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Artículo Original

Estimación de retrasos lógicos de pavimentación en 2022 por restricciones de tráfico del COVID-19 en la ciudad de La Plata, Argentina

Estimation of logic paving tasks delay in 2022 due to COVID-19 traffic restrictions in La Plata city, Argentina

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Resumen

Desde marzo de 2020, la ciudad de La Plata (Buenos Aires, Argentina) ha registrado restricciones de movimiento debido a la pandemia por COVID-19. Debido a ello, en septiembre de 2020, se realiza un estudio de predicción de cuáles son los plazos lógicos en los que podrían posponerse las obras de pavimentación durante el año 2021, en base a datos facilitados por la empresa Google. El estudio se basa en el impacto que tendría una disminución del tráfico en la vida útil de diferentes obras viales urbanas (conservación, rehabilitación y obra nueva realizada antes de las restricciones), tanto las registradas como las previsibles mediante un modelo de tendencia. El resultado obtenido es de utilidad para las autoridades municipales, quienes de esta manera pueden destinar recursos a otras actividades de mayor prioridad durante ese período, sin que exista un deterioro en el estado de su red vial por encima de lo ya admitido antes de la pandemia. La serie más completa de datos de Google está disponible hasta mediados de 2021, lo que permite corroborar o ajustar las predicciones realizadas, buscando obtener un valor lógico actualizado para diferir los trabajos en el primer semestre de 2022. Como resultado relevante se tiene que se pueden diferir las intervenciones siete meses y medio debido a las restricciones impuestas, optimizándose de ese modo el empleo de los recursos disponibles.

Palabras clave: COVID- 19, Ingeniería Civil, rutas, políticas municipales, pavimentación

Abstract

Since March 2020, La Plata city (Buenos Aires, Argentina) has registered movement restrictions due to the COVID-19 pandemic. Because of it, in September 2020, to carry out a prediction study of what are the logical deadlines in which the paving works could be postponed during the year 2021, based on data provided by Google. The study is based on the impact that a decrease in traffic would have on the useful lives of different urban road works (conservation, rehabilitation, and new work carried out prior to restrictions), both those registered and those predictable by means of a trend model. The result obtained is useful for municipal authorities, who can thus allocate resources to other activities of higher priority during that period, without there being a deterioration in the state of their road network above that which was already admitted prior to the pandemic.
With the advance of time, the most complete series of Google data is available until mid-2021, which allows to corroborate or adjust the predictions made, seeking to obtain a logical updated value to

defer the works in the first half of 2022. As a relevant result, the interventions can be deferred for seven months and a half due to the restrictions imposed, optimizing in this way the available resources.

Keywords: COVID-19, Civil Engineering, Roads, Municipal Policies, paving

1. Introduction

In 2020, the global pandemic caused by the SARS-CoV-2 virus has significant consequences for the entire planet. Since March 2020, traffic mobility data has been collected, provided by Google company, which significantly differs from those recorded previously [1]. Based on the different classifications of mobility information offered by the website, an analysis of the movement in the vicinity of workplaces in La Plata city is carried out, seeking to arrive at useful conclusions. From the analysis of daily data obtained, weekly averages are taken, registering a reduction that, in principle, presents a linear trend in the recovery of traffic to its original volume. When these data are compared with a situation without a pandemic situation, the incidence in the useful life of a road intervention in the downtown area of the city can be estimated, whether it is maintenance interventions or new construction carried out previously to movement restrictions. Based on this analysis and with different useful life scenarios, in September 2020, was estimated the logic of deferring the interventions in the road works for a period of 4 months without this, leading to a loss of the stage that would have occurred at the time of the intervention, considered before the onset of the pandemic. In a second part of the work, with a broader data record, it is required to observe if the validity of the initial conclusions is maintained and, if not ratified, to indicate a new term that could be used for interventions.

The pandemic caused by the SARS-CoV-2 virus (commonly identified by its consequences as COVID-19), has presented a strong impact worldwide in various aspects (whether economic, political, or financial) and Argentina has not been left to the margin of that. One of the most remarkable effects at the local level is the reduction in the movement of people, whose information has been collected by Google [2]. From these data, various aspects can be quantified that allow understanding the scope of the effect. For example, the reduction of movement throughout the planet brought with it a series of positive issues [3], such as the reduction of pollution on a global scale [4], the decrease both in China and in Italy for a period of greenhouse gases (such as carbon dioxide), etc. These issues appear as a result of the pandemic and its control through restrictions. In this context, the daily traffic of the population in the main Argentine cities is strongly affected, especially in the first months, with almost zero vehicular traffic.

The reduction of road incidents also was significantly reduced. According to a study, in the AMBA region (the Spanish acronym for Metropolitan Area of Buenos Aires), where La Plata city is located, serious road incidents were reduced by 35% in the first half of 2020 compared to the previous year. On the other hand, there is also a sharp drop in mortality associated with vehicular incidents, in the order of 40% taking the same reference. This highlights the great impact that the pandemic has had in its multiple areas.

The logical reasoning of interest for the purposes of a road structure indicates that the decrease in movement of people directly leads to a reduction in traffic, which should have a direct impact on the useful life of the pavement. This aspect is important to be measured, because due to the negative economic consequences generated by the pandemic. Any delay in time of road maintenance of urban arteries allows resources to be used for other higher priority purposes [5, 6]. The great unknown then

is to establish what would be the logical delay of these road interventions, without this leading to a decrease in the quality of the pavements below what was originally planned.

Within the framework of new construction and pavement maintenance policies that each city must have, it is vitally important to schedule periodic paving tasks, depending on the degree of importance of the roads involved. Facing the correct corrections on time of the various incidence factors leads to a strong saving, not only of economic resources but also of other resources involved in the construction of the corresponding roads.
As shown in Figure 1, once the pavement reaches a certain "stage", the cost to face to return to achieve a level of traffic service similar to the initial level is approximately 10 times higher compared to if the problem is addressed at an appropriate time [7].

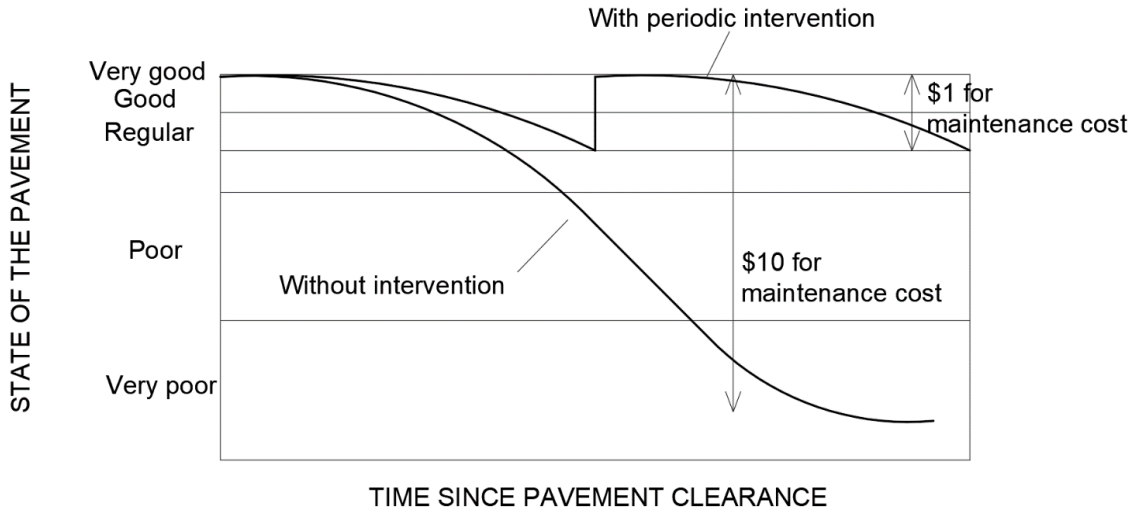

Fig.1 Relationship between the state of the pavement and the time of clearance

2. Materials and Methods

Initial Analysis-The available data

Since April 3, 2020, Google publishes statistical data on the reduction in population movement on a global scale. Anyone who has a device with an Android operating system, and has the geo-locator enabled, helps to collect this data, of which Google keeps anonymity. In this way, one more tool is provided for any government or country that needs it to face the pandemic [8]. Currently, various works have been presented in which the use of both the data provided by Google as well as by Apple company can be seen. In this work, Google data is used due to the higher geographic precision they offer compared to those offered by Apple.

As a measure to protect the privacy of users, the data is only shown in the form of percentages (positive or negative) with respect to a "reference value" (initial for the purposes of this work) that is not specified, but that if expressed corresponds to the average between January 3, 2020 and February 6, 2020. It should be noted that this specific period could have a strong seasonal incidence, but that is later denied due to an analysis carried out, since the effects are analyzed in a relative and not nominal way, as can be confirmed in this work.

The data provided by Google is divided into:

- Shops and leisure
- Supermarkets and pharmacies
- Parks
- Transport stations
- Work places
- Residential areas

From these data, the scatter graph of Figure 2 is generated, in which all the data collected up to the end of August 2020 are added.

Analysis used

In the first instance, it was decided to work only with the data in Figure 2 belonging to "Workplaces" since these data are the ones that are estimated, they have a higher correlation with the reduction of vehicular movements itself. In the rest of data, as for example in "Residential Zones", it would be in front of movements of people related to a low (or null) use of the vehicle fleet (it is assumed that the increases in movement that are observed, accurate are of "cell phone movements" in areas near the housing for reasons of provisioning and others).

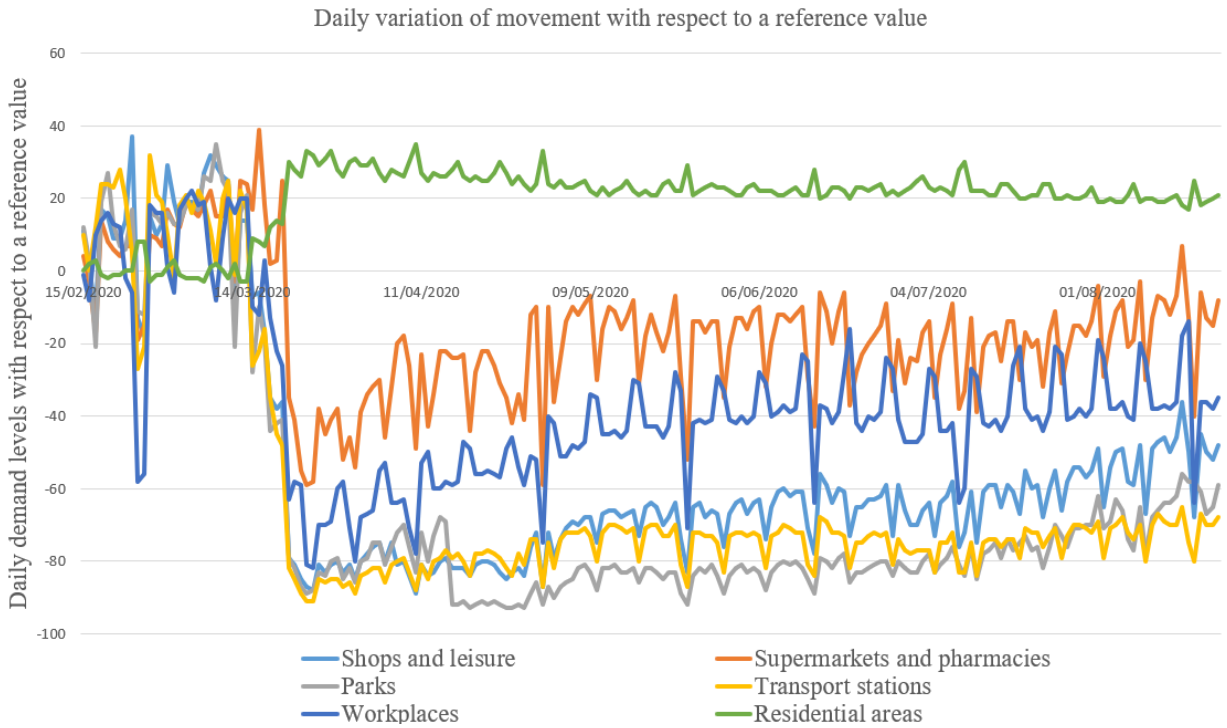

Fig.2 Google data discriminated by activity 02/15/2020-08/21/2020 (with respect to 100% of the reference value)

Since these data are collected from daily records, it was decided to take the averages of daily demand on a weekly basis, and thus reduce their degree of dispersion. These values were then compiled in a table, from which Figure 3 was generated. On the other hand, there were records showing that the last week corresponded to a regular movement is between Saturday 7 and Friday 13, March 2020. Figure 3 shows the weekly averages between Saturday, March 21, 2020 (the first date that shows a

sharp drop in the daily movement and marks the start of strict restrictions) and Friday, August 21, 2020. The new “reference value” (that is, a new record of 100% demand) for work, is therefore taken outside, and is calculated as an average of the levels between the weeks of February 29 and March 13, 2020. It can be commented, only at a complementary level, that this new reference value is approximately 12% higher than the base reference value estimated by Google.

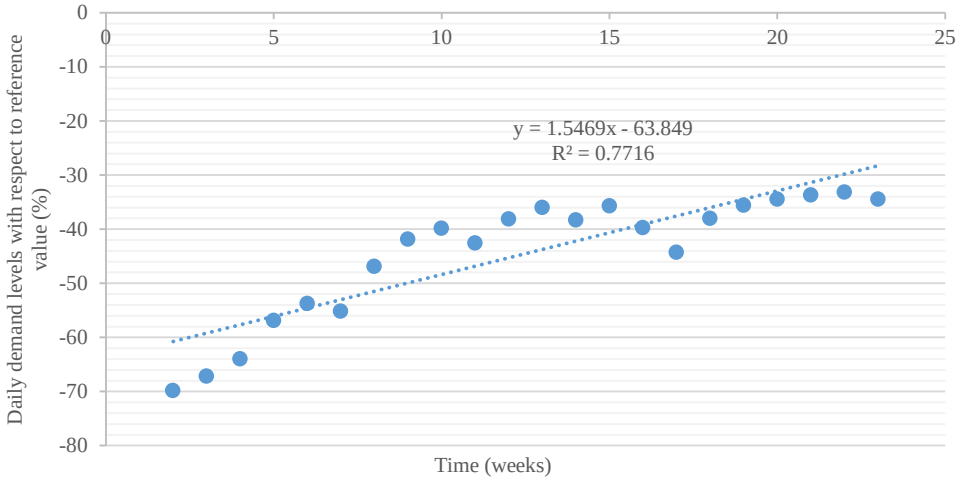

Fig.3 Trend analysis in daily demand on a weekly basis until the end of August 2020

As the records taken into account are directly affected by the movement restrictions, it is not appropriate under these circumstances to apply corrections for seasonality, which would have their logical application in periods of "normality". However, to clear up any type of doubt in this regard, the seasonality applicable to these roads established by previous studies in the area [9], which are shown in Table 1, must be taken into account.

The roads to which this analysis is directed are of the "urban", "commercial" (non-tourist) and do not have any type of "toll" collection type; therefore, they registered a reduced degree of seasonality, which would allow approximately (especially in estimative studies such as this one) to reject the corresponding applicable corrections, as can be seen in Table 1. Therefore, it is justified to work with the “raw” data available and, based on the data in Figure 3, to find the trend curve corresponding to a simple linear regression. With this calibrated function, which has a value of 0.77 of the coefficient of determination R^2 (which exceeds the empirically taxable limit of 0.70 for an estimative analysis like the present one [10]), the data can be extrapolated to the future; and in this way find when, at least statistically, the level of demand considered as the base for the analysis would be reached again. In this way, there are two curves, one considered in blue for a normal period without a pandemic, with a constant level of demand (according to the caveats already explained); and the other in red with the weekly average pandemic data up to August 21 and with the data extrapolated by the regression after this date. The comments can be seen in Figure 4 and the two curves proposed (with pandemic and without pandemic). It can be seen how from the regression function found, the normal state of displacement of society around the work zones, in September 2020 it was deduced that it would not be reached that year, but would only be in the year 2021.

Table 1. Applicable seasonality in central area of Argentina [9]

URB	USE	TOLL	Monthly coefficient											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dec
Rural	Tourist	Without	no applicable											
Rural	Tourist	With	0.650	0.798	0.922	1.021	1.092	1.134	1.146	1.125	1.071	0.982	0.855	0.690
Rural	Commerc.	Without	0.991	0.987	0.990	0.997	1.006	1.018	1.029	1.038	1.044	1.045	1.039	1.025
Rural	Commerc.	With	0.995	0.993	0.997	1.003	1.011	1.019	1.025	1.028	1.026	1.017	1.000	0.974
Urban	Tourist	Without	0.699	0.836	0.949	1.037	1.098	1.130	1.131	1.101	1.037	0.937	0.801	0.627
Urban	Tourist	With	0.578	0.769	0.935	1.074	1.184	1.264	1.313	1.327	1.307	1.250	1.154	1.019
Urban	Commerc.	Without	1.044	1.032	1.024	1.020	1.018	1.016	1.012	1.005	0.994	0.976	0.950	0.914
Urban	Commerc.	With	0.997	0.998	1.002	1.009	1.015	1.021	1.023	1.020	1.012	0.995	0.969	0.933

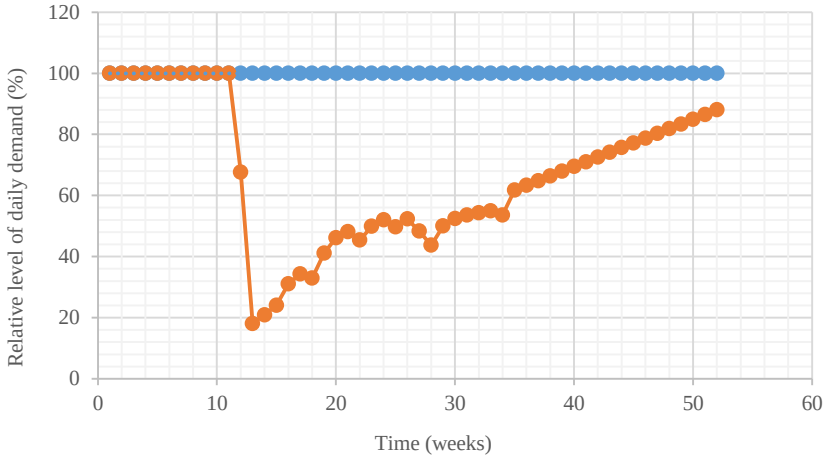

Fig.4 Demand curves "without pandemic" vs. "with pandemic" up to the end of August 2020

Initial results analysis

The calculations could then be applied with the differences in areas below the curve according to Equation 1 (based on the collected data extended to the established useful life periods), supplemented with Equation 2 to establish the demand with respect to 100% that would have been registered without a pandemic.

$$Total\ demand = \sum_{i=1}^{n} \frac{(Relative\ demand_i + Relative\ demand_{i+1})}{2} \quad (1)$$

$$Percentage\ of\ demand = \frac{Demand\ with\ pandemic}{Demand\ without\ pandemic} * 100 \quad (2)$$

From the corresponding analysis, it can be deduced that the level of demand prior to the restrictions is reached in week 50 after their implementation, registering a demand percentage of 69% compared to what would have been expected. Thus, the new interventions on the roads, with data at the end of August 2020 (week 34 of the pandemic), could be deferred approximately 4 months (by difference with the level close to 2/3 of the demand with respect to the forecast for 50 weeks, Figure 5); in La Plata city and from Google records [7].

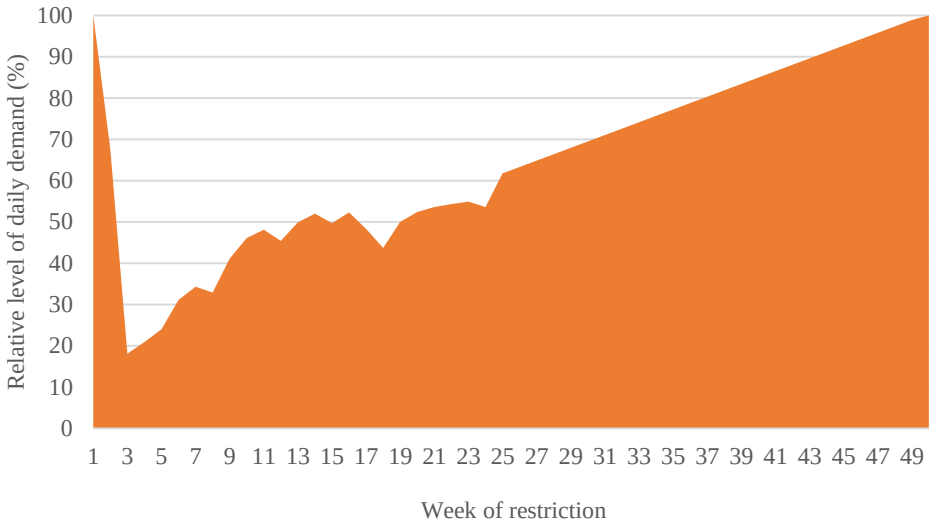

Fig.5 Effective demand with data up to week 34 of restrictions, compared to the 100% expected up to week 50

3. Results and Discussions

Advance analysis in June 2021

In this second instance of analysis, the objective was to complement the data obtained in September 2020 with those updated until the end of May 2021, applying the methodology already proposed as a checking tool. In this way, the delay in the intervention on the pavements can be obtained to meet the specified life cycle prior to the appearance of the restrictions. At the end of May 2021, there is an update of the traffic data since the imposition of restrictions (which takes from 24 weeks of data for the first study to more than 60 weeks for the advanced study), which are turned into Table 2.

The survey carried out by Google takes as a reference value equal to 0 on February 16 2020; therefore the reduction in traffic from that date is reflected as negative data in Table 2. From this, a similar analysis to that carried out with the data collected up to the end of August 2020 is followed, to compare with the predictions previously made. Figure 6 is made from this analysis, contrasted with those carried out in the initial study. As can be seen in Figure 6, there is a difference between the recovery in demand estimated in September 2020 and the one actually registered. The reasons for this difference are public knowledge, and are fundamentally related to the concept of subsequent “waves” of contagion registered worldwide, although in different ways depending on the geographical region. This is how "second" and "third" wave have been registered in some sectors of Europe [11-13], and in some eastern countries it has come to speak of "fourth" wave [14-16]; having in the American continent, and more specifically in Argentina, so far only talked about a "second" wave [17-19]. Beyond these conventions, the effects are clear, resulting in outbreaks of the pandemic in one form or another and the resurgence of restrictions of some kind.

Table 2. Estimated weekly averages of traffic variation at the end of May 2021 from Google data

Week	Weekly averages	Week	Weekly averages	Week	Weekly averages
3/13 to 3/20	-20.4	8/1 to 8/7	-33.7	12/19 to 12/25	-22.4
3/21 to 3/27	-69.9	8/8 to 8/14	-33.1	12/26 to 1/1	-26.4
3/28 to 4/3	-67.1	8/15 to 8/21	-34.4	1/2 to 1/8	-19.3
4/4 to 4/10	-64.0	8/22 to 8/28	-31.4	1/9 to 1/15	-22.0
4/11 to 4/17	-56.9	8/29 to 9/4	-33.3	1/16 to 1/22	-27.4
4/18 to 4/24	-53.7	9/5 to 9/11	-31.3	1/23 to 1/29	-26.4
4/25 to 5/1	-55.1	9/12 to 9/18	-29.4	1/30 to 2/5	-26.1
5/2 to 5/8	-46.9	9/19 to 9/25	-29.9	2/6 to 2/12	-23.0
5/9 to 5/15	-41.9	9/26 to 10/2	-30.6	2/13 to 2/19	-31.1
5/16 to 5/22	-39.9	10/3 to 10/9	-27.6	2/20 to 2/26	-20.3
5/23 to 5/29	-42.6	10/10 to 10/16	-29.3	2/27 to 3/5	-17.1
5/30 to 6/5	-38.1	10/17 to 10/23	-24.6	3/6 to 3/12	-15.3
6/6 to 6/12	-36.0	10/24 to 10/30	-24.6	3/13 to 3/19	-13.6
6/13 to 6/19	-38.3	10/31 to 11/6	-21.1	3/20 to 3/26	-20.9
6/20 to 6/26	-35.7	11/7 to 11/13	-20.4	3/27 to 4/2	-24.0
6/27 to 7/3	-39.7	11/14 to 11/20	-19.7	4/3 to 4/9	-17.0
7/4 to 7/10	-44.3	11/21 to 11/27	-23.4	4/10 to 4/16	-20.6
7/11 to 7/17	-38.0	11/28 to 12/4	-17.1	4/17 to 4/23	-23.3
7/18 to 7/24	-35.6	12/5 to 12/11	-24.6	4/24 to 4/30	-21.3
7/25 to 7/31	-34.4	12/12 to 12/18	-13.9	5/1 to 5/7	-23.3

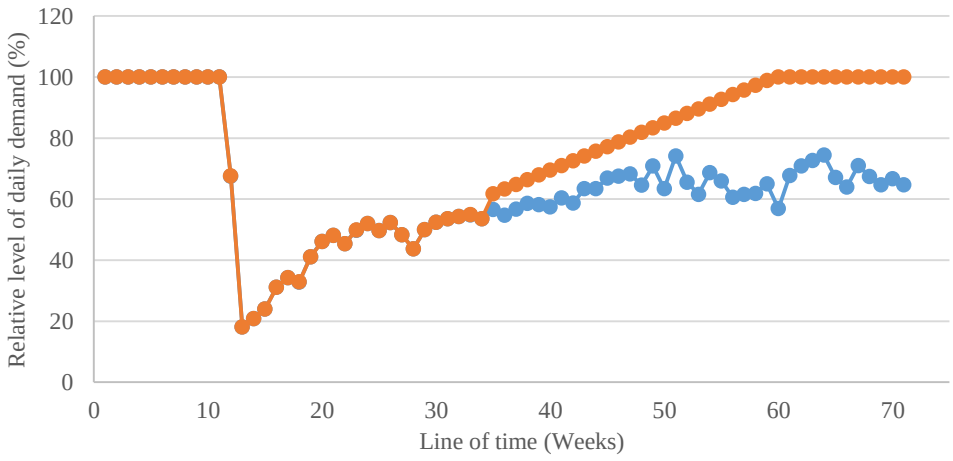

Fig.6 Comparison between the forecast as of September 2020 (in orange) and the record as of June 2021 (in blue)

The new data obtained allow to clearly appreciating that it is still far from reaching normality in terms of the movement of traffic that was had in March 2020. Various causes (such as inconveniences in the arrival of vaccines, new strains of coronavirus more contagious than the original, increases in cases, and variable restrictions) allow to find some justification for not reaching a situation of expected normality. Among them, a point to be strongly considered is related to the new trends brought about by the pandemic. One of the most important to consider is the implementation of teleworking (regulated by law in Argentina) which prevents workers from physically attending their workplace on most days of the week, if possible, and carry the usual chores around the home. These trends, glimpsed tepidly in advance, the coronavirus pandemic accelerates them completely; and everything indicates that they are assiduous practices to carry out from now on. The aforementioned can be seen in the graph in Figure 7, in which it is observed that some of the main cities in Argentina are below the main indicator of "mobility in work areas" or barely exceed it; constituting the imposition of teleworking as the notorious identifying aspect between "Buenos Aires (CABA) - La Plata - Santa Fe" and "Mendoza - Córdoba", at least until the time of registration (strictly speaking, given the latest rates in terms of contagions in Mendoza city and Córdoba city, and the measures that in those cities are finally decided to take, it is possible that in the short term graphs can be constructed in which all these cities are below the indicator). The values quoted in the figure are considered in reference to the initial value previously quoted and stipulated by Google.

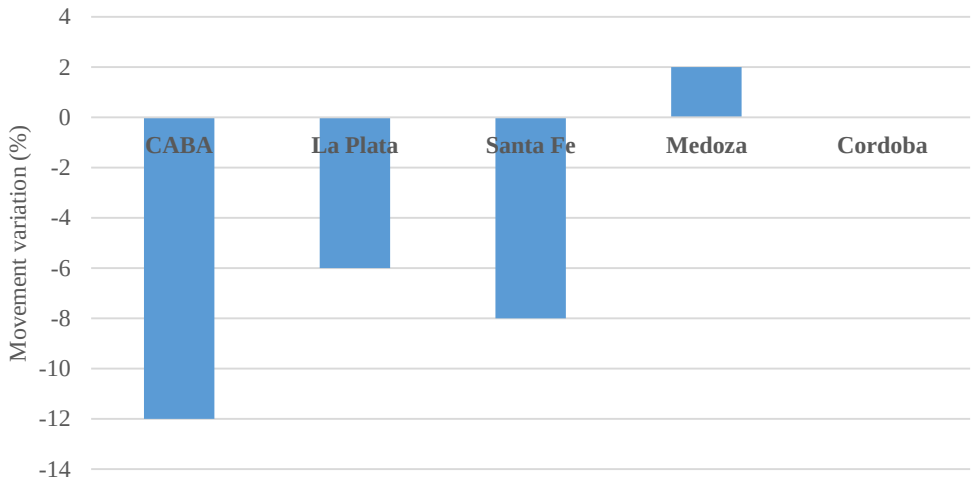

Fig.7 Variation of movement in work zones in some of the main cities of Argentina as of May 2021

Beyond what was expressed, in June 2021 in Argentina, the snapshot would allow to suppose that a new scenario of a reliable trend towards a recovery of previous levels of movement seems to have been found, given this fundamentally by the last-minute situation in terms of the effective acquisition of various vaccines for the prevention of COVID-19 and its application in citizens. However, that pace towards recovery appears to be slower than previously assumed (i.e., in September 2020), requiring a new trend analysis. The percentage of traffic reduction in this period is calculated, with respect to the last traffic considered normal, which corresponds to March 2020, using Equation 1 and Equation 2 with all the data until May 2021 (week 61 from the restrictions). In this period, the percentage of demand obtained is 57.1%. In this way, taking into account the reduction in mobility, it can be said that to June 2021 an intervention on the pavements carried out prior to the pandemic can be postponed approximately 6.5 months (by difference with 57.1% of 61 weeks), without theoretically affecting the expected state at the time of said intervention (Figure 8).

The trend of the records available can then be analyzed to establish when the 100% level of demand prior to the restrictions would be recorded from the expanded data again. For this, a linear regression was initially proposed, which gives an acceptable R^2 of approximately 0.73 (Figure 9).

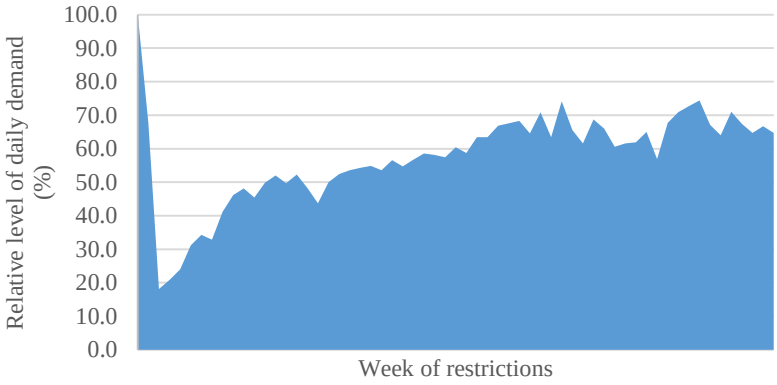

Fig.8 Effective demand with data up to week 61 of restrictions, compared to the 100% expected for week 61

From the regression formula that is observed in Figure 9, the new forecast for week 100 can be found by future extrapolation from the restrictions, regarding the moment at which it would return to 100% of the existing demand level prior to them (Figure 10).

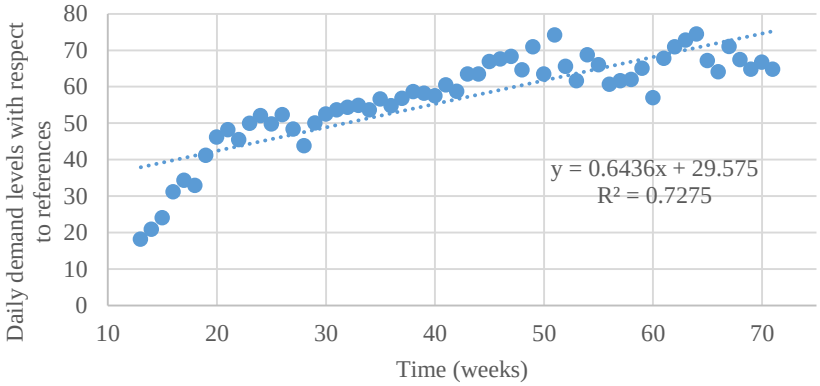

Fig.9 Tren with real data until May 2021

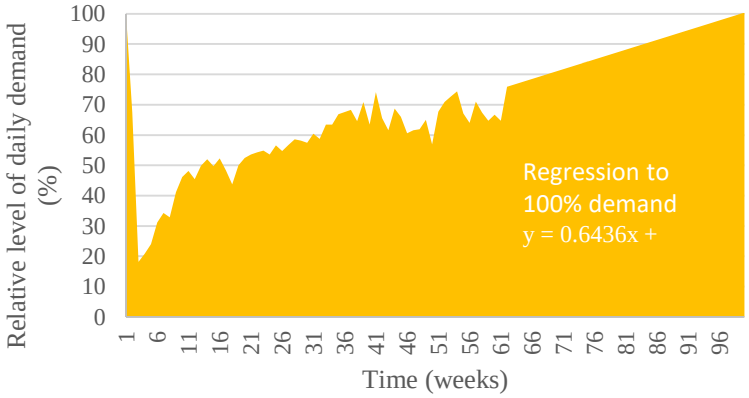

Fig.10 Effective demand with data up to week 61 of restrictions and extrapolation compared to 100% expected for week 100 of restrictions

According to the parameters of Figure 10, 69.4% of the demand would be obtained, having a new travel period in road interventions without theoretical consequences in terms of final deterioration of approximately 7.5 months (by difference with 69.4% with respect to 100 weeks).

4. Conclusions

In the present article, an analysis of the traffic demand in La Plata city is carried out based on the data collected by Google in relation to the "work zones". Data obtained from 2020 and 2021 are compared in which trends are obtained until reaching a state of normality prior to movement restrictions due to the pandemic. With the data available at the time of the initial analysis carried out in 2020 (that is, September 2020) and the analysis of its trend, a return to 100% of the demand levels prior to the pandemic was deduced approximately in week 50 since restrictions were imposed; which meant that a logical term to defer interventions on previously materialized pavements was at least 4 months. With the updated data until week 61, since the restrictions and their analysis (June 2021), it can be concluded that this logical period to defer the interventions has been increased to at least 6.5 months. If with the data available up to week 61 of restrictions, the recovery of movements is extrapolated linearly and with an acceptable 0.73 of R^2, it can be estimated that demand levels prior to the restrictions would occur in week 100 from that they were imposed (February 2022); which would imply a new logical period in which interventions can be deferred, without compromising the previous perspectives on said pavement materialized before the restrictions, of at least 7.5 months. However, if is looked at the variation in the data between the current analysis and the one previously performed, can be see a large variation in the samples that were collected. The evolution of the pandemic caused by the SARS-CoV-2 virus is deduced posing an unclear scenario for the estimates to have a significant statistical value (which could be reached empirically, for example, with an R^2 greater than 0.90). In turn, due to the reasons raised (teleworking, new strains, etc.), it is likely that the estimated terms are still short and that the reality will lead to even longer recovery periods. This would allow the authorities to allocate even more time and certain resources to foresee for road intervention to other activities that could have a higher priority, even if this would be to the detriment of certain partial interests of the road sector.

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Conflict of Interests

No potential competing interest is reported by the authors.

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