisdiction lines fare elasticities were calculated for the periods 1992–1999, 2000–2009 and 2010–2019, in a model using as explanatory variables only the average real fare, supply in terms of vehicle-km, and monthly seasonally dummies. The elasticity in the most recent period is -0.15, about half of its values in previous years (-0.26 over 1992–1999, and -0.35 over 2000–2009) (Table 6). The decline in the last decade can be explained by the fact that fares have been relatively low in real terms and as a share of household income, hence marginal fare changes were not able to drive significant changes in travel behavior, and also by the fact that high inflation might have affected the perception of real prices relatively to other goods and services

Although the overall bus ridership and, specifically, NJ bus ridership do not, overall, appear to be responsive to changes in real fares, the sensitivity likely varies across the individual bus lines, depending on factors such as population density in the surrounding areas, the income level of the passengers (i.e., as proxied by the share of the passengers benefiting from the ATS subsidy), availability of alternative transport options on the routes served by the bus lines, and the extent to which the passengers using the lines rely on the bus for only part of the trip (i.e., as proxied by the share of riders taking advantage of the integrated fare). Understanding the heterogeneity in response to fare increases is important not only for identifying the extent to which fare changes have been a significant driver of mobility patterns in AMBA in the past but also for any future planning of changes in the fare structure and the targeting of any fare discounts.

The granular analysis of the individual bus lines serving routes in AMBA – of which 293 have time series data on ridership – reveals that the average fare elasticity is statistically significant for ridership on 34 of them, and of these, for 26 bus lines the elasticity is *negative*, corresponding to the intuition that demand is negatively correlated with price. Figure 30 shows the distribution of the estimated real average fare elasticities for the overall sample of bus lines (whether or not the elasticity coefficients are statistically significant), suggesting that for the vast majority of the lines the elasticity centers around -0.2-0. Among the subset of the 26 lines for which the fare elasticity is estimated to be negative and statistically significant, most values are centered

around -0.3 to -0.1, meaning that a 10-percent increase in the real average fare would be expected to be associated with a decline in ridership by between 1 and 3 percent.

Figure 30: Density distribution of estimated real average fare elasticity for bus ridership (number of lines)



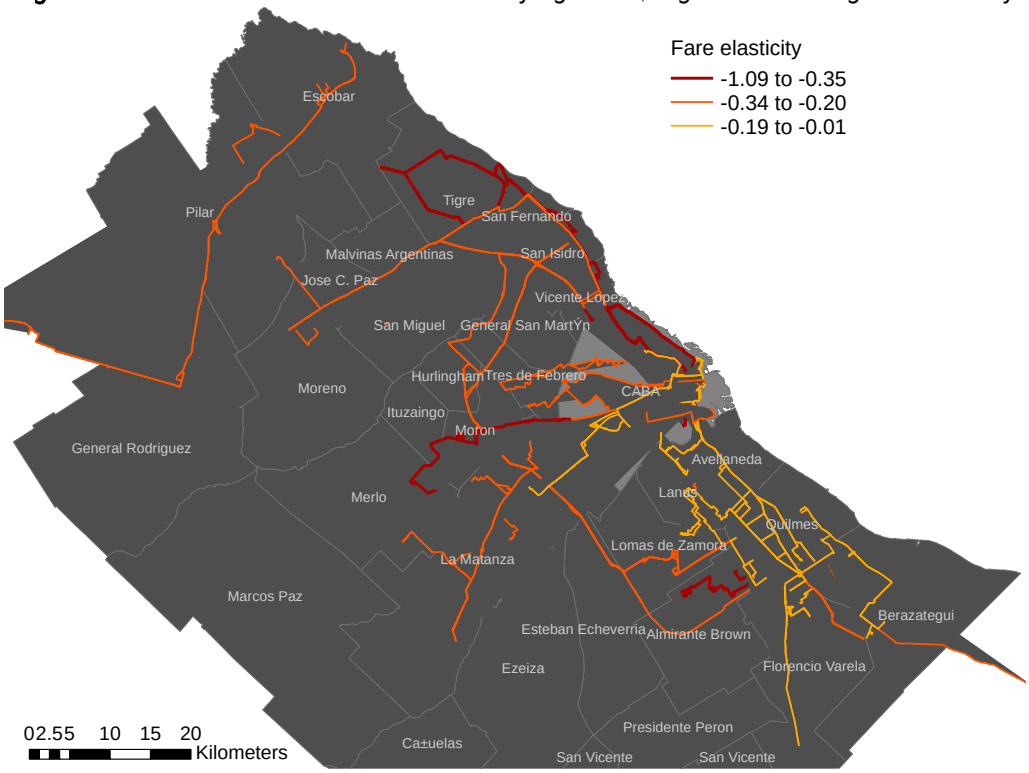
Source: Analysis by the study team

In the overall sample of 294 bus lines, there appears to be no apparent correlation between fare elasticities and the share of ATS subsidy beneficiaries (correl= -0.04) or the share of integrated fare users (0.10). However, the correlations are stronger for the subset of the bus lines for which the estimated fare elasticities are statistically significant: against what intuition about transit "captivity" would suggest, fare elasticities are higher for those bus lines with a higher share of passengers using the integrated fare, indicating that a transfer to another public transport line is made as part of the same trip (0.21), and they are lower for bus lines with a higher share of ATS subsidy beneficiaries (-0.19).

There does not seem to be a strong socioeconomic pattern in terms of the bus lines for which the fare elasticity is relatively high and statistically significant: in other words, these lines do not necessarily serve communities that are more well off or more poor. Nonetheless, visually, **the lines with the strongest negative elasticities are slightly more concentrated in northern AMBA compared to the southern,** which corresponds to the intuition of higher elasticity in higher-income users because of their access to substitute modes of transport, while lower-income users are captive users of public transport (Figure 31). The results support the overall findings that, likely because fares are so low, changes in them do not drive a consistent and significant response in demand, compared to what is observed in other cities/countries, where elasticities range between -0.2 and -0.5 (Litman 2021).

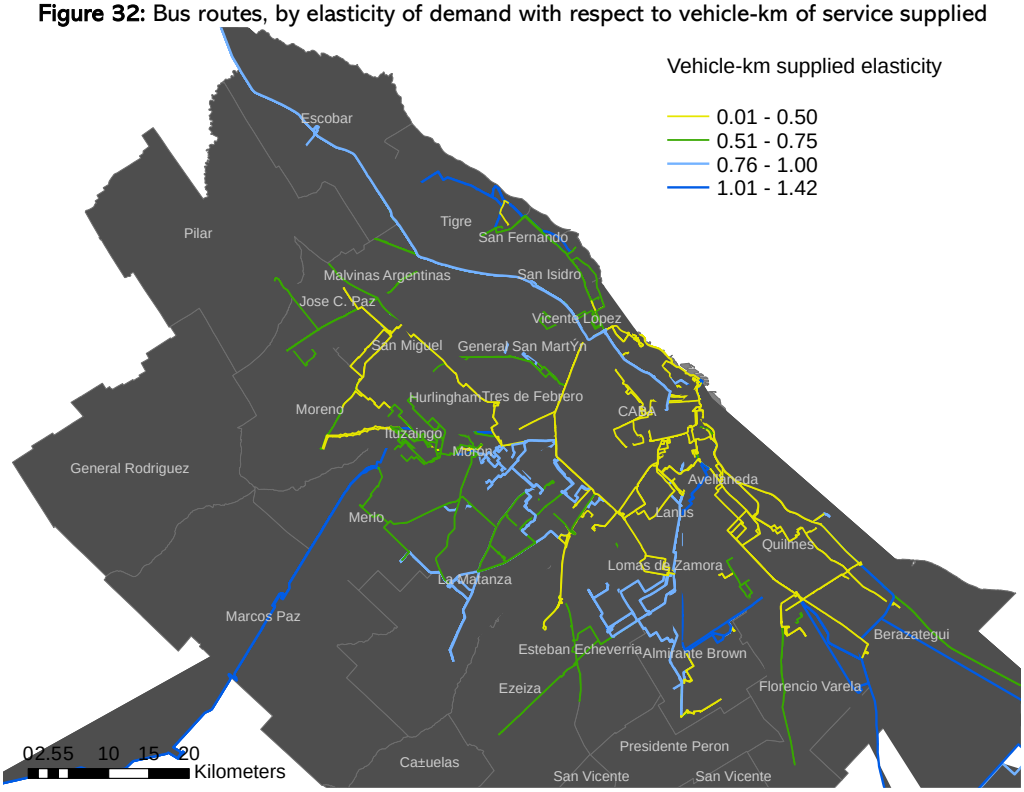
Across most of the bus lines, ridership appears to be strongly and statistically significantly responsive to changes in private sector economic activity and with the vehicle-kilometers of service offered. On 31 percent of all the bus lines, the elasticity of demand with respect to the v-km of service offered exceeds 0.5, and on 6 percent of the lines it exceeds 1 (meaning that ridership has tended to increase by more than the v-km supplied). The lines with the highest elasticities with respect to the v-km supplied tend to be ones that serve longer distance trips on the radial access roads connecting CABA and GBA (Figure 35). In comparison, the elasticities with respect to v-km supplied are much lower – between 0 and 0.5 – on the bus routes serving CABA's internal trips and the *partidos* in CABA's periphery. Thus, on these more centrally located routes, changes in supply did not see a commensurate response in ridership, while, in contrast, on the more radial routes the demand response to any changes in the quantity of bus service supplied were much more significant.

Figure 31: Bus lines with an estimated statistically significant, negative real average fare elasticity



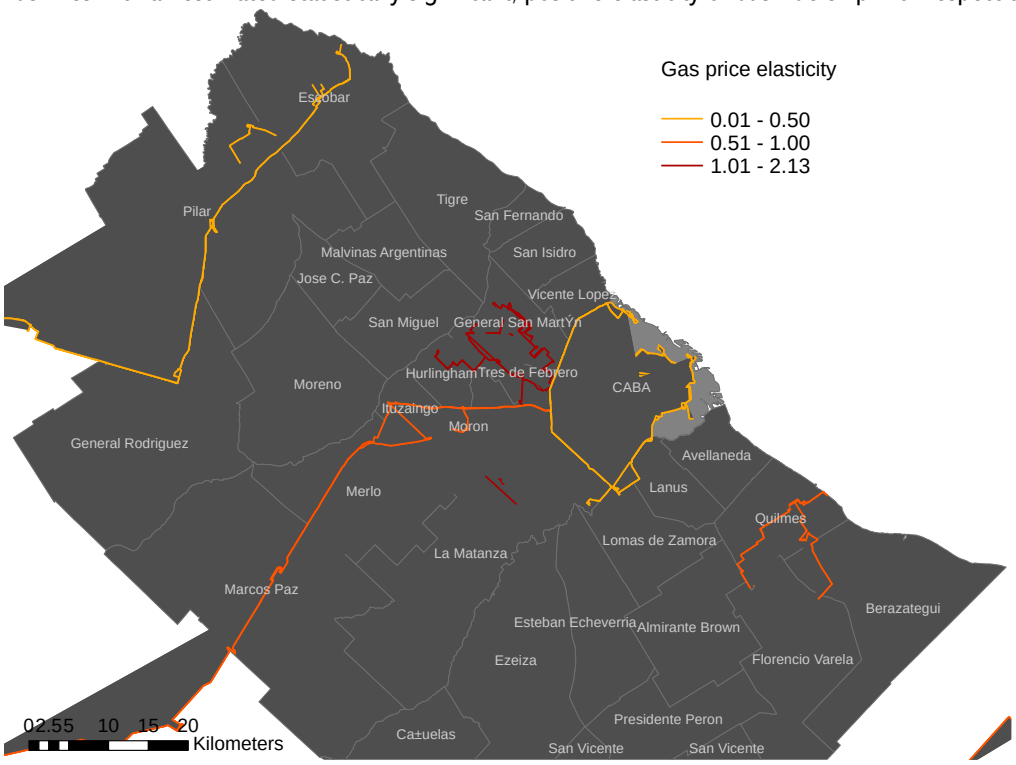
Source: Analysis by the study team

Figure 32: Bus routes, by elasticity of demand with respect to vehicle-km of service supplied



Source: Analysis by the study team

Figure 33: Bus lines with an estimated statistically significant, positive elasticity of bus ridership with respect to gas price



Source: Analysis by the study team

Only in the case of 17 bus lines the gas price cross-elasticity is statistically significant and, as expected, positive, meaning that bus ridership increased when there was an increase in the price of gas (i.e., the cost of using private cars or motorcycles). While not all of these lines could be identified in the available GIS network data, Figure 33 illustrates most of them, suggesting that the routes where ridership has strongly responded to gas price changes are concentrated in and near CABA, corresponding to the areas with higher economic incomes compared to most other parts of AMBA. On most routes where the gas price elasticity of bus ridership has been statistically significant, it has exceeded 0.5, meaning that an increase in the gas price by 10 percent was associated with a 5-percent or greater increase in bus ridership.

❖ Elasticity analysis for rail ridership

The regression analysis of monthly rail ridership data for 20013-2019 vis-à-vis the rail fares in constant terms, v-km supplied, gas price, and economic activity suggests that, overall, the fare elasticity is low and not statistically significant from zero, aligned with the bus ridership results (Table 7). This is also the case at the level of individual lines such as Belgrano Sur and Mitre. In the case of the Belgrano Norte and San Martin lines, the fare elasticity is positive – although not statistically significant – which is counterintuitive and likely caused by noise in the data and possibly by the service disruptions in the line during upgrade works, which the model is not directly controlling for. To account for service quality to at least some degree, the model subsequently also includes a variable capturing the punctuality of the trains (percentage of all trains that arrive on time). Adding this variable does not qualitatively change the previous results, with minor exceptions.

In the case of the Sarmiento line, the fare elasticity is larger and negative in the initial model, although only marginally statistically significant. The line has suffered from performance issues and has undergone several infrastructure rehabilitation works following the Once crash; these works have been associated with disruptions, cancellations, and possibly increased fare evasion that is difficult to estimate accurately. The area crossed by the line is inhabited mostly by low-to-middle income households, and the incomes increase as the line approaches CABA. It is

not likely that a marginal increase in the rail fare would see a strong demand response, given that the average fares for buses throughout the period were significantly higher and the commercial bus speeds in the area of the line are relatively low due to the high population density. Similarly, shifting from rail to charter buses operating on the Oeste highway is not likely for a significant number of the passengers, as that would imply a completely different fare. Once the punctuality of the trains is controlled for, the magnitude and already marginal significance of the fare elasticity coefficient for the Sarmiento line declines further. On the other hand, ridership on the Sarmiento line appears to be very responsive to changes in train punctuality (specifically, steep increase in punctuality since 2013 compared to a steep decline in 2005-2013). This is the case only for one other line – San Martin.

Table 7: Estimated elasticities of ridership in rail lines with respect to real average fare and other variables

	Overall	Belgrano Sur	Belgrano Norte	San Martin	Sarmiento	Mitre
Real average fare	**-0.05**	**-0.14**	**0.39**	**0.14**	**-0.28**	**-0.08**
Vehicle-km of service supplied	0.79 ***	0.35	0.93 ***	0.40 *	0.31 *	0.77 ***
Share of trains on time	1.99	0.09	0.10	2.90 *	1.59 ***	-0.47
Real average gas price	0.26	0.48	-0.06	0.19	-0.22	0.32
Registered private sector jobs in CABA	5.9 *	4.9	5.0	12.4	10.6	8.9 *

Note: *** and ** denote statistically significant results, * denotes marginally statistically significant results

One of the explanations for the low responsiveness to changes in rail fares – besides the low absolute fare level as a share of even minimum salary – is that many of the rail line users perform multi-leg trips in which the rail is combined with bus. Thus, over the past five years, even given an increase in the price of the rail leg, these passengers would get a 50-percent discount for their bus trip.

Both overall rail ridership and ridership on individual lines – especially Belgrano Norte and Mitre – appears to respond quite strongly to changes in the service supplied (v-km); on the other hand, ridership does not appear to clearly correlate with the gas price or private sector job activity.

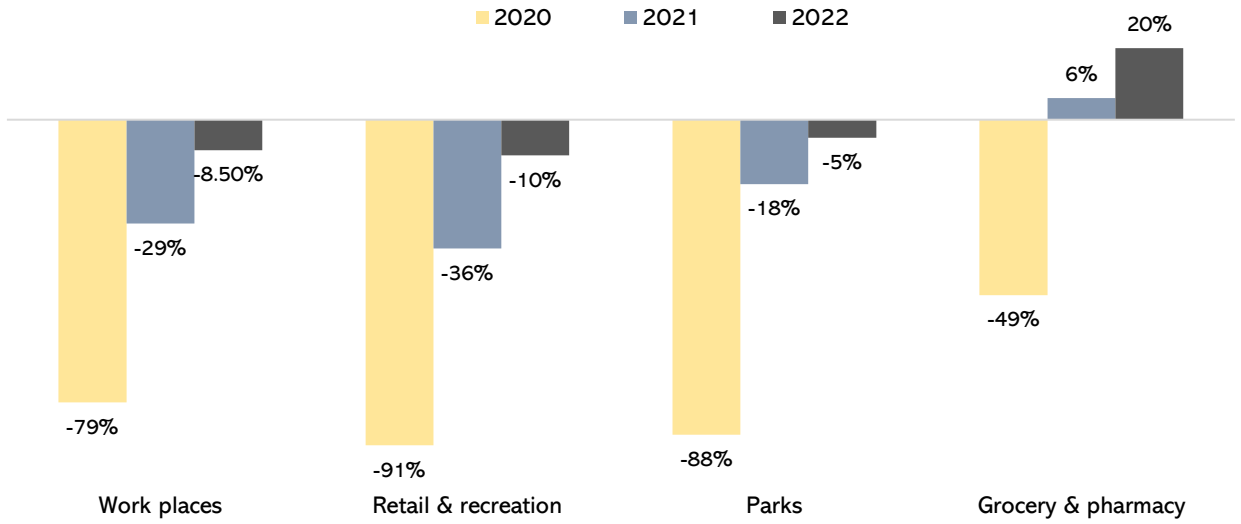
3. Changes in mobility patterns since the start of COVID-19

3.1. The economic context

Teleworking grew significantly during the pandemic, with the number of employees working from home tripling from pre-pandemic levels, from 6 percent to 17 percent (INDEC 2021), and it is estimated that 18 to 29 percent of the jobs in Argentina can be conducted remotely (Albrieu 2020). However, there is a direct relationship between a person's income and their need to work in person - those with less income tend to have manual or face-to-face jobs or no access to computers or broadband connection (Avdiu and Nayyar 2020). Therefore, public transport has remained essential for ensuring the access of the lower income and most vulnerable populations to their places of work, as it is the case with domestic service workers who travel mainly between low- and high-income residential areas and are captive users of public transportation.

Nevertheless, according to the high-frequency data tracked through Google Mobility Reports, trips to workplaces in CABA initially declined by about 80 percent in the first two weeks of the pandemic, and, while most of this drop was recovered within the following year, **in the last week of March, 2022, the volume of trips to workplaces was still 8-9 percent below the pre-pandemic level** (Figure 34). This gap between the March 2020 and March 2022 figures could at least in part be due to a continuation of remote/hybrid work arrangements also going forward, as well as due to lingering unemployment and underemployment.[37] In GBA, the initial drop in trips to workplaces was lower than in CABA, ranging from 67-68 percent in the Berazategui, Ezeiza, Florencio Varela, Merlo, and Presidente Peron partidos to 77-79 percent in San Isidro and Vicente Lopez. And, if in the last week of March 2020 the volume of trips to workplaces in CABA overall was still below the pre-pandemic level,[38] in most GBA partidos it was at least 15 percent *above* it.

Figure 34: Trips to key destinations in CABA (% change of the average of March 21-28 compared to March 7, 2020)



Source: Data from Google Global Mobility Reports

[37] According to INDEC, in Q3 2021, the unemployment rate in CABA and GBA was 7 percent and 9.5 percent, respectively. In addition, 10 percent in CABA and 12.4 percent in GBA were under-employed (in the latter, reaching 17.7 percent among individuals with less than complete secondary education).

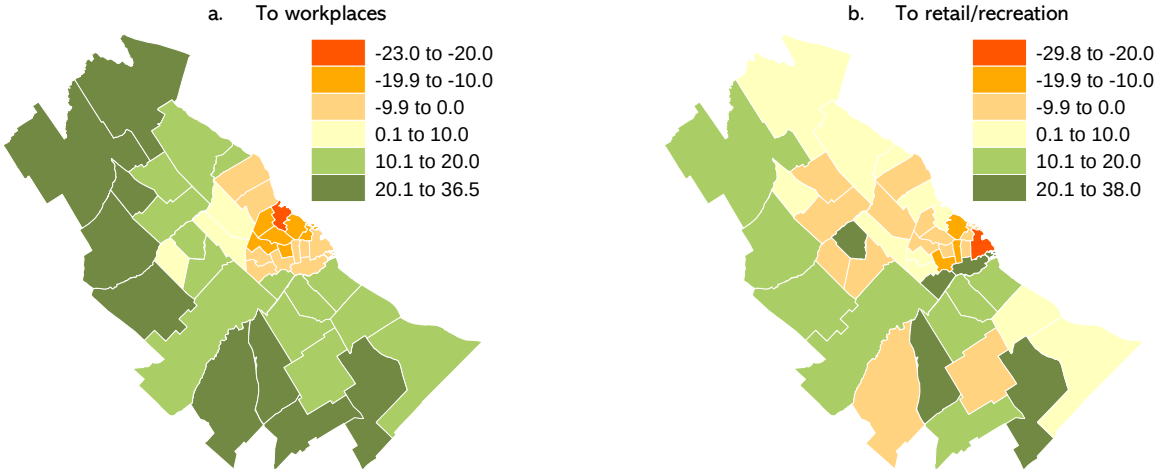
[38] In individual Communes trips to workplaces had nearly fully recovered (Commune 1 and 4) or exceeded the pre-pandemic levels (Commune 8).

Already having grown significantly in the last few years, e-shopping and food delivery have boomed even more during the pandemic, with more than doubling in e-sales in Argentina overall in the first half of 2020 compared to the first half of 2019, according to CACE (inflation during this period was 43 percent). Compared to the first quarter of 2020, in its second quarter the share of online purchases in total sales almost tripled, from 18 percent to 49 percent, suggesting a fast acceleration of e-commerce. Moreover, 2 out of every 10 purchase orders in Q2 2020 came from new customers, and about 8 percent of all Argentines bought online for the first time during the quarantine, with most of the newcomers being young people and people of lower socio-economic status, and with a large share of the purchases concentrated in online food deliveries and grocery shopping. In 2020 overall, over 1.28 million additional people in Argentina started online shopping for the first time ever. Home delivery, the ease of finding products quickly, and the security of the operation drove more purchases than in 2019, according to surveys conducted on behalf of CECI. On the other hand, the delivery fees were perceived as the main barrier (44 percent of shoppers). The quarantine eliminated tourism and entertainment from the ranking of categories bought for the first time (as in 2019), giving way to categories related to food, home improvement, personal care, courses, and seminars, among others. In 2020 overall, e-sales increased by 124 percent compared to 2019, reaching 905.1 billion pesos.[39] The share of online shoppers who selected the goods to be delivered to their home (as opposed to picking them up or arranging for a different option) increased to 80 percent, up from 62 percent in 2018.

Surveys conducted in mid-2021 on behalf of CECI indicated that **35 percent of Argentines now buy more than half of the products of mass consumption online, compared to only 15 percent before the pandemic**. Food and beverages continued to dominate the online shopping space. The time savings and the possibility to buy at any time are gaining relevance as the main reasons for turning to online shopping.

That said, by late 2021, the overall boom in online shopping had slowed somewhat compared to 2020, with annual growth of 68 percent[40] in Argentina overall, compared to the 124-percent growth the year before. AMBA's share in overall sales was 39 percent, up slightly from 37 percent in 2019 and 38 percent in 2020. During 2021, Argentine online shoppers went out to eat more than in 2020, went to the movies, and visited more physical stores to buy shoes and clothing. In sum, while new shoppers joined the online commerce space in 2021, the frequency of purchases subsided relative to the boom of 2020.

Figure 35: Trips to workplaces and retail/recreation in AMBA (% change in March 21-28, 2022, vs. March 7, 2020)



Source: Analysis by study team using data from Google Global Mobility Reports

[39] Annual inflation in 2020 was 36.1 percent, according to INDEC.

[40] E-commerce sales volume in 2021 totaled 1,520 billion Pesos, against annual inflation of 50.9 percent.

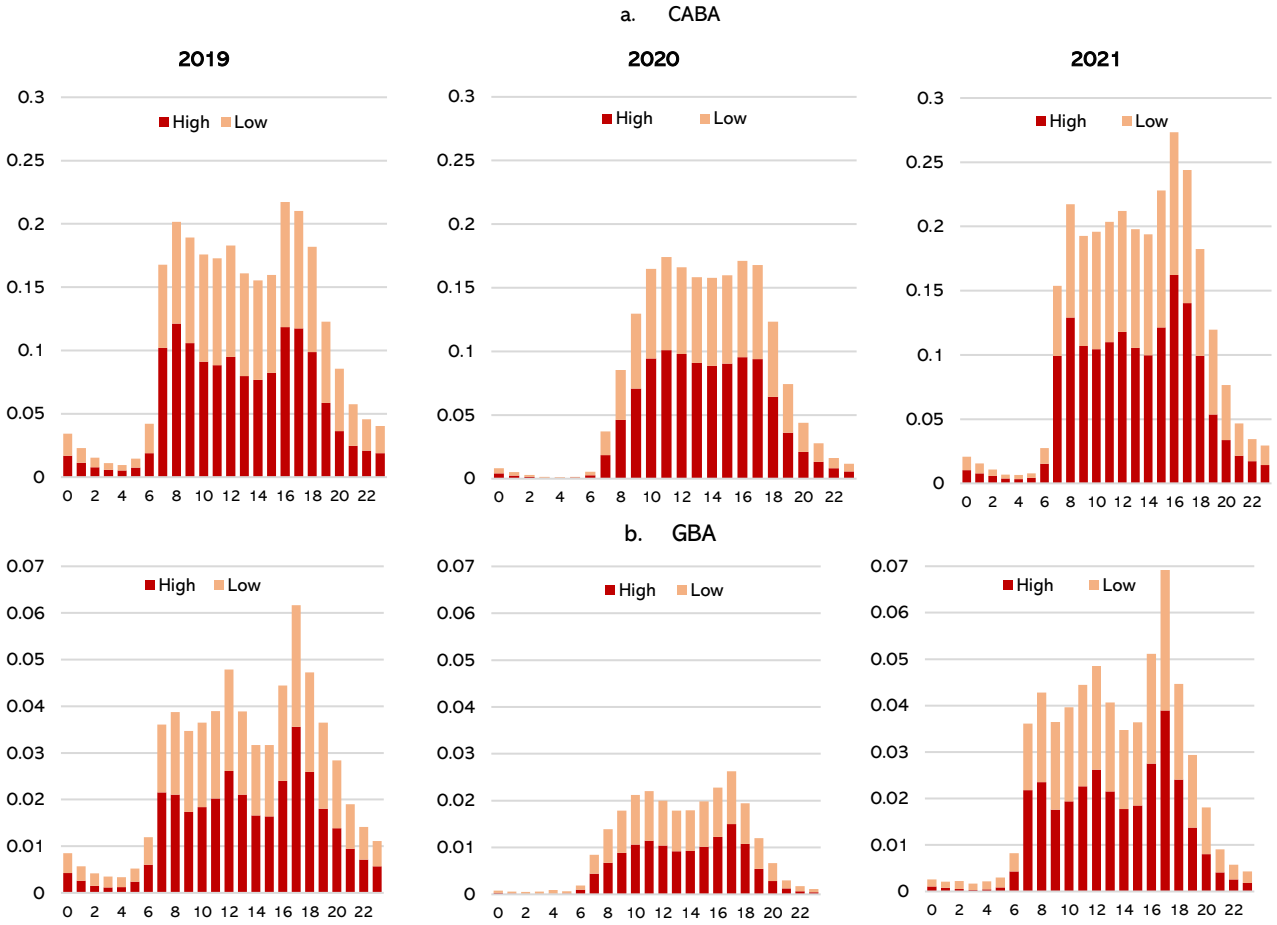
Whether or not the longer term trajectory in e-commerce in AMBA has changed permanently over the last two years is still not clear. For example, trips to grocery stores and pharmacies in CABA in mid-May 2022 were already about 20-30 percent above the March 2020 level, having initially fallen by 40-50 percent. In GBA, trips to retail and recreation have returned to their pre-pandemic level in about half of the *partidos* but remain below it in large parts of northern GBA.

3.2. Overall changes in mobility patterns based on "big" data

3.2.1. Changes in the intensity and patterns of congestion

Congestion in AMBA initially declined significantly but appeared to have fully recovered already by September 2021, as tracked by the TomTom platform. By partnering with the Waze for Cities through the World Bank's Development Data Partnership (DDP), **the current study analyzed the changes in the traffic intensity patterns in more detail,** comparing across space (different *partidos* / communes and individual corridors) and across three different time periods, namely, a typical work week day in October 2019 (pre-pandemic), October 2020 (pandemic), and October 2021 ("new normal").[41]

Figure 36: Changes in congestion index in CABA and GBA in 2019-2021



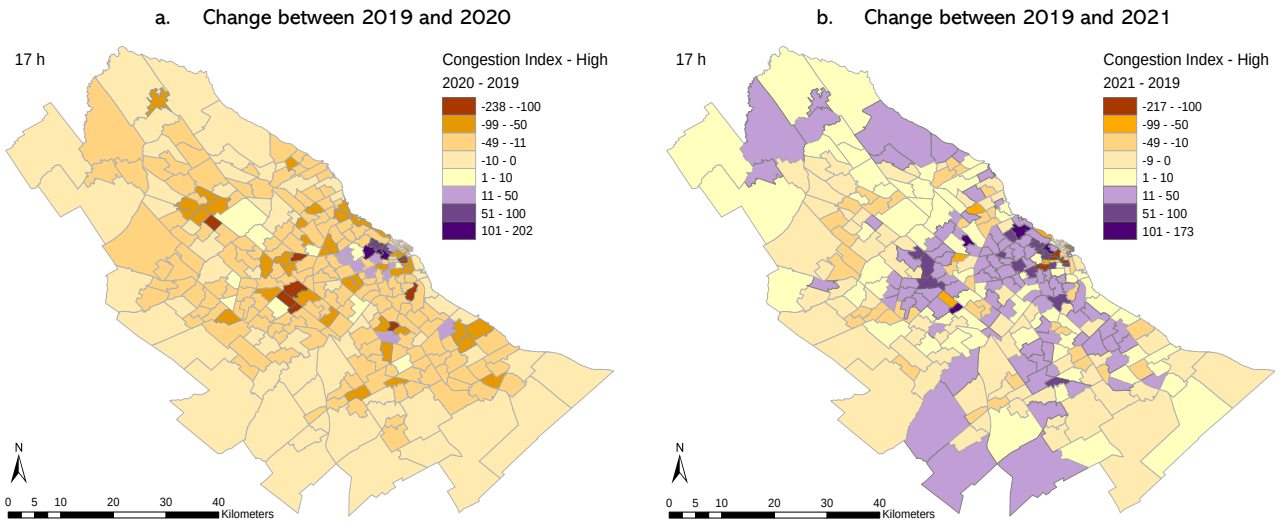
Source: Analysis by study team using Waze for Cities data

[41] According to the Waze data classification, the congestion level was analyzed as being either low (levels 1 and 2) or high (levels 3 and 4). A detailed description of the approach and additional graphs are provided in Annex 3.

The congestion index (CI) in CABA – as measured by the kilometers of roads congested for a specific duration of time as a share of the total road network kilometers – is orders of magnitude higher than in GBA in all three periods. On the other hand, traffic in GBA peaks more than in CABA during the evening rush hour around 5-6 pm. **While the CI declined in both CABA and GBA in 2020 compared to 2019, the decline in relative terms during the most congested times of the day was much stronger in GBA**; for example, during the evening rush hour, the CI in CABA declined by about 20.4 percent, compared to 57.5 percent in GBA.

Across AMBA, "high" congestion in October 2021 appears to have exceeded the October 2019 level during the highest activity hours (Figure 37 b.), even though *total* traffic intensity measured across the entire day was 11 percent lower. Congestion in AMBA appears to have returned to the previous distinct morning and evening peak travel profile compared to a more even hourly distribution in 2020; moreover, there was a particular increase in the "high" level of congestion in CABA. In CABA, the overall CI during the evening rush hour in 2021 was 63 percent higher than in 2020 and 29.4 percent higher than in 2019. Within the overall index, "high" congestion during the same hour in 2021 was 73 percent above the 2020 level and 37 percent above 2019. In GBA, the evening rush hour overall congestion in 2021 was 163 percent above the 2019 level and 12 percent above 2019.

Figure 37: Changes over time in "High" congestion index at peak rush hour (17:00)



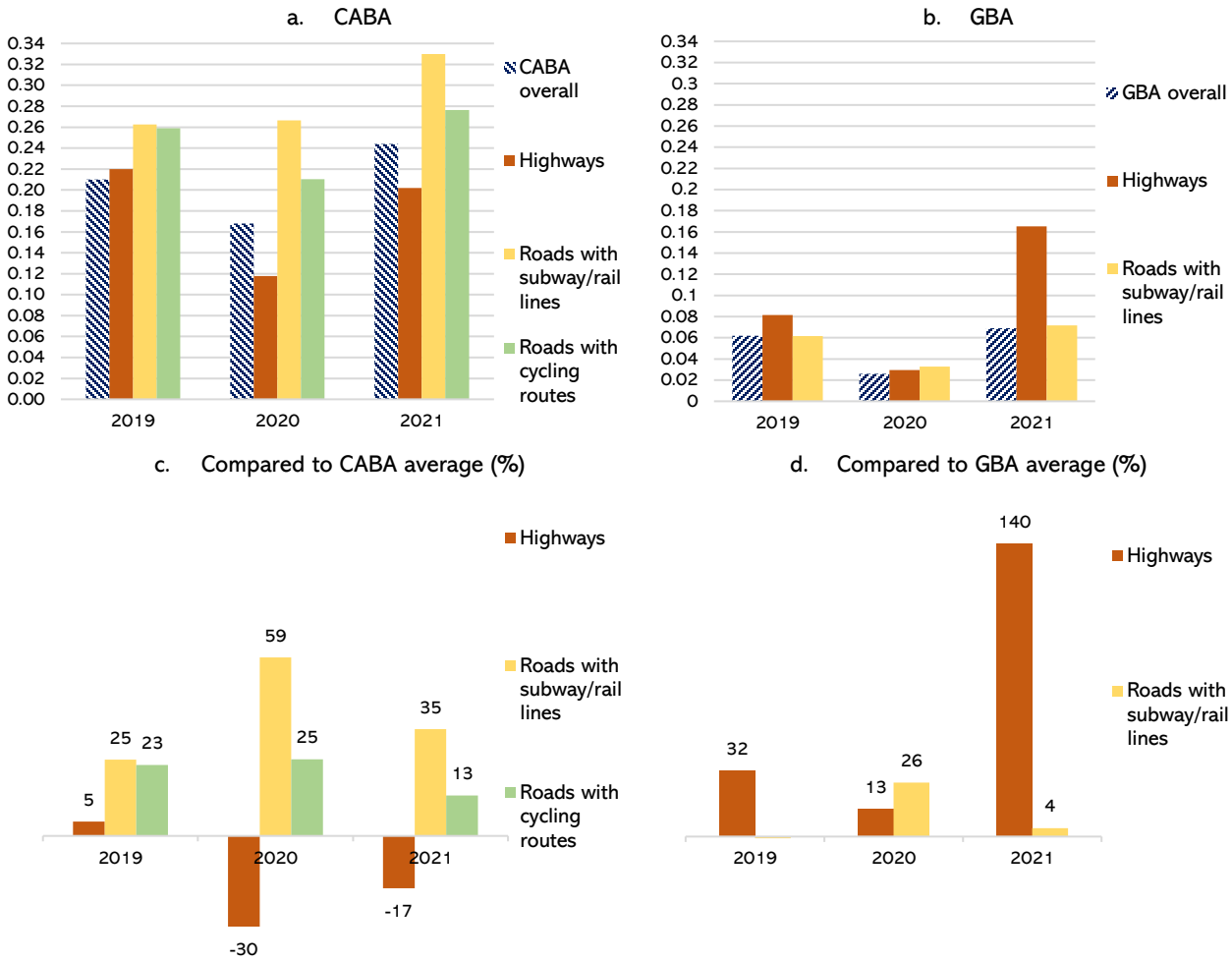
Source: Analysis by study team using Waze for Cities data

One of the objectives for analyzing the highly spatially disaggregated Waze dataset was to see whether traffic intensity changes in 2019-2021 during the most congested hour of the day in CABA or GBA, on average, differed from those on specific types of roads – such as highways, roads above or near subway/rail service routes, roads in macrozones with high bus service density, or roads with secure cycling lanes (ciclovias).

- CABA: The results suggest that the CI in CABA overall decreased in 2020 (-20%) and in 2021 was above the 2019 level (+16%). The CI on highways specifically showed a similar overall trend over time although in 2021 it was still 8-percent below the 2019 level. On the roads with subway/rail lines, the CI did not see a dip in 2020 before increasing quite significantly in 2021. On roads with cycling routes, the CI in 2021 was about 7-percent higher than in 2019 (Figure 38). **Overall, the peak rush hour CI in CABA appears to be driven by congestion on major roads (although not autopistas), as congestion throughout 2019-2021 was higher on roads near rail/metro routes and roads with ciclovia lanes compared to CABA's overall average** (Figure 38 c.). While in 2019 the CI was higher on CABA's autopistas than in CABA on average, this was not the case in 2020 and 2021.

- GBA: The overall CI decreased significantly in 2020 compared to 2019 (-58%) but in 2021 was above the 2019 level (+11%). The trend over time was more extreme for GBA's highways, with the CI dropping by 64 percent in 2020 but by 2021 already being over double the 2019 level. On the roads near rail lines, the CI dipped by 47 percent in 2020 and in 2021 was about 17-percent above the 2019 level.

Figure 38: Congestion index at peak rush hour (17:00): specific types of roads vs. CABA/GBA averages



Source: Analysis by study team using Waze for Cities data

The fact that congestion increased more on roads near rail/subway lines in 2021 seems aligned with the intuition that, if there was mode shift from rail/subway to cars, then there should be more cars on the roads where that mode shift took place. It is not fully clear why traffic intensity on highways in 2021 increased much less in CABA than in GBA (albeit in percentage rather than absolute terms), as these highways are essentially the same, starting in CABA and ending in GBA.

Finally, comparing congestion levels at the macrozone level, it appears that across the entire 2019-2021 period traffic intensity at peak rush hour (17:00) was higher in macrozonas with higher bus route density per land area (although at very high densities the congestion index starts to decline) and more bus route availability per total road length. A possible explanation could be that there tends to be more traffic on major avenues, which also happen to have more bus service, and that the density of bus routes as such (different from quantity and quality of

actual bus *services*) does not necessarily help significantly reduce overall traffic intensity.

3.2.2. Changes in total trips and origin-destination patterns as inferred from CDR data

The study developed updated origin-destination (OD) matrices for AMBA using cell phone data – Call Detail Records (CDR) – as a primary source. The methodology, defined based on the project team's experience in similar studies and a review of the scientific literature, is based on the fusion of the CDR and other data sources, including land use data and points of interest, resident population data and other socio-demographic statistics, data on the network and supply of transport services, and transport demand data. The analysis used mobile telephony data from Claro Argentina.[42] The results presented below cover AMBA residents and their trips with origin and destination within AMBA, excluding professional trips (e.g., trips by professional taxi or bus drivers that are not for the purpose of returning to their homes).

The approach for data processing and analysis consisted of (i) pre-processing and cleaning of mobile data; (ii) analysis of network event data; (iii) analysis of the network typology based on the locations of the antennas; (iv) generation of activity and travel diaries; (v) sample expansion to the total population; and (vi) generation of OD matrices, segmented according to the specified criteria (age, purpose of the trip, mode of transport).

An adaptation of the general methodology was made for the specific case of Buenos Aires taking into consideration the available data: for the identification of the 'study' purpose, data from the 2009/10 ENMODO mobility survey was used, while for the identification of the mode of transport a hybrid method was implemented, using data from the ENMODO and data from validations of the SUBE system. The result of this process are a set of OD matrices of Buenos Aires with the following specifications:

- Zoning: transportation zoning of 2010 zones within the Buenos Aires Metropolitan Area.
- Time resolution: 1-hour time slots, assigning the time of the trip as the trip start time.
- Segmentation: passengers vs. professional drivers; socio-demographic profile of the traveler; trip purpose; and transport mode (public transport, private vehicle, and NMT).

The study zoning corresponds to that used in the city's transport model and consists of 2,010 zones, of which 534 are in CABA. This zoning is convenient because it is the one used by both the transport model and the mobility surveys. The trips that were analyzed are those with origin and destination within the study area, i.e., those trips that begin and/or end outside the AMBA region are out of scope.

Three study periods were identified to be able to assess pre-pandemic (2019), pandemic (2020), and "new normal" (2021) mobility patterns. Within each period, three OD matrices were generated corresponding to weekday, Saturday and Sunday averages in a non-vacation period (the month of October). For the analysis of an average weekday, three individual days were selected, while for Saturday and Sunday, two individual Saturdays and two individual Sundays were selected from the corresponding period. The time resolution of the matrices are 24 1-hour slots, taking as a time criterion the trip start time. This criterion was selected in order to more easily link the OD matrices to existing transportation models.

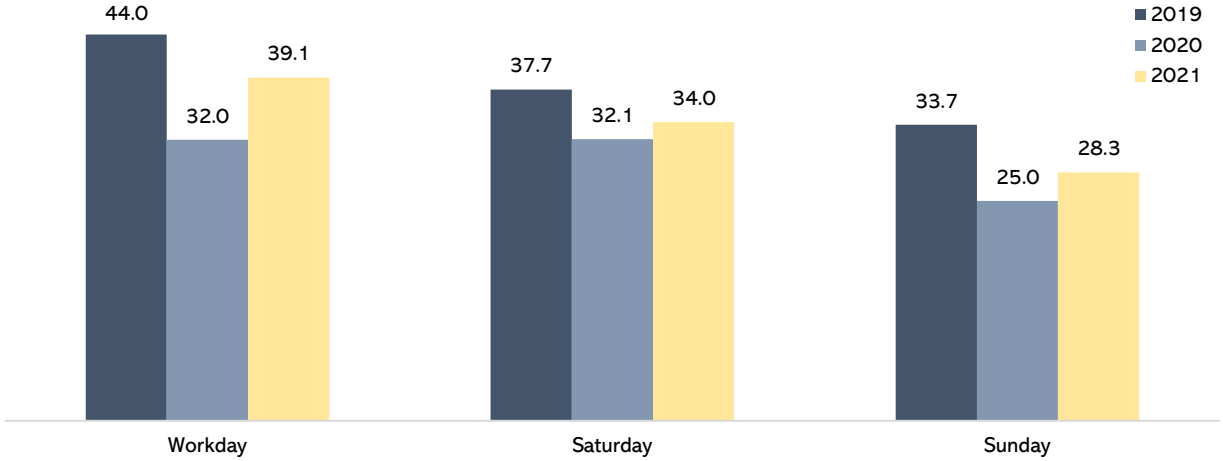
The SUBE system validations include data for all public transport for each day of each study period and were used to generate trip matrices specific to public transport. The 2009-2010 ENMODO survey was used to segment the mobility matrix into private and non-motorized transport.

The key indicators analyzed for the three periods included the hourly trip distribution, the average distances traveled, the share of trips traveling within certain parts of AMBA (such as between the jurisdictions of CABA and GBA), and the modal split. Overall, **the total number of trips made in AMBA on**

[42] Claro is the main mobile operator in Argentina, with a market share of 37 percent. Data is available for both customers and users who roam on the operator's network. Cell tower coverage areas are smaller in areas of high population density.

an average weekday was found to be 27.2 percent lower in 2020 than in 2019, having declined from 43.98 million to 32.00 million (Figure 39). Moreover, in 2021 the total number of trips was also still quite significantly below the 2019 level (-11.1 percent).[43] The corresponding figures are lower when considering Saturdays: the initial drop in total number of trips on the typical Saturday in October in 2020 as compared to 2019 was 14.9 percent, and in October of 2021 it remained 9.8 percent the 2019 level. On the other hand, on Sundays, the initial drop in trips appears to be nearly equally sharp as on weekdays (-25.7%), while the recovery of trip volumes has been weaker (-16.1% in 2021 compared to 2019).

Figure 39: Total daily trips in AMBA in October 2019, 2020, and 2021 (million)



Source: Analysis by study team, based on CDR data from Claro Argentina

On an average working day of the week, all modes saw some decline in total trips in October 2020 compared to 2019; however, private motorized transport by October 2021 had recovered more than public transport, while total trips by NMT modes (walking and biking) continued to decline slightly. Total daily trips by private motorized modes initially declined by 16.9 percent (19.28 million in 2020 compared to 23.19 million in 2019) and in 2021 were 5.9-percent the 2019 level (21.83 million). Public transport trips declined from 10.28 million on a typical workday in October 2019 to just 2.82 million in 2020 (a 72.5-percent drop) and by October 2021 were still 26.5-percent below the 2019 level (7.55 million). Finally, NMT trips declined by 5.8 percent between October 2019 and 2020 and by 7.7 percent between October 2019 and 2021, although the CDR analysis does not allow distinguishing whether the decline applies equally to walking and biking trips.

The changes in the modal patterns were slightly different when considering weekends rather than weekdays. So, **on an average Saturday, trips by both private motorized transport and public transport declined proportionately less in 2020 compared to 2019 (by 11.7 percent and 56.6 percent, respectively) than they did on an average workday, while the total number of NMT trips even increased (+1.8%).** By October 2021, the total number of trips on an average Saturday by private motorized modes was 8.4 percent below 2019 while in public transport trips had recovered more compared to weekdays (-16.5 percent below 2019). Overall, while the total number of trips by NMT modes and private motorized modes was comparable on weekdays and weekends throughout the period, the trip volumes by public transport in 2019 and 2021 were nearly twice as high on weekdays as on Saturdays although at a comparable level on both types of days in 2020.

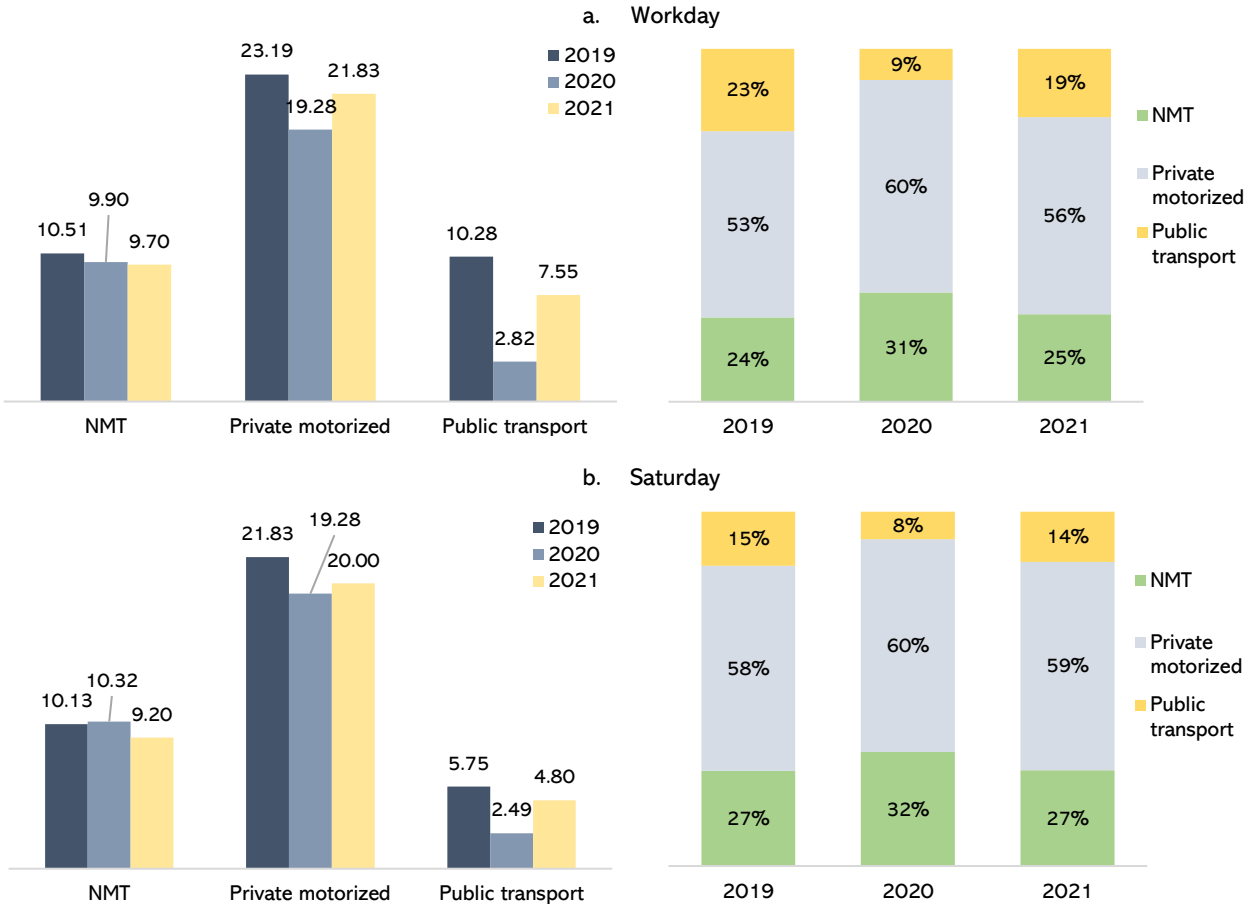
As a share of total trips on weekdays, private motorized modes increased their share from 53

[43] This figure is consistent with the estimated decline in the total Congestion Index over the course of the 24-hour period for AMBA in October 2021 compared to October 2019 based on Waze for Cities data, presented earlier.

percent in 2019 to 60 percent in 2020, although in 2021 the share had declined to 56 percent. Public transport saw a steep decline in its share initially, from 23 percent in 2019 to 9 percent in 2020, although by 2021 was again significantly back up, at 19 percent. Finally, while NMT increased its share by 7 percentage points in 2020 compared to 2019, it lost nearly all that gain in 2021. The modal share patterns were similar on Saturdays, albeit with a higher participation of NMT modes and lower share of public transport compared to weekdays.

While the methodology used for estimating the total trips by mode in the current analysis is different from that applied in the ENMODO surveys it is worth pointing out that, **since 2009, the share of private motorized modes appears to have increased by over 20 percentage points, almost entirely at the expense of public transport.**

Figure 40: Total daily trips in AMBA (million) and share of trips by mode, October 2019 vs. 2020 vs. 2021



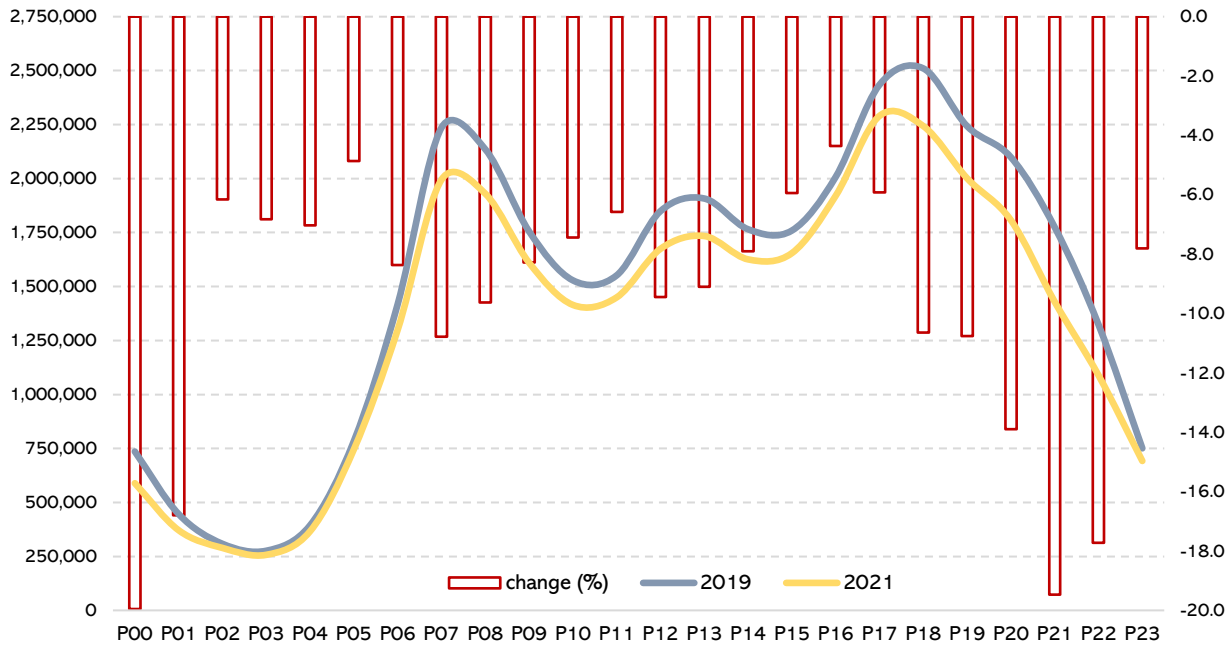
Source: Analysis by study team, based on CDR data from Claro Argentina

For the purposes of planning for the future, the "deep pandemic" (2020) patterns are likely less relevant than the longer trajectory between 2019 and 2021; therefore, the next set of indicators focus on the comparison of 2019 and 2021. As shown in Figure 41, the overall hourly trip pattern in the pre-pandemic and the "new normal" periods was similar, with the highest peak at around 5-6 pm (the evening rush hour) and a second one at 7-8 am (morning rush hour). A third peak can be observed in both periods at around noon-1 pm, corresponding to the return home by school children.

While the overall hourly trip distribution pattern appears to not have changed much, the intensity of the highs and the lows has. For one, the morning,

mid-day, and evening rush hour peaks in 2021 were lower than in 2019, accounted for by the lower share of people commuting to in-person jobs, among other factors. For example, in 2021 there were nearly 11 percent less trips starting at 7am or at 6 pm. However, a significant difference between the two periods can also be observed in the late evening hours, whereby in 2021 there were about 14 percent less trips starting at 8pm and 18-20 percent less trips starting at 9-10 pm. These differences can likely be explained by the remaining gaps in the number of people coming home from work, eating out after work, and engaging in social/entertainment related activities. In contrast, the volume of trips in the early morning hours and off-peak hours during the day was only about 4-7 percent lower in 2021 compared to the pre-pandemic.

Figure 41: Hourly trip distribution on a weekday in October in 2019 vs. 2021 (number of trips and % change)

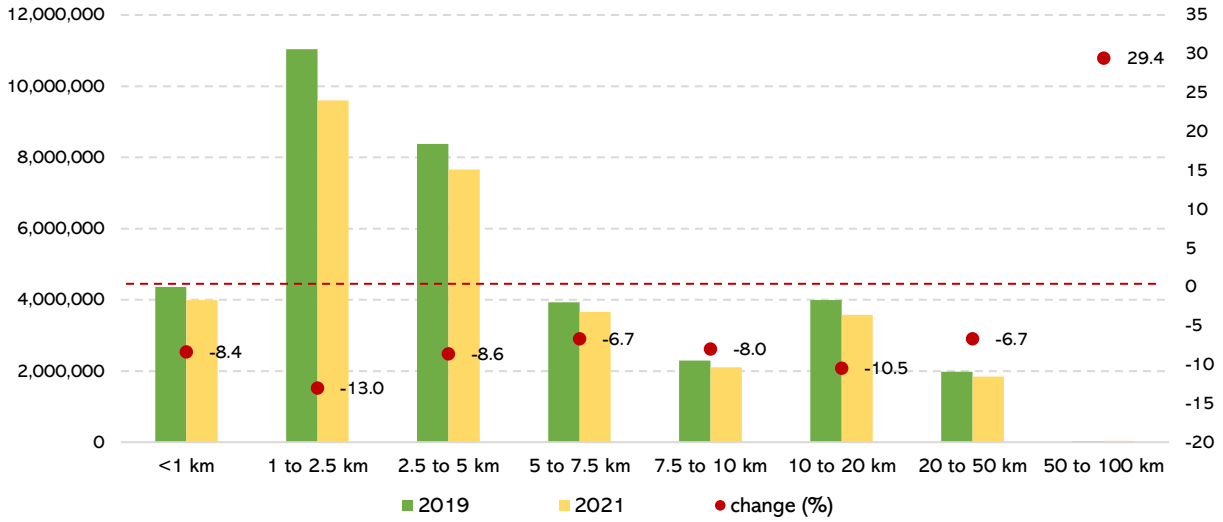


Source: Analysis by study team, based on CDR data from Claro Argentina

In AMBA overall, the trips generation rate on a workday in October in 2019 was 2.95, compared to 2.12 in 2020 and 2.57 in 2021. Consistent with the figures related to the economic context presented earlier, trip generation rates per person in 2021 were still significantly below the 2019 level in CABA and the first ring of GBA, while in the peripheral parts of AMBA they had recovered more. In absolute terms, trip generation rates in 2021 were the highest in northern AMBA, downtown CABA, la Matanza, and some other *partidos* just West of CABA.

In light of the overall lower number of trips made on the typical weekday in October of 2021 compared to 2019, the number of trips declined nearly across all distance categories, except for long trips (50-100 km) which increased but continued to account for a negligible share of all trips. **Trips spanning between 1 km and 2.5 km continued to account for the largest individual share of trips both pre-pandemic and in 2021 (approximately 30-31 percent)** although their absolute number declined by 13 percent, the steepest decline of any distance category (Figure 42).

Figure 42: Trip distance on a weekday in October in 2019 vs. 2021 (number of trips and percent change)



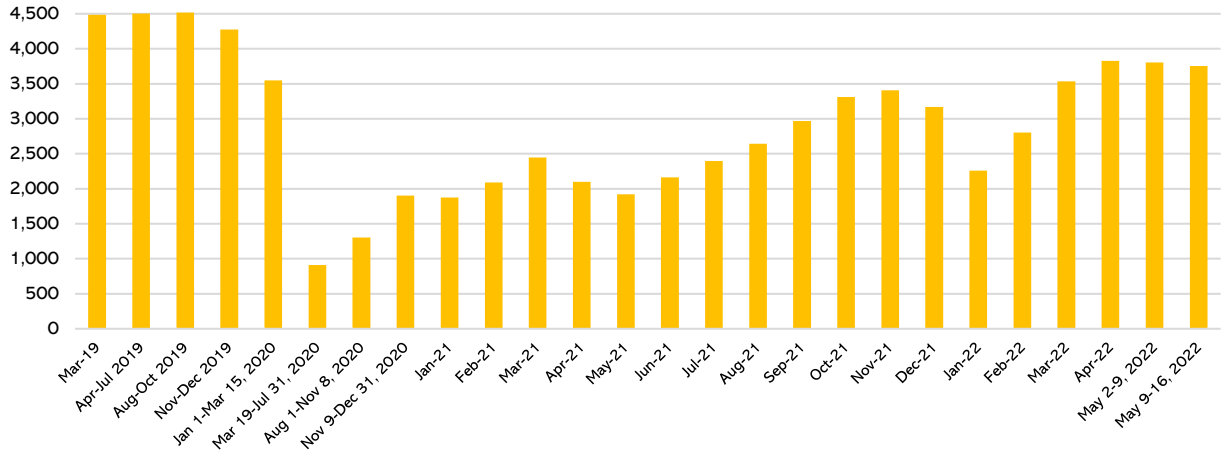
Source: Analysis by study team, based on CDR data from Claro Argentina

3.3. Public transport ridership patterns, costs, and impacts on the system's financial performance

The COVID-19 crisis induced significant changes in modal choices in AMBA and, specifically, a shift to private transport, at least temporarily. In response to the COVID-19 pandemic, the Government of Argentina implemented a strict quarantine in AMBA in March 2020 until November 2020. The capacity of buses and trains was limited to seated passengers only, and the use was restricted to "essential" employees while operators were required to maintain their usual schedules to ensure social distancing among users. In addition, the Ministry of Transport decided to freeze transport fares during the year. Mass transit operators adopted sanitary protocols to mitigate the risk of contagion, such as obligatory mask-wearing, occupancy caps, ventilation and disinfection. The combination of these measures and the temporary decrease in traffic congestion due to the overall reduction of mobility led to an increase in the modal share of private vehicles. The number of public transport passengers fell drastically (90 percent in the first week of mobility restrictions) and services were reduced, which in turn reinforced the shift to private transport. These trends have caused large financial losses for mass transit operators, which have required additional subsidies from the government to support the ongoing operations despite the decreasing number of fare-paying passengers.

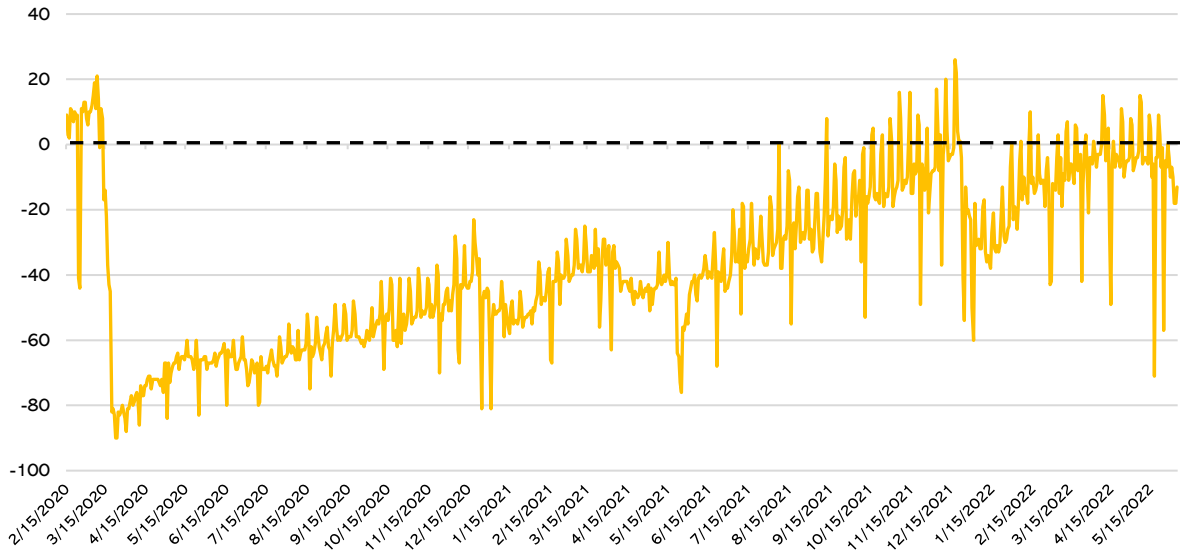
Public transport ridership in AMBA declined sharply in March 2020 and has not yet fully recovered. Analysis by the Buenos Aires Mobility and Road Safety Observatory finds that in mid-May 2022 there were 3.69 million unique users of public transport in AMBA (Figure 43), or only 79 percent of the level in the same month of 2019. The average work week transactions in public transport were at only 61 percent of the 2019 level in the case of the subway, at 79 percent in the case of rail, and at 93 percent in the case of buses. The municipal and provincial bus lines had recovered ridership to a greater extent than the national lines (serving CABA-GBA and within-CABA trips). In the case of provincial bus routes, the ticketing transaction volume in mid-May 2022 appears to have already exceeded the respective figure of May 2019.

Figure 43: Average number of unique public transport users in AMBA on work days in 2019-2022 ('000)



Source: Buenos Aires Observatory of Mobility and Road Safety

Figure 44: Number of trips to transit stations in CABA (% change compared to March 7, 2020)



Source: Data from Google Global Mobility Reports

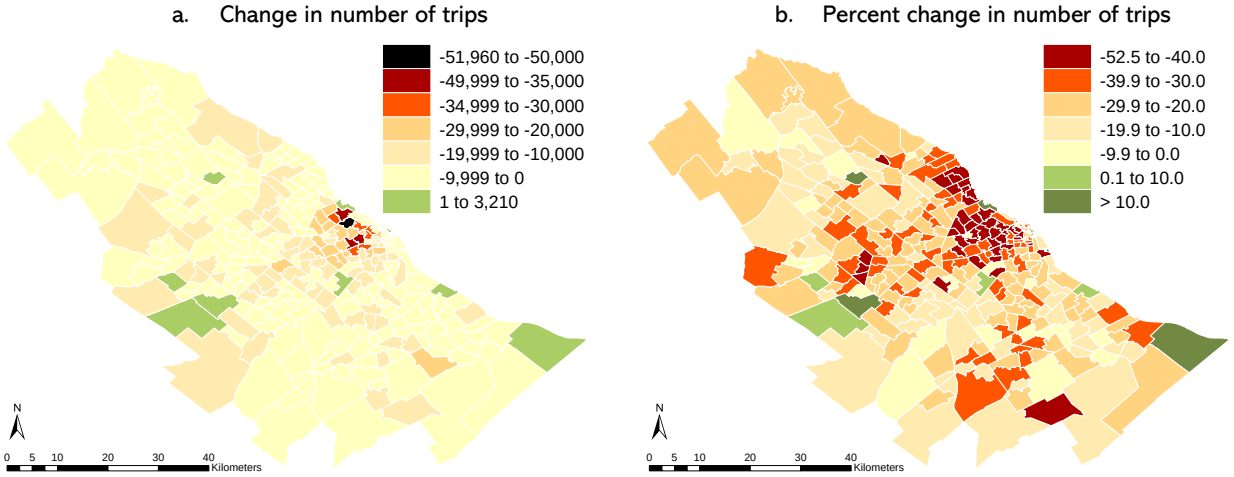
Based on data from Google, the number of trips to transit stations in CABA declined by 85 percent in the first two weeks of March 2020 and, as of the first week of June 2022, was about 15 percent below the level of the first week of March 2020 (Figure 44). The remaining gap in the recovery in trips to public transit stations appears to be compensated by a more than full recovery of private motorized trips (see discussion later); thus, it is likely due to a combination of telework substituting for in-person work, especially in CABA, and a degree of modal shift from public transport to private transport. In GBA, the initial drop in trips to transit stations ranged from -71 percent in the Pilar *partido* to -81 percent in Tigre. Thus, overall it was smaller than in CABA, likely due to the lower share of the population in GBA being employed in jobs that are conducive for teleworking. By the first week of June, 2022, the number of trips to transit stations in GBA appears to be already about 5-8 percent above the pre-pandemic level.

As per the initial data (SUBE), **public transport trips within CABA during the pandemic decreased their share even further**, declining from 27.5 percent of all trips in 2019 to 21 percent in 2020. On the other hand, the share of trips between GBA partidos increased quite significantly, from 19.3 percent to

24.1 percent, and there was also an increase in the CABA-GBA trips which before the pandemic had shown a declining tendency. In both 2019 and 2020, the largest share of trips in AMBA remained within GBA partidos, at about 32-33 percent.

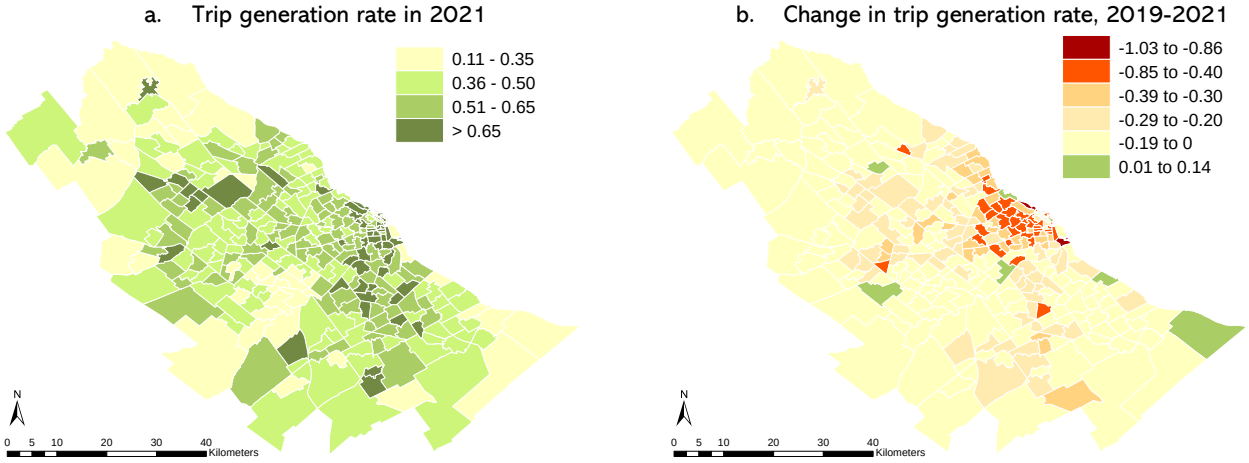
Based on the CDR data analysis and disaggregation of trips by mode, as already noted, public transport trips on a typical workday initially declined by about 72.5 percent between 2019 and 2020, and also by the Fall of 2021 they were still 26.5-percent the 2019 level. At the level of macrozones, **the highest absolute loss and also percentage loss in trips was concentrated in CABA, with individual macrozones still seeing over 35,000 *less* trips by public transport in October 2021 compared to October 2019, equivalent to a loss of over 40 percent** (Figure 45). However, in a small number of macrozones on the outskirts of AMBA, public transport trips had returned to or started to exceed the pre-pandemic level.

Figure 45: Number of trips by public transport starting in the macrozone, a workday in October 2019 vs. October 2021



Source: Analysis by study team, based on CDR data from Claro Argentina

Figure 46: Trip generation rate per person by public transport, a workday in October



Source: Analysis by study team, based on CDR data from Claro Argentina

In terms of the daily trips generation rates per person by public transport on a typical workday, the decline between October 2019 and 2021 exceeded 0.4 in most parts of CABA. In other words, **in central AMBA, the average resident was still taking over 0.4 public transport trips *less* each day in October 2021 than prior to the pandemic** (Figure 46 b.).

However, despite the loss relative to 2019, in absolute terms the public transport based daily trip generation rates per person also in October 2021 remained the highest in CABA, exceeding 0.65 trips per person in the downtown. In contrast, in the outer neighborhoods of AMBA and also in macrozones just west of CABA's border the daily trip rates per person by public transport were below 0.35 (Figure 46 a.).

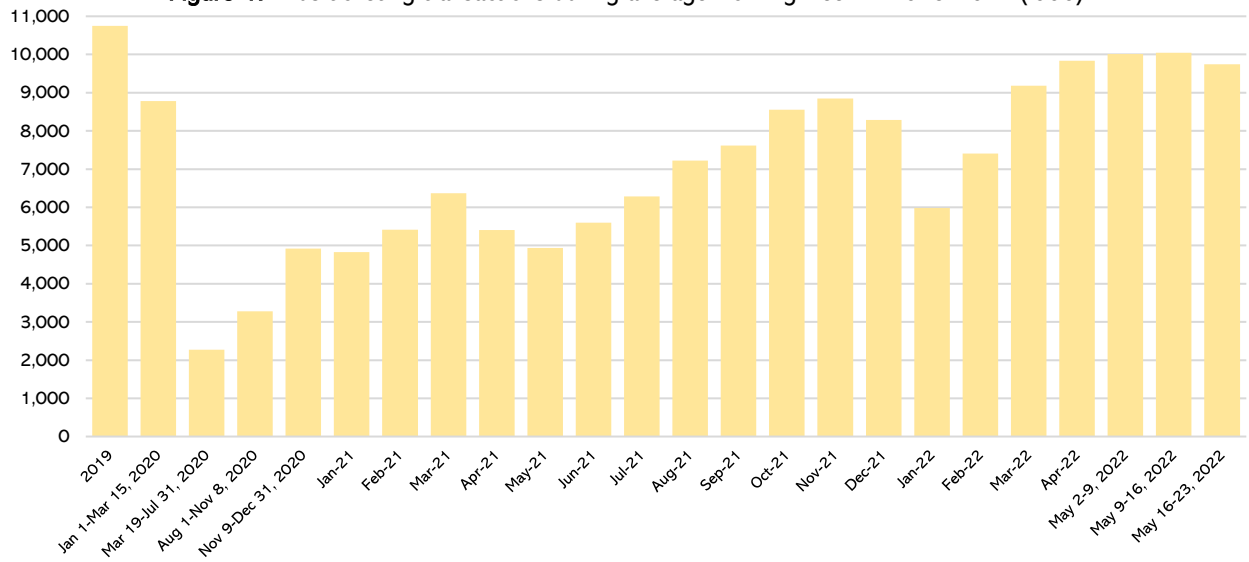
❖ Bus system

In the case of the bus system, the steep decline seen in 2020 – of about 57 percent compared to 2019, or from about 3.04 billion passengers to about 1.31 billion – was partially recovered in 2021. Nevertheless, **demand during 2021 was still 35 percent below 2019 figures, which, as a matter of fact, was already the lowest point in the time series since at least 2013.** As of mid-May, 2022, as already noted, the average work week transactions in bus lines stood at 93 percent of the 2019 level (Figure 47) although outperformed the recovery of the rail and the subway trips. The municipal and provincial bus lines had recovered ridership to a greater extent than the national lines (serving CABA-GBA and within-CABA trips).

The gradual reduction in the bus system operational costs in real terms observed since 2015 continued even during the pandemic; **however, while the need for subsidy has fallen in real terms since 2015, this trend was interrupted in 2020; by end-2020 the fares in constant terms had reached their lowest point since 1992, and by December 2021 were one-third below the 1992 level** (Figure 48). The collapse in bus ridership resulted in a steep decline in fare collection, of -52.7 percent (in nominal terms) in 2020 compared to 2019, while costs in nominal terms have continued to grow during the pandemic. Operating costs increased by 25.8 percent between 2019 and 2020 and a further 42.5 percent in 2021.

The cost of labor, the largest component of operating costs, grew by 92.2 percent in 2021 compared to 2019. Capital costs, on the other hand, increased by 51.7 percent during 2020, the growth pace slowing down in 2021. In real terms, the recent cost trend did not differ from that of the previous years since 2016, i.e., a constant reduction in the overall operating costs of the system.[44]

Figure 47: Bus ticketing transactions during average working week in 2019-2022 ('000)



Source: Buenos Aires Observatory of Mobility and Road Safety

[44] These are "recognized" costs as per the cost structure; many operators have reacted to this by, e.g., increasing the average age of their fleets (reducing the number of new vehicles purchased). So the "output" might not be the same at a lower cost.

Figure 48: Average Fare in National Jurisdiction Buses (in constant prices of December 2021)

Costs declined by 14.9 percent between 2019 and 2021, with the main driver being reductions in fuel expenditure in 2020, a reflection of how the operation was adjusted in terms of kilometers provided. In 2021, fuel expenditure picked up again, while labor was the main source of cost reduction.[45] While ridership increased significantly in 2021 compared to 2020 (+51.2 percent), fare revenue in real terms continued to fall, and in 2020-2021 stood at one third of the 2017-2019 figures.

As a result of reduced ridership and fare revenues and higher costs, fare coverage of system total costs fell from about 33 percent in 2019 (the highest level since 2012) to 12 percent in 2020 (the lowest level since 2013). In 2020, the required subsidy was 70.7 percent higher in nominal terms and 21.8 percent higher in real terms than in 2019. Thus, 2020 marked a turning point in the downward trend in subsidy allocation that started in 2016 (reflecting falling costs). Subsidies continued growing in 2021 and were expected to be 136 percent above 2019 levels in nominal terms and 12 percent in real terms. Increased ridership in 2021 did not result in a significant increase in fare coverage.

The 2019-2021 period saw a reduction in the amount of subsidies paid on social discounts and fare integration as well as the commissions paid for SUBE usage, but a strong growth in the rest of the subsidies. The subsidy components related to demand parameters were heavily impacted by the lockdown restrictions. ATS compensations in real terms continued to fall in 2021, even when the economic activity was recovering. The fall was even higher than the reduction in overall fare collection during 2021 in constant prices, which might be indicative of the impact of the pandemic on vulnerable populations. Subsidies to cover operational expenses grew in 2021, reflecting the official request to maintain nearly regular operational levels even with a large reduction in demand. The City and Province of Buenos Aires have been more affected by the need to cover the operational expenses of the lines under their jurisdiction, while discounts for social fare and integration are de facto fully covered by the Federal Government.

❖ Rail and metro systems

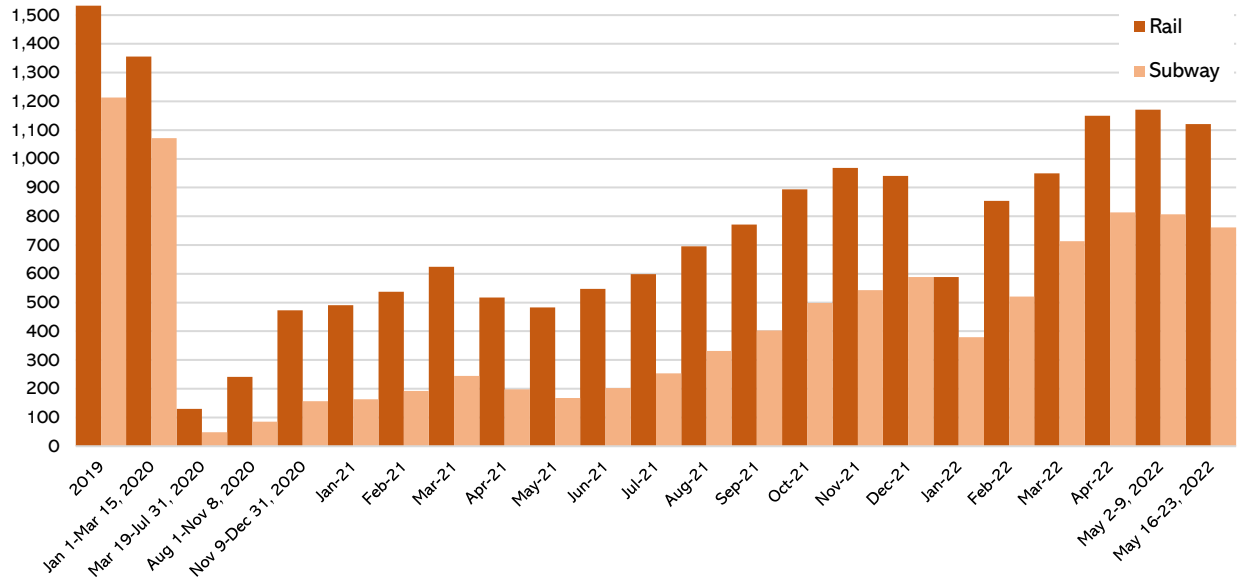
Ridership in the rail system, including metro and suburban rail, saw a similar initial drop; however, ridership has not recovered to the same extent. Overall rail system ridership fell by nearly 72 percent between 2019 and 2020, with Metrovias (Urquiza line and *Subte*) affected the most: a decline of nearly 77 percent, or from 353 million annual passengers to 83 million. Ridership of SOFSE,[46] which in 2019 served the largest number of passengers of any of the rail sub-systems (384 million), declined by 68 percent in 2020 to 122 million. In 2021, the SOFSE ridership recovered slightly better than that of Metrovias. Still, total ridership in SOFSE lines in 2021 was 56 percent below the 2019 level, while in

[45] This is mostly explained by wages increasing slower than inflation, in addition to improvements in average commercial speeds and adjusted services during the night and public holidays. The staff/bus relation is fixed since 2009, and the fleet in operation has not changed.

[46] Mitre, Sarmiento, San Martín, Belgrano Sur, and Roca lines.

the case of Metrovias and Ferrovias the respective figures were 74 percent and 42 percent. **Also by mid-May, 2022, the daily ticketing volume in AMBA's rail system was still at only 79 percent the average of the typical day in 2019** (Figure 49).

Figure 49: Rail and subway ticketing transactions during average working week in 2019-2022 ('000)

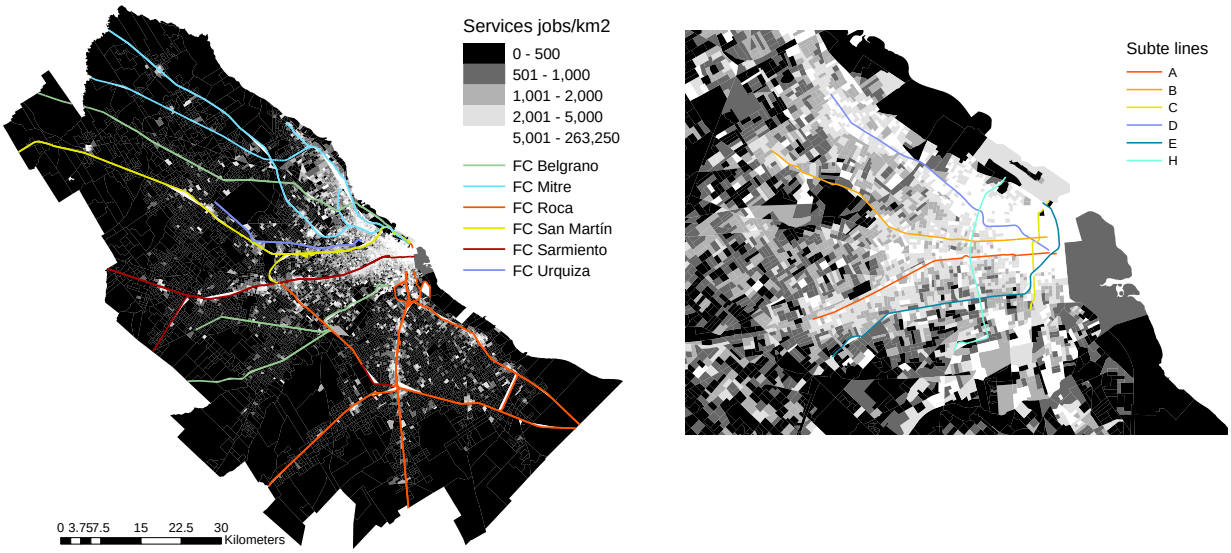


Source: Buenos Aires Observatory of Mobility and Road Safety

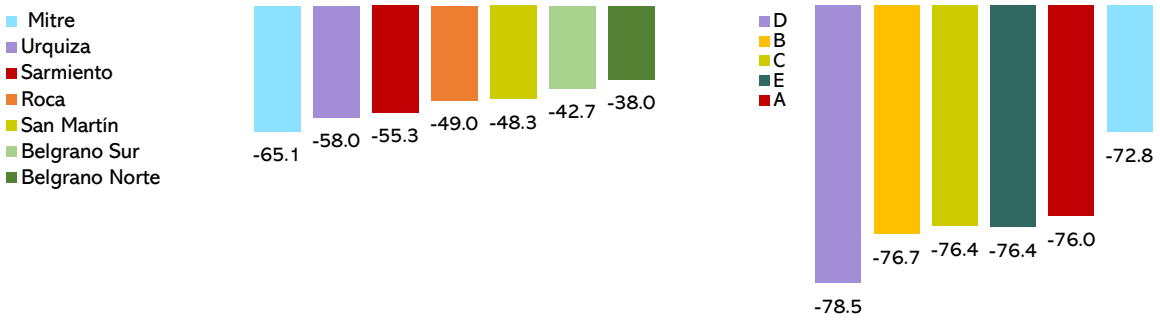
Demand recovery – at least as tracked through the SUBE ticketing system – has so far been the weakest in the subway system, where the total volume of ticketing transactions in mid-May, 2022, still stood at only 61 percent the level of an average work week in 2019. This can be explained by the spatial coverage of the subway system (serving CABA only) and is consistent with the much lower recovery of trips to workplaces in CABA as opposed to the rest of AMBA as tracked by the Google Mobility Reports.

Figure 50: Recovery of demand in rail (left) and subway (right) lines and density of services sector jobs

a. Public transport lines and density of services sector jobs per km2



b. Change in total ridership, by line, in 2021 v. 2019 (%)

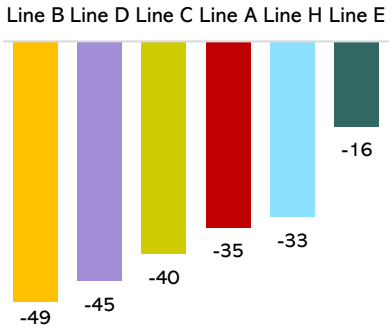


Source: Censo Economico 2004/2005; CNRT demand data; Note: paid passengers only

Across the individual rail lines, ridership in 2021 – as compared to 2019 – was still the most suppressed on the Mitre, Urquiza, and Sarmiento lines, which tend to travel through areas in AMBA characterized by a high density of services sector jobs. On these lines total demand in 2021 (considering paid passengers only) was still more than 50 percent below the 2019 level. In the case of the subway, demand in 2021 had recovered nearly equally poorly across all the lines, at between 73 percent (H line) and 79 percent (D line) below the 2019 level (Figure 50 b.). Across all subway lines, demand recovery was below any of the rail lines, again, possibly explained by the higher prevalence of services sector jobs in the area (CABA) served by subway and the disproportionate effect the pandemic had on these types of jobs as well as by better walkability and wider availability of alternative modes such as the ciclovia throughout CABA.

Also as of the last week of March 2022, the transactions in the subway system were at between 51 percent (Line B) and 84 percent (Line E) the level of the average week of the same month in 2019, according to data tracked by the Buenos Aires Observatory of Mobility and Road Safety. In fact, Line E was the only one where demand had recovered to over two-thirds the 2019 level (Figure 51).

Figure 51: Subway transactions (% change in last week of March 2022 compared to 2019)



Source: Observatory of Mobility and Road Safety

The pandemic hit the *subte* (operated by Metrovias) harder than the rest of the rail system. Fare coverage was already low before the pandemic, and now it stands at only 1 percent for some operations. While during the first year of the pandemic the system appeared to have adjusted its operational figures as a result of reduced ridership, during 2021 it showed a vigorous increase in operational costs.

For the consolidated rail transport system, the aggregate nominal cost figures show an upward trend in both 2020 and 2021. The 36.9-percent increase in 2020 was mainly driven by an increase in labor costs (accounting for the largest share of operational costs) of almost 30 percent, as well as a significant increase in costs classified as "Other" (over the last couple of years, fuel costs are included within this category for SOFSE). In 2021, all components grew significantly, especially "fuel and power", reflecting the response of the system, especially the *subte*, to increasing demand. The increase in operational costs in 2019-2021 was of

almost 115 percent in nominal terms and 1.7 percent in real terms.

Revenues from fare collection remained low as a result of reduced ridership (-74 percent in 2020 compared to 2019) and in 2021 were still 42.6 percent below the 2019 level in nominal terms. While 73.4 percent more was collected from fares in 2021 than in 2020, this failed to compensate for the loss of two-thirds of revenues (from ridership) of the integrated rail system in 2020. Metrovías shows the greatest loss in fare collection among the different rail operators, which might be explained by the fact that the lockdown hit demand harder in the central area of AMBA where the *subte* concentrates its operation feeding the Microcentro. On the flipside, in 2021 Metrovías showed the strongest increase in fare collection, reflecting the recovery of demand in the central city as well as the increase in *subte* fares in November 2020 (by 2 Pesos), and a further 9 Pesos in March-April, 2021, being the only subsystem in the AMBA with fare increases since 2019.

The loss of fare revenues of the overall rail system in 2020 compared to 2019 was even starker in real terms, declining by 76.4 percent, and, despite a 15.3-percent increase in fare revenues in 2021, fare revenue in real terms in 2021 was nearly 73 percent below the 2019 level. In other words, while in nominal terms the increase in fare collection appeared to be high (73.4 percent), the figure in constant prices (15.3 percent) suggests that not updating fare levels severely impacted the system's financial KPIs, even in a context of demand recovery.

To cover operational expenses, dedicated subsidies grew by nearly 164 percent between 2019 and 2021 (in real terms, the amount of subsides required to cover the rail system operation grew by 20.2 percent in 2020 and another 4.1 percent in 2021). In 2021, fares covered only 4 percent of total system costs, down from 13 percent in 2019. The consolidated rail system saw the same trend as the bus system described earlier: while fare coverage had experienced a gradual increase before the pandemic, of around 1 pp per year between 2015 until 2019, this was reversed during the pandemic.

3.4. NMT patterns

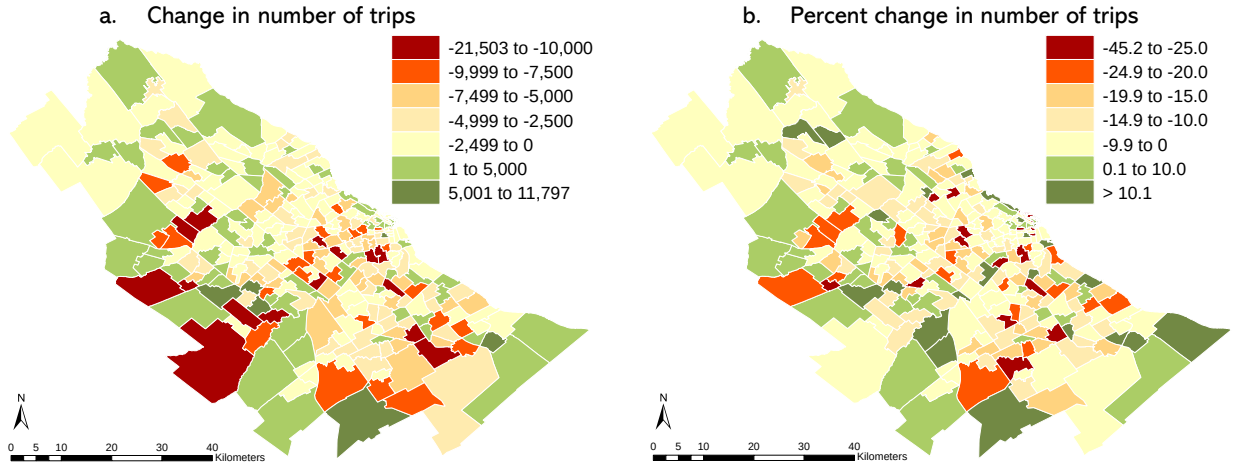
As already noted, the overall number of NMT trips on a typical workday in AMBA decreased by about 5.8 percent between October 2019 and 2020 and declined slightly again in 2021.[47] Within AMBA, however, there was a lot of variability in the NMT patterns in 2019-2021, **with many macrozones in CABA and the first ring of GBA seeing an additional several thousand trips in 2020 compared to 2019, while individual outlying macrozones experienced a *loss* of 10,000 or more daily NMT trips**. In percent terms, while some macrozones lost over 25 percent of their daily NMT trips in 2019-2020, others gained 10 percent or more.

Similarly, when comparing a workday in October of 2019 to 2021, NMT trips, on balance, had declined in many macrozones but increased in many others. The areas with the highest decline – having lost 7,500 or more NMT trips per day – were somewhat more concentrated in CABA and the southern half of AMBA. NMT trips in both absolute and percentage terms grew the most in peripheral GBA.

The highest daily NMT trip generation rates per person in October 2021 were in downtown CABA and individual macrozones in GBA, exceeding 1 trip per day per person on average. The lowest rates were in macrozones in parts of GBA, at below 0.4 trips per person per day (Figure 53 a.). When comparing to October 2019, NMT trip generation rates per person appear to have declined by between 0 and 0.2 across most macrozones (Figure 53 b.).

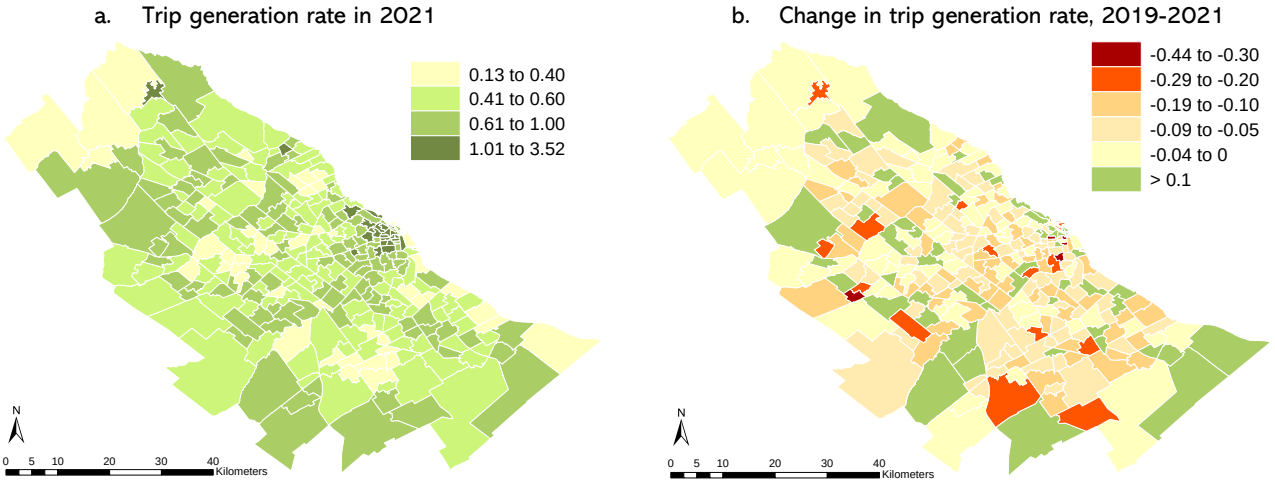
[47] The CDR data based analysis of mobility patterns in NMT cannot distinguish between cycling and walking trips.

Figure 52: Number of trips by NMT starting in the macrozone, a workday in October 2019 vs. October 2021



Source: Analysis by study team, based on CDR data from Claro Argentina

Figure 53: Trip generation rate per person by NMT, a workday in October

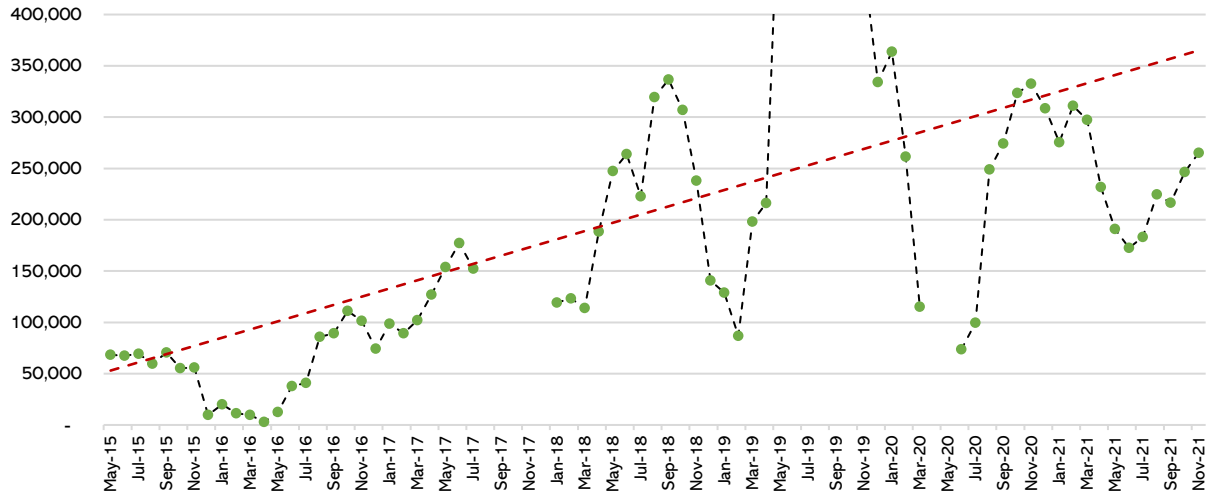


Source: Analysis by study team, based on CDR data from Claro Argentina

Analysis of the CABA public bicycle system data covering ridership in the second half of 2015 to end-2021 suggest that ridership has increased steadily, fluctuating seasonally, and **even in 2020 ridership continued its upward long-term trend despite an initial drop in March-July**, from a record high in 2019 (Figure 54). Of the 400 Public Bicycle Transport System stations, 200 were kept operational after the onset of the COVID-19 pandemic in 2020.

The use of bicycles for delivery has also increased significantly during the pandemic, and it is estimated that there were between 60,000 to 90,000 bicycle delivery service workers in Argentina in 2021. Overall, during the pandemic, the mode share of bicycles increased from 4 percent to 10 percent of all trips in the city of Buenos Aires, the highest ever observed (Observatorio de Movilidad y Seguridad Vial et al. 2021).

Figure 54: Trips in CABA's public bicycle system, May 2015-November 2021



Source: BA Data, Secretaría de Transporte y Obras Públicas. Jefatura de Gabinete de Ministros

3.5. Private motorized mode users: mobility, mode choices, and their drivers

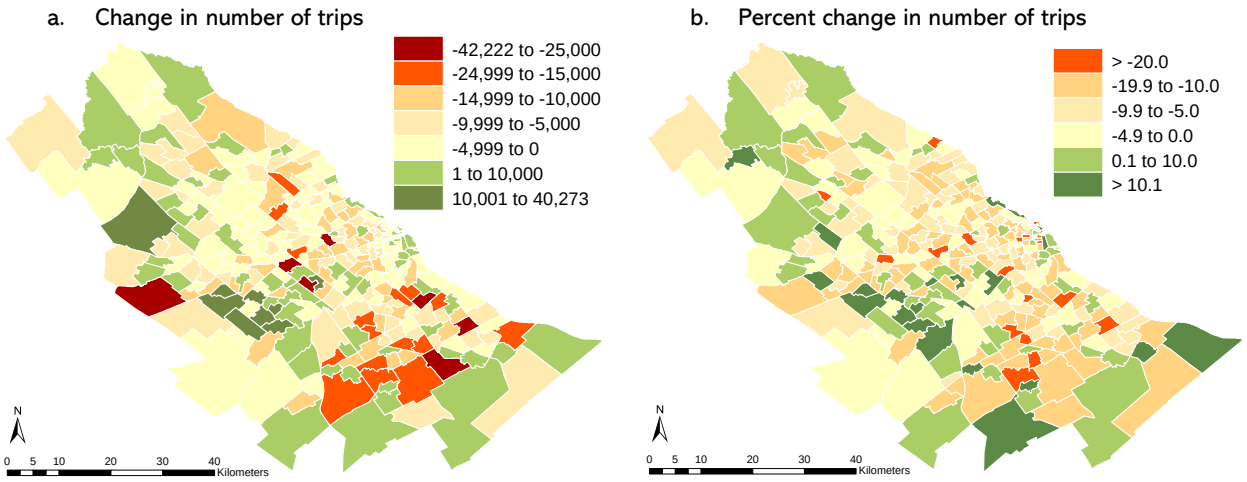
3.5.1. Private mobility patters and changes since pre-pandemic

Patterns in private motorized mobility, as detected by "big" data sources, mirrored those of public transport in the initial phase of the pandemic; however, private mobility appears to have recovered much quicker. According to data tracked through Apple Maps, private motorized mobility saw an immediate drop of about 90 percent at the very beginning of the pandemic in March 2020; however, within a year it had more or less fully recovered. Data tracked by the Buenos Aires Mobility and Road Safety Observatory indicates that by mid-May, 2022, the volume of private vehicle flows on AMBA's highways was at 107 percent the level of the same week in 2019.

As already noted, mobility analysis based on CDR data suggests that total daily trips by private motorized modes on a typical workday declined by 16.9 percent in 2020, while by October 2021 they were only 5.9 percent below the 2019 level. As with the other modes, however, there was significant variability in the patterns within the metropolitan area. **In October 2020 compared to 2019, a number of macrozones – scattered throughout AMBA – lost upwards of 25,000 daily private motorized trips.** In a small number of areas (mostly in western GBA), the number of private motorized trips slightly increased between 2019 and 2020. In percentage terms, most macrozones saw a decline in the number of private motorized trips of between 10 and 20 percent.

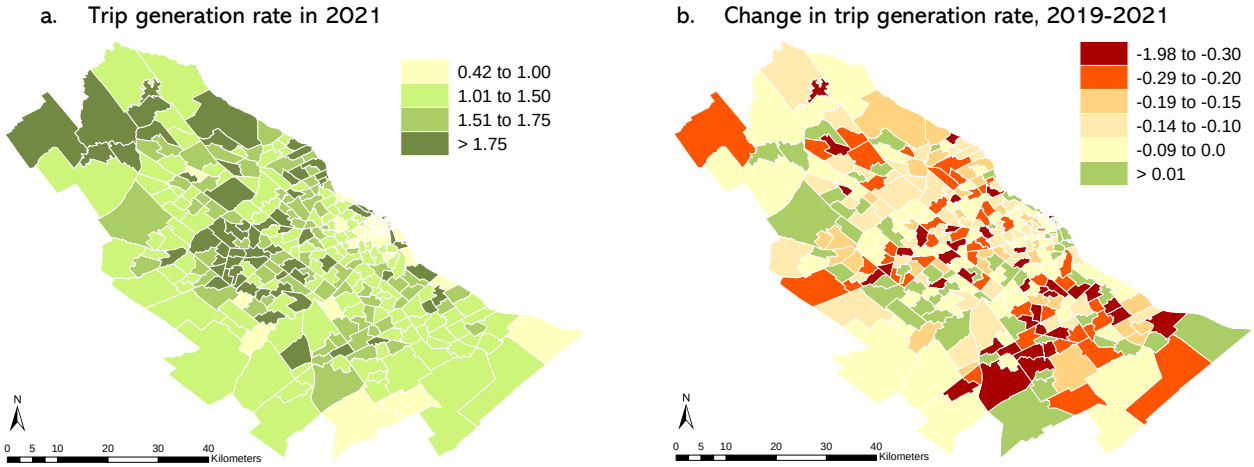
If comparing October 2019 to 2021, private motorized trips in large parts of AMBA were still lower (mostly by no more than 10 percent); however, **in quite a few macrozones throughout the metropolitan area the number of trips was already above the 2019 level**. In several macrozones in GBA, private motorized trips had increased by over 10 percent compared to 2019.

Figure 55: Number of private motorized trips starting in the macrozone, a workday in October 2019 vs. October 2021



Source: Analysis by study team, based on CDR data from Claro Argentina

Figure 56: Trip generation rate per person by private motorized modes, a workday in October



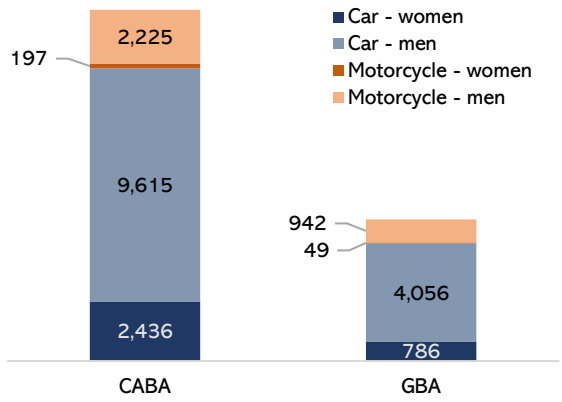
Source: Analysis by study team, based on CDR data from Claro Argentina

Absolute trip generation rates per person by private motorized modes on a workday in October 2021 were the highest in northern and western GBA, exceeding 1.75 trips per person per day in individual macrozones, and they were the lowest in central CABA, at below 1 trip (Figure 56 a.). **Compared to October 2019, trip generation rates had declined the most in southern GBA** (Figure 56 b.). In several peripheral macrozones, private motorized trip generation rates declined in 2021 compared to 2019, while the *number* of trips increased, which could be explained by population relocation to/increase in these areas.

❖ Characteristics of the current car and motorcycle users and their trips

Complementing the CDR-based analysis, the study implemented an extensive survey of current private motorized transport users in AMBA in the last week of November and first two weeks of December, 2021, to shed light on the current trip patterns of this sub-set of the population, changes vis-à-vis the pre-pandemic period, and main stated drivers of modal choices. This data collection effort was conducted in close collaboration with the city of Buenos Aires and was informed by its parallel data collection activities (e.g., vehicle counts at pre-determined points across the urban area).

Figure 57: Private motorized mobility survey sample, by residence, intercepted vehicle, and gender



Source: Survey implemented by study team

The private motorized mobility survey was implemented as an interception survey at 25 points (service stations and parking lots) across the CABA. The survey randomly intercepted drivers of motorized vehicles that stopped, and the final sampling ensured that the survey sample meets predetermined (based on previous travel surveys) quotas of women and men that travel by car or by motorcycle and that live in CABA vs. GBA. The sampling was adjusted to the approximate volume of traffic at the mentioned points and considered peak and off-peak hours based on data provided by the Secretary of Mobility of CABA. Altogether, 20,306 people were surveyed, with the breakdown by gender, mode, and residence shown in Figure 57.

CABA was the trip origin for 77.6 percent of the surveyed individuals and the destination for 79.8 percent. The trip origins in GBA are quite evenly distributed across the 40 municipalities; individual municipalities with a relatively high share of trip origins include Avellaneda and La Matanza, Vicente López, Lanús, and General San Martin. Also the most common trip destination municipalities besides CABA are largely the same.

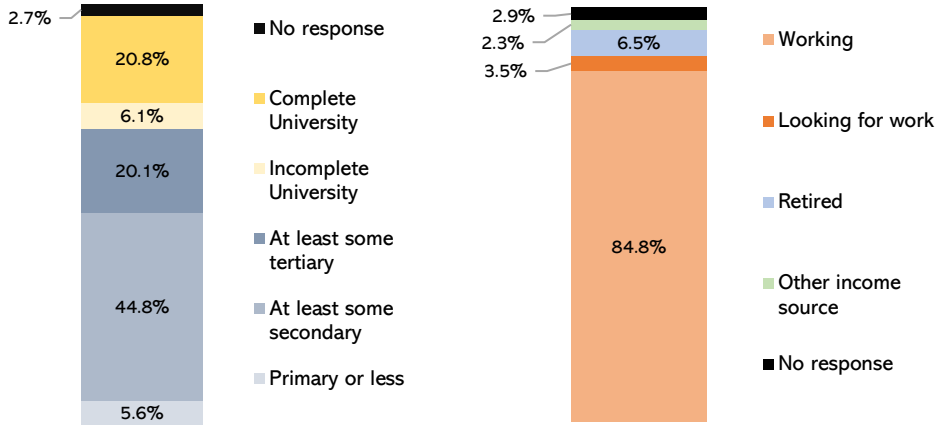
Regarding the trip during which the surveyed individuals were intercepted, the majority had traveled from home (54 percent) or from work (24 percent), and the main destination, similarly, was work or home. The vast majority of the survey sample (94 percent) relied only on the private motorized vehicle for the entire trip; among those who did use another mode or were planning to do so, 79 percent used public transport.

The car/van users were, on average, older, more likely to have university education, and have another occupational status besides "working" (such as being retired or looking for work). The intercepted car/van users were also slightly less likely to have used or planning to use another mode to complete the trip. However, among the subgroup of those who did use or were planning to use an additional mode, a higher share among car users than motorcycle users used public transport specifically (81 percent vs. 71 percent among motorcycle users), such as parking the vehicle near a train or metro station and then continuing by that mode. **Trips were also more likely to involve another mode if either their origin or destination was is in CABA rather than in GBA.**

Current car or van users…

45 years old, on average

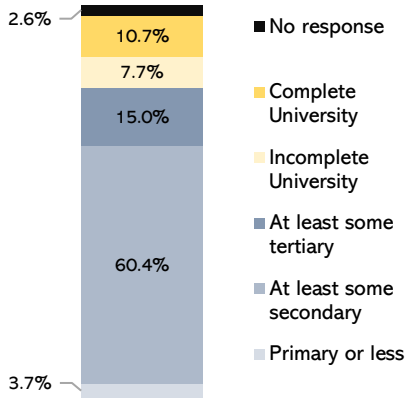
81% are men

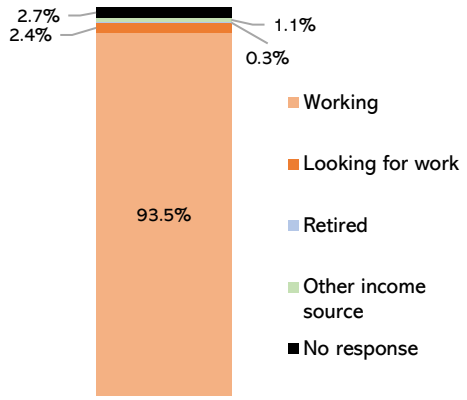


Current motorcycle users…

35 years old, on average

93% are men



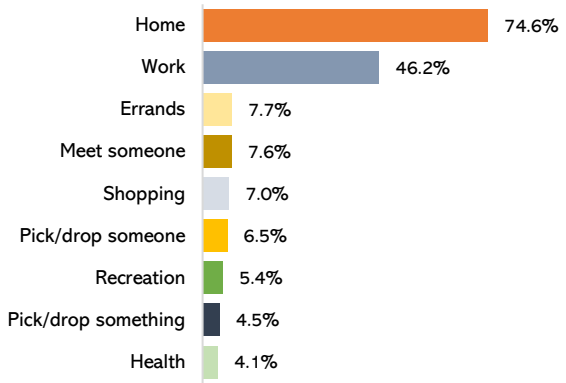


The intercepted motorcycle users were more likely than car/van users to be either coming from or going to work rather than other activities (60 percent vs. 44 percent), which is consistent with the differences in the current occupation status between the two groups, while car/van users were more likely to be traveling for recreational purposes or to pick up/drop off someone, for example (more details are provided in Annex 5).

However, there are equally significant differences in the trip purpose between men and women *within* each of the vehicle user subgroups. Among the current car/van users, women are less likely than men to be traveling for work or to pick up/drop off something and more likely to travel for the other types of reasons, such as shopping, recreation, or health. Among the current motorcycle users, similarly, women are less likely than men to travel for work or to pick up/drop off something but much more likely for reasons such as shopping or health needs. Overall, the trip purpose breakdown appears to be more similar across modes than across genders. However, some distinct patterns that are common to both men and women include, for example, picking up/dropping off something being a much more common trip purpose among motorcycle users than car users; traveling for either health or recreational reasons being more common among car/van users than among motorcycle users; and traveling to meet someone ranking among one of the top most important travel purposes.

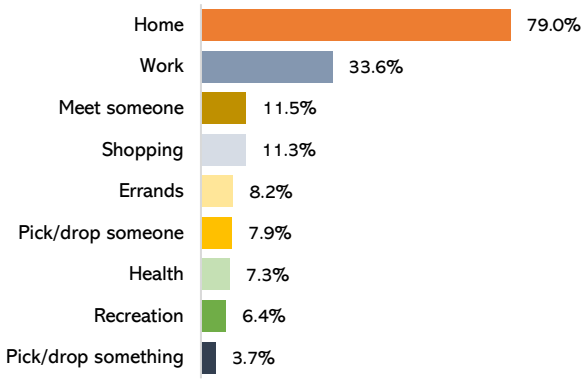
Men

% of current car or van users with the following as either the trip origin or destination…

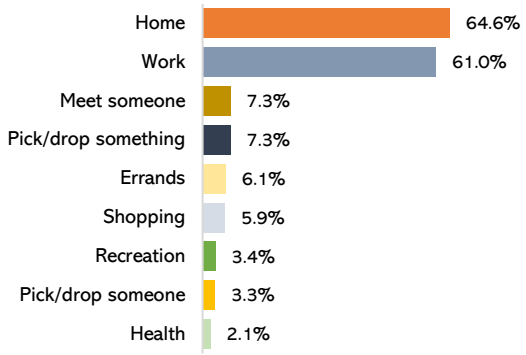


Women

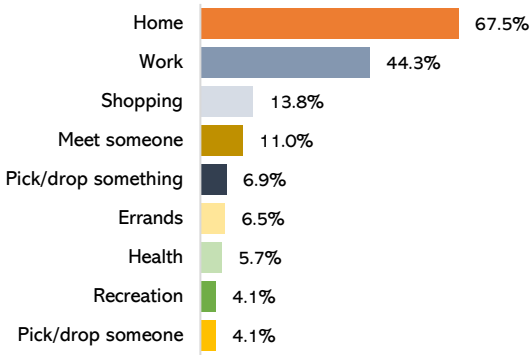
% current car or van users with the following as either the trip origin or destination…



% of current motorcycle users with the following as either the trip origin or destination…



% of current motorcycle users with the following as either the trip origin or destination…

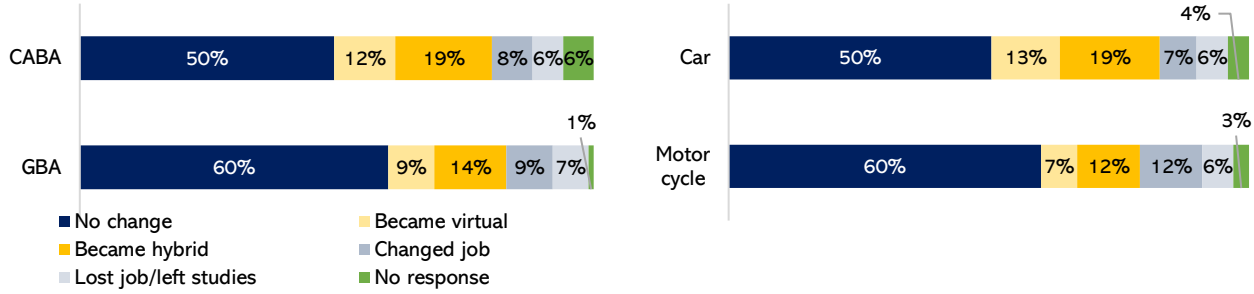


❖ Changes in the employment status as compared to pre-pandemic

One of the main objectives of the survey was to better understand the scale of modal shift from sustainable (public transport and NMT) modes to private motorized modes as compared to the pre-pandemic period, and to identify if the shift was particularly strong for certain origin-destination pairs or people of specific socio-economic characteristics, and what motivated the shift. **It was therefore first important to establish how the economic situation of the current motorized vehicle users had changed since the pre-pandemic period**, in order to understand the extent to which the travel patterns and mode choices could have been expected to remain the same as before.

The employment/occupation status had changed for nearly half (47 percent) of the surveyed individuals, of whom most had either started working only remotely or in a hybrid remote/in-person mode (28 percent of the overall survey sample). About 8 percent of all surveyed individuals had changed jobs, and 6 percent had lost their job or left studies. Change in the occupation/study status was more common among the CABA residents, of whom nearly one-third switched to an all-virtual or hybrid working mode, compared to 23 percent of the surveyed GBA residents. A shift to virtual/hybrid work mode was more common among the current car users than motorcycle users (32 percent vs. 19 percent), while changing one's job altogether was more common among the current motorcycle users than car users (12 percent vs. 7 percent).

Change in the work/study environment compared to pre-pandemic



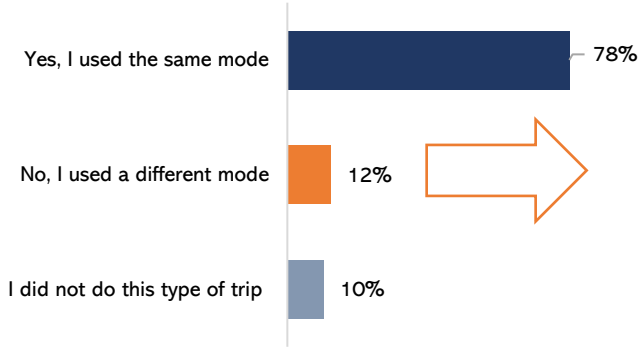
❖ Mode change compared to pre-pandemic

About 12 percent of the surveyed individuals had previously used a different mode for making this type of trip, with the share being slightly higher among CABA residents than GBA residents and among current car users as compared to motorcycle users. If only considering the individuals who had made this type of trip prior to the pandemic at all, 13.2 percent had switched to private motorized transport from a different mode. The vast majority of people who

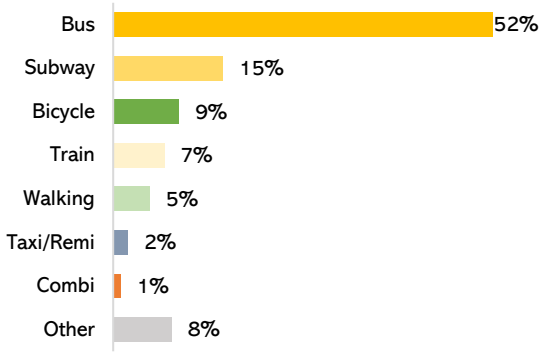
made a switch to private motorized modes had previously used public transport (about 73 percent).

By far the largest shift to private motorized vehicles was among individuals who previously used a bus (representing 52 percent of those who said they had previously used a different mode), and this share was nearly identical among both CABA and GBA residents. The second largest share of individuals reporting mode shift compared to pre-pandemic had previously taken the subway (15 percent), the share, understandably, being significantly higher among CABA residents (19 percent) than GBA residents (5 percent), given the spatial scope of the subway system. The share of previous subway users is much higher among current car users than motorcycle users (17 percent vs. 7 percent).

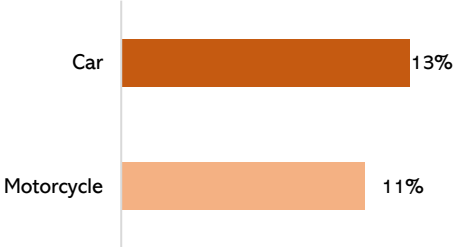
Prior to the pandemic, I used the same mode for this trip



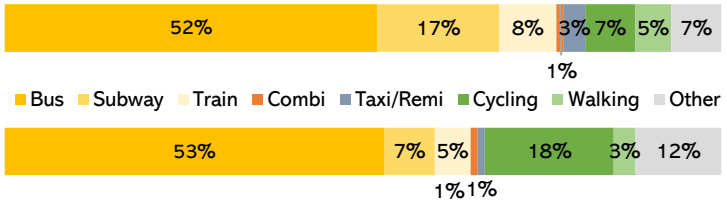
The mode I used to use for this trip was…



The share of current car or motorcycle users who previously used a different mode …

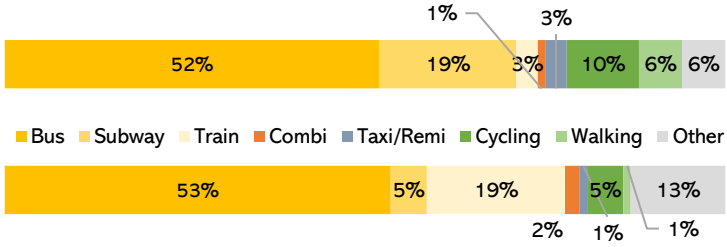


… among these, the vast majority had switched from public transport, especially so among current car users



The share of CABA and GBA residents who currently use a car or a motorcycle but previously used a different mode …

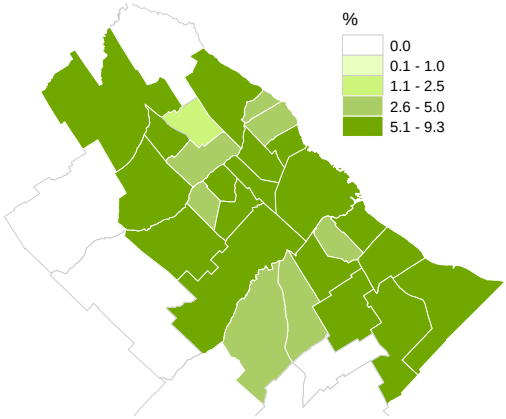
… among these, a bigger share had switched from public transport in GBA than in CABA, while in CABA a bigger share shifted from NMT



A surprisingly large share of the respondents who report having switched modes previously relied on non-motorized modes – biking (9 percent) and walking (5 percent). The shift from NMT modes to private motorized modes was more prevalent among the surveyed CABA residents; however, this is at least partly due to the longer trip lengths of the surveyed GBA residents and, thus, the lesser relevance of NMT modes in these trips also prior to the pandemic. The bicycle-motorcycle switch appears

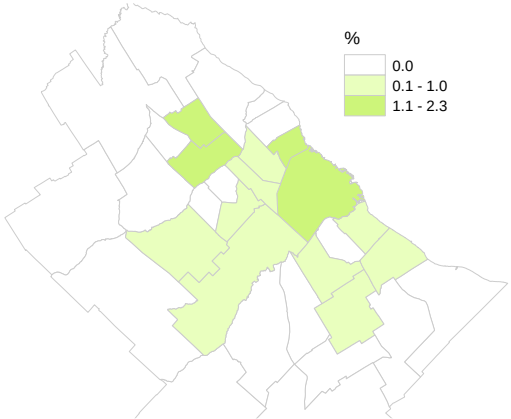
to be much more common than bicycle-car switch (18 percent of current motorcycle users who report switching modes previously biked, compared to 7 percent of current car users who switched modes). This suggests that convenience, rather than fear of contracting the virus, might have been a more important motivation.

Figure 58: Share of individuals who used bus for the trip prior to the pandemic (trip origin)



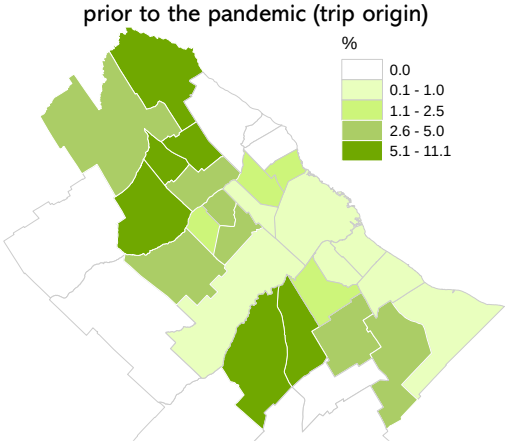
Source: Survey conducted by study team

Figure 59: Share of individuals who used subway for the trip prior to the pandemic (trip origin)



Source: Survey conducted by study team

Figure 60: Share of individuals who used train for the trip prior to the pandemic (trip origin)



Source: Survey conducted by study team

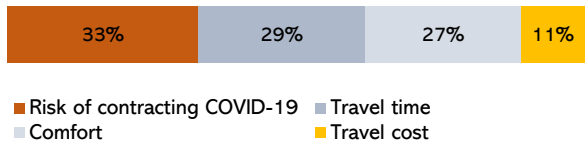
Finally, about 7 percent of those who reported shifting modes as compared to the pre-pandemic had previously taken the train, and the train-car or train-motorcycle shift was much more common among GBA residents than CABA residents (19 percent vs. 3 percent), which can be explained by the train mostly serving longer distance trips from GBA to jobs in CABA. The share of previous train users is slightly higher among the current car users than motorcycle users, possibly again explained by the longer trip distances typical to train riders.

3.5.2. Stated preferences of mode choice

❖ Most important reported drivers of mode choices

Based on the overall interception based survey of 20,306 current private motorized mode users across AMBA, travel cost appears to be the least important factor in determining mode choice, as reported by the respondents themselves. Only 11 percent of the respondents consider it the single most important mode attribute, while 41 percent say it is the least important one. The risk of contracting the COVID-19 virus is both very important for a large sub-set of the respondents as well as not important at all for a nearly equally significant share. The risk of COVID-19 appears to be much more salient for women than men, with over 40 percent of women naming it the single most important factor determining travel choices, compared to less than 32 percent of men. On the other hand, comfort and travel time are more likely to be named as the most important travel attributes by men than women. The importance of travel cost is roughly similar for men and women, with 12 percent of women and 11 percent of men ranking it as the most important attribute.

The most important travel attribute is …



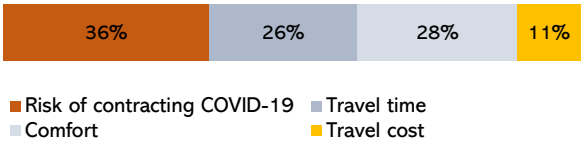
The least important travel attribute is…

In the 18-25 age group, 26 percent consider the risk of COVID-19 to be the most important travel choice factor, compared to over 45 percent in the 60+ age group. On the other hand, 37 percent of the youngest age group members consider travel time to be the most important attribute, compared to only 20 percent of the 60+ group. Of all the age groups, cost appears to be the most salient for the youngest (18-25) travelers.

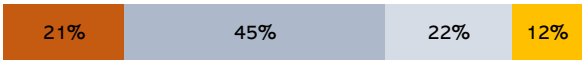
The current car/van users are much more likely to worry about the risk of COVID-19 while motorcycle users care much more about travel time. Comfort is somewhat more important for car users. There are no real differences in the concerns expressed by the CABA versus the GBA residents, although CABA residents are slightly more likely to consider travel comfort as the most important while GBA residents are slightly more likely to mostly care about travel cost.

Perhaps intuitively, the relative importance of the risk of COVID-19 differs between those travelers who used private motorized modes for this trip also prior to the pandemic and those who made a switch from other modes (in the vast majority of cases, public transport). COVID-19 risk is the number one travel attribute for 32 percent of the travelers in the first subgroup but for as many as 40 percent in the second subgroup.

Among car/van users, the most important factor is …



Among motorcycle users, the most important factor is …



❖ Socioeconomic characteristics associated with becoming a new user of private modes

Considering the subset of people who had taken the same type of trip also before the pandemic, the study analyzed **whether the odds of becoming a new user of private motorized transport since the pandemic – as opposed to already being a private modes user before the pandemic – is statistically predicted by certain socio-economic characteristics**. This analysis also provides some insight as to who and for what types of trips may possibly shift back to the earlier (more sustainable) modes under the right circumstances. The analysis applies a logistic regression model with the dependent variable being a binary yes/no of whether the person is a new user of private motorized modes as compared to the pre-pandemic (see detailed regression results in Annex 5).

The results suggest that **the odds of being a new user of a car/van or motorcycle** – as opposed to already using these modes for the specific type of trip also before the onset of COVID-19 – **are statistically significantly higher for women, people with at least some university education, and people who had at least some type of change in their occupation status** (Table 7). The odds decrease with the person's age, meaning that the older the respondent, the more likely he or she was already using the private motorized vehicle already before the pandemic as opposed to becoming a new user. The odds of recently switching to private motorized modes are also higher if the start of the trip is in

CABA rather than in GBA. The odds are lower if the specific trip in question is a relatively irregular type of trip such as to meet someone, to see a doctor, or for recreation purposes. In other words, for these types of ad-hoc trips it is more likely that the traveler used a private motorized mode already before the pandemic. Finally, the results are intuitive regarding the statistical association with the person's stated most important travel attributes: the odds of becoming a new user of private motorized modes are statistically significantly higher if the person states the risk of contracting COVID-19 as the single most important travel attribute.

Table 8: Statistical predictors of becoming a new user of private motorized modes (estimated coefficient)

	Coefficient
Male (dummy)	- 0.378 ***
Age	-0.015 ***
At least some university education (dummy)	0.364 ***
Change in occupation status since pre-pandemic (reference = no change)	
Became virtual	0.504 ***
Became hybrid (virtual and face-to-face)	0.392 ***
Lost job/left studies	0.797 ***
Changed jobs	0.362 ***
Trip start in CABA as opposed to GBA (dummy)	0.244 ***
Recreation trip (dummy)	- 0.355 **
Trip to meet someone (dummy)	- 0.225 **
Trip for health purposes (dummy)	- 0.608 ***
Most important travel attribute (reference = trip cost)	
Comfort	- 0.049
Travel time	0.011
Risk of contracting COVID-19	0.322 ***
Constant	- 1.592 ***

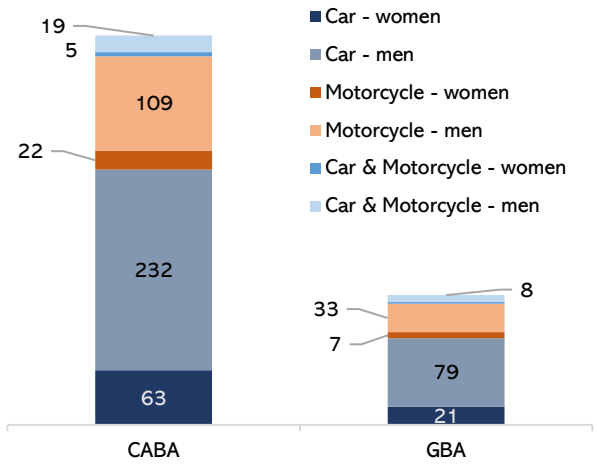
Note: *** and ** denote statistically significant results, * denotes marginally statistically significant results
Source: Survey conducted by study team

- Willingness to consider shifting from private motorized modes to public transport or NMT

Following the interception-based survey conducted in November-December, 2021, a much smaller and more targeted mode choice survey module was implemented in February-March, 2022, to gather data on the willingness of AMBA residents who have a motorized vehicle in their household and use it for daily needs to shift to public transport or NMT, and on how it varies depending on their residence, socioeconomic characteristics, current access to public transport/NMT options, and the hypothetical attributes of these alternative modes in the future. This analysis allows to at least tentatively quantify the window of opportunity for mode switch among this population segment.

The mode choice survey module was implemented using CATI (phone-based) survey approach. It applied a multistage cluster sampling, where, first, the sample was stratified by the regions that constitute AMBA (CABA and GBA) and, second, within these regions, a probabilistic sampling was applied according to the proportion of population in each region. Secondly, within CABA and GBA, respectively, three geographical sub-zones were established. Subsequently, the phone numbers were randomly drawn based on the census population parameters of each subzone. Gender quotas of the respondents, based on the previously documented use of private motorized modes, were targeted at the CABA/GBA level but not at the sub-zone level.

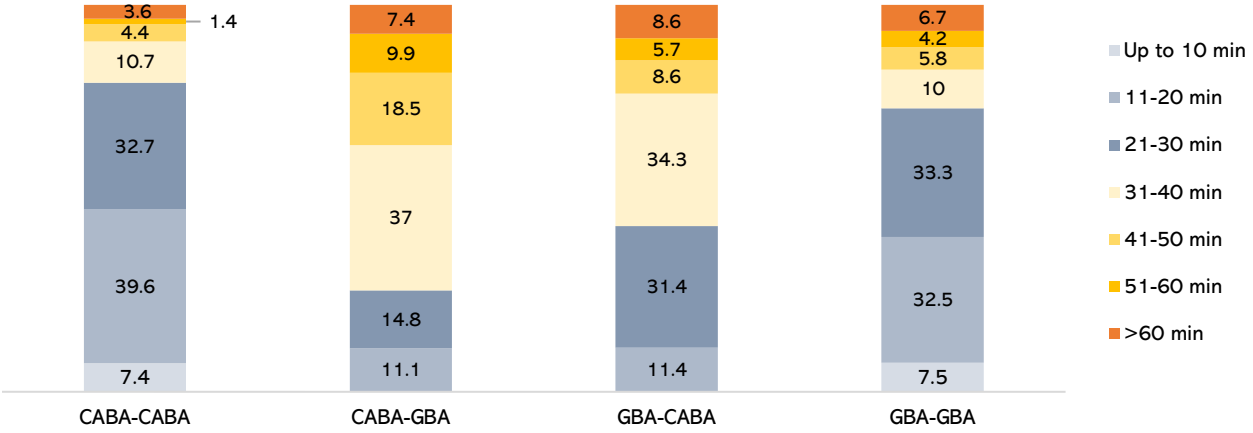
Figure 61: Stated preference survey sample, by residence, household vehicle, and gender



Source: Survey conducted by study team

In total, the mode choice CATI survey delivered completed useful surveys[48] of 600 individuals – AMBA residents aged18 and above who have a car, motorcycle or both in their household and who have made a typical trip in that vehicle in the last 7 days. In case the person had had several typical trips over that time period, they were asked to report on the main trip, such as a work commute. The survey first asked several questions about the typical trip and then followed up with stated-preference type questions using that typical trip as the reference. Nearly 61 percent of the typical trips reported in the survey were from an origin in CABA to a destination in CABA, followed by GBA-GBA (20 percent), CABA-GBA (13.5 percent), and GBA-CABA (6 percent).

Figure 62: Duration of the typical trip, by origin-destination (%)



Source: Survey conducted by study team

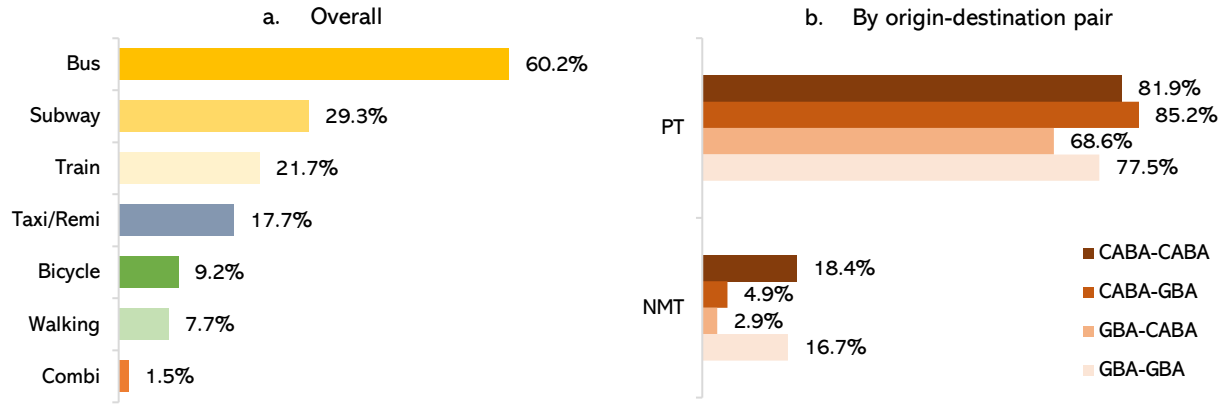
By far the largest share of the respondents had traveled to work (66.5 percent), followed by school/university (7 percent), to pick up or to drop off someone (5.8 percent), for healthcare needs (5.2 percent), and shopping (4 percent). Work purpose dominates in the GBA-CABA trips much more than in the trips between the other origin-destination pairs. Both shopping trips and trips for health purposes appear to be more local, as they represent a higher share in the CABA-CABA and GBA-GBA trips than in the trips between CABA and GBA.

Close to two-thirds of all of the typical trips had lasted between 11 and 30 minutes one way; however, 5 percent of the trips took over an hour. Trips lasting up to 20 minutes are much more common in the case of the relatively "local" – CABA-CABA or GBA-GBA – origin-destination pairs, where they account for about 47 percent and 40 percent of all trips, respectively (Figure 62). Both within-CABA and within-GBA trips that take up to 10 minutes represent nearly the same share, about 7.5 percent. In contrast, the typical trip length in the case of CABA-GBA and GBA-CABA trips is 31-40 minutes, and none of the trips are reported to be shorter than

[48] 223 initially contacted individuals provided answers that were not considered useful for the purposes of the survey because of the initial filter questions (for example, whether the person has used a motorized vehicle in the last 7 days).

11 minutes. It is likely that for these routes trips of such short duration are not only less common but also more likely to be conducted by non-motorized modes. Women tend to have a higher share of short trips – lasting less than 10 minutes – as compared to men (9.2 vs. 5.2 percent), as do motorcycle users compared to car users (8.2 vs. 5.3 percent).

Figure 63: Availability of other modes besides car or motorcycle for realizing the typical trip



Source: Survey conducted by study team

Overall, nearly 81 percent of the respondents have available a public transport mode that could be used to realize the same typical trip instead of using their current mode (car/motorcycle). Over 60 percent of the respondents could potentially use a bus, nearly one in three could use the subway, and nearly 22 percent – the train (Figure 63). About 15 percent of the respondents could potentially complete the trip using at least one non-motorized mode. Biking would be an option for over 9 percent of the respondents and walking – for nearly 8 percent. In sum, only about 13 percent of the respondents do not have any other modes available for realizing the typical trip besides their private motorized vehicle. By trip origin-destination pair, public transport is available for a higher share of the CABA-CABA and CABA-GBA trips than the GBA-CABA or GBA-GBA ones; NMT could be a feasible alternative for about 17-18 percent of the trips within CABA and within GBA but for less than 5 percent of the trips between CABA and GBA. A higher share of women than men (17.5 vs. 14.8 percent) report that NMT options could theoretically be used for completing the trip, which is consistent with the higher share of short trips reported by women than men.

When asked why they used the private motorized vehicle rather than one of the other available modes, 40 percent of the respondents named comfort/convenience, and 39 percent – travel time. These motivations were followed distantly by the concern about contracting COVID-19 (7 percent) and safety (6 percent). The high importance of comfort and travel time is consistent with the findings of the interception survey conducted in November-December of 2021; while concern with the risk of COVID-19 appears to be lower in this smaller survey module, this could be explained by the fact that the survey covers disproportionately more people whose typical trips are outside CABA and also by the two-month gap between the two surveys, which likely matters for the overall perception of the risk and the relevance of the pandemic as a travel choice motivator in general. It is also possible that the risk of COVID-19 is less salient for typical trips in particular, which the smaller survey module focused on.

Travel time more significantly dominates as the main reason for using motorcycles compared to cars (60.8 vs. 30.1 percent), which mirrors the findings of the larger interception survey. For both groups comfort/convenience is the second most important driver of mode choice. Cost considerations are much more salient for motorcycle users than for car users, while the opposite is true when it comes to safety considerations and the risk of COVID-19.

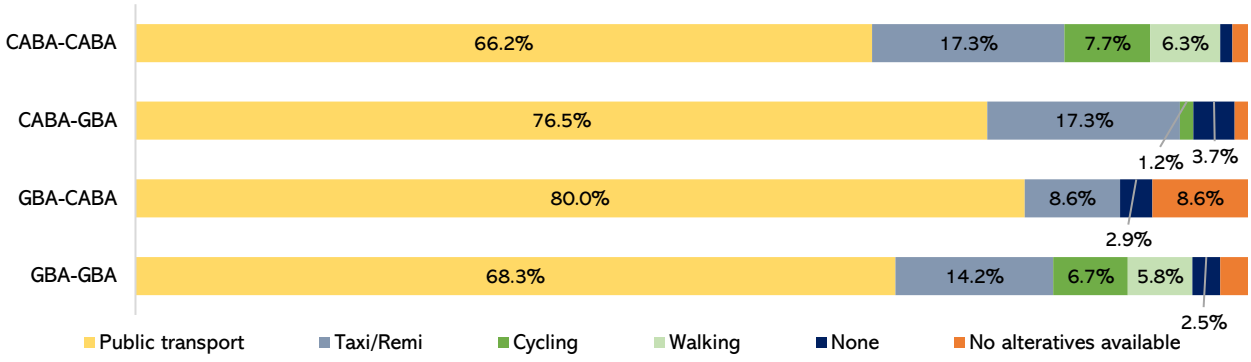
The relative importance of the different mode choice drivers is similar across the origin-destination pairs

(CABA/GBA). However, **travel time appears to matter more in the mode choice among the respondents whose typical trip started in CABA and ended in GBA** (over 53 percent of the respondents said travel time was the main reason for using the private motorized vehicle) compared to only 31-39 percent of the respondents on the other origin-destination pairs. On the other hand, the respondents traveling from CABA to GBA were much less likely than the other respondents to name comfort/convenience as the main reason for using the private vehicle. Travel cost was a more important driver of using private vehicles for the trips within CABA compared to the other routes.

The share of respondents who had used the private motorized vehicle also prior to the pandemic is much higher among those who do not have any public transport or non-motorized transport alternatives compared to those who do (97.3 vs. 88 percent), and among men compared to women (91.4 vs. 81.5 percent), the latter being consistent with the results of the much larger interception survey. A greater share of the respondents who live in GBA compared to those who live in CABA switched to private motorized modes only since the start of the pandemic, and, similarly, the share is much higher among the respondents whose trips were within GBA (15 percent) or between CABA and GBA (12-14 percent) compared to those who traveled within CABA (6 percent). Nearly 84 percent of those who had switched to a car or a motorcycle for their trip since the start of the pandemic had previously used public transport, the share being slightly higher among the CABA residents than GBA residents. Similarly, while nearly 6 percent of the CABA residents who had switched modes since the pandemic had previously used a bicycle for their typical trip, there are no such respondents among the GBA residents. On the other hand, a higher share of the GBA-residing respondents previously used a taxi/remis, walked, or relied on another mode.

In the case of not using the private motorized vehicle, nearly 69 percent of the respondents said they would, instead, use public transport for their typical trip, the share being slightly higher among GBA residents than CABA residents. The second most likely alternative mode the respondents would switch to is taxi/remis, with 17.3 percent of CABA residents and 12.7 percent of GBA residents, followed by cycling (6.4 percent and 5.3 percent, respectively). About 5 percent of all respondents would walk, the share being nearly the same in both regions.

Figure 64: Mode that would be used for the typical trip if not using private motorized vehicle, by origin-destination pair

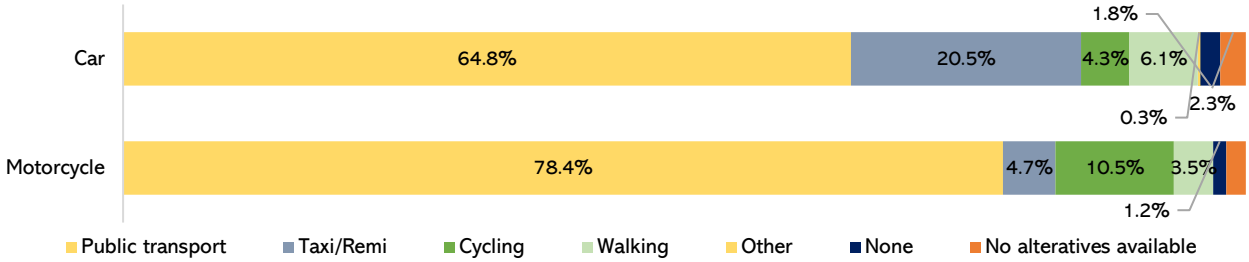


Source: Survey conducted by study team

Likely because of the associated distances, **the preference for public transport as the alternative mode is much higher among the respondents whose typical trip is between CABA and GBA (77-80 percent) rather than *within* CABA or GBA (66-68 percent)** (Figure 64). On the other hand, the preference for NMT modes is higher for the trips within the jurisdictional boundaries – in the case of within-CABA trips, 14 percent of the respondents would cycle or walk if not driving, while in the case of within-GBA trips, 12-13 percent. In comparison, less than 1 percent of all respondents whose typical trips involve crossing the CABA-GBA boundary would bike and none would walk. These findings are consistent with the breakdown by trip duration, whereby 39 percent of those respondents whose

typical trip currently takes 10 minutes would choose walking or biking as their alternative mode (11.1 percent biking and 27.8 percent walking), while the corresponding share drops to only 13 percent for respondents whose typical trips last 11-20 minutes. For trips lasting over 30 minutes by car/motorcycle, less than 5 percent of the respondents would choose a NMT mode (and nearly none of them walking) as the most likely alternative.

Figure 65: Mode that would be used for the typical trip if not using private motorized vehicle, by respondent's vehicle



Source: Survey conducted by study team

The preference for public transport as the possible alternative mode is much higher among motorcycle users than car users (78.4 vs. 64.8 percent) (Figure 65). Motorcycle users are also much more likely to say they would use a bicycle but are less likely than car users to select taxi/remis as the mode they would use if not using the private motorized vehicle.

Women are generally less likely than men to say that they would use public transport but are more likely than men to prefer taxi/remis or walking as the alternative; the higher willingness to switch to walking can be explained by the <10 minute trips being more common among women than men. By age group, public transport is named as the alternative preferred mode by 71-79 percent of respondents in the 18 to 55 age groups, but the share declines steeply in the older age groups, to less than 55 percent among those aged 56-65 and just 38 percent in the >65 group. A similar relatively consistent decline is observed in terms of the share of respondents selecting cycling as the alternative mode they would use if not driving, at nearly 13 percent in the 18-25 group but less than 5 percent among those older than 45. On the other hand, the share of respondents selecting taxi/remis or walking increases with the respondents' age: over 14 percent of respondents over 65 would walk, compared to only about 3 percent of those aged 18-45.

To formally test whether the stated preference for using an alternative mode to driving for the typical trip is statistically associated with certain characteristics of the person or the trip itself, the study implemented a multinomial logit (MNL) regression model. The dependent variable represents the three possible alternative modes – "public transport" (including bus, rail, and subway), "non-motorized transport" (including walking and biking), and "taxi/remis" – while selecting "none of the above" is the reference category,[49] essentially equivalent to not wanting to consider switching away from the current private motorized vehicle. The only personal characteristic that appears to have a statistically significant association with the stated alternative mode choice is the education level (a proxy, albeit imperfect, for income), with **respondents who have at least some tertiary education being more likely than respondents with only primary education to be willing to switch to public transport as opposed to choosing none of the hypothetical alternatives** (Table 9). The education level matters less for the odds of choosing taxi/remis, with respondents with at least some university education being statistically more likely to select this option as opposed to "none of the above". In the case of NMT options, the person's education level does not appear to matter for whether or not they select it. The household's ownership of a car does not have a statistically significant association with the

[49] The reference category includes less than 2 percent of all respondents.

hypothetical mode choice; however, including this variable in the model significantly improves its explanatory power.

The stated willingness to consider using public transport as an alternative to the current private vehicle is statistically significantly higher for those respondents who in reality have a bus option available for completing their typical trip. However, it does not appear to be associated with the actual availability of rail or subway. The stated willingness to consider switching to another mode is also not statistically associated with whether or not the person was using a different mode for their typical trip prior to the pandemic.

The stated willingness to consider using NMT modes instead of driving is strongly associated with the trip duration/distance. Respondents are significantly less likely to state that they would consider using NMT if their typical trip is inter-jurisdictional rather than if it takes place within CABA or within GBA. The respondents with inter-jurisdictional trips are also somewhat less likely to say they would be willing to consider switching to taxi/remis, which may have to do with the associated cost.

Table 9: Relative log odds of selecting public transport, NMT, or taxi/remis as the mode the person would use if not using private motorized transport, compared to choosing "none of the above" as dependent on the person's characteristics and trip characteristic

	Would use PT	Would use NMT	Would use taxi/remis
	Coefficient	Coefficient	Coefficient
Education level (reference = primary or less)			
At least some secondary	1.472	-0.161	0.464
At least some tertiary	2.386 .	0.603	1.372
At least some university	2.464 .	1.178	2.031
Household owns a car (dummy)	-0.833	-0.786	0.882
Bus available as an alternative mode (dummy)	3.401 **	1.661	1.703
OD of the typical trip (reference = CABA to CABA)			
Between CABA and GBA	-0.553	-3.861 **	-1.452 .
GBA to GBA	-0.728	-0.869	-0.984
Constant	1.503	2.436 .	0.593

Note: *** and ** denote statistically significant results, * and . denote marginally statistically significant results
Source: Survey conducted by study team

Looking separately only at the respondents who would be willing to use *any* alternative modes to private motorized transport – the vast majority – a second set of MNL regression models was implemented to identify the personal and trip characteristics associated with the specific choice. Choosing public transport serves as the reference category to which choosing NMT or taxi/remis is compared. The results suggest that **respondents who have a car are significantly more likely to prefer taxi/remis over public transport compared to respondents who don't have one** (Table 10). Age also appears to be a significant predictor of the stated mode choice, with individuals older than 55 being more likely to prefer NMT and taxi/remis over public transport compared to younger respondents.

The respondents are significantly *less* likely to state they would use NMT or taxi/remis (over public transport) if they have a bus service actually available. A similar association is observed also in the case of subway and rail availability, although the latter seems to matter less. Respondents are also significantly more likely to say they would use NMT over public transport if they have a bike.

Finally, respondents are much less likely to choose NMT over public transport if their typical trip is inter-jurisdictional, as explained by the associated distances, and there does not appear to be a statistical difference between within-CABA and within-GBA trips. Similarly, respondents traveling between CABA and GBA are less likely to prefer taxi/remis over public transport compared to

respondents traveling within CABA, which might be due to the associated cost. Moreover, those who travel within GBA appear to be even less likely to prefer taxi/remis over public transport compared to those traveling within CABA, likely explained by the different income levels of the two groups.

Table 10: Relative log odds of selecting NMT or taxi/remis as the mode the person would use if not using private motorized transport, compared to choosing "public transport", as dependent on the person's characteristics and trip characteristics

	Would use NMT	**Would use taxi/remis**
	Coefficient	Coefficient
Household owns a car (dummy)	0.272	1.456 **
Age over 55 (dummy)	0.635 .	0.832 **
Bus available as an alternative mode (dummy)	-2.272 ***	-2.332 ***
Subway available as an alternative mode (dummy)	-1.590 ***	-2.085 ***
Rail available as an alternative mode (dummy)	-1.763 **	-1.781 ***
Bike available as an alternative mode (dummy)	2.045 ***	-0.288
OD of the typical trip (reference = CABA to CABA)		
Between CABA and GBA	-3.056 **	-0.986 *
GBA to GBA	-.388	-0.688 .
Constant	-0.216	-0.455

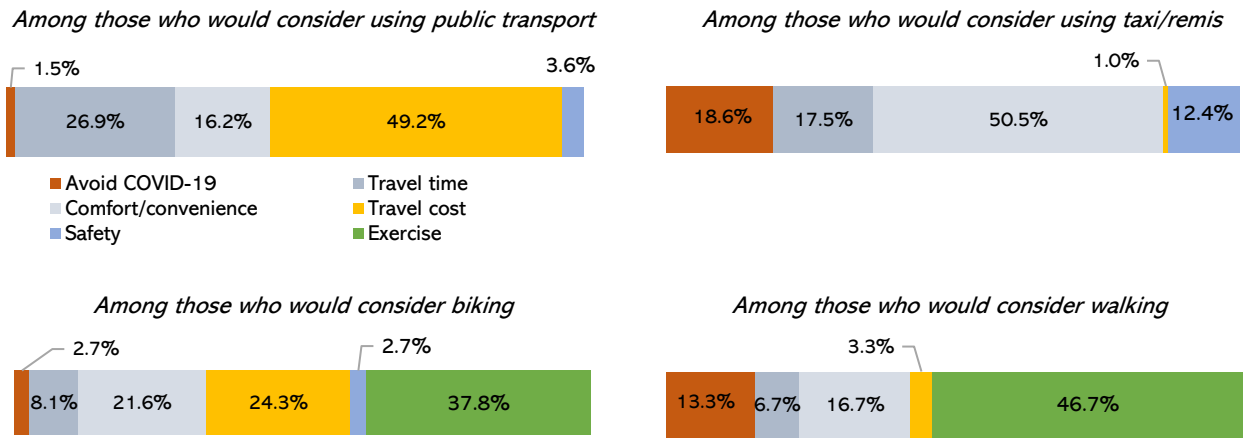
Note: *** and ** denote statistically significant results, * and . denote marginally statistically significant results
Source: Survey conducted by study team

By far the most commonly named reason for picking the specific alternative mode for the typical trip is the cost (35.7 percent of the respondents who would be willing to consider any alternative mode besides their private motorized mode), which is intuitively the main advantage of public transport or NMT over private motorized modes in the context of the low public transport fares. Travel time (22.2 percent) and comfort/convenience (21.5 percent) are the next main reasons. Safety, low risk of contracting COVID-19, and opportunity to exercise follow distantly, each with about 4.7 percent of all respondents.

Travel cost is the main reason among those who would be willing to consider using public transport for their typical trip, and cost is important also for those who would consider biking (Figure 66). Travel time is a relatively important reason for the motorized alternative mode choices (public transport and taxi/remis) but not for walking and biking. On the other hand, comfort/convenience appears to be especially important for those who would consider using taxi/remis. Taxi/remis is also perceived as the safest of the mode choice alternatives, as over 12 percent of those who would consider using it name safety as the most important reason, compared to less than 4 percent of those who would consider using public transport and less than 3 percent of those who would consider biking. Similarly, among those who would consider taxi/remis or walking as the most likely alternative mode choice to driving, a significant share would do so because of the lower risk of contracting COVID-19.

Finally, the opportunity to exercise is by far the main reason for considering biking and, especially, walking as an alternative to driving. In contrast, exercise is not at all a motivating factor for choosing any of the motorized alternative modes (public transport or taxi/remis).

Figure 66: The main reason for considering the specific alternative mode to driving (% of respondents)



Source: Survey conducted by study team

Finally, respondents were offered several hypothetical scenarios regarding changes in the cost or travel time of their current mode and alternative modes. The design of this part of the survey was a simplified version of a typical stated preference mode choice survey, given that the survey was conducted by phone, with the associated cognitive limitations in terms of the information that can be presented for each hypothetical scenario. Specifically, the scenarios used the respondent's typical trip of the past week as the reference and asked about whether or not the respondent would still continue using their private vehicle if: (1) the cost of private motorized travel increased due to an increase in gas prices; (2) the travel time by the private motorized vehicle increased due to congestion; (3) it were possible to conduct the trip by public transport in less time than by the current motorized mode; and (4) there was an option of using a safe ciclovia/bike path for the trip.

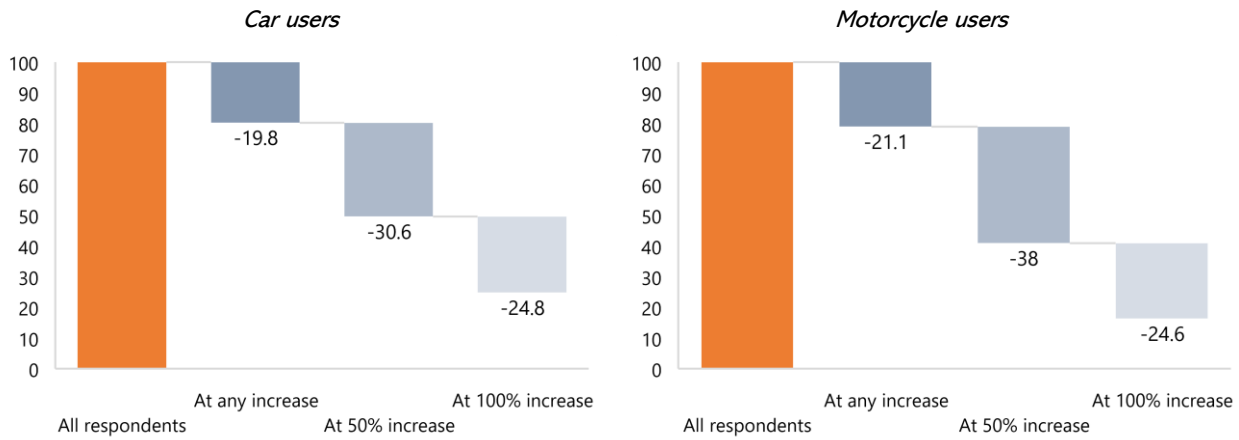
When asked about a hypothetical gas price increase, nearly 20 percent of the respondents stated that they would no longer use private motorized transport at *any* level of increase. Another 33 percent would switch to another mode if gas prices increased by 50 percent or more, and a further 25 percent would do so assuming the price doubled. However, 23 percent of the respondents would not stop using their private mode for the typical trip even with a doubling in the gas price. The share of those who would not shift to other modes even in this scenario is much higher among the car users (24.8 percent) than motorcycle users (16.4 percent) (Figure 67). Even some increase in the gas price would be sufficient for about 18 percent of CABA residents and 26 percent of GBA residents to switch to another mode for their typical trip.

About 16 percent of the respondents said they would discontinue using their current mode for the typical trip at *any* increase in travel time (such as due to congestion), and another 25 percent would follow suit at an increase of at least 15 minutes (Figure 68). However, about 23 percent of the respondents stated that they would continue using their private motorized vehicle even if travel time increased by an hour. CABA residents, on average, appear to be more sensitive to travel time increases compared to GBA residents, likely because of the better availability of alternative modes in CABA compared to GBA: at an increase of at least 15 minutes, nearly 43 percent of the current private motorized mode users living in CABA would switch to another mode, compared to 36 percent of those living in GBA. Similarly, travel time increase would incentivize mode switch among a larger share of the current motorcycle users compared to car users: if travel time were to increase by 15 minutes or more, nearly 48 percent of current

motorcycle users would discontinue driving, compared to about 38 percent of current car users.

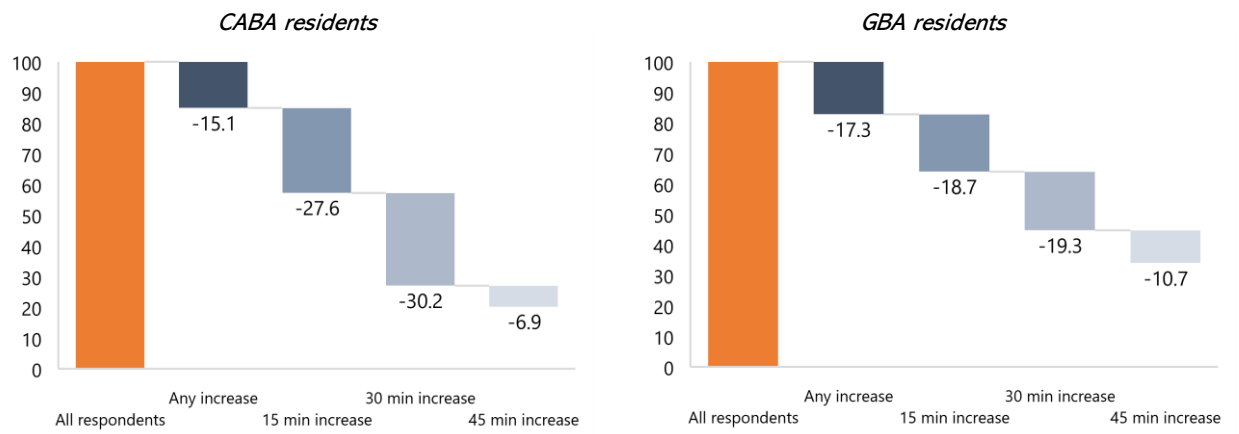
Among the current private motorized mode users who were not willing to consider switching to another mode even assuming a doubling in the price of gas, about 17 percent *would* switch assuming an increase in travel time of 15 minutes or more.[50] Similarly, among the current private motorized mode users who would not consider switching to another mode even assuming an increase in travel time by an hour, over 23 percent *would* switch at even a modest increase in the price of gas. In other words, about 4 percent of all current car/motorcycle users are not at all sensitive to price signals but are quite sensitive to changes in travel time, while over 5 percent are not sensitive to increases in travel time but are quite sensitive to gas prices.

Figure 67: Share of respondents who state they would discontinue using their private vehicle for the typical trip at different levels of increase in the price of gas (%), by type of vehicle currently used



Source: Survey conducted by study team

Figure 68: Share of current car/motorcycle users who would discontinue using their private vehicle for the typical trip at different levels of increase in travel time (%), by respondents' residence



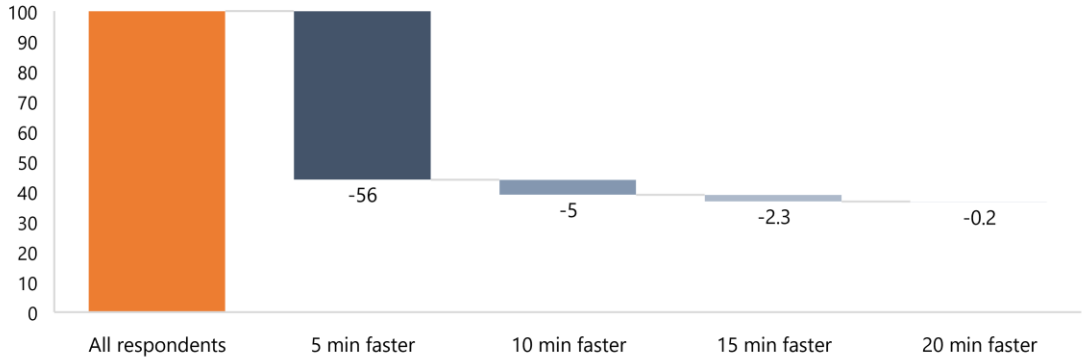
Source: Survey conducted by study team

A slightly different question asked about whether travel time *savings* compared to the current travel time by car/motorcycle would be enough of an incentive for switching to public transport specifically. **Most of the current motorized mode users (56 percent) would, in fact, switch to public**

[50] This is assuming the gas price stays as is.

transport even if they could save 5 minutes, but the marginal effect of yet additional time savings is quite modest, with only 7.5 additional percent willing to switch even if travel time savings reached 20 minutes (Figure 69). The share of those who would switch at even minimal time savings is higher if the respondent's typical trip is already of shorter duration,[51] which could be explained by the fact that the fixed costs associated with driving are more salient for these trips and any comfort advantages of traveling in private modes are easier to forego. Among the current car/motorcycle users who were not willing to consider switching to another mode even assuming a doubling in the price of gas, nearly 36 percent would switch to public transport if they could save even just 5 minutes of travel time. Younger car/motorcycle users (18-25) are much more willing than those above 55 years of age to switch to public transport even if 5 minutes of time could be saved by doing so, with the respective shares at 64 percent and 48 percent. Individuals with at least some university education – a proxy for higher income – are somewhat less willing to consider switching, but even among this group, about 50 percent would do so even at 5 minutes of savings.

Figure 69: Share of current car/motorcycle users who would discontinue using their private vehicle for the typical trip at different levels of possible time savings by using public transport (%)



Source: Survey conducted by study team

Finally, **nearly 30 percent of the respondents said they would consider using a ciclovia/safe bicycle route for their typical trip instead of the motorized vehicle**. The share of respondents who would do so is much higher among the current motorcycle users than car users (47.4 vs. 22.3 percent) and among women compared to men (43.3 vs.26.3 percent). The share of those who would consider this mode is particularly high among the respondents whose typical trips take place within GBA (40 percent) and even higher if the trip within GBA is currently up to 20 minutes long (48 percent).

[51] Two-thirds of respondents with trips currently requiring up to 10 minutes by car/motorcycle would do so, compared to 40 percent of those currently traveling over an hour.

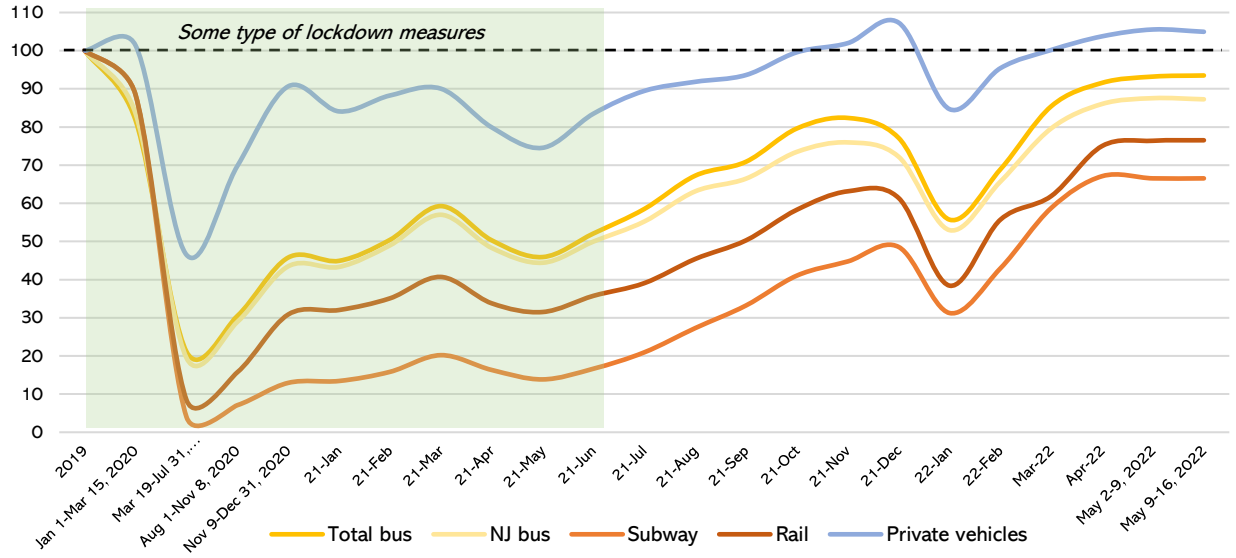
4. What does this mean for future mobility planning in AMBA?

4.1. How will urban mobility in AMBA evolve in the coming years in the context of the past and recent trends?

The trends in urban mobility patterns over the last two decades in AMBA can be classified as (1) being driven by a specific policy looking to achieve mobility goals (shaped by the organizations in charge of designing transport policy such as the National Ministry of Transport or the Secretary of Transport and Public Works in CABA) or (2) driven by a wider economic policy or external circumstances that in turn impacted mobility. The first group of trends includes the NMT policies pursued by CABA, as well as to some extent the investment in the subway and rail systems and the policy of maintaining low fares, especially in the rail and bus systems. It can be argued that the first of these was more successful in reaching its objectives, while the last has had more ambiguous effects. With respect to the second group of trends, the two main ones are the increase in private motorization rates in AMBA, especially GBA, and the gradually declining role of inter-jurisdictional trips and the bus routes serving them. In addition, as part of the same broader trends with an impact on mobility can be included the expansion of remote and hybrid work arrangements in certain sectors, e-commerce, and the emergence of new mobility solutions enabled by digital technologies. Some of these trends were first observed before the 20-year period, while others much later. They will continue to shape mobility in AMBA over the next decade, albeit with some modifications introduced by the COVID-19 pandemic.

As of May 2022, the effects of the pandemic and the lockdowns on transit ridership had tapered significantly but not nearly fully. Overall bus ridership had recovered the most, although less so on NJ routes, while ridership in the subway and rail systems – having initially fallen more significantly – was still 20-30 percent below the 2019 level (Figure 70). In short, having seen the most consistent growth in the decade before the pandemic, subway was hit the hardest by the pandemic and recovered the least, while the opposite was the case for the bus system. In contrast, vehicle flows on AMBA's motorways, dropping by about half in the first months of the pandemic, had recovered to their 2019 average already by October 2021 and exceeded it by March 2022.

Figure 70: Change in SUBE transactions and private vehicle flows on AMBA's motorways, 2020-2022 (2019=100)



Source: Buenos Aires Observatory of Mobility and Road Safety

4.1.1. Trends driven by policies looking to achieve specific mobility objectives

❖ A consistent policy to promote NMT in CABA

Cycling in CABA is the only mode that has shown a sustained growth in demand over time, increasing by orders of magnitude over the last decade. A strong increase in cycling trips took place also during 2020, the initial phase of the pandemic. In a context of falling overall trip numbers in CABA, cycling was the only mode that saw an absolute increase, growing from 323,000 trips (just considering the public bike system) in 2019 to 414,000 trips in 2020. While figures for 2021 show a fall in the number of trips to 385,000, in the context of other modes partially recovering their demand, the overall long-term upward trend in 2021 continued. The initial surge in the number of bike trips in CABA in 2020 was likely a result of occupancy restrictions in public vehicles, the requirement to have a "COVID permit", and the unwillingness to travel in crowded public transport.

The increase in cycling observed during the pandemic – at least in CABA – is likely to continue, given that Buenos Aires has the necessary characteristics to promote non-motorized modes. The average number of intersection density in AMBA is 167, while UN-Habitat considers that 100 intersections is a level that makes a city suitable for non-motorized trips (Mendiola and Gonzalez 2021). The "Work" motive is by far the most dominant in overall bicycle trips, and, while this may mean that bicycle trips could decline somewhat with the reorganization of work patterns (home-based work) in the post-pandemic context, it suggests that the bicycle infrastructure is already well targeted to serve this basic commuting need for many people.

The growth in demand appears to be closely linked to the targeted development of infrastructure and the network effect generated by the increase in the available kilometers of bicycle lanes; likewise, the public bicycle system gained momentum as the available stations increased. **Also with respect to the sustainability of this public policy in the future, there do not appear to be any direct threats in the next few years**. Infrastructure investment will likely continue to be favored by the CABA authorities, including investment in updated designs (e.g., enhanced segregation of bike lanes on Del Libertador Avenue) and addition of new corridors (e.g., on avenues), thus attracting new users. New programs may also be implemented, like incentivizing the shift from cars to cycling, and the identification of new revenue streams, such as from parking permits, to finance these programs. Expectations are that similar policies will be implemented in neighboring municipalities in GBA, with plans already introduced during the pandemic.

❖ Investment in the subway and rail systems

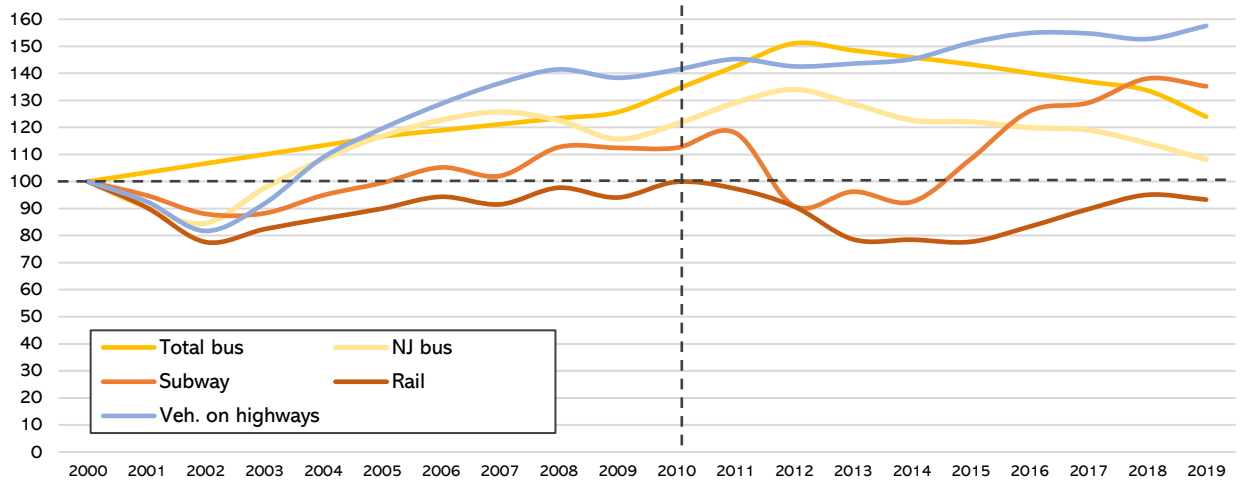
The expansion of the subway can also be included within this first group of trends, although the last wave of line extension started in the 1990s. An important characteristic of the subway expansion was that it was championed by both governments – national and CABA – throughout the years.

Despite the lower absolute ridership figures, subway was the only public transport mode that saw a relatively consistent increase in the last twenty years before the pandemic. In 2019, subway ridership was 35 percent above the 2000 level and also quite significantly above the 2010 level (Figure 71). In comparison, overall bus ridership and, specifically, NJ bus ridership were 24 percent and 8 percent, respectively, above the 2000 levels, but both were slightly below the corresponding 2010 figures. Finally, rail ridership in 2019 was slightly lower than in both 2010 and 2000. In the meantime, the number of cycling trips in 2010-2019 in CABA increased by orders of magnitude.

The subway is the only public transport subsystem that has increased fares substantially while also not seeing a fall in demand. That could indicate a better level of service than other modes, including as a result of not facing road congestion and frequent street protests. However, if the subway continues to increase its fares at a faster pace than the rest of the modes and the difference in their fare levels continues to widen, there is a risk that users shift to other modes, especially buses, where road segregated infrastructure has been built.[52]

[52] For example, Metrobus infrastructure was built on top of long sections of subway line D, making it attractive to travel by bus on that corridor.

Figure 71: Change in the demand for public transport services and vehicle flows on highways, 2000-2019 (2000=100)



Source: CNRT, INDEC, and Dirección General de Estadística y Censos

During the pandemic, the initial loss of passengers was more significant in closed systems with little ventilation, such as the subway, which has also meant a slower demand recovery than in other modes. Moreover, none of the future plans for the subway include extension beyond CABA boundaries into GBA. Current jurisdictional regulation and the fact that the system's operation and expansion is funded by the CABA Government makes it difficult to think of such a scenario in the short run. Current investment is being targeted at improving the level of service within the existing network, and the city's fiscal performance – combined with the technical challenges of implementing these types of complex infrastructure projects – may set limits to the expansion of the subway network in CABA in the next decade.

While no specific objectives were set in terms of ridership or level of service (the policy just aimed to modernize the infrastructure), **the rail system has shown improvements in service levels as a result of increased investments made after the accident at the Once train station, and these have been associated with demand growth or at least preservation**. For example, demand has grown significantly on the Roca line which has undergone a significant increase in electrification since 2015. The fact that the rail system is operating below the 1990s figures could imply that there is space and capacity to achieve a growth in demand. However, it is also possible that, going forward, the system could lose passengers as the trend towards the growth of trips between GBA's *partidos* strengthens, for which the railway system (radial trunk lines towards the center of the CABA) might not be well suited.

The rail sector is expected to receive most of the investment channeled to public transport in the next decade, with various projects being implemented or in preparation. **Its ability to attract new users and increasing its share of public transport trips will depend on rail being a convenient mode for shorter commutes**, which could be enhanced by developing transit oriented development (TOD)[53] projects around stations. It is also expected that the planned future works – construction of the Belgrano Sur viaduct and extension to Constitución, elimination of Sarmiento barriers, electrification of the San Martin line, incorporation of the fleet in various branches, comprehensive renovation of Belgrano Norte – could increase the relative attractiveness of the mode. However, the current fiscal constraints and the cancellation of some tendering processes create uncertainty regarding these projects and whether they will effectively be implemented.[54]

[53] TOD is generally defined as mixed-use development near, and/or oriented to, public transport facilities. Common TOD traits include urban compactness, pedestrian- and cycle-friendly environments, public and civic spaces near stations, and stations as community hubs (e.g., Keeling 2019).

[54] For example, plans for electrifying FC San Martin were recently postponed, and the tunnelling of the FC Sarmiento has been stalled since 2018.

- Fare policy and investment boosting certain types of bus services

Buses continue to be the main public transit mode, especially within GBA, and overall serve about 25 percent more trips than twenty years ago. Nevertheless, ridership in public modes – especially NJ buses and rail – saw a certain degree of stagnation despite the steady reduction in the relative cost of public transport when compared to private transport costs and wages. Even though public transport infrastructure was improved in 2000-2020 (and especially after 2010), the total number of trips by public transport have remained relatively steady over the past ten years (since SUBE records allow to make proper comparisons), at about 11 million daily trips.

The maintenance of low levels of commercial fares for public transport, with increases below inflation, could be classified as policy driven, aimed at preserved the affordability of the public transport system for low-income families.[55] At the same time, there has not been an explicitly defined public transport fare policy, and the fare structure is not necessarily defined or sized in a way that internalizes the public transport system's positive externalities. The way in which fares increased over the past years was highly irregular, and uncertainty remains as to what would have been the impact in terms of ridership had fare levels moved at the same pace as inflation. The continued relevance of the bus over the other public transport modes – despite even lower fares for rail services – might be explained by the levels of coverage the network presents as well as by the evolution of the overall urban economy (discussed below), with trips of more local nature gaining weight and more easily served by municipal and provincial bus lines than rail.

The relative price of public transport with respect to private modes (as well as to other goods and services) has fallen during the pandemic, as there have not been any fare increases since April, 2019. **Given the current context in which fiscal policy might be forced to target subsidy reductions, fare increases might be expected across all public transport modes.** If fares increase, there might be a shift to private modes, not only motorized, but also non-motorized, but there is uncertainty about how much the relative prices of different modes would have to change for people to actually change their mode of choice. The competitiveness of the public modes will greatly depend on how other prices vary in a context of high inflation.

Support to bus operations was further enhanced through the development and implementation of the Metrobus corridors over the past decade, with segregated bus lanes that were first implemented in CABA and then in GBA. Productivity gains have been significant in the corridors in which these have been implemented, with improved levels of service to users: depending on the specific Metrobus corridor, travel times were reduced by between 29 and 35 percent ((Ministry of Transport, 2019). However, for the foreseeable future, plans for Metrobus expansion are limited to CABA (Metrobus del Bajo Fase 2 is the only corridor being built, and another corridor, Alberdi/Directorio, is planned to be built); all previous plan for expansion in GBA have been halted. Given the current levels of congestion, commercial speeds for buses might therefore start to decline on the non-segregated bus corridors, impacting service quality.

4.1.2. Trends mostly driven by wider economic policies or circumstances

- Growth in private motorization rates and use of private vehicles on CABA-GBA routes

The drivers of private motorization in the past decades are many, including growing incomes but also increasing land values in CABA and the resulting suburban expansion, which was further fostered by the expansion of access road infrastructure that was part of the wider strategy for infrastructure modernization in the 1990s. The construction of the access roads to CABA, the development of gated communities, and the increase in the motorization rate are directly linked. Gated communities in the peri-urban areas generated a significant amount of associated employment: gardeners, domestic employees, electricians, maintenance staff, merchants, schools, health centers, shopping malls, etc. These jobs attracted settlers and increased the number of short trips for work reasons. This also to

[55] This was not only the case of public transport fares but other public services as well.

some extent changed the travel destination of the new developments' inhabitants, fostering a phenomenon that was already taking place: the growth of internal trips within those municipalities, and trips between neighboring municipalities.

The use of private modes in recent years has increased on AMBA's main access roads. Road expansion works have promoted the use of private vehicles for interjurisdictional trips, by reducing the associated travel times. Going forward, it is likely that the number of vehicles using the road access infrastructure might grow at a reduced pace, driven by increasing congestion and the emergence of home office as a possible work modality.

In addition to land use change, the growth in private motorization was also driven by rising incomes. Between 2003-2011, median income in AMBA more than doubled, at least to some extent explaining the increase in motorization rates. On the other hand, during 2011-2020, Argentina's economy barely grew. Overall, the evolution of the main socioeconomic indicators during the past two decades makes it difficult to identify structural trends: between 1994 and 2019, in 16 of the years the GDP grew and in 10 it declined, while since 2010, GDP grew in just 5 of the years. According to recent research by Lebrand et al. (2021), in countries across all income levels, the household expenditure elasticities of private transport are above 1 with respect to income, while expenditure elasticities for transport services are below 1. In other words, households spend disproportionately more on private transport as their incomes grow, although the relationship is stronger for car ownership than motorcycle ownership. Moreover, with rising incomes, households are not only more likely to own a vehicle (extensive margin) but also to use it more (intensive margin).

However, more recently, as the economy transitioned to stagflation[56], and restrictive measures were imposed in the private vehicle market – including a tax on sumptuary goods affecting most of the available vehicles in the market, and limitations on foreign currency availability thus capping imports – **the past few years saw a significant drop in the number of cars sold**.[57] While it doesn't seem likely that the private motorization trend could be reversed in the foreseeable future, the trend might be delayed for some time, creating a window of opportunity for public modes to retain or attract new users, if current levels of service are improved.

At the same time, during the pandemic, there was a significant population relocation to gated communities in GBA, as telecommuting – both for work and educational purposes – allowed to stay at home without the need to spend time commuting. Families that already had a house in a gated community opted for staying there as restrictive measures on personal movement were enforced, and there was a surge in property prices as more people decided to move to these communities.[58] As a result, **plans for new developments continued to consolidate through GBA**, and new gated communities are being built, especially in the western and southern areas.

Current figures indicate that private traffic has regained its pre-COVID levels, in a context in which public transport figures have not yet fully recovered. The number of vehicles through main access roads now stands at 101 percent the pre-pandemic level. **A threat lies in the potential reinforcement of the trend of population migration towards private urbanizations, leading to an intensive use of private cars**. There is currently uncertainty on how and to what extent will telecommuting be allowed in most industries after COVID, and if the new inhabitants of the gated communities would still find it optimal to permanently relocate to these areas should the public health situation change.

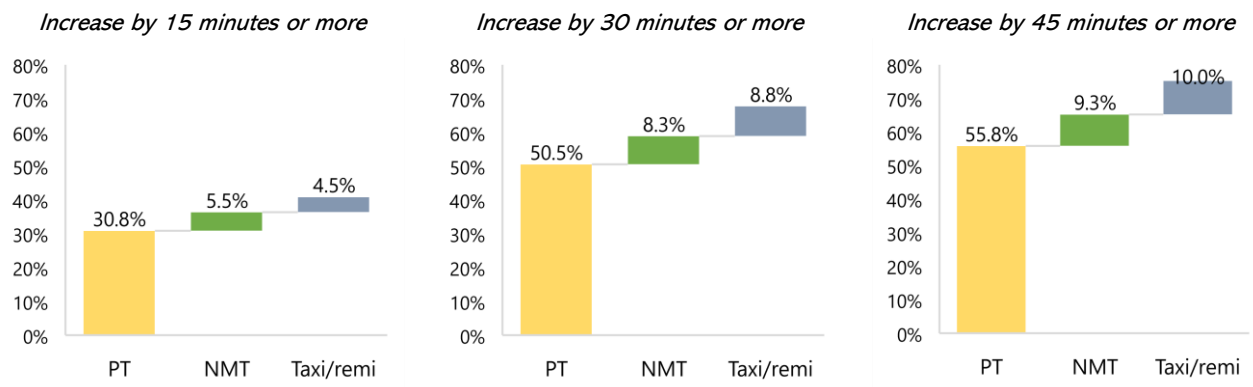
Nonetheless, the level of service of private transport will likely experience a decline as there is limited room for expanding access roads, either from a fiscal or land availability perspective. Therefore, travel times are expected to grow for a fraction of

[56] The combination of high inflation and limited growth.
[57] New vehicle sales peaked in 2017 with 883,802 vehicles sold. After that, annual sales dropped to 681,816, 368,806, 312,789 and 334,389 in 2018, 2019, 2020, and 2021 respectively. Source: ADEFA.
[58] The published rental prices in the Northern corridor in GBA (the area with the highest concentration of gated communities) grew strongly during the pandemic, increasing by 95 percent between March, 2020 and March, 2021. The increase in CABA in the same period was 23 percent (and 32 percent and 26 percent in the Western and Southern corridors in GBA, respectively). Source: Indicadores Inmobiliarios UdeSA – Mercado Libre.

commuters that live in gated communities in the second and third Ring, but also for poorer commuters living in GBA using motorized modes (either private or public).

The increasing congestion in AMBA over time, driven by the continuing rise in motorization (especially motorcycle based) and the limits to road expansion, is likely to impact the modal split to at least some extent. As suggested by the results of the stated preference choice survey, if private motorized travel times were to increase by at least 15 minutes, nearly 31 percent of the current car and motorcycle users would potentially switch to public transport, and another 5.5 percent and 4.5 percent would switch to NMT modes and taxi/remis, respectively (Figure 72). An increase in travel time by 45 minutes would be a sufficient incentive for about 65 percent of the current car/motorcycle users to switch to more sustainable modes (public transport and NMT), the effect being roughly the same as with a doubling in the price of gas. As with the price of gas, the marginal effect of the increase in travel time on potential mode switch diminishes at higher levels of increase.

Figure 72: Share of all current users of private motorized modes that would be willing to switch to an alternative mode for their typical trip (%), by hypothetical level of increase in travel time by private vehicle



Source: Analysis by the team, based on the stated preference survey implemented in February-March 2022

❖ Gradual shift away from inter-jurisdictional trips and the bus routes serving them

In the last decade, there has been a fall in the overall demand for bus services in AMBA, possibly explained by the economic crisis; on the other hand, a fall in the demand for NJ services appears to be due to structural causes, such as changes in the urban structure and the emergence of new centralities, the increase in private motorization, and the growth of alternative modes – development of bicycle lanes, subway extension, rail improvements, and the emergence of micro-mobility (Alzaga et al. 2021). There has been a progressive shift to trips that are more local in nature, which has led to a consolidation of the role of the bus compared to other public modes, but within the bus sector, to a greater share of trips in municipal and provincial lines. In turn, new municipal and provincial lines appeared allowing to better serve these types of trips.

The trend towards shorter trips and less CABA-GBA trips has been driven, among others, by the decentralization of public service provision. Structural changes in the job market might have played a role as well, with non-registered jobs and self-employment gaining share in recent years. Moreover, **over time there has been an increase in jobs in "non-defined destinations", including remote work and highly irregular work.** As per preliminary data from SUBE, the patterns of travel by public transport during the pandemic have changed slightly: CABA-CABA trips decreased their share even further, at the expense of increased trips between jurisdictions, as well as between GBA *partidos*. But, given the extent of the fall in overall trips, this change has to be carefully analyzed. According to the most recent EPH household surveys, the starkest change

appears to be a further increase of the share of people living in GBA and working either in GBA or in "non-defined destinations". These grew mostly at the expense of the share of trips made by people living in CABA and also working in CABA.

The structural trend would probably not significantly change as a result of the pandemic. Trips' ODs might temporarily show some changes compared to the pre-pandemic, but these likely reflect the fact that some economic activities have not yet fully recovered. As of April 2022, presential attendance is already being encouraged in workplaces, or at least hybrid schemes are being implemented. Full attendance is required for the elementary and high school levels in schools across AMBA. Universities might still implement hybrid approaches, but most of them would probably eventually return to the pre-pandemic modalities.

AMBAs bus system is characterized by low average productivity, even the sub-systems (MJ and PJ) that have grown the most, despite more proactive infrastructure and policy changes implemented in recent years to improve efficiency. If neither the trend in decreasing demand nor decreasing productivity is reversed, the need for subsidies is likely to continue to grow.

The average age of the bus operating fleet is one of the aspects that influences the perceived quality of the system, driven by the economic incentives implemented by the authorities, including the subsidy distribution mechanisms. There has not been a clear trend in the average age of the bus fleet over the last two decades; however, currently, the system is witnessing a period of fleet aging, with the NJ fleet average age at 5.6 years compared to 3.3 years in 2013. The recent increase in the average age of the fleet does not, however, constitute a structural trend, as it had declined significantly in 2005-2013. The more recent trend is, rather, a response the economic incentives launched in 2016 which do not encourage fleet renewal.[59] It is likely that the average age of the bus fleet, which picked up since 2016, will continue to grow, impacting the overall actual and perceived service quality of the system, considering that, as a result of the budgetary restrictions imposed by the pandemic, the maximum period for which a unit can provide service within the AMBA was extended from 10 to 13 years.[60]

- Expansion of telework in some sectors and emergence of new mobility solutions

Current figures show that the number of daily trips by public transport still lags with respect to the pre-pandemic levels, ranging from 60 percent of the pre-pandemic level for the subway system to 86 percent for the bus system. Within the bus system, the number of trips has reached 82 percent of their previous levels for the NJ lines but are at 90-91 percent for the PJ and MJ lines. **Whether the gap in ridership vis-à-vis the pre-pandemic levels will persist is uncertain, as many economic and employment activities are still evolving**. All public servants at the national level – around 700,000 in total, a majority of them based in AMBA – are set to return to their workplace by May 1st, 2022.[61] People in these positions might return to using public transport more intensively, so a further recovery of these modes might occur in the next months.

However, the pandemic may lead to more people working from home at least part-time also going forward rather than opting to make the daily commute. As presented earlier, trips to workplaces in AMBA initially declined by 90 percent in the first two weeks of the pandemic; and, while most of this drop was recovered within the following year, still, in the last week of March, 2022, the volume of trips to workplaces remained 8-9 percent below the pre-pandemic level. This share may represent either residents that continue to be concerned with the risk of the virus or, at least in part, residents who also in the future may continue to work remotely or in a hybrid work arrangement, with a lower overall intensity of work commute related trips.

If telecommuting grows over time, it might primarily affect internal CABA trips, as these types of work schemes mostly benefit higher-income people living in CABA working in or around Microcentro. Moreover, the current macroeconomic situation in Argentina provides a competitive advantage for overseas

[59] Frequent negotiations between the Ministry of Transport and the operators to update the cost of the system resulted in a reduction in the margin of the operation recognized by the Government in the cost structure, as well as an update in the cost of vehicle at a lower rate than inflation. This has led to a reduction in the rate of fleet renewal by operators.
[60] Resolutions 65/2020 and 66/2020
[61] As per a presidential decree (Resolution 58/2022)

remote work for foreign companies. Combined, these factors might affect trip generation rates or a shift to off peak travel to avoid congestion. Similarly, trip configurations might change at a more micro level if employer headquarters continue to move outside of the Microcentro, such as to more residential areas like Nuñez or Olivos, but this would not much affect the distribution of trips between CABA and GBA.

Work reasons account for about 40 percent of the trips in AMBA (over 60 percent if also counting study related trips), and **the territorial distribution of jobs and schools will not change very fast even if the pandemic-related trends -- such as increased propensity to work from home in certain sectors -- continue.** The CABA Government intends to redefine land use in the central business district, shifting towards more residential uses; however, this shift might take years to consolidate. On the other hand, there is a risk of potential reinforcement of the trend of population migration towards private urbanizations, leading to more intensive use of private cars. On the other hand, in the face of a possible change in travel patterns or in demand levels, frequency reductions for public modes would bring negative impacts to lower income population that depends on public transport.

As rent prices continue to increase in CABA, **more vulnerable populations can be expected to continue to move into GBA to be able to access the housing market**, as median rent prices for apartments are lower in GBA than in CABA, especially in the Southern and Western corridors.[62] Between 2017 and 2021, rent prices in the GBA increased by 303 percent (INDEC), compared to 454 percent in CABA (Dirección General de Estadística y Censos)[63].

Automation and digitalization are enabling a variety of emerging mobility services, such as shared mobility systems, demand responsive transport, and mobility as a service (MaaS). **The mobility restrictions imposed as a response to the COVID-19 pandemic reduced travel in the near term, but they have also accelerated a number of innovations that will impact mobility in the medium and long term.** For example, in urban logistics and last-mile delivery, the introduction of e-cargo bicycles for goods distribution and the introduction of new platforms to communicate, collaborate and meet online are modifying firms' location decisions and therefore the mobility patterns of people and goods. The full effects of these changes are still difficult to predict and are likely to vary across different population segments.

4.2. Implications for transport policy and planning

The transport planning authorities in AMBA can influence which transport behaviors remain more permanent after the crisis. As new mobility patterns emerge with the pandemic—such as increase in bicycle use—building on the lessons learned in the past can help ensure sustainable transport behaviors persist. Infrastructure investments can be crucial for building trust in public and active transport. On the other hand, pricing and regulatory policies can help – at least to some extent – incentivize less energy-intensive transport behaviors once the pandemic is over. Finally, as demonstrated by CABA's experience with cycling, public behavior change campaigns can work under the right conditions.

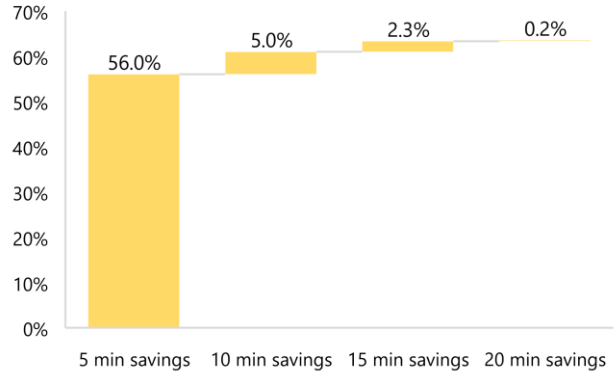
4.2.1. Public transport and NMT expansion and reorganization

During the last decade, price signals favored public transport. In order to be successful, however, price-based incentives have to be combined with infrastructure supply and improvement. As shown by the results of the demand elasticity analysis, ridership on most public transport sub-systems and routes in AMBA has historically significantly responded to changes in the v-km of service supplied and improvements in punctuality.

[62] Indicadores Inmobiliarios UdeSA – Mercado Libre, https://udesa.edu.ar/indices-meli/alquileres

[63] INDEC takes into consideration effective rent prices, while the methodology in CABA considers advertising prices. While prices at which contracts are effectively arranged in CABA might therefore be lower, the trend is indicative of how prices evolve.

Figure 73: Share of all current car/motorcycle users that would switch to public transport if able to save time compared to current private motorized travel time (%)



Source: Survey conducted by study team

Similarly, the stated preferences of the surveyed current car and motorcycle users indicate that improvements in the public transport *performance* could incentivize a significant modal shift from private to public transport. In fact, the results of the survey suggest that travel time savings of just 5 minutes by public transport compared to the current times by private modes would be sufficient for 56 percent of the current private mode users to shift from private to public transport (Figure 73). In other words, public transport would have to offer travel times that are on par with or slightly better than those offered by private motorized modes to be able to attract significantly more riders.

The patterns of private versus public transport use appear to be relatively set in the most well-off localities in AMBA where nearly half of the households own a vehicle. For example, the subway service, which is available in these localities, is commonly used also by residents that own private vehicles. Could public transport become a real option for higher income commuters living in gated communities in GBA? Currently gated communities don't allow for public transit within their premises, so better transfer facilities between private cars and rail would need to be developed. Rail attractiveness could be improved by enhancing services, running express services where possible – with different class cars that would allow for fare discrimination, – reducing headways, and providing better information to users, among others.

In the context of shorter average trips and less CABA-GBA travel, the bus system, with a greater coverage and flexibility to cater for more locally oriented trips, appears to be better adapted to also attracting the high-income individuals living in the gated communities. **However, increasing these residents' use of buses or trains will likely require changing their perception of these modes by improving the safety and security, comfort, and the objective aspects of journey time and frequency**. As suggested by the results of the stated preference survey, 36 percent of those current private motorized vehicle users who are not sensitive to price signals – i.e., would not switch to another mode even at a doubling in the price of gas – *would* switch to public transport if it offered even 5 minutes of travel time savings as compared to the current travel time by private modes.

Mendiola and Gonzalez (2021) developed a statistical model to estimate the effectiveness of public transport interventions in AMBA to estimate if all localities would respond similarly to policies aimed at promoting public transport. Their results show that in the poorer areas of AMBA people would not react to extended public transport supply, as cars are used for very specific trips (covering long distances), which would likely not be replaced by public transport. Similarly, in richer localities, people wouldn't turn to public transport more than they currently do as its negative reputation prevents them from doing so. So, **expanding public transit in the poor or the wealthy areas would have a statistically similar impact, but for different reasons**. This can partly be explained by the fact that only about 1 in 4 low-income households own a vehicle, so private transport use is limited, mostly intended for longer journeys and trips that are not feasible by public transport (on secondary roads, in sparsely populated areas, etc.). Also going forward, it is unlikely that public transport could be expanded to cover these types of routes/destinations, and the use of private vehicles would still be necessary.

Opportunities for mode shift towards public transport are likely the greatest in AMBA middle-income localities, where in the past improvements in public transport supply have led to increased public transport use and decreased private car use. The localities with a medium socioeconomic profile are located along the axes formed by motorways and

public transport lines and thus have both modal options potentially available. Around 36 percent of households in these localities have access to private vehicles, but it appears that some would be willing to switch to public transport for commuting if the offer were improved. Thus, in considering which rail improvement works should be prioritized in order to encourage sustainable mode shift or at least prevent a shift to private mobility, it is likely that investments in the Belgrano Norte or San Martin lines serving middle-income neighborhoods would have a bigger impact. On the other hand, considering rail improvements that will increase accessibility to jobs and services for low-income populations and encourage mode shift from bus transport, it is likely that rail investments in the Belgrano Sur line would have a higher impact.[64] Furthermore, given that in GBA in particular there has been a shift towards more local trips, investments in, for example, the Haedo–Temperley branch of the Roca rail line, connecting localities in GBA, could be an effective policy response.

The spatial analysis of NJ lines indicates a high degree of overlap, with 99 lines sharing more than half of their route with another line and 17 sharing more than 80 percent of the route. The overlaps are particularly concentrated in the Centro corridor, the Southwest, and the South. The overlaps imply a sub-optimal level of demand for each individual line. In April 2018, in only one in five lines did the total number of regular passengers (with 20 or more trips per month) exceed 30 percent of the total demand for the line for the month. Most lines have less than 200,000 unique monthly passengers. There are opportunities for rationalizing the network to reduce the overlaps; flexible on-demand solutions could be introduced to replace or supplement the underperforming routes. Similarly, in areas – such as large parts of CABA – where demand is lower than pre-COVID, an on-demand bus service could be introduced to replace some of the underperforming NJ bus routes, keeping transit available to those citizens while shifting the underutilized buses to support higher demand areas.

The MJ bus routes could be reorganized to make trips to rail stations more direct and efficient, and the services could be operationally better integrated with rail services, such as in terms of the alignment of arrival times and dedicated transfer infrastructure. The proposed reorganization and integration could benefit from some of the funds that are currently allocated to sustain the NJ bus system operations. In order to make a significant push towards sustainable mobility, there is also scope for cross-subsidization of multi-modal public transport and NMT development and future TOD projects from the tolls collected on the access roads and internal CABA highways.

The levels of concentration in bus operations are increasing, which may have benefits but also present a risk. The main risk is that a large company could influence the regulators by obtaining modifications in their routes and / or operating parameters to maximize their profits at the expense of consumer welfare. However, the larger company size would allow obtaining better prices from suppliers and more advantageous financing conditions, especially in times of crisis and delays in the payment of subsidies. There would also be some small economies of scale in the operation and maintenance. There may be an opportunity to move to a system of new contracts with operators of larger average size, seeking to improve average productivity.

The city administration and transit operators will need to work together in implementing regulations to create a safe public transport environment. As shown by the study's car and motorcycle user surveys, safety concerns and fear of contracting COVID-19 rank very highly among the mode choice factors among those who became users of private motorized modes only since the start of the pandemic. For example, agencies and operators can use data to improve the management of passenger flows in order to avoid excessive crowding, whether on buses, trains or in the stations serving them. The updated OD matrices, by mode, combined with improved real-time information on current occupancy levels, can help AMBA's transport planning agencies better understand when and where crowding may take place. For example, the National Government has already designed and implemented a mobile app for suburban train users to make reservations and

[64] The cost benefit analysis of the Buenos Aires - Belgrano Sur Passenger Railway Lina Modernization Project (P178067) shows that expected mode shift with the project from cars is about 8 percent of the total mode shift to the railway.

allocate spaces on trains and preserve social distancing, while improving the real-time availability of data on expected demand.

Transit Oriented Development

Overall, private vehicle use has tended to be lower in those parts of AMBA that are characterized by a broader range and density of public transport. However, to prevent a shift to private motorized mobility going forward – **in the post-COVID context where an increasing share of the population may be considering moving to lower density environments but do not necessarily want to live in gated communities that lack sustainable connectivity options – public transport supply must be accompanied by a proactive land use policy.**

Recent expansions of the subway system have not resulted in noticeable increases in population density in the direct vicinity (i.e., a densification effect due to improved accessibility). In the case of the extension of line D, the area already previously had high population density. Line E has very low levels of traffic outside the central area, and population growth in the vicinity of the line has been weak. **The densification of the areas served by the subway thus appears to require additional policies complementing the extensions** (Müller 2021). Line H, the first in recent years to expand to a low-income and low-density area, has benefited from government actions to proactively adjust land use (creation of the Technological District in Parque Patricios, relocation of government offices to the City's southernmost districts). The confluence of both effects should be further analyzed to understand whether complementary measures and government actions beyond infrastructure expansion have significant positive effects in terms of density creation and, thus, maximize the ridership benefits of investments in guided modes.

Going forward, the rail infrastructure provides a good opportunity to engage in TOD projects to densify areas around train stations, especially in Rings 1 and 2 and attract middle-income households to move into these areas and avoid the connectivity limitations associated with living in the more segregated gated communities. Transit-oriented developments near rail could foster multimodality by setting the right incentives and policies that would expand the effective rail coverage area by integrating rail services with NMT or municipal bus lines. Increasing density near stations and modal integration with bus would require joint work between municipal, provincial and national authorities; stations and rail lines are federal jurisdiction, while the provincial authorities would regulate land use, and municipalities could provide local incentives for investments and redevelopment. In this regard, the Metropolitan Transport Agency could play a key role in coordinating the different jurisdictions in terms of bus planning and management to enhance such multimodality.

As the expansion of gated communities in GBA continues, **public policies can be oriented toward the generation of new mixed-use centralities, thus helping avoid long commuting trips from GBA into CABA**. For example, many private schools with headquarters in CABA have opened branches in GBA next to these communities. Moreover, there is an opportunity to avoid the intensive use of private modes by complementing these trends with economic incentives for companies to adopt telecommuting.

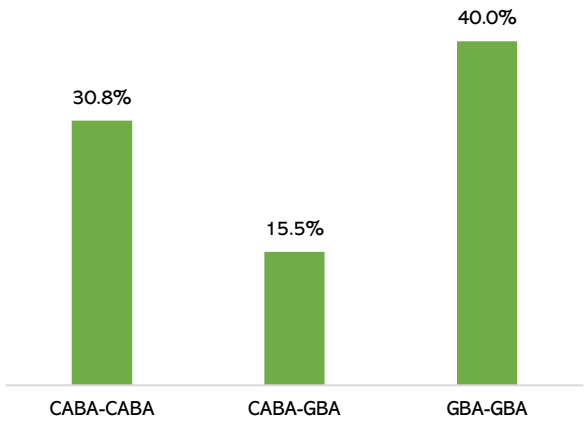
Modeling by ITF (2021) of the impacts of enhancing TOD in a macrozone in northern AMBA assumes that public transport access time would thereby decrease by 10 percent, making public transport more attractive to the users and increasing the mode share of public transport, while increasing population near transit hubs would reinforce this effect. The results show that **implementing TOD would increase the passenger-km by public transport originating in the macrozone by 13 pp compared to the reference in 2050**, while also reducing private vehicle mode share by 3.5 pp.

Investing in Non-Motorized transport

The strategy set forward to prioritize NMT in CABA is an example of a public policy that was sustained over an extended period, and **the potential for cultural change – such as away from cars and towards walking and biking – is more likely to be realized when a long-term policy is put in place.** Even though its impact in relation to overall trips in AMBA is limited, partly because of its so-far restricted geographic scope, the cycling policy is an example that could be learned from for metropolitan public transport planning.

Mobility in AMBA over time has become more "local" in nature. One-third of the public transport trips in AMBA are less than 5 km long, and the metropolitan area overall produces 1.7 million short trip chains per day (with each leg less than or equal to 5 km and a total daily trip distance of less than or equal to 15km), of which 500,000/day are in CABA (Anapolsky 2020). This trip typology suggests that **a policy aimed at promoting non-motorized travel could attract users throughout the metropolitan area and could gain increasing traction in the post-COVID context** of heightened aversion to enclosed public spaces/vehicles. Indeed, as shown by the CDR data analysis comparing the pre-pandemic period (October 2019) with the "new normal" (October 2021), the share of trips spanning 2.5-7.5 km has seen the biggest increase, corresponding to trips that could feasibly be made by cycling. Over 60 percent of the trips made in AMBA are trips in GBA *partidos* without entering CABA, and of these almost ¾ are made within *partidos*, with implications for the mobility system. For example, in the southern and western municipalities, the second most used mode is NMT.

Figure 74: Share of current car/motorcycle users who would consider biking instead of driving, if a ciclovia were available for their typical trip



Source: Survey conducted by study team

Also as suggested by the results of the stated preference choice survey, **the share of the current private motorized mode users who would be willing to switch to cycling for their typical trip if a ciclovia were available to them is by far the highest among those whose trip takes place within GBA** (40 percent). However, even among the respondents who travel between CABA and GBA, over 15 percent would consider this mode (Figure 74). According to a model developed by ITF (2021), even expanding the bike-sharing system in CABA would increase the growth in cycling-km in 2015-2050 by 74 pp compared to the reference scenario, while enhancements in the pedestrian infrastructure would increase the share of walking in the central CABA's modal split by 2.3 pp.

Given the context in which local and shorter trips concentrated within the GBA *partidos* are gaining share, **fostering NMT through investment in segregated cycleways and provision of public bike-sharing systems could be effective at expanding cycling in GBA in the near-term future**. Indeed, some local governments like Tres de Febrero, Lomas de Zamora, Quilmes and Berazategui and the national Ministry of Transport have begun to work on projects to develop dedicated bike lanes that would benefit short trips in GBA. In addition, there are opportunities to expand the availability of additional demand-responsive modes of transport by partnering with micro-mobility service providers (e.g., shared scooters), especially during rush hours and in case of overcrowding on public transit, as people return to their daily lives.[65] Ciclovías should follow the same standards as those in CABA, segregated and with good pavement quality, but also providing improved lighting so this could be a safe alternative in terms of personal security.

An increased focus on micro-mobility can also be particularly effective at serving the mobility needs of women whose average travel distance is only 4.77 km compared to 6.72 km for men (Quiros et al. 2014). Moreover, as suggested by the results of the stated preference modal choice survey, among the current private motorized mode users, women are much more likely than men to state that they would

[65] Given the low public transport fares, however, it is to be determined whether these types of providers could in fact develop a sustainable business model in AMBA.

consider biking if a ciclovías /safe bike route were available for them to conduct their typical trip.

There are no current comprehensive data on how many rail, subway or Metrobus stations are physically integrated with NMT modes. However, it is clear that **there is an untapped opportunity to deploy NMT infrastructure prioritizing rail and subway stations as the hubs for trip attraction in GBA in order to improve rail ridership** (both for GBA-CABA trips but also for GBA-GBA trips), with infrastructure within stations (safe storage, access ramps, surveillance cameras, etc.) and a better allocation of space within rail cars to foster multimodal trips. Ciclovías could be built between train stations and main residential areas, the municipalities' civic centers, and, where available, public universities, which tend to attract trips from within the municipality or neighboring municipalities. The City of Buenos Aires has already started deploying bike racks inside subway stations, with initial plans to pilot the scheme in eight subway stations,[66] complementing the recently introduced possibility of travelling with bicycles in subway cars.[67] Several municipalities in GBA are also deploying safe storage facilities in the vicinities or rail stations to foster multimodality.[68]

The success of the NMT policy in CABA to increase demand and attractiveness of active modes suggests that proper planning over time can effectively contribute to modal shift to NMT. However, it has to be taken into consideration that the urban context in GBA is different from that in CABA. While CABA has a relatively high level of personal security, good road infrastructure, and cyclists are predominantly young male adults, in parts of GBA there are significant security concerns and many of the short trips are carried out by women accompanying their children to school or for traveling for various errands. Still, as in CABA, **if proper infrastructure is built, especially if it is integrated with public transport modes, it is likely that the share of trips using active modes will increase**, even if at the expense of a share of the short-distance public transport trips.

The ATM can play a cross-cutting role in the post-COVID recovery context. It could build on the Plan developed in 2018, by updating the baseline and defining concrete and measurable objectives for shifting towards public and non-motorized modes and by considering the entirety of the transport network in AMBA as an integrated system. The long-term implementation and adjustment of the Plan should be supported by regular and consistent surveys – or use of appropriate "big data" – that would allow to better understand the evolution of the main parameters of metropolitan mobility and anticipate more structural changes.

4.2.2. More selective road infrastructure investment

Most of the access roads to CABA are currently managed by private concessionaires, but modernization works are either funded (directly or via toll increases) or authorized by the public authorities. In order to reduce the incentives for private motorized mobility, authorities could limit further expanding the radial access road capacity while **increasing investment in road safety and improving the connectivity between the access highways and public transit infrastructure** – for example, the connection between the Belgrano Norte line and the Pilar branch of the Acceso Norte – thus fostering multimodal integration.

Additional road space could also be allocated to public transport corridors, such as following the example of the Metrobus segregated corridor on the 25 de Mayo highway in CABA. Bus lines travelling over greater distances in AMBA are frequently confined to "colectoras", which are slower traffic lanes besides the main road, or have to share space with the general traffic, thus reducing their commercial speeds and attractivity. Segregated lanes could be enforced on main access roads – even if only operational at certain times of the day. Bus stop infrastructure on the access highways could be improved to improve current user experience, by adding better shelters, real-time information, and enhanced ramps and staircases for people to access the elevated stops.

[66] https://www.buenosaires.gob.ar/subte/noticias/semana-de-la-movilidad-sustentable-bicicleteros-en-el-subte
[67] https://www.buenosaires.gob.ar/subte/noticias/viaja-en-subte-con-bicicleta-o-monopatin
[68] Tres de Febrero, San Isidro, Morón, San Miguel and Lomas de Zamora are some of the municipalities that have already installed safe storage places.

4.2.3. Pricing tools

The public transport system was hit hard by the pandemic at a time when it struggled to meet sustainable coverage from fare revenues. Among other factors, the price of public transport compared to the other modes declined in the last two decades as a result of the several discount schemes that were introduced into the fare structure, and the decline in public transport ridership over the past 24 months has further worsened the financial unsustainability of the transit system and poses some challenging questions for the future of the system. **The change in relative prices in favor of public transport are likely to have played a role in preserving the share of trips in public transport in relation to trips in private transport**. Rail is the most heavily subsidized system, with subsidization rates having increased from 7 percent of the companies' income in 2002 to about 95 percent currently. As the government is the operator of around 85 percent of the rail services (and provides subsides to cover the operating deficit of private operators), it faces a trade-off in terms of resource allocation between funding operating subsidies to maintain low fare levels while also being responsible for infrastructure development and preservation of service quality. Even in a context of increased ridership in 2021, the lag in fare increases combined with recognition of higher public transport service operators' costs, means that the "new normal" for the public transit system in AMBA will be characterized by very low cost recovery that could only be overcome by a strong increase in average fares, or by a significant reform process.

Analysis of the longer-term response of public transport ridership to changes in fares suggests that there is certainly room for increasing fares on the vast majority of bus and rail routes without jeopardizing ridership. The elasticity of demand with respect to fares is either statistically non-significant or marginally significant and low in magnitude on most of the bus lines (except individual lines that are mostly concentrated in northern and western AMBA), and there appears to be a small demand response to fare changes on either of the rail lines.

Assuming a public transport fare elasticity of between 0.1 and 0.4, which is higher than the elasticities estimated for AMBA by the current study, ITF (2021) modeled the impact of a 20-percent fare increase every five years over 2030-2050 across the metropolitan area. Their results show that this level of fare increase would be expected to reduce the 2015-2050 growth in public transport p-km traveled by only 1 pp compared to the reference.

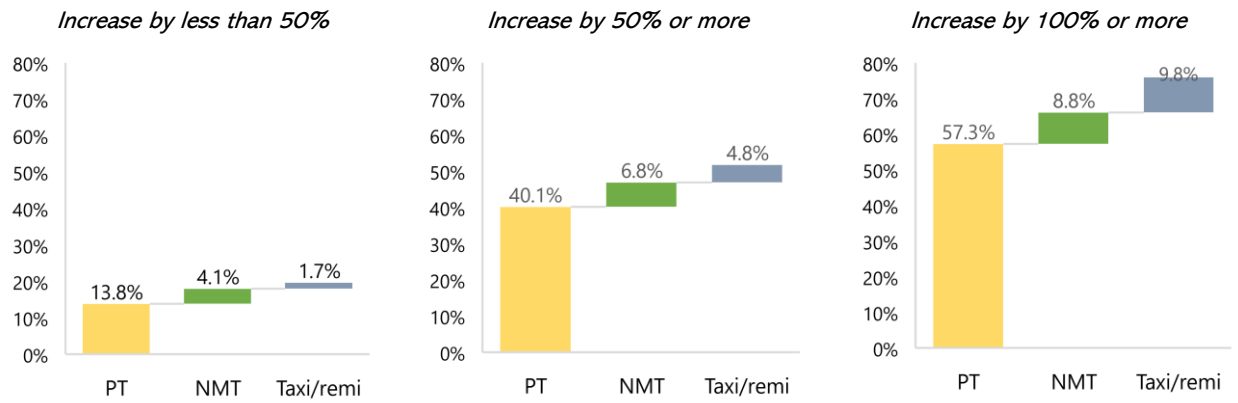
An important aspect for the development of an integrated system is the deepening of the price signals, including not only public transport fares but also road pricing, gas taxes, tolls, and licenses for Uber-type services. Financing can be better targeted to optimize accessibility and connectivity. For example, some level of cross-subsidization could be implemented via the Metropolitan Transport Agency to support public transport. For example, a small surcharge on road tolls could fund infrastructure that would improve the level of service for public transport, following a similar model as was implemented in 2002 whereby subsidies for public transport started to be funded by a surcharge on diesel fuel.[69]

An increase in the price of gas, such as through increased taxes, would likely have at least some impact on mode choices in AMBA, as suggested by the findings of the stated preference survey implemented by the study team. At a 50-percent increase in the price of gas, it could be expected that approximately 40 percent of the current car/ motorcycle users would shift to public transport, and an additional 7 percent and 5 percent, respectively, would shift to non-motorized modes and taxi/remis (Figure 75). At a doubling in the gas price, about two-thirds of the current private motorized mode users would switch to either public transport or NMT, and another 10 percent to taxi/remis. However, these assumed price increases are rather large and also somewhat difficult to interpret in a high-inflation context; increases of such magnitude are much more likely to result from external factors such as logistics bottlenecks and limitations in the global supply of gas rather than from local policy.

[69] The relevance of diesel surcharge has fallen in relative terms over time, and the subsidy is currently mostly financed by treasury funds coming from general taxation.

Modeling by ITF (2021), similarly, suggests that a **gradual application of transport pricing tools would have a relatively limited effect on the modal split and CO_2 emissions.** For example, implementing an AMBA-wide increase by 25 percent in parking prices for cars and motorcycles every five years until 2050 would result in a reduction in the growth of private car p-km in 2015-2050 by 4 percentage points compared to the reference scenario and a modest decline by 0.8 percentage points in the modal share of private vehicles in 2050. Similarly, the introduction of congestion charging in central CABA for cars, motorcycles, and taxis would have a relatively small effect, increasing the growth in public transport p-km in 2015-2050 by 2 percentage points and reducing private vehicle mode share by 0.8 percentage points in 2050. Each of the measures would be expected to reduce the growth in CO_2 emissions in 2015-2050 by 2 percentage points.

Figure 75: Share of all current users of private motorized modes that would be willing to switch to an alternative mode for their typical trip (%), by hypothetical level of increase in the price of gas



Source: Analysis by the team, based on the stated preference survey implemented in February-March 2022

4.2.4. An agenda for improving the financial sustainability of the bus system

Several actions can be taken to progressively improve the financial sustainability of the bus network.

Governance consolidation: The level of bus service and the system's productivity could be improved by reorganizing the current network of bus routes according to the current and expected ODs, and reconsidering whether the regulation of the system – divided into the national, provincial and municipal jurisdictions, each with different incentives and objectives – is working. Many municipalities in AMBA do not have the required technical skills to produce efficient networks that would improve productivity. Moreover, the lack of proper infrastructure (like paved roads) means that bus companies operate their lines where possible, leading to inefficiencies. By means of jurisdictional agreement within the ATM, current operational permits could be consolidated as "metropolitan permits", to avoid the routes and operations be affected by jurisdictional boundaries and competition between jurisdictional levels, and thus allowing for more flexibility, less overlaps, and better integration of the services. The integration of bus lines under a single jurisdiction would allow setting homogeneous parameters and consistent business rules across AMBA. A single system would be easier to optimize, with more flexibility in terms of frequencies and headways according to the time of the day, different route segment according to demand, etc. Metropolitan permits would also allow for fleet interchange between companies and between lines from different jurisdictions, thus possibly reducing the size of the overall fleet that needs to be maintained.

Route Network rationalizing: There is a high degree of overlap between bus routes, which could be rationalized by designing a simpler network without affecting coverage. The updated OD matrix specific to public transport should be considered to identify the truly redundant routes. KPIs should be used that could identify the various degrees of overlapping, but

also characterize lines into trunk or feeder, for example. This would allow designing a network in which trunk routes run along rail corridors, and feeder lines serve neighborhood access needs, as well as better allocating supply to complement rail services, ultimately aiming at better accommodating shorter and more frequent trips. High level parameters should be designed, and each type of service should be guided by those standards (for example, no one should be more than 10 minutes away from a bus stop, not just considering the physical distance but also frequencies). Occupancy factors should determine supply, types of services, and types of vehicles to be operated. New last-mile services could be added, operating smaller vehicles, to improve accessibility in low density environments as efficiently as possible.

Improved infrastructure to improve productivity: The deployment of a hierarchized network should be supported by dedicated infrastructure, including through building additional segregated infrastructure that would improve commercial speeds, especially in GBA, reducing the gap with CABA in terms of the availability of paved roads, shelters, and information at stops and, thus, overall user experience. Consolidating the governance of the system would also make it possible to provide better in-vehicle information to users to promote transfers, by means of installing screens in buses, subways, rail cars, and in stations.

Reducing operational expenses: As the greatest operational cost is that of drivers (around 50 percent), when looking to reduce the extent of the system, not every driver should be replaced when they retire.[70] Through discussions with the unions, the drivers' time allocation could be improved. Many of the routes are not well tailored for the current 8-hour daily schedule, leading to extra hours or not being able to program a driver for the entire daily time. Negotiations to implement flexible hours considering a 160-hr month allowance would improve the system's financial performance.

Reconsidering the subsidy scheme: The current subsidy scheme could be reassessed so that not all lines are benefited equally, given their significant differences in terms of their operational parameters. While some lines can be considered social lines (they have to be operated because there is no other accessibility option for people living in the area), other lines operate in dense corridors with improved infrastructure allowing for higher commercial speeds, so their operations are naturally more productive. More analysis to understand the productivity and real cost per passenger should be carried out, at a more micro level. Considering the breadth of the SUBE data available, a competitive scheme that awards subsidies based on supply requirements could be designed and implemented, favoring lines that require subsidies in vulnerable, lower-demand areas.

4.2.5. Data Alliances for mobility planning

The proliferation of mobile devices, the widespread adoption of geolocation technologies and the increasing digitization of mobility have given rise to new data sources with enormous potential to complement, enrich or even replace data sources traditionally used for mobility analysis and transportation planning. Many of these new data sources are in the hands of private entities, so it is of interest to explore the establishment of data partnerships from which cities, the private sector, and society as a whole can benefit. Data collected by public authorities and private companies are often complementary, so both the public and private sectors can benefit from the establishment of data sharing agreements, generating important benefits for the city in the short, medium and long term.

The establishment of mobility data exchange agreements between the public and private sectors is of interest to different stakeholders.

- **Private companies** that share their data can obtain in return various compensations, either in the form of financial or other types of remuneration (e.g. privileged access to data from public sources that allow them to improve their service); in addition, companies can obtain a return in terms of visibility and corporate reputation.
- **Transport authorities** can collect information of better quality and/or at a lower cost than information obtained through traditional

[70] An estimated 45,000 drivers are employed within the system and approximately 6 percent of them retire each year.

approaches, reducing the cost of data collection processes and thus improving decision-making processes related to mobility planning and management.

There are numerous international initiatives focused on data sharing. Some of these initiatives are global in nature, such as the World Bank's Development Data Partnership, while many others are more local. Initiatives can be public or private and can be classified into different categories:

- **Advice and support:** initiatives aimed at providing guidelines and best practices on how to define policies and collaboration agreements for data sharing. These initiatives may also offer documentary support (e.g., standard templates for licenses of use), tools (e.g., platforms for interaction between stakeholders) or other value-added products and/or services (e.g., legal advice).
- **Data exchange:** two or more entities exchange data without economic transactions between the parties, so that each party benefits from the information provided by the other parties. A particular case is that in which only one of the parties shares data with the other; usually this type of collaboration is part of the corporate social responsibility activities of the company providing the data.
- **Data-driven products**: the developer integrates one or more data sources (private and sometimes also public) to provide value-added products to the end user. The data may be provided in raw form or with minimal processing (e.g., pseudonymized location data from shared vehicles), or information generated from the raw data (e.g., trip matrices generated from pseudonymized location data from mobile devices). The developer may be the owner of one of the data sources or a third party acting as an integrator and entering into agreements with the owners of the different data sources.
- **Marketplace:** the developer offers a single point of access to a set of data. Usually different types of data are offered from different providers, but there are also initiatives that offer data from a single provider.

Buenos Aires already has experience with several data sharing initiatives, including (1) the cross-licensing agreement between the Government of the City of Buenos Aires (GCBA) and Google Inc. and (2) the Transportation API for developers. The first of these consists of an agreement through which the City accesses private data to improve mobility management; the second is an initiative oriented towards private companies that require access to public data in an organized and continuous manner, but at the same time it can also be configured as a mechanism for companies to share information with GCBA.

(1) In 2016, an agreement was signed between GCABA and Google Inc, operator of the real-time navigation and traffic service Waze, with the purpose of granting each other license to use their traffic data to optimize traffic efficiency. The agreement is still in force today. Google provides the GCABA with a license to use Waze data (limited to the scope of the City of Buenos Aires), while GCABA grants Google a license to use its traffic data.

(2) Buenos Aires has had an open data policy since 2012, when Decree 156 was issued and the BA Data portal was created. BA Data[71] is an open data platform where information assets from all areas of government are centralized and accessible. BA Data collects more than 300 datasets, including 54 mobility datasets. GCABA has developed the Unified Transport API,[72] which combines data for each transport mode, with the same format and consistent structures, allowing access to the same types of data for all modes of transport quickly, facilitating the development of multi-mode applications.

There are several opportunities to improve the mobility information available in Buenos Aires through access agreements to non-public data.

- **Using cell phone data to update mobility diagnostics**. The characterization of mobility patterns in Buenos Aires is mainly based on the

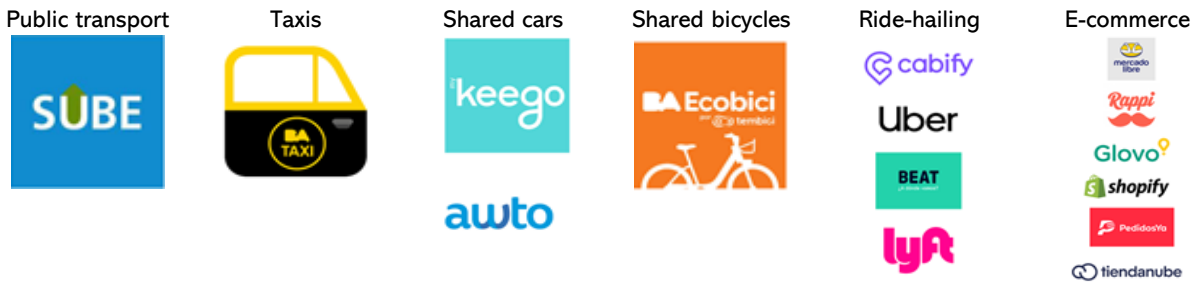
[71] https://data.buenosaires.gob.ar/

[72] https://www.buenosaires.gob.ar/desarrollourbano/transporte/apitransporte

Household Origin-Destination Survey (ENMODO), the last of which was conducted in 2010, so the available information is now obsolete. The use of cell phone data, taking advantage of the knowledge generated in the present project, would enable a periodic or even continuous monitoring of mobility patterns, allowing the detection of changes in such patterns and facilitating the updating of AMBA's transport models.

- **Making use of SUBE card data** for a better characterization of public transport demand. SUBE card data allows constructing matrices of trips between stations, stopping points, and transport zones, which would allow monitoring public transport mobility continuously and build predictive models; this information could also be combined with OD matrices of total mobility obtained from cell phone data to obtain matrices by mode of transport on a periodic or continuous basis and keep the city's transport models updated. Work is already underway in this area, but there are opportunities for improvement in data storage, processing and analysis and modeling capabilities in order to obtain quality results more quickly.
- **Making use of Waze data for transportation planning.** To date, these data are used solely for traffic management purposes; however, its use could be extended to transportation planning as well. Some of the uses to be explored in this area are the estimation and updating of network speeds and the estimation of vehicle volumes, among others, in order to feed strategic transportation models and monitor the evolution of road traffic.
- **Making use of data from different mobility services.** There are currently a variety of urban transport services in Buenos Aires, both passenger and freight, based on digital platforms that collect information on aspects such as user profiles, vehicle trajectories and users' use of the services (see overview in Figure 76). These data sources could help mitigate some of the city's mobility information gaps, such as the absence of information on cab services, new mobility services (ride hailing, shared mobility) and freight mobility. However, the city does not currently have mechanisms in place to leverage the data generated by these services.

Figure 76: Transportation services available in Buenos Aires based on digital tools



Based on the review of the existing public data and the past experience of Buenos Aires with data sharing initiatives with the private sector, a roadmap was developed for the establishment of non-public data access agreements in Buenos Aires. The proposed roadmap includes 6 pilot projects, giving priority to obtaining information on the transport modes with the highest share. Data on other modes, such as ride hailing and shared mobility, is considered less urgent, although their importance is expected to increase in the coming years.

There would likely be important synergies among the proposed projects. For example, the second proposed project (see Table 10) would directly complement the first. The simultaneous implementation of both projects would allow integrating the information extracted from the SUBE card in the data fusion processes of Project #1, obtaining more detailed and higher quality matrices by mode. Projects #4 and #5 would build on the knowledge and experience gained from the previous data sharing initiatives (e.g., the Waze agreement).

Table 11: Roadmap for the establishment of data access agreements with private entities in Buenos Aires

Description	Priority	Scheme	Proposed scope	Expected impact
1. Periodic/ continuous updating of OD matrices from cell phone data.	High	Acquire data and/or services through public bidding	Continuous or periodic acquisition of OD matrices according to segmentations of interest (time of day, trip purpose, mode of transportation, etc.). The frequency of updating the information will depend on budget availability.	Monitoring the evolution of transport demand; possibility to more frequently update AMBA's transport model.
2. Development/ acquisition of a software solution for the generation of public transport OD matrices from SUBE card data.	High	Acquire data and/or services through public bidding	Acquisition of a software solution for obtaining matrices of stages and trips in collective public transportation and other indicators of interest (e.g., travel times, transfers, occupancy levels, etc.) from the processing and analysis of SUBE card data. Continuous/ periodic and/or on-demand generation of indicators.	Detailed and updated knowledge of the use of collective public transport, which will make it possible to evaluate the impact of mobility policies, adapt supply to the evolution of demand, optimize the operation of the service, etc.
3. Improved mobility monitoring and prediction tools.	Medium	Acquire data and/or services through public bidding	Development of an interactive scorecard for continuous mobility monitoring and analysis using data generated in Projects 1 and 2. Development of a methodology for the improvement and periodic updating of the strategic transportation model using data generated in Projects 1 and 2 and other available data, such as speed data available through the agreement with Waze. Improvements may include aspects such as incorporating tour information.	Monitoring evolution of transport demand (e.g. to assess the impact of mobility policies, adapt supply to the evolution of demand, etc.). Increasing the capabilities and reliability of the strategic transport model.
4. Freight transport data access agreements	Medium	Data Sharing Alliance / Data Donation	Design & implementation of data access agreements for private companies with significant participation in urban freight transport. Development of infrastructure and capabilities for data access, storage and use. Access to urban freight transport data in a continuous and standardized manner to carry out analyses that feed into mobility planning/operations.	Better understanding of freight transportation behavior, which in turn will allow for better mobility planning and regulation decisions.

5. Individual public transport data access agreements	Low	Data Sharing Alliance / Data Donation	Design and implementation of data access agreements for private companies with significant involvement in individual public transport (e.g., cab payment applications). Development of infrastructure and capabilities for data access, storage and use. Access to individual public transport data in a continuous and standardized manner to feed into mobility planning and operation processes.	Better understanding of individual public transport behavior, which in turn will allow for better mobility planning and regulation decisions.
6. Regulatory strategy to require the sharing of data associated with new mobility services	Low	Data sharing obligatio n in cases of public interest	Development of a regulatory framework governing data sharing obligations by operators of new mobility services (ride-hailing, shared mobility, etc.). Development of infrastructure and capabilities for data access, storage and use. Continuous access to data from different mobility services.	Better understanding of the behavior of emerging mobility services, which in turn will enable better mobility planning and regulation decisions.

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Annex 1: Detailed results of the fare elasticity analysis

Figure 1.1: Ridership in NJ buses vs. real average fare (simple correlation)

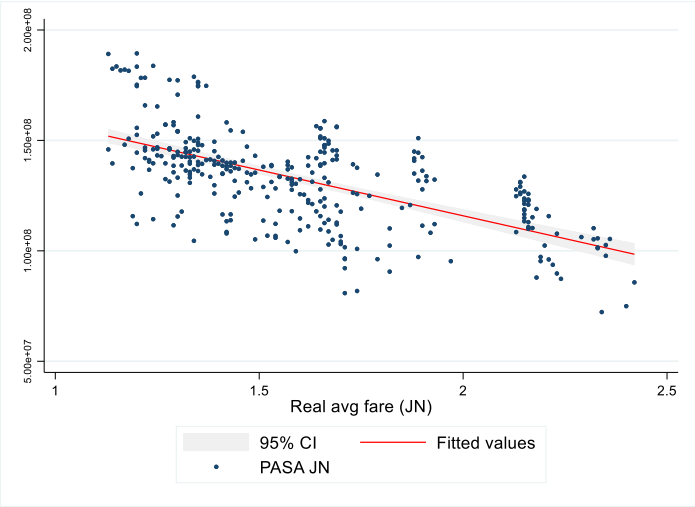


Figure 1.2: Ridership in all buses vs. real average fare (simple correlation)

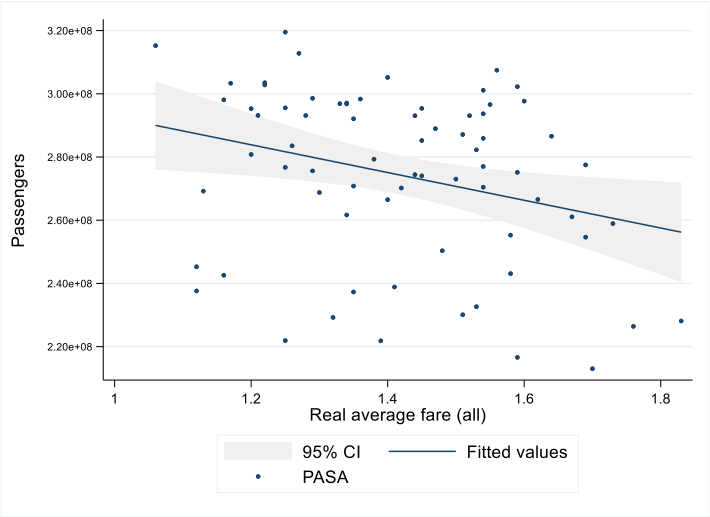


Figure 1.3: Real average fare in NJ buses vs. minimum fare (simple correlation)

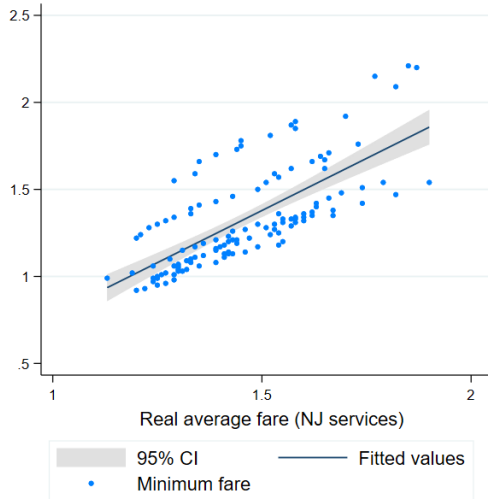


Figure 1.4: Ridership in all rail lines vs. real average fare (simple correlation)

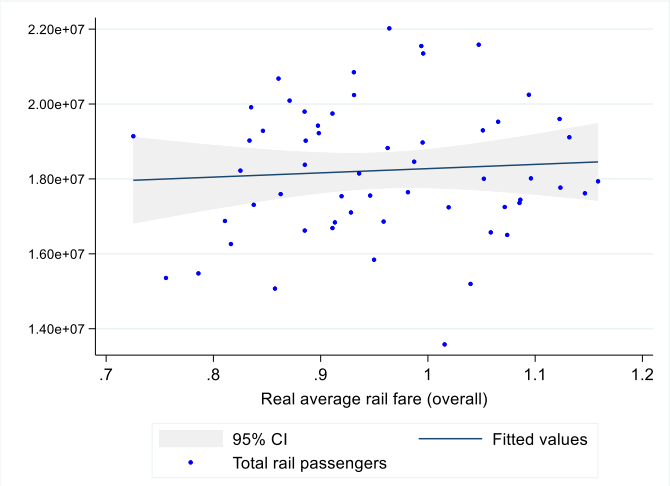
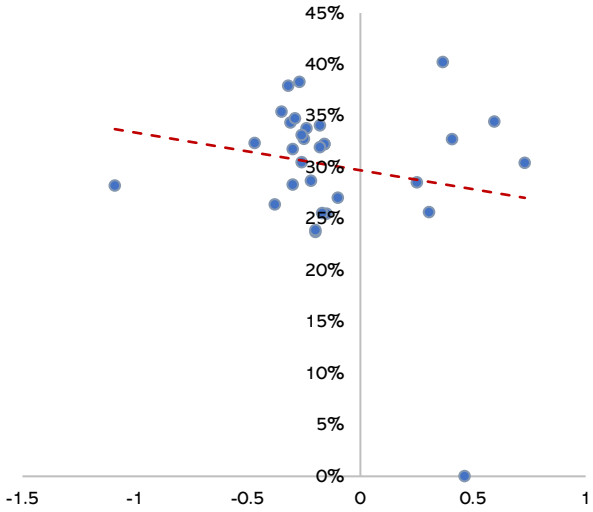


Figure 1.5. Correlation between real average fare elasticity and share of ATS beneficiary passengers and share of passengers benefiting from the integrated fare for bus lines with statistically significant real fare elasticities

a. Correlation with share of ATS beneficiaries



b. Correlation with share of integrated fare users

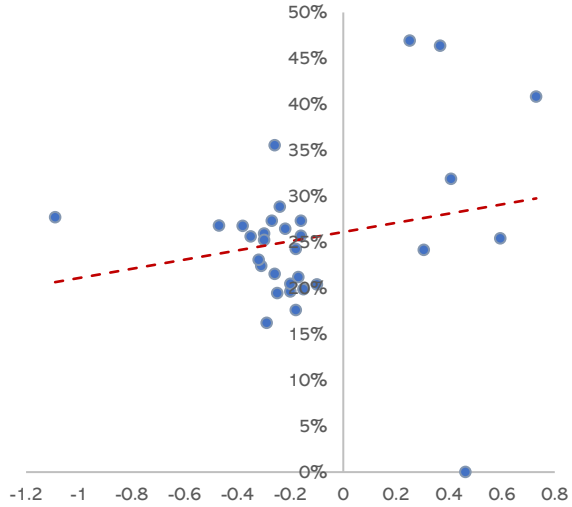
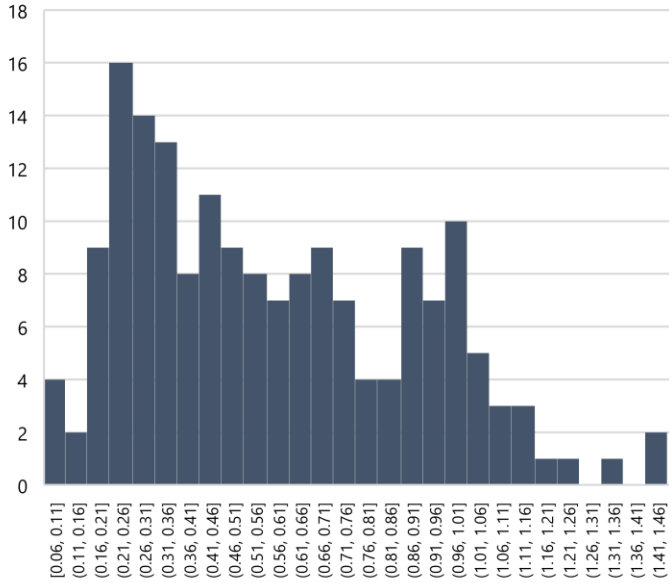


Figure 1.6. Density distribution of estimated elasticity of bus ridership with respect to vehicle-km of service offered and private sector economic activity in AMBA (number of lines)

a. Elasticity with respect to vehicle-km supplied



b. Elasticity with respect to private sector jobs

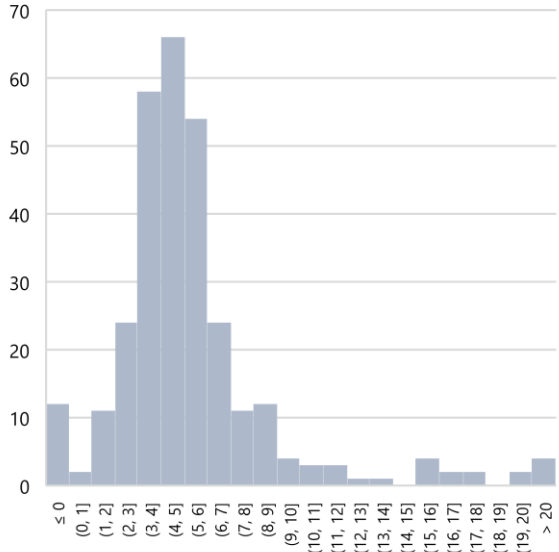


Table 1.1 Estimated elasticities of ridership in all bus lines with respect to nominal average fare and other variables, while controlling for time dependency in data (auto-correlation)

	(1)	*(2)*	*(3)*	*(4)*
Nominal average fare	-0.133 *	-0.118	-0.085	-0.085
Vehicle-km of service supplied	0.095 **	0.094 **	0.096 **	0.068 *
Nominal average gas price		-0.061	0.103	0.080
Registered private sector jobs in AMBA			4.307 ***	
Registered private sector jobs in CABA				4.211 ***
T	71	71	71	71

Table 1.2: Estimated elasticities of ridership in NJ bus lines with respect to nominal average fare and other variables, while controlling for time dependency in data (auto-correlation)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Nominal average fare	-0.127 ***	-0.125 **	-0.125 **	-0.116 **	-0.078
Vehicle-km of service supplied	0.849 ***	0.545 ***	0.545 ***	0.523 ***	0.522 ***
Nominal average gas price			0.013	0.041	0.035
Registered private sector jobs in AMBA				1.224	1.387
Minimum fare					-0.033
T	328	76	76	76	76

Table 1.3: Estimated elasticities of ridership in NJ bus lines with respect to nominal average fare and other variables for different periods of time, while controlling for time dependency in data (auto-correlation)

	(1) 1992-1999	*(2)* 2000-2009	*(3)* 2010-2019
Nominal average fare	-0.218 ***	-0.355 ***	-0.134 ***
Vehicle-km of service supplied	0.917 ***	1.422 ***	0.632 ***
T	95	120	113

Table 1.4: Estimated elasticities of ridership in rail lines with respect to real average fare and other variables

	Overall	Belgrano Sur	Belgrano Norte	San Martin	Sarmiento	Mitre
Nominal average fare	-0.02	-0.11	0.39	0.21	-0.28*	-0.04
Vehicle-km of service supplied	0.76 ***	0.37	0.95 ***	0.58 ***	0.28 **	0.75 ***
Evasion	0.96	-0.03	-0.07	-0.57***	-0.53 *	-0.00
Real average gas price	0.29	0.42	-0.12	0.13	-0.21	0.33
Registered private sector jobs in CABA	6.6 ***	4.42	6.23	14.7**	10.1	9.2**

Annex 2: Mobility changes during the COVID-19 pandemic – overview

Figure 2.1: Number of trips to workplaces in CABA (% change compared to March 7, 2020)

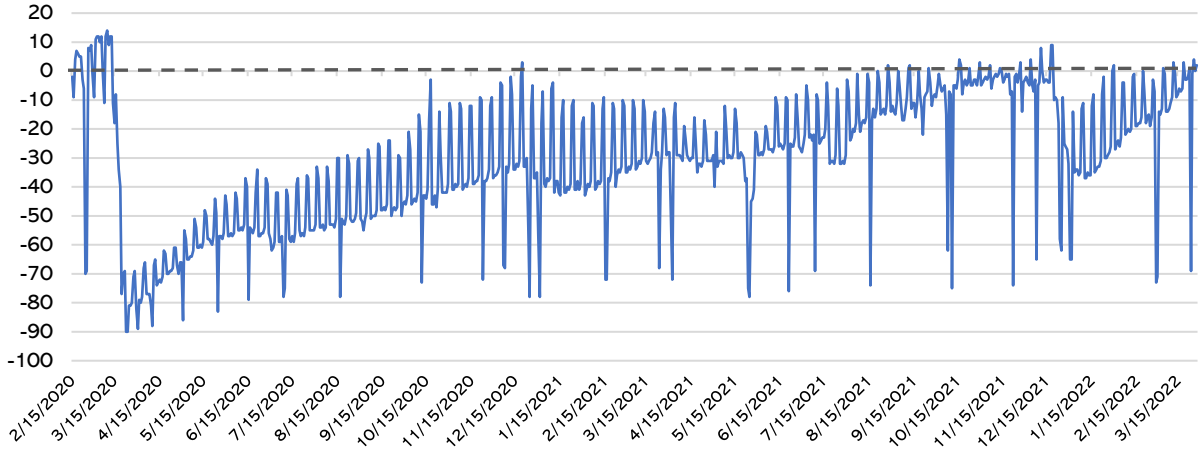


Figure 2.2: Number of trips to retail and recreation destinations in CABA (% change compared to March 7, 2020)

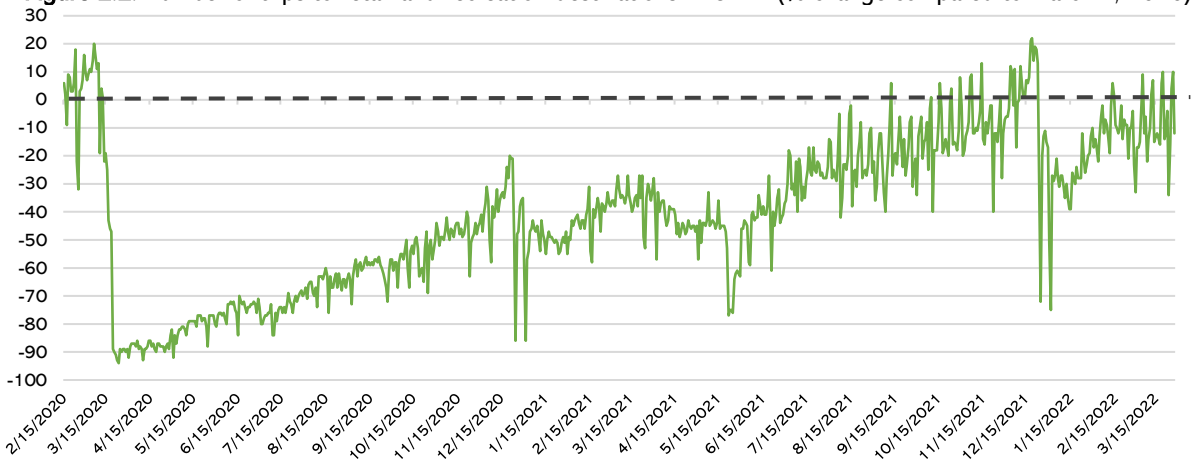
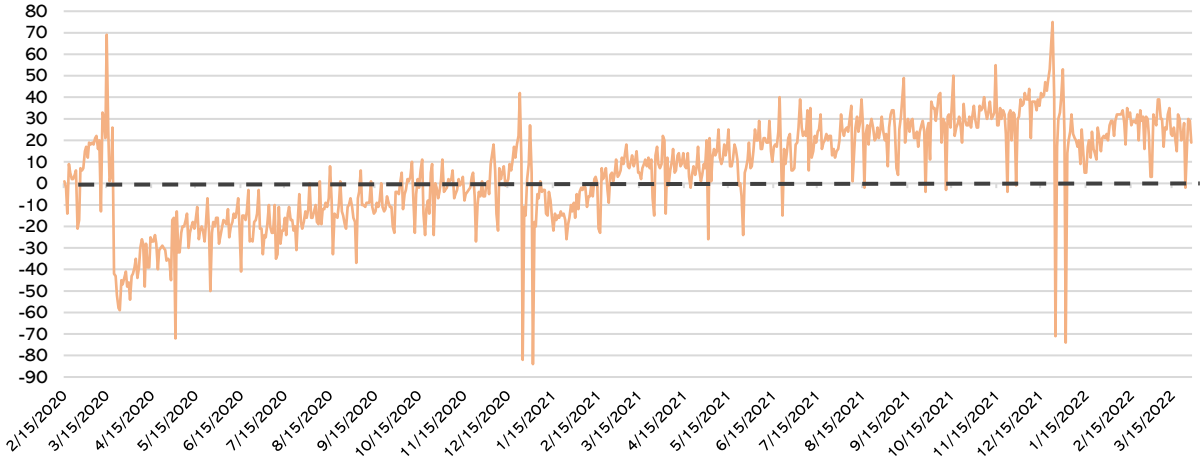
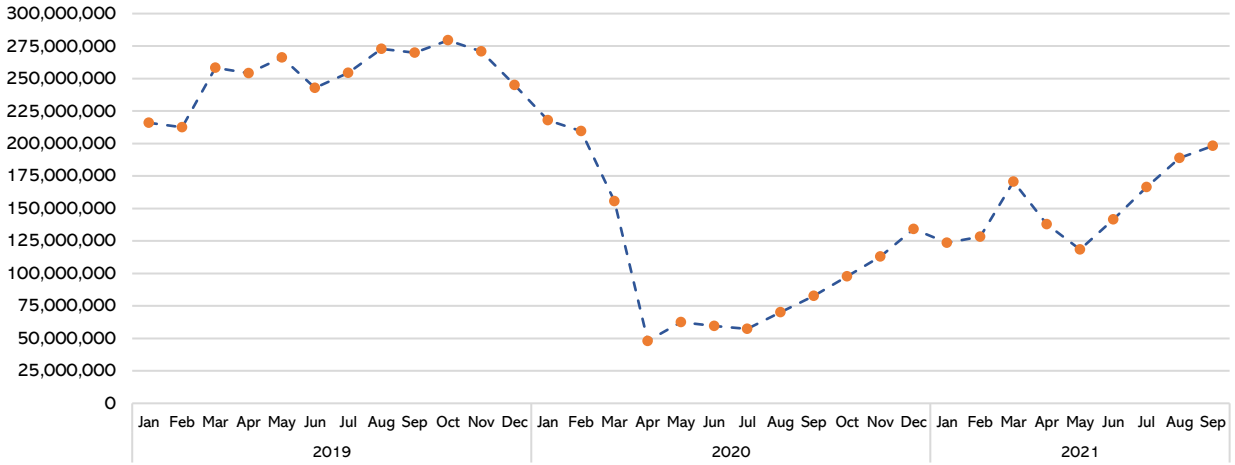


Figure 2.3: Number of trips to grocery stores and pharmacies in CABA (% change compared to March 7, 2020)



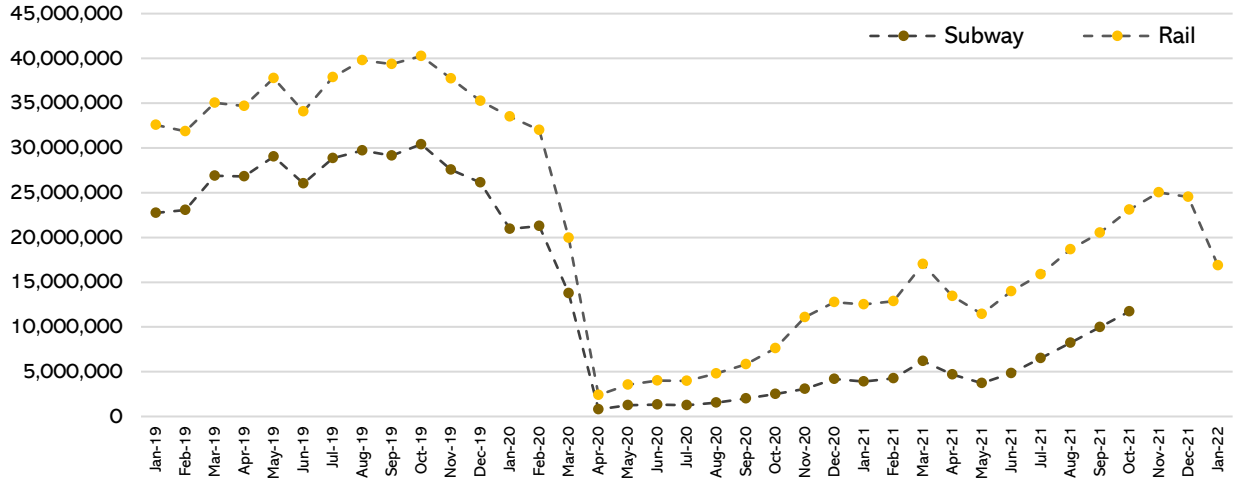
Source: Google Mobility Reports

Figure 2.4: Bus system passengers carried, 2019-2021



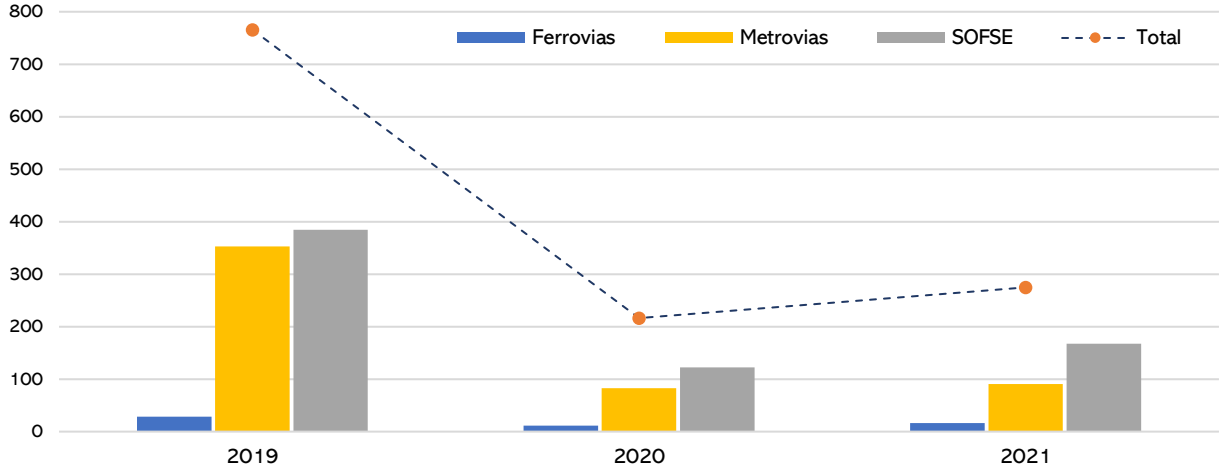
Source: CNRT and SUBE

Figure 2.5: Subway and rail system passengers carried, 2019-2021



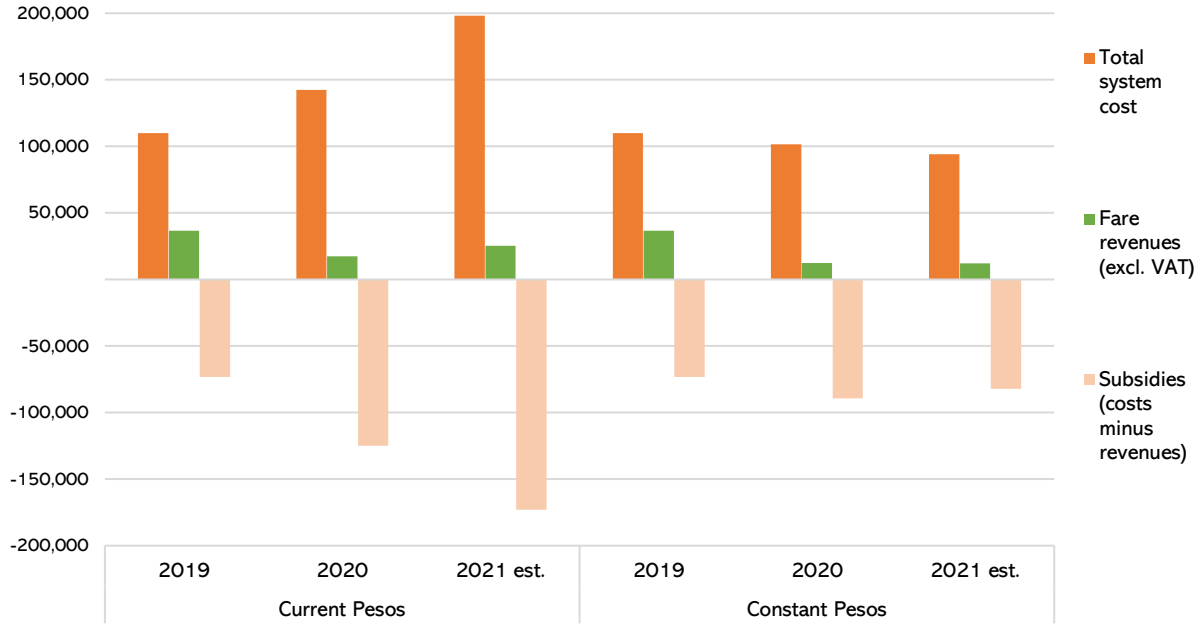
Source: CNRT

Figure 2.6: Total annual number of passengers carried in all rail-based systems, 2019-2021 (million)



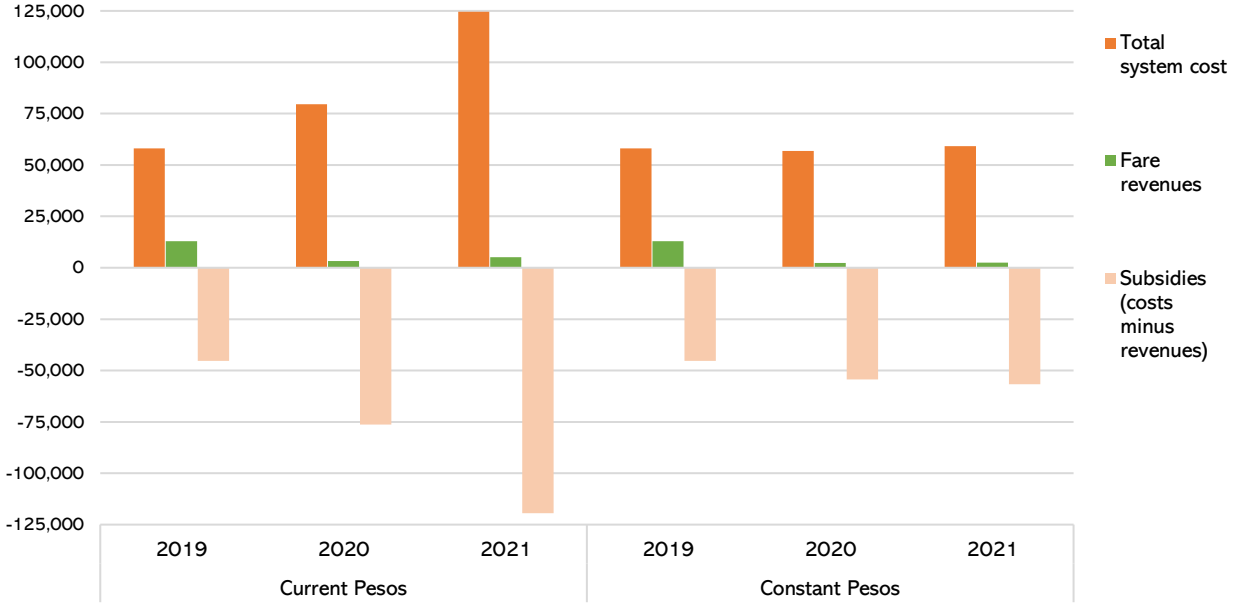
Source: CNR

Figure 2.7: Bus system costs and revenues, 2019-2021 (millions of Pesos)



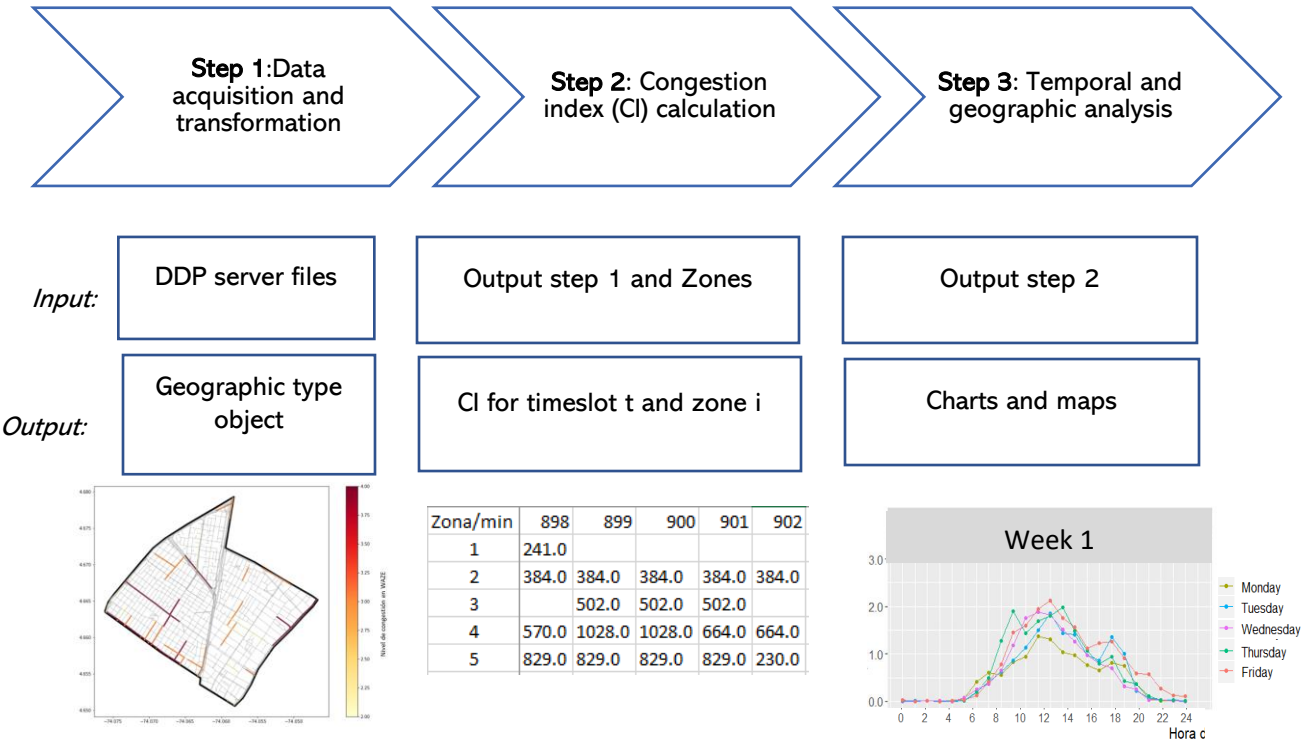
Source: CNRT and SUBE

Figure 2.8: Rail system costs and revenues, 2019-2021 (millions of Pesos)



Source: CNRT

Annex 3: Description of Waze for Cities data analysis to track congestion over time



Zona/min	898	899	900	901	902
1	241.0				
2	384.0	384.0	384.0	384.0	384.0
3		502.0	502.0	502.0	
4	570.0	1028.0	1028.0	664.0	664.0
5	829.0	829.0	829.0	829.0	230.0

The Congestion Index was defined as follows: $$CI_p = \sum \frac{JAM_{ip}}{roads_p}$$

Where: $$JAM_{ip} = \sum L_{tjp}$$

JAM_{ip} sum of jam length in zone *p* and timeslot *t*

L_{ijp} each individual congested link (*j*) in zone *p* and timeslot *t*

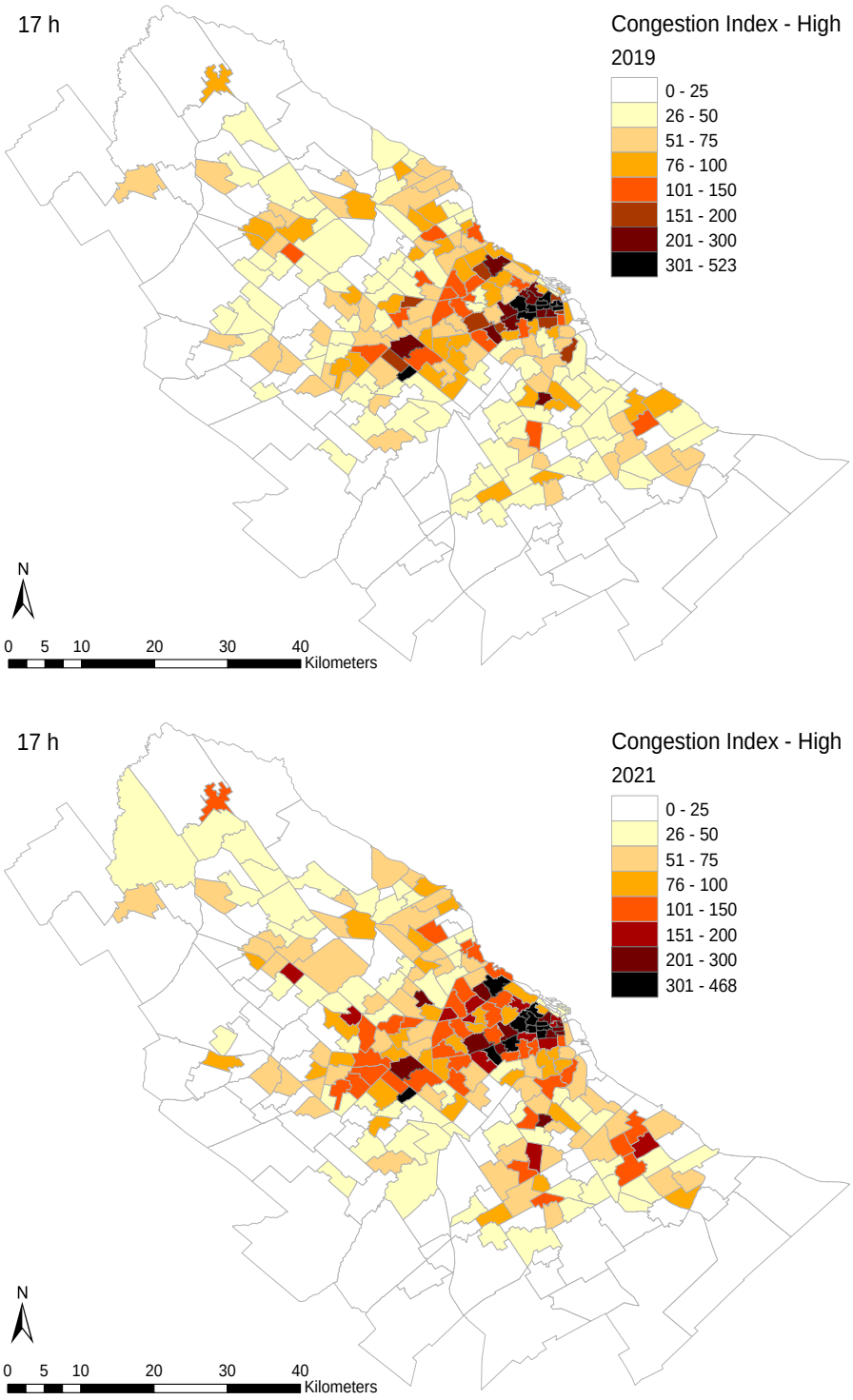
CI_p Congestion Index in zone p for a selected timeslot t

$roads_p$ sum of road length in zone p

t can be days or hours for a typical workday or weekend

- Analysis for the GBA, CABA and overall AMBA
- Timestamp October 2019, 2020, and 2021
- Weekday is any Tuesday, Wednesday or Thursday in October in order to match the definition of "día laborable" assumed in the CDR data analysis
- Congestion profile graphs show the hourly average for all weekdays in October
- Jam level is shown as two types: low (1 and 2 levels in Waze data) and high (3 and 4 levels in Waze data)

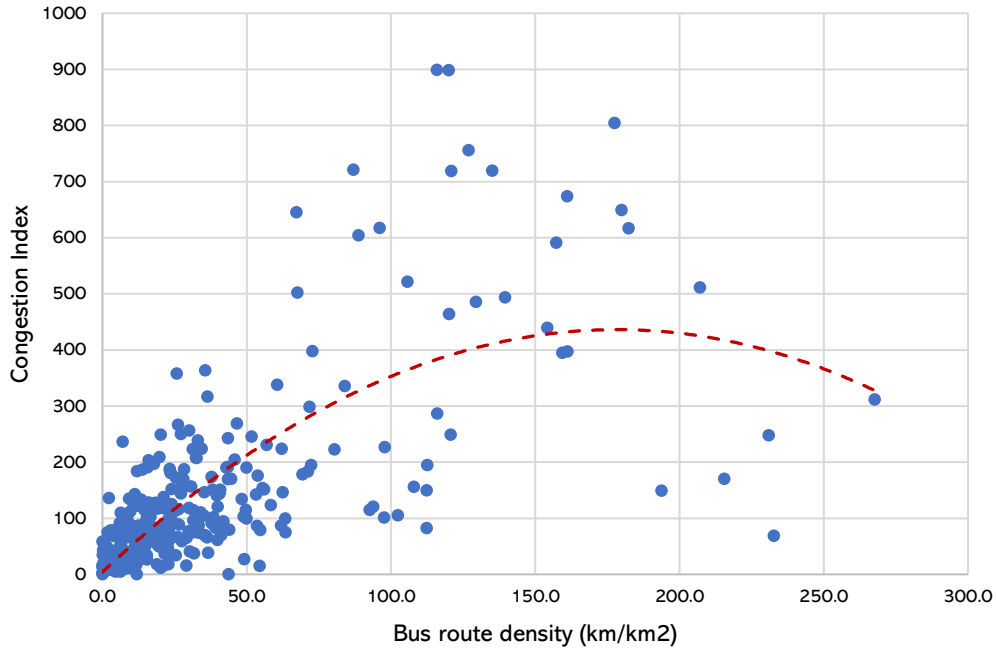
Figure 3.1: "High" congestion index at peak rush hour (17:00) in 2019 vs. 2021



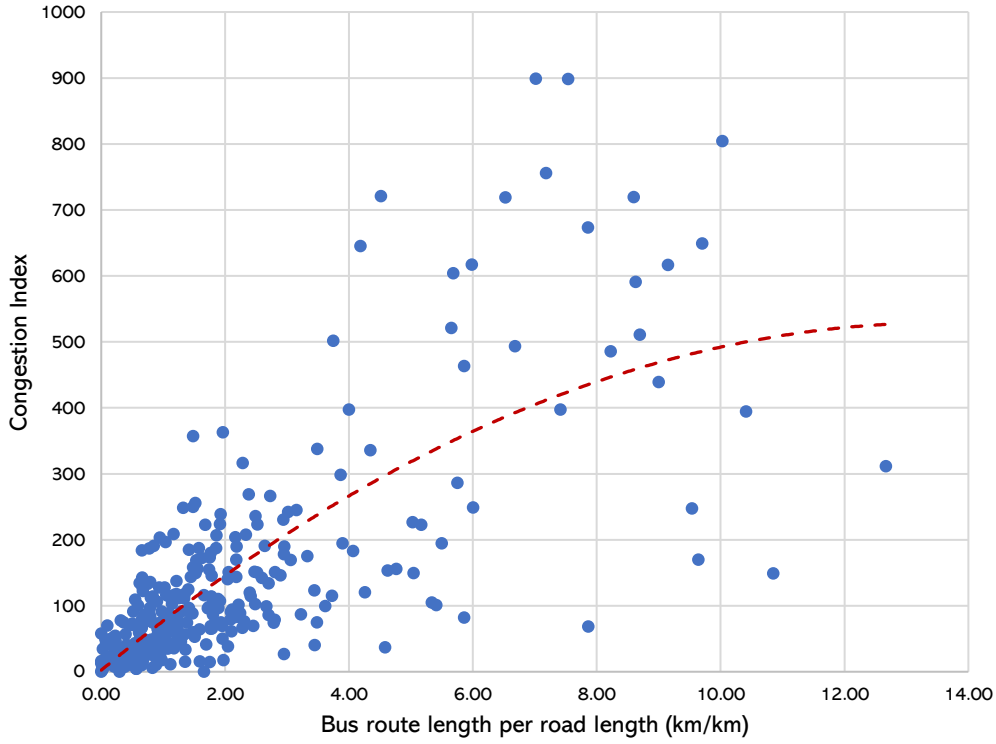
Source: Analysis by study team using Waze for Cities data

Figure 3.2: Congestion index at peak rush hour (17:00) vs. bus route availability in each macrozone (2021)

a. Congestion vs. Bus route density per land area (km/km²)

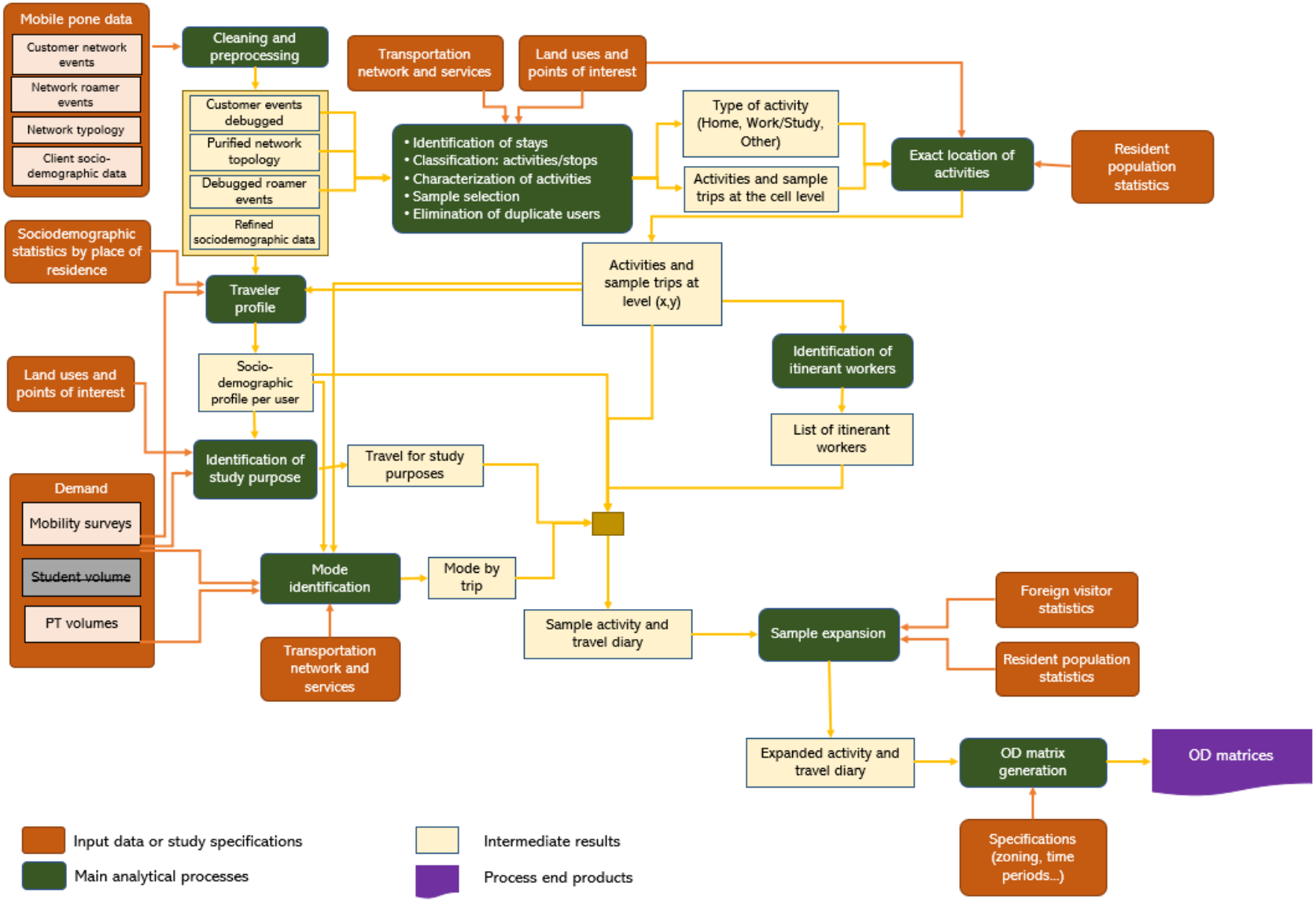


b. Congestion vs. Bus route length per total road length (km/km)



Source: Analysis by study team using Waze for Cities data

Annex 4: Flowchart for OD estimation using CDR data



Annex 5: Detailed presentation of Private Motorized Mobility Survey results

5.1. Interception survey (20,306 observations)

Figure 5.1: Distribution of survey respondents by age, gender, residency

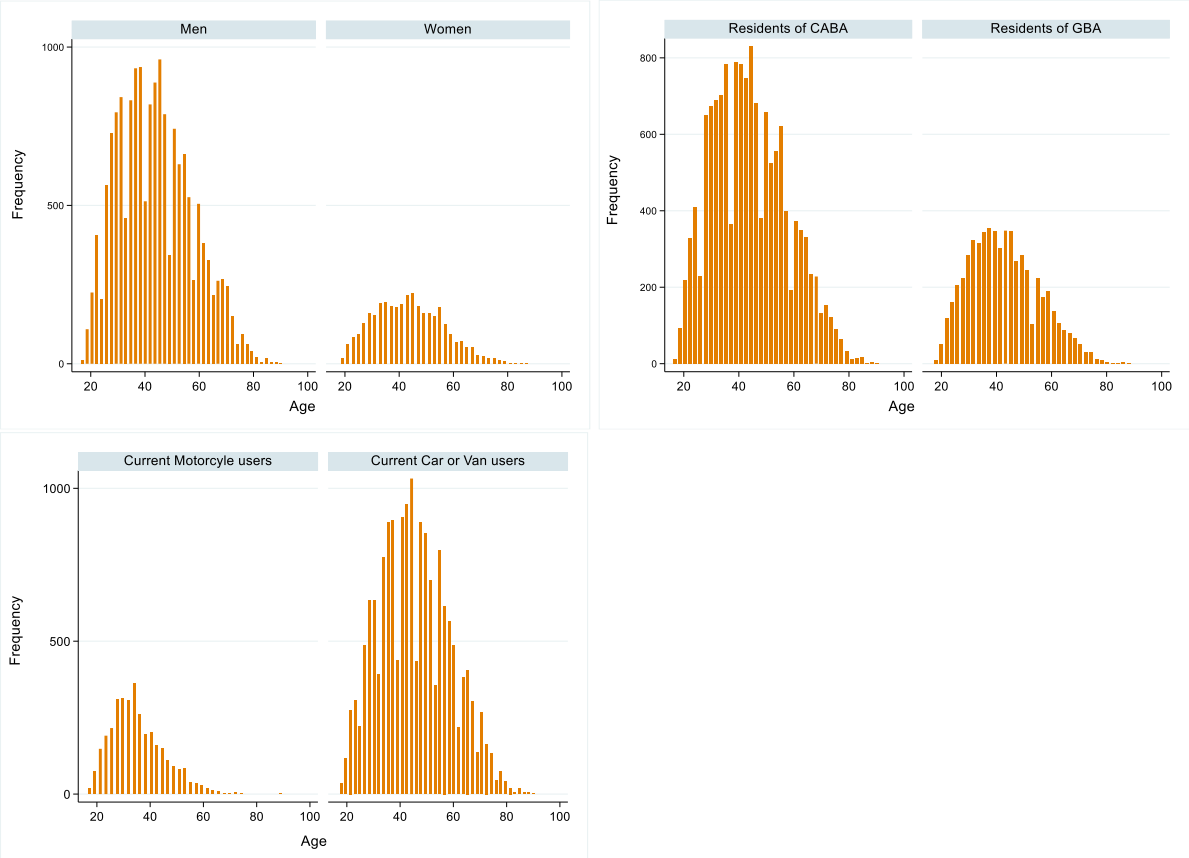


Figure 5.2: Trip origin municipality

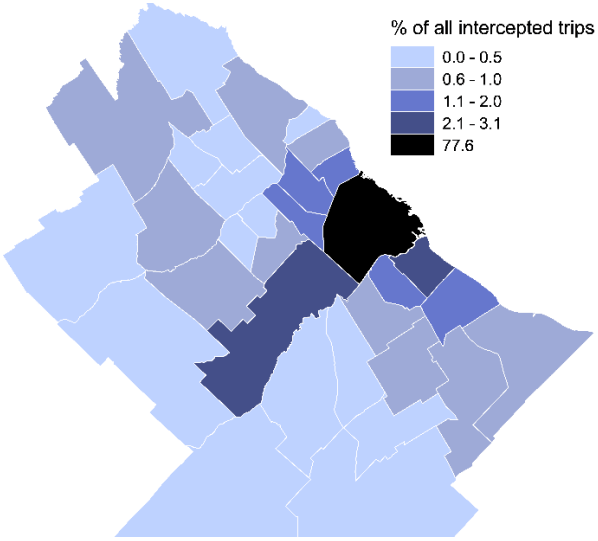
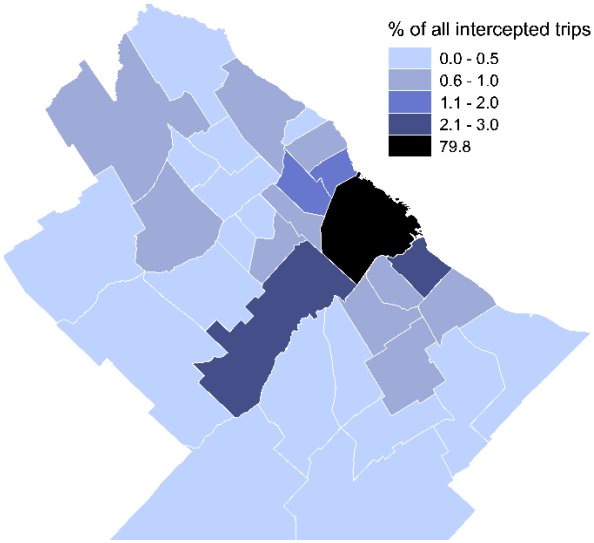


Figure 5.3: Trip destination municipality



Source: Car and motorcycle interception survey conducted by study team in November-December 2021

Figure 5.4: Origin and destination activities of the intercepted car and motorcycle users

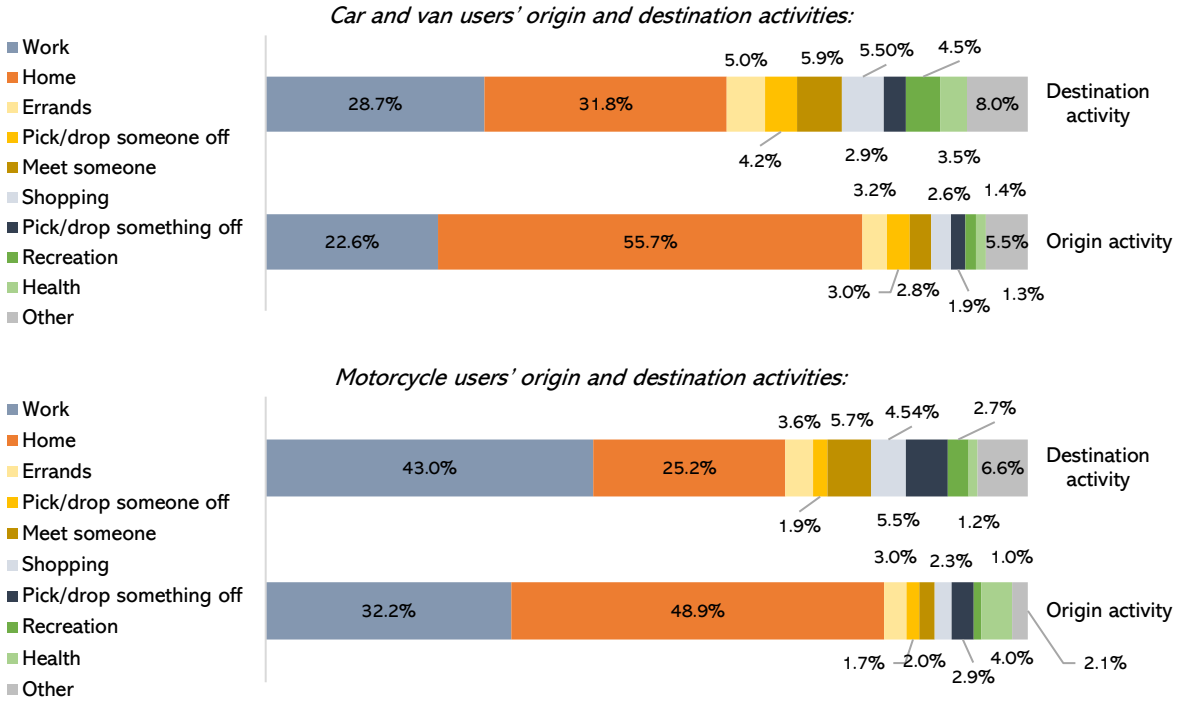


Figure 5.5: Share of trips that were conducted by a different mode prior to the pandemic (origin municipality)

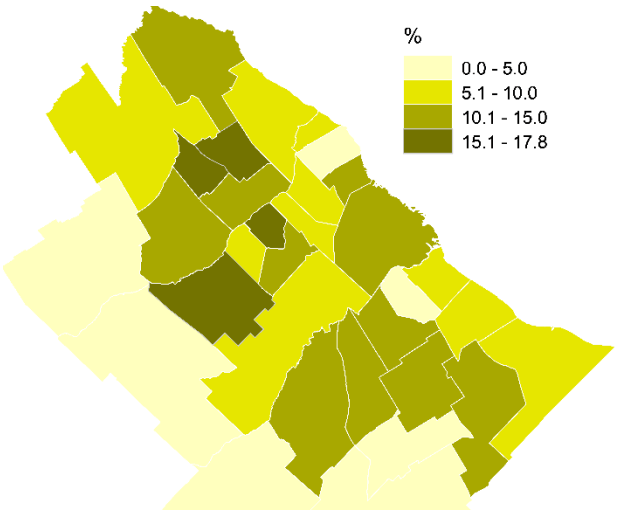


Figure 5.6: Share of trips that were conducted by a different mode prior to the pandemic (destination municipality)

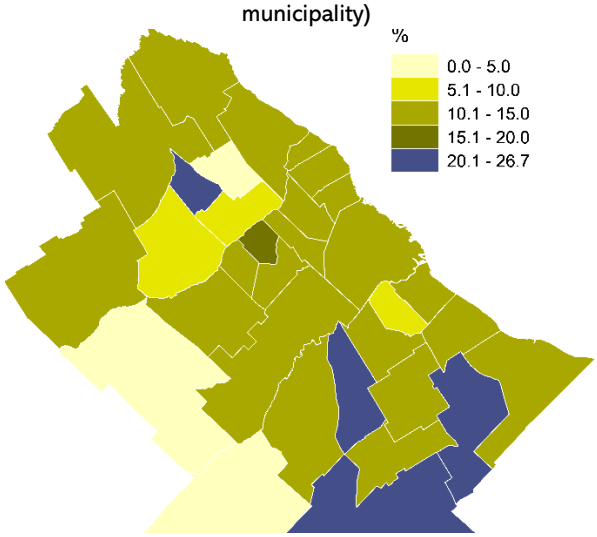


Table 5.1: Factors statistically associated with having become a new user of private motorized modes since the start of the pandemic (among people who currently use private motorized modes)

```
Logistic regression                               Number of obs     =     18,269
                                                  LR chi2(16)       =     555.15
                                                  Prob > chi2       =     0.0000
Log likelihood = -6838.1909                       Pseudo R2         =     0.0390
```

changed_mode_sincepandemic	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
gender_male	.6855508	.037512	-6.90	0.000	.6158339	.7631603
age	.9851047	.0017553	-8.42	0.000	.9816704	.9885511
edu_some_university	1.439358	.0718464	7.30	0.000	1.30521	1.587292
change_occupation_since_prepande						
2	1.654821	.116026	7.18	0.000	1.442347	1.898594
3	1.479407	.0903817	6.41	0.000	1.312457	1.667594
4	2.217958	.194133	9.10	0.000	1.868312	2.633038
5	2.560157	.1991433	12.09	0.000	2.19814	2.981795
6	1.435921	.154211	3.37	0.001	1.163364	1.772334
trip_start_caba_vs_gba	1.276274	.0735786	4.23	0.000	1.139912	1.428949
recreation_trip	.7012526	.0779288	-3.19	0.001	.564004	.8719003
social_trip	.7988041	.067138	-2.67	0.008	.677483	.941851
health_trip	.5445263	.074555	-4.44	0.000	.4163656	.712136
important_factors_1st						
2	.9519294	.0793255	-0.59	0.554	.8084869	1.120822
3	1.011187	.0825984	0.14	0.892	.8615913	1.186756
4	1.379663	.108427	4.10	0.000	1.182708	1.609417
5	.2017247	.2058764	-1.57	0.117	.0272922	1.491006
_cons	.2034514	.0247167	-13.11	0.000	.1603432	.2581492

Note: _cons estimates baseline odds.

5.2. Stated preference module – CATI (phone) survey (600 observations)

Figure 5.7: Purpose of the typical trip, by origin-destination

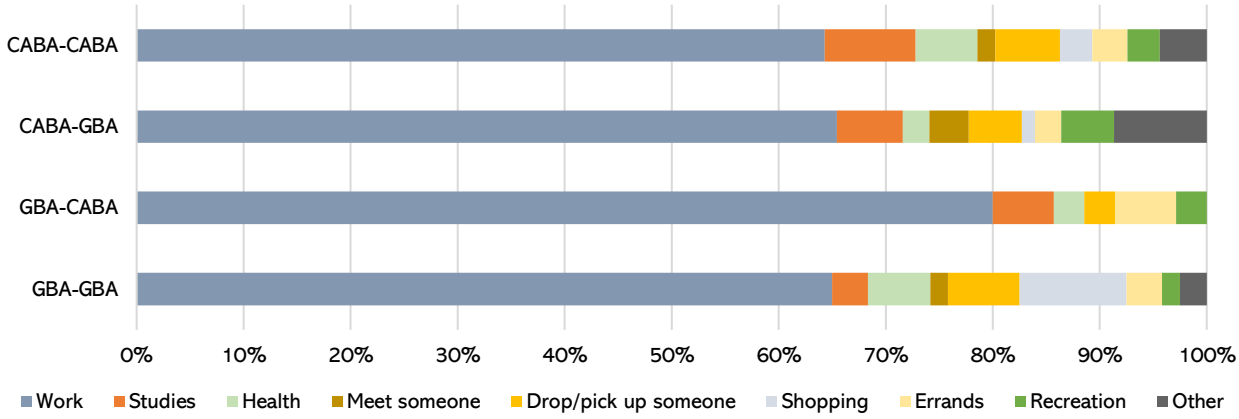


Figure 5.8: Motivation for using a car or motorcycle for realizing the typical trip, by current mode

Among car users, the motivation was …

Among motorcycle users, the motivation was …

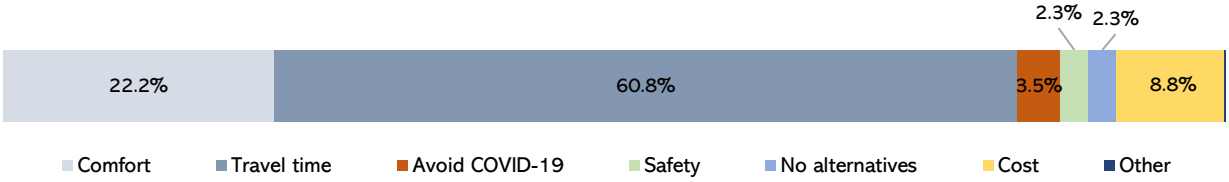


Figure 5.9: Motivation for using a car or motorcycle for realizing the typical trip, by origin-destination pair

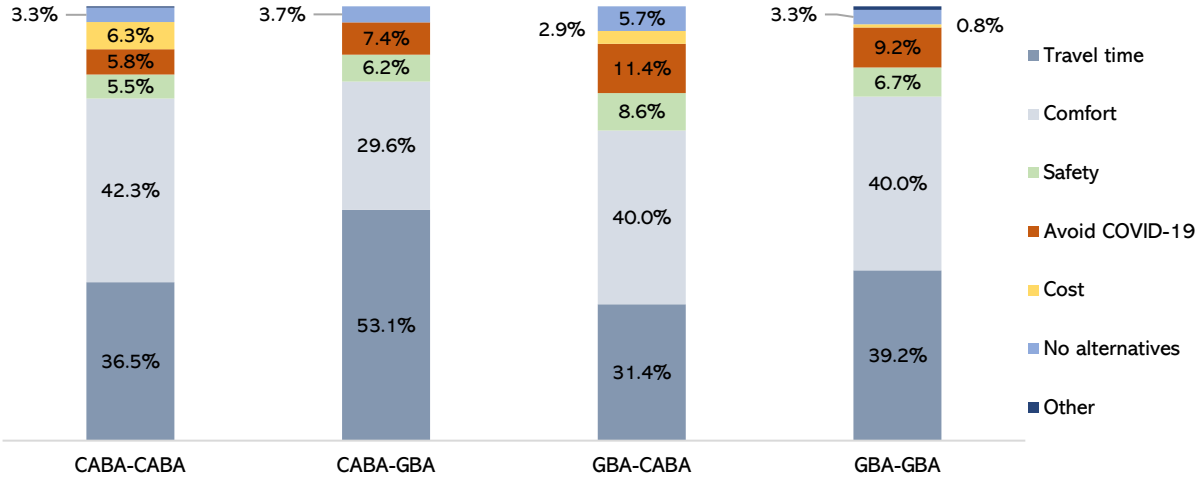


Figure 5.10: Mode that would be used for the typical trip if not using private motorized vehicle, by respondent's gender

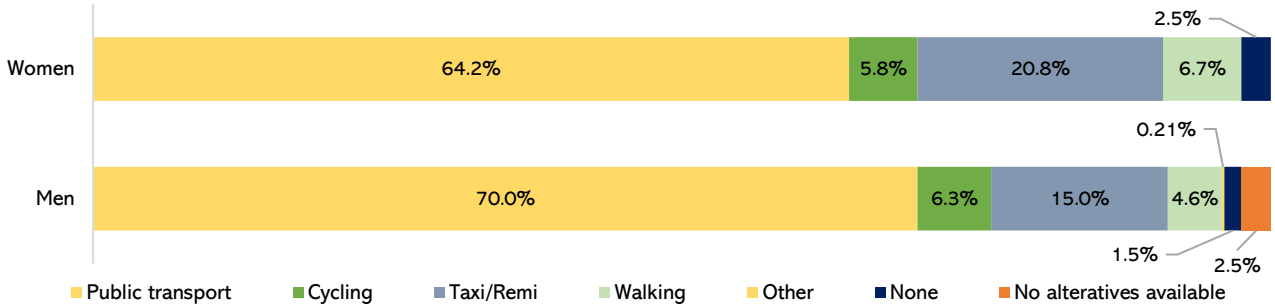


Figure 5.11: Mode that would be used for the typical trip if not using private motorized vehicle, by respondent's age

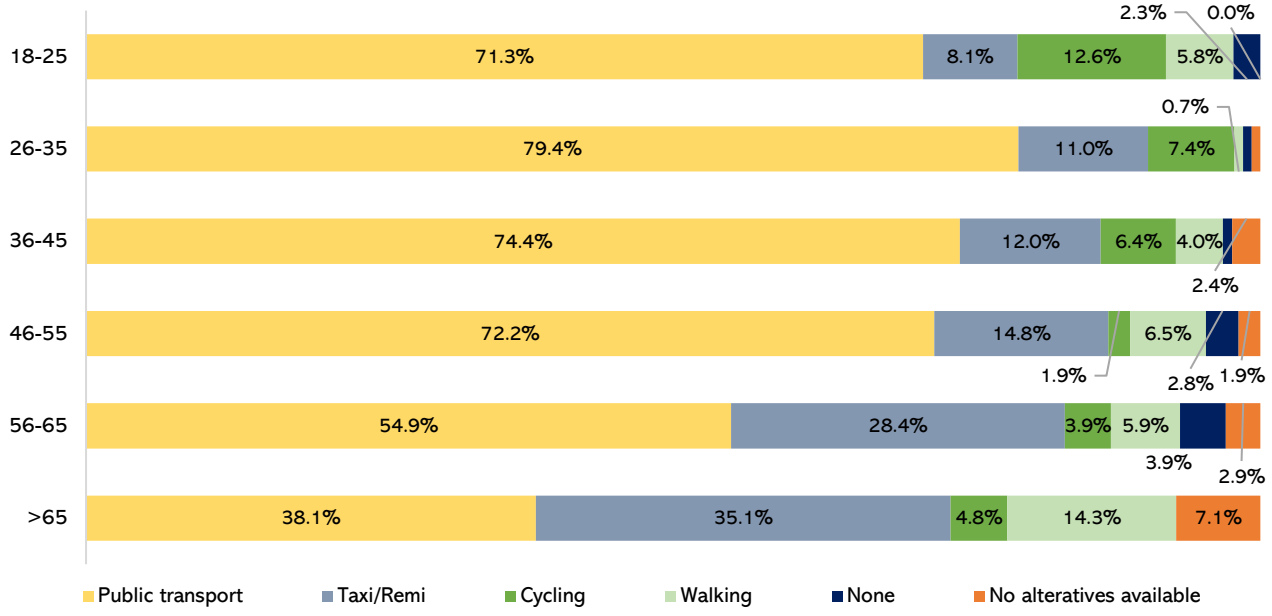


Figure 5.12: Mode that would be used for the typical trip if not using private motorized vehicle, by trip duration

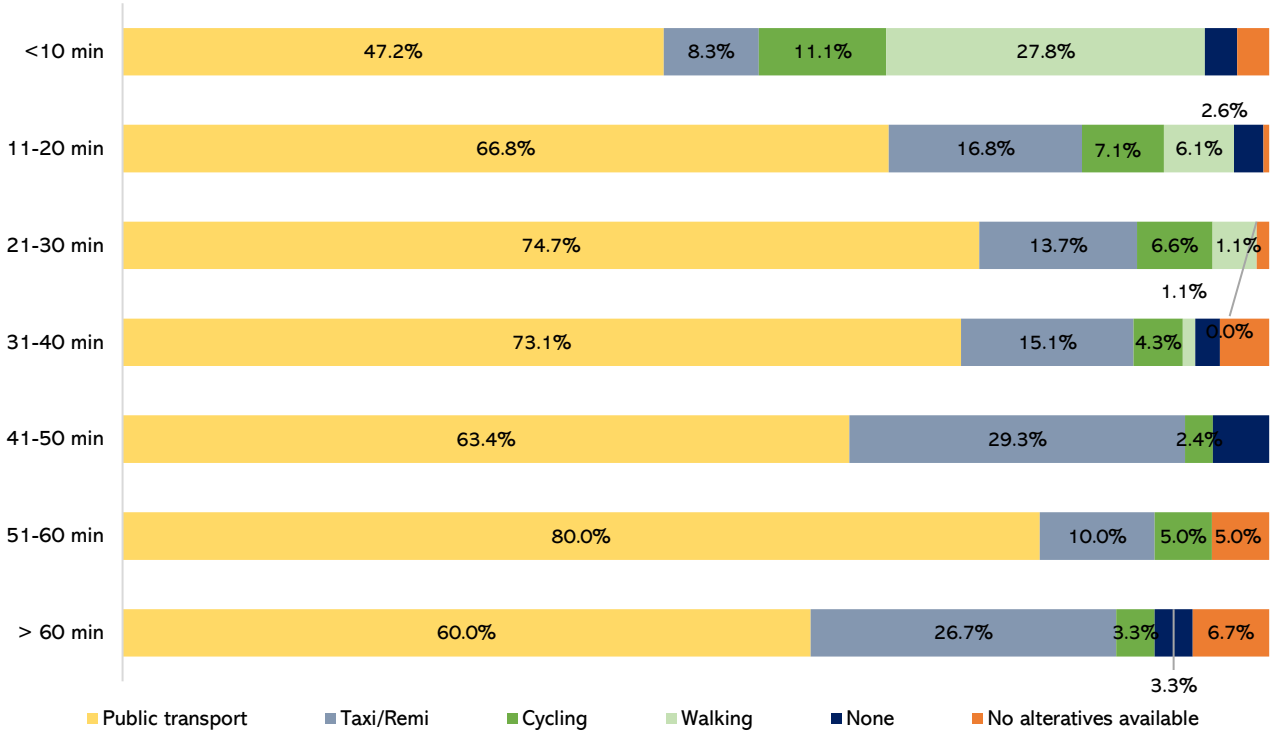


Table 5.2: Relative log odds of selecting public transport, NMT, or taxi/remis as the mode the person would use if not using private motorized transport, compared to choosing "none of the above"

Multinomial logistic regression	Number of obs	=	588
	LR chi2(21)	=	158.31
	Prob > chi2	=	0.0000
Log likelihood = -430.83972	Pseudo R2	=	0.1552

P16_SP_chosen	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
own_car	-.8328654	.8446115	-0.99	0.324	-2.488273	.8225427
education_reduced						
2	1.47252	1.286391	1.14	0.252	-1.04876	3.993799
3	2.386381	1.423252	1.68	0.094	-.4031406	5.175903
4	2.464384	1.409635	1.75	0.080	-.2984498	5.227218
available_modes_bus	3.401396	1.064637	3.19	0.001	1.314746	5.488045
OD_pair						
2	-.5530048	.7760642	-0.71	0.476	-2.074063	.9680531
3	-.7281271	.8078553	-0.90	0.367	-2.311494	.8552401
_cons	1.50309	1.38162	1.09	0.277	-1.204836	4.211016
2						
own_car	-.7858664	.8692488	-0.90	0.366	-2.489563	.9178299
education_reduced						
2	-.1613788	1.359236	-0.12	0.905	-2.825432	2.502675
3	.602726	1.504991	0.40	0.689	-2.347002	3.552454
4	1.178192	1.484382	0.79	0.427	-1.731144	4.087527
available_modes_bus	1.660739	1.090189	1.52	0.128	-.4759918	3.79747
OD_pair						
2	-3.860814	1.262134	-3.06	0.002	-6.334551	-1.387078
3	-.8695571	.8389321	-1.04	0.300	-2.513834	.7747196
_cons	2.435846	1.455169	1.67	0.094	-.4162321	5.287925
3						
own_car	.8821915	.9084026	0.97	0.331	-.8982448	2.662628
education_reduced						
2	.4640251	1.377454	0.34	0.736	-2.235735	3.163785
3	1.371788	1.505648	0.91	0.362	-1.579228	4.322804
4	2.031026	1.48807	1.36	0.172	-.8855379	4.94759
available_modes_bus	1.702575	1.081616	1.57	0.115	-.4173525	3.822503
OD_pair						
2	-1.452412	.8048599	-1.80	0.071	-3.029909	.1250842
3	-.984208	.8316201	-1.18	0.237	-2.614153	.6457374
_cons	.5928118	1.500865	0.39	0.693	-2.34883	3.534453
4	(base outcome)					

Note: 1 = public transport; 2 = NMT; 3 = taxi/remi; 4 = none of the above;
OD pair reference category is CABA-CABA; 2= CABA-GBA; 3 = GBA-GBA

Table 5.3: Relative log odds of selecting NMT or taxi/remis as the mode the person would use if not using private motorized transport, compared to choosing "public transport"

Multinomial logistic regression	Number of obs	=	577
	LR chi2(16)	=	260.93
	Prob > chi2	=	0.0000
Log likelihood = -324.86581	Pseudo R2	=	0.2865

P16_SP_chosen_3cate~s	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1	(base outcome)					
2						
OD_pair						
2	-3.0556	1.072968	-2.85	0.004	-5.158579	-.9526205
3	-.3876804	.4051751	-0.96	0.339	-1.181809	.4064482
own_car	.2721667	.373187	0.73	0.466	-.4592665	1.0036
available_modes_bus	-2.271594	.3440939	-6.60	0.000	-2.946006	-1.597182
available_modes_subte	-1.589777	.4015583	-3.96	0.000	-2.376817	-.8027371
available_modes_train	-1.763031	.6500016	-2.71	0.007	-3.03701	-.4890508
available_modes_bike	2.04463	.4206197	4.86	0.000	1.22023	2.869029
age_over_55	.6354998	.3716311	1.71	0.087	-.0928837	1.363883
_cons	-.2159929	.4155303	-0.52	0.603	-1.030417	.5984316
3						
OD_pair						
2	-.9856948	.4106487	-2.40	0.016	-1.790551	-.1808382
3	-.6875128	.3707582	-1.85	0.064	-1.414186	.03916
own_car	1.455951	.4293632	3.39	0.001	.6144148	2.297488
available_modes_bus	-2.331581	.3017406	-7.73	0.000	-2.922981	-1.74018
available_modes_subte	-2.085218	.3784606	-5.51	0.000	-2.826987	-1.343449
available_modes_train	-1.781062	.4452896	-4.00	0.000	-2.653814	-.9083105
available_modes_bike	-.2889179	.6300637	-0.46	0.647	-1.52382	.9459844
age_over_55	.8320916	.2895527	2.87	0.004	.2645787	1.399605
_cons	-.4552714	.4543538	-1.00	0.316	-1.345788	.4352457

Note: 1 = public transport; 2 = NMT; 3 = taxi/remi
OD pair reference category is CABA-CABA; 2= CABA-GBA; 3 = GBA-GBA

Annex 6: "Big data" for transport and mobility planning

Urban mobility planning and management requires accurate, reliable, and up-to-date information about the transportation system. This information has different uses:

- **Descriptive analysis:** refers to the measurement of different variables that characterize the city's mobility, either to diagnose the current situation and identify the main problems and possible solutions, or for ex post evaluation of the results of different actions (new services, policies, etc.). Traditionally, descriptive analyses of mobility have had a cross-sectional character, providing a static picture on a periodic basis; this is the case, for example, of the household mobility surveys that are carried out periodically in Buenos Aires. The emergence of new forms of mobility, the rapid evolution of mobility patterns brought about by technological change and new phenomena such as teleworking and online shopping, in many cases amplified by the recent COVID-19 pandemic, make it increasingly necessary to have longitudinal studies that monitor the transport system continuously: the aim is to be able to detect new trends in order to adapt the supply of services and mobility policies to an increasingly dynamic and uncertain environment.
- **Predictive analytics:** refers to the use of data to build predictive models capable of anticipating the future evolution of mobility. This use includes strategic demand forecasting models (e.g., traditional 4-stage models), as well as other types of predictive models (e.g., data-driven artificial intelligence models) for predicting transportation demand in the short term.

The most relevant non-public data sources for mobility planning and management include:

- Geolocated data from **electronic transactions**, such as data from cell phone networks.
- Geolocated data from **transportation services** operated by private companies, including both traditional services such as cabs and emerging forms of mobility such as ride-hailing, shared mobility services or on-demand transportation services.
- Geolocated data from other **mobility-related services**, such as driving navigators and traffic information services or trip planners and MaaS applications.

❖ Mobile phone data

Over the last decade, the use of data from cell phone networks for the study of mobility has received increasing attention both in the scientific literature and in transportation planning practices. Numerous studies have addressed the development of algorithms and data analysis and fusion methodologies to derive OD matrices and other mobility and transportation demand indicators from cell phone data. Mobile phone data - collected by mobile network operators – can be used to obtain OD matrices and other transport demand indicators. From the cleaning and proper processing of these data, it is possible to extract information on the door-to-door travel of the population. Currently, this data source is considered to be one of the most suitable for extracting information on the generation and distribution of population trips (origin-destination matrices). The advantages of this data include: passive and continuous data collection, the possibility of accessing historical data, the volume of the sample of users, a spatial precision (tens/hundreds of meters in urban areas, several kilometers in rural areas) and temporal precision (from seconds to a few minutes) suitable for most applications in the transport and mobility sector, and the property of integrating mobility associated with all modes of transport. This last advantage makes this information particularly useful for the knowledge of global mobility in the territory. Among the limitations of cell phone data it is important to note the limited sociodemographic information available compared to traditional methods such as surveys, the limited range of trip purposes that it is possible to differentiate, and the difficulty of identifying the mode of transport used for short-distance urban trips.

In AMBA, an approximate accuracy of 250-500 meters or better is available for most locations. The spatial accuracy is determined by the antenna density, being higher as the density increases.

However, for about 5 percent of phone users in AMBA, the accuracy is 1 km or worse. Sociodemographic data of Claro's users are available, specifically age and gender data of the operator's customers.

A potential alternative to this data source is data from mobile apps. These data have the advantage of potentially providing higher spatial accuracy than data from mobile phone operators. However, at present, the smaller sample size of these data, the biases derived from the profile of users who use the apps and their lower temporal granularity mean that, in general, the use of data from mobile operators is more appropriate for obtaining quality information on overall mobility.

Data from mobile phone operators are non-public data, containing personal information, and are very complex and costly to process, so it is generally recommended to acquire source-target matrices produced by specialized companies with access to raw data. Alternatively, it is possible to establish raw data sharing agreements with the operators for processing by a third party. The first scenario is the most widespread.

While many of the basic principles for the use of mobile phone data for travel demand analysis are applicable to any mobility study, obtaining OD matrices in urban and metropolitan settings presents some particular requirements. The main difference with interurban mobility studies lies in the fact that, **in the case of urban mobility studies, the difficulty in differentiating between modes of transport is greater,** due to the fact that different modes of transport coexist in cities and can generate very similar sequences of spatio-temporal records. Thus, in urban and metropolitan environments, cell phone data alone are not always sufficient to reliably estimate OD matrices segmented by mode of transport, requiring the use of other sources and data fusion techniques. Table 6.1 presents the different types of data required and their usefulness in obtaining OD matrices segmented by mode of transport.

Table 6.1: The use of CDR data and complementary data to construct OD matrices

Category	Use
Cell phone data	▪ Analysis of users' activities and trips. ▪ Characterization of users.
Land uses and points of interest	▪ Improved spatial accuracy of cell phone data. ▪ Identification of travel purpose.
Transport network and the supply of transport services	▪ Estimation of mode of transport.
Sociodemographic statistics (resident population statistics, tourist and visitor statistics, student statistics)	▪ Expansion of the sample. ▪ Sociodemographic characterization of users. ▪ Identification of the purpose of the trip.
Transportation demand data (e.g., from travel cards)	▪ Transport mode estimation.

The methodology to be used for segmentation by mode of transport will depend on the sources of demand information available. Three possible situations include: (i) availability of recent mobility surveys; (ii) availability of data on public transport trip volumes; and (iii) availability of surveys *and* volumes of public transport trips.

- **If only a recent mobility survey is available,** it will be used to calibrate classification algorithms for trip segmentation by mode. From the survey data, a set of metrics will be generated, such as time of day, day of the week, distance and trip purpose or sociodemographic characteristics of travelers, among others. These metrics will be used to calibrate machine learning models for modal classification. A fundamental aspect is the definition of the number of modal categories to be considered.

- **If only data on public transport trip volumes are available,** these data will be used to identify public transport trips and then the remaining trips will be segmented.

- **If both survey data and data on public transport trip volumes are available**, the two approaches will be combined. In particular, survey data will be useful for refining the criteria for identifying potential public transport trips, as well as for estimating modal segmentation for all other non-public transport trips. During the period of study, there is a single source of information that reliably provides data on mobility patterns in AMBA, i.e., ENMODO 2009. Even though other surveys were carried out in 2014 and 2018, they are either partial or not fully reliable as judged by transport specialists.

❖ Public transport smartcard data

Public transport use data contain information on the day and time of access to the public transport system as well as the station, stop and/or vehicle used for the trip. This information is of particular interest when access is made using smart cards that allow longitudinal analysis of user behavior. In some cases, it is also possible to have certain socio-demographic information on users, such as age ranges or a proxy for income (e.g., based on whether or not the person benefits from a discount). These data allow estimating the sequence of public transport stages carried out by users, which allows obtaining information on OD matrices specific to the public transport system, information on transfers, travel times, wait times, and vehicle occupancy levels, among many other demand indicators. **The main advantages of this data are the passive and continuous collection, the access to historical information, and the sample size of users** (there are public transport systems where the access/egress with smart cards is 100%). The main limitations of the data are the limited trip context information (purpose), the scarce sociodemographic information of the users, and the fact that information is only collected within the public transport system, so information on the origin and final destination of the trip is not available. There are successful experiences in the use of smart card data for mobility management and planning in cities such as London, Hong Kong or Santiago de Chile. However, although these data generally belong to public agencies, in order to leverage them to the full extent possible, advanced capabilities and technologies are required, so it is important to evaluate whether it is convenient to develop these capabilities internally or to establish collaboration agreements with companies specialized in the processing of these data.

❖ Data from shared mobility systems, vehicle GPS, and others

To access data from shared mobility systems, data sharing agreements are needed with the different operators. These data make it possible to obtain information on the number and location of vehicles as well as on the trips made in these systems: origin, destination, time, route, frequency of use, etc. As with the sources mentioned above, these data have limitations in terms of trip purpose and socio-demographic information of users.

Vehicle GPS data provide information about the vehicle, both in terms of its location and the operation of its systems and the information collected by its sensors. Vehicle location information can be exploited to estimate speeds and travel times on different stretches of road. **The main advantage of this data over traditional technologies such as deploying sensors or performing field work is the cost savings in equipment and personnel and the ability to collect the data continuously for a very large network extent**. In recent years, applications have appeared for the use of these data for the estimation of OD matrices; however, some of them face limitations due to the quality of the sample used and its possible biases. It is foreseeable that in the coming years, with the generalization of connected and autonomous vehicles, this data source will become increasingly valuable and will give rise to new applications.

In summary, each of these sources provides relevant information for mobility analysis, but none provides a complete picture by itself, and data fusion is needed. For example, cell phone data provide very relevant information on total mobility in urban and metropolitan areas, but the quality of the information in relation to the modal split is limited. Data from public transport and shared mobility systems can help to complement cell phone data to refine modal split estimates. The aim would be to exploit the complementarity and synergies between the different data sources in order to reconstruct the best possible picture of mobility at minimum cost.

Table 6.2: Examples of relevant data sharing initiatives

Iniciative	Promoters	Type	Category	Description	Link
Waze for Cities	Waze	Private	Data exchange	Waze for Cities is an initiative that seeks to share data with cities with the goal of reducing traffic, supporting infrastructure decision-making and helping to create safer communities. Public authorities get free access to Waze traffic data in exchange for sharing traffic operation data.	https://www.waze.com/wazeforcities
Uber Movement	Uber	Private	Data exchange	Uber Movement is an initiative to share with cities data on travel times and speeds, among others, with the aim of contributing to more sustainable mobility.	https://movement.uber.com
Location Data	Cuebiq	Private	Data-driven products	Cuebiq collects positioning data based on the aggregation of data from different mobile applications, consolidating this data into a single integrated dataset.	https://www.cuebiq.com/
Google Maps Platform	Google	Private	Data-driven products	Google Maps Platform provides information on multimodal transportation options, travel times and other indicators through different APIs. This information is generated from data collected from mobile devices and other data sources such as traffic cameras.	https://console.cloud.google.com/google/maps-apis/api-list?project=map-for-work-int-01145205
OpenTraffic	WBG, Conveyal, Mapzen	Private	Data-driven products	OpenTraffic is a global platform that provides real-time and historical traffic statistics information. It uses anonymous vehicle positioning and cell phone data to generate this information. The information is shared openly using open source software.	http://opentraffic.io/
Nommon Mobility APIs	Nommon	Private	Data-driven products	Nommon Mobility APIs is a platform that provides mobility information from the analysis of data coming from cell phone networks. It provides a set of APIs for information access and analytics services for data exploration and exploitation.	https://www.nommon.es/services/our-apis/
Whim	MaaS Global	Private	Data-driven products	Whim is a MaaS application that provides its users with integrated information on urban transport services. The information offered is based on data sharing between different public and private service operators.	https://whimapp.com/
Spatial Data Calatog	CARTO	Private	Marketplace	Spatial Data Catalog is a repository of both public and private data including mobility, socio-demographic or points of interest data. The objective is to provide a single point of access to a large set of datasets to minimize data collection and cleaning tasks.	https://carto.com/ https://carto.com/spatial-data-catalog/browser/
Data Exchange Platform	Dawex	Private	Marketplace	Data Exchange Platform is a platform that facilitates communication and collaboration between companies interested in monetizing their data and users interested in obtaining such data, providing a set of tools for data management and sharing.	https://www.dawex.com/en/data-exchange-platform/