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International Borders, Integration and Economic Development: Evidence from Argentina

Nazarena Delicia Maffini[1] and Fernando Antonio Ignacio González[2+]

[1]*Universidad de Buenos Aires, Buenos Aires, Argentina*
[2]*Universidad Nacional de Misiones, Posadas, Argentina*

Abstract This paper analyzes the effects of international borders and of trade agreements on subnational development in Argentina. The identification strategy leverages the Mercosur trade services agreement in 2005, and the different proximity of the districts to the international border with member countries. Two main outcomes are analyzed: economic growth and inequality. For this purpose, an annual panel of districts covering more than two decades (1992-2013) is used. The results show that the presence of an international border has a negative and significant effect on the economic growth of border districts (-0.14 percentage points of GDP annually) but also contributes to reducing inequality compared to districts without a border. On the other hand, a commercial integration agreement tends to partially offset the negative effects on economic growth (+0.04 percentage points of GDP annually). The results of the paper are relevant in terms of trade and development policy recommendations: deepening integration agreements constitutes a potential mechanism to boost growth in the poorest regions and thus reduce subnational disparities.

Keywords: international border, trade agreement, Mercosur, economic development, growth, inequality

JEL Classifications: D31, F14, F15, F43, I30, R12

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I. Introduction

International borders can impose a significant barrier to economic growth by limiting trade (McCallum, 1995), which is an essential component of the economy. Specifically, by increasing the costs of trade between regions of neighboring countries compared to trade within the same country, international borders can hinder trade between international regions and promote trade with domestic neighbors. Adam et al. (2021) provide evidence of a negative effect on economic growth derived from the presence of international borders ("border effect") and a positive effect as a result of integration agreements ("integration effect"), examining 1,350 subnational regions worldwide.

To reduce these barriers to international trade, countries sign trade agreements, which increase

+Corresponding Author: Fernando Antonio Ignacio González
Full Professor of Economics, Universidad Nacional de Misiones, Posadas, Argentina. E-mail: fernando.gonzalez@fce.unam.edu.ar
Co-Author: Nazarena Delicia Maffini
Graduate student, Universidad de Buenos Aires, Buenos Aires, Argentina. E-mail: nazarenamaff@gmail.com

the likelihood of international trade expanding in border regions with countries that have signed such agreements. Border regions that benefit from trade agreements experience higher economic growth compared to regions without international borders, which do not face direct regional boundaries affecting trade costs (Adam et al., 2021).

In this context, Argentina offers an interesting case for studying the impact of international borders on economic development. Argentina shares international borders with Paraguay, Brazil, Uruguay, Chile, and Bolivia, spanning over 9,000 km, and three of these countries (Paraguay, Brazil, and Uruguay) are full members of the Southern Common Market (Mercosur) with Argentina. This allows for the use of the trade in services protocol to causally identify the effects of deepening integration agreements on economic development.

The Mercosur is a regional integration process founded in 1991 initially by Argentina, Brazil, Uruguay, and Paraguay. Later, Venezuela and Bolivia joined (the latter still in the process of accession), and to this day, cooperation agreements have been signed with Chile and the countries of the Andean Community, which include Bolivia, Ecuador, Colombia, and Peru (Laborde and Ramos, 2007, June). In 2005, Argentina, Brazil, and Uruguay implemented the services protocol. According to Bekerman and Rikap (2010), Mercosur has acted as a learning platform for the larger partners (Argentina and Brazil) to expand globally. Furthermore, the benefits are evident in the trade in services: Berlinski, Celani, and Bebczuk (2008) find significant gains from the liberalization of trade in services in Argentina, Brazil, and Uruguay, resulting from improvements in productivity, quality, and efficiency in the service industries. Figures A1 and A2 show the substantial increase in exchange after that year (2005).

In this context, this paper aims to analyze the impact of international borders and trade agreements on economic growth and inequality at the subnational level in Argentina. This is the first analysis that considers border effects and the effects of trade agreements on Argentina's regions at the district level and is especially relevant due to the significant regional disparities in this country. In particular, the region of Northern Argentina (which includes the Northeast and Northwest regions) concentrates a large part of the international borders with Mercosur countries and, has historically exhibited lower well-being levels, including lower incomes, lower literacy rates, reduced life expectancy, worse housing conditions, and higher incidence of poverty (González and Santos, 2020).

The lack of a periodic official series of Gross Domestic Product (GDP) at the subnational level in Argentina hinders a detailed analysis of economic development in different provinces and districts. Since 1993, the Ministry of Economy has delegated the calculation of GDP to provincial statistical institutes, whose series have updates and methodologies that are not uniform. The last official estimation of GDP by province dates back to 2004 and was carried out by the National Institute of Statistics and Census of Argentina (INDEC). To address this gap, the strategy used is to approximate economic activity, its evolution, and concentration

in Argentina at the district level using night luminosity satellite imagery published by the National Oceanic and Atmospheric Administration (NOAA) of the United States.

Night luminosity maps have been widely used in similar studies (Chen and Nordhaus, 2011; Doll, Muller, and Elvidge, 2000; Elvidge et al., 1997; Henderson, Storeygard, and Weil, 2012; Seminario and Palomino, 2022; Sutton, Elvidge, Ghosh et al., 2007; Stymne and Jackson, 2000) and to estimate urban population (Amaral et al., 2006), population density (Sutton et al., 1997), construct poverty maps at the global (Elvidge et al., 2009a), regional (Noor et al., 2008), or national level (Wang et al., 2012), as well as to evaluate rural poverty and inequality (Smith and Wills, 2018) and locate forest fires (Fuller and Fulk, 2000).

The identification strategy of the paper exploits the deepening of the Mercosur agreement concerning international trade in services (2005). A generalized difference-in-differences model is used to analyze the 503 districts of the country during the period 1992-2013 (the annual NOAA luminosity series was discontinued in 2013). While the paper does not precisely identify the mechanism through which borders affect regional income and inequality, the findings reported here are of academic interest in exploring regional disparities and how trade agreements can mitigate these effects.

The findings suggest that border districts experience lower economic growth than non-border districts. However, integration agreements favor growth in border regions. This indicates that districts with trade agreements may be less adversely affected by the presence of international borders than those without agreements. Additionally, districts without international borders exhibit greater inequality than border regions. Given that the NEA districts, the poorest region in Argentina, make up the majority of the border with Mercosur countries, deepening commercial integration agreements could reduce the wide regional disparities present in the country. In other words, trade policy can contribute to boosting development and reducing high disparities between Argentine regions.

The paper is structured as follows: Section 2 addresses the state of the literature, presenting background information related to the link between trade, trade agreements, international borders, and economic development. Additionally, the use of night luminosity as a proxy for economic activity and inequality is discussed. Section 3 provides the detailed methodological design, model construction, and description of the database. Section 4 presents the main results obtained and the analysis of their robustness. Finally, Section 5 presents the conclusions.

II. Literature

A. Trade, border effect, and agreement: Their relationship with development

In this section, the literature related to three main topics is examined: (i) trade and its impact on economic development, (ii) the border effect on international trade, and (iii) the relationship between trade agreements and economic development.

First, existing literature indicates the positive effects of trade on economic growth. Frankel and Romer (1999) found that trade benefits the per capita income of 63 countries in 1985, considering geographic factors such as size and population. Furthermore, subsequent studies have reinforced this idea, including Feyrer (2009, 2019) and Anderson, Larch, and Yotov (2015). Trade policy has also been investigated in relation to economic growth, and several studies have found a positive causal relationship between trade openness and economic growth, such as Wacziarg (2001), as well as other works by Wacziarg and Welch (2008), Anderson et al. (2020), and Farrokhi and Pellegrina (2021).

Secondly, the border effect refers to the negative impact that international borders have on trade due to additional trade costs associated with differences in language, culture, customs, and regulations. This often leads regions to avoid trading with their international neighbors and instead focus on domestic trade. Although Isard (1956) and McCallum (1995) were the first to provide evidence of the border effect by finding greater trade between Canadian provinces than with bordering U.S. states, McCallum's model has faced criticism due to the presence of unobservable bilateral heterogeneity. However, Anderson and Van Wincoop (2003) included the multilateral resistance term in their model to account for bilateral endogenous prices in the gravity equation, and their results supported the border effect. To control for the impact of unobservable bilateral heterogeneity, several authors have advanced models with fixed effects by country and year, as done in studies by Baier et al. (2008), Baldwin and Taglioni (2006), Egger and Pfaffermayr (2003), Fugazza and Nicita (2013), and Gil-Pareja, Llorca-Vivero, and Martínez-Serrano (2014). Since then, numerous studies have focused on the issue of border effects, utilizing new data and econometric models, as demonstrated in works by Anderson and Yotov (2010), Carballo et al. (2021), Chen (2004), Coughlin and Novy (2013), Drápela (2020), Head and Mayer (2002), Maffini (2021), Minondo (2003), Nitsch (2000), San Román et al. (2012), Vancauteren et al. (2002), and Wei (1996).

Third, the impact of regional integration agreements on trade has been of broad academic interest. In an early study, Brada and Mendez (1983) examined the effect of five regional integration schemes on intra-member trade volume using a gravity model and found that trade agreements reduce trade costs, resulting in increased trade. Baier and Bergstrand (2007) employed instrumental variable and control function techniques to demonstrate the positive

effects of free trade agreements on trade flows, with subsequent support from Baier, Bergstrand, Egger, and McLaughlin (2008) and Baier, Bergstrand, and Feng (2014). Gil-Pareja and Llorca-Vivero (2017) studied the influence of European integration on Spain's exports and imports for the period 1960-2012 through gravity equation estimation and suggested that Spain's incorporation into the current European Union led to a significant increase in trade with other partners. Other studies also support the positive effects of trade agreements on trade, such as Anderson and Yotov (2016), Baier, Yotov, and Zylkin (2019), Caliendo and Parro (2015), Carrere (2006), and Maggi (2014).

Adam et al. (2021) combine three strands of research on trade: the positive effect of trade on economic growth, the negative effect of borders on trade, and the positive effect of trade agreements on trade. They use a panel covering 1,350 regions in 86 countries worldwide for the period 1950-2017 to study the link between trade and regional growth. The results suggest that an international border has a negative effect, while a trade agreement has a positive effect on regional per capita income. International borders decrease income by approximately 6%, while trade agreements increase regional income by 4% in border areas. This finding suggests that regions with an international border benefit more from a trade agreement than regions without international borders. This finding could help explain income differences between border areas of the same country related to the existence or absence of trade agreements with neighboring countries.

Since information on regional income is limited, alternative indicators, such as georeferenced data and night lights, have been used to study the economic development of regions. For example, Brülhart et al. (2019) find that regions near land borders tend to be poorer than inland regions, using satellite night light images. In contrast, Eberhard-Ruiz and Moradi (2019) analyze the spatial impact of establishing a regional economic community between Kenya, Tanzania, and Uganda in 2001, using satellite images of night lights, and find that cities near internal community borders experienced more expansion than more distant cities.

Various authors have addressed the relevance of different types of borders in studies related to trade and the economy. For instance, Anderson and van Wincoop (2003) emphasize how characteristics such as distance and transportation costs affect international trade patterns. Additionally, the type of border, whether land or river, can influence transportation costs and the ease or difficulty of conducting trade. In particular, logistics play a fundamental role in the economic growth and development of countries, as development in this sector facilitates international trade, increases competitiveness, and appears to be an important determinant of growth and development (Feyrer, 2009; Grigoriou, 2007; Grushevska & Notteboom, 2016; Hayaloğlu, 2015; Nguyen & Hoang, 2021)

In Argentina, the relationship between international trade and regional development has been analyzed, considering how different types of borders may influence transportation costs, trade

patterns, and the geographic distribution of economic activity. Moreover, the influence of transportation costs on Argentina's international trade has been examined, highlighting the significance of border types in export competitiveness.

In this context, land and river transport play a crucial role in strengthening economic growth and sustainable development (Sánchez & Gómez, 2017; Sánchez & Saade, 2017). The types of borders, whether land or river, can impact international trade, transportation costs, and the spatial distribution of economic activity in Argentina. Specifically, in Argentina, rivers are fundamental to the local economy, enabling accelerated and deepened integration processes between countries, bringing closer regions that are relatively isolated (Cabrera, 2021). Economically, water transport offers numerous advantages over land transport. According to the Secretary of Agriculture, Livestock, and Fisheries of the Argentine Ministry of Economy, the cost per ton/km for barges is approximately USD 0.02, which is significantly lower than truck and railway rates, which are around USD 0.10 and USD 0.045, respectively. Water transport is responsible for nearly 75% and 93% of Argentina's total export and import tonnage, respectively (Ministry of Transportation - Presidency of Argentina, 2017).

Therefore, including a control related to the type of border crossing could help provide a more comprehensive and precise understanding of the impact of borders on the country. The aforementioned studies highlight the importance of considering different types of borders to comprehend how they affect transportation costs and international trade patterns in Argentina. Additionally, river transport plays a significant role in the local economy, offering significant economic advantages over other means of transport.

B. Night luminosity and economic activity

The use of night luminosity satellite images has gained popularity in various research studies to approximate economic activity, its evolution, and its concentration at the national and district levels. Existing literature shows a strong correlation between luminosity, GDP, and local levels of economic development (Chen & Nordhaus, 2011; Doll, Muller, & Elvidge, 2000; Elvidge et al., 1997; Henderson, Storeygard, & Weil, 2012; Seminario & Palomino, 2022; Sutton, Elvidge, Ghosh et al., 2007; Stymne & Jackson, 2000). Additionally, luminosity maps have been used to estimate urban population (Amaral et al., 2006) and population density (Sutton et al., 1997), as well as to construct poverty maps at the global (Elvidge et al., 2009a), regional (Noor et al., 2008), or national level (Wang et al., 2012), assess rural poverty and inequality (Smith & Wills, 2018), and locate forest fires (Fuller & Fulk, 2000).

In Argentina, Ciaschi (2021) has studied how per capita night luminosity can be used to approximate poverty rates and measures of inequality using data from DMSP and NOAA during the period 1992-2013. The author has estimated inequality based on the standard deviation

of night luminosity[1] and has shown a correlation between the Gini index at the cluster level using averages of per capita family income and luminosity. However, it has been noted that the estimations using night luminosity are not capable of reproducing the declines in poverty and inequality observed in household surveys from 2000 onwards, due to the significant drop in luminosity in Argentina during the 2008-2009 crisis. Following this methodology, night light maps have also been used in Argentina to infer the effects of natural disasters on economic growth (approximated by nighttime luminosity) at the district level (González, London, & Santos, 2021), as well as to evaluate the impact of the federal intervention in Santiago del Estero in 2004 on economic growth (approximated by night luminosity) and on inequality (approximated by the dispersion of the standard deviation of that luminosity) (González, Santos, & Fernández, 2021).

However, the use of night luminosity maps presents several challenges in an academic context. Firstly, potential interferences arising from cloud coverage and other non-human sources of light, such as those originating from volcanic activities or fires, can affect the accuracy of the data. To address this limitation, this study relies on the annual series published by NOAA, which normalizes such interferences. Secondly, during the period from 1992 to 2013, a total of six satellites provided luminosity images (identified as F10, F12, F14, F15, F16, and F18), which are not strictly comparable due to the absence of official calibration. In this study, when information is available from multiple satellites, data from the earliest device is employed following the approach outlined by Ayadi et al. (2018). Furthermore, the saturation of the luminosity scale (0-63) could potentially lead to an underestimation of per capita income in densely populated areas.

III. Data and Empirical Strategy

A. Data

In the paper, NOAA satellite images are used within the framework of the Operational Linescan System (OLS) of the Defense Meteorological Program (DMSP) to approximate economic activity and its evolution in the 503 Argentine districts during the 1992-2013 period, following González et al.'s criteria (2021). The records of the satellite images provide a luminosity scale ranging from 0 to 63, with each value having a precision of 30 arc seconds (approximately 1 km² at the equator)[2], and each pixel storing data in 6 bits (i.e., up to 64

1) Other studies have employed satellite imagery for inequality analysis. For example, González, Cantero, and Szyszko (2022); Mendez and Santos-Marquez (2021); Montalvo, Reynal-Querol, and Muñoz (2021); Seminario and Palomino (2022); Valenzuela Vega (2022).

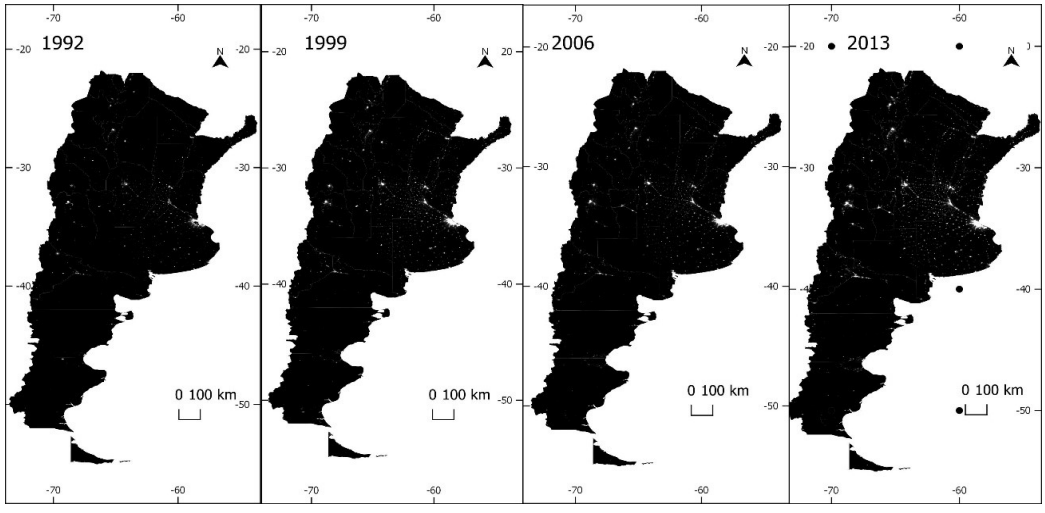
2) According to Argentina's geographical latitude, the area represents 0.8 km² in the north, 0.32 km² in the south,

positions). The annual series was utilized, which normalizes potential noise related to cloud cover and other non-human light sources. The data refer to the average of all pixels for each district and year and were obtained through data processing in the QGIS software. Figure 1 shows the average nighttime light for selected years in Argentina.

The data related to the international border, a cross-referencing was carried out between the Global Administrative Areas (GADM) database and the data from the National Geographic Institute (IGN) with the NOAA satellite images. As a result, a total of 84 neighboring districts were identified, detailed in Table A1 of appendix A. It is worth noting that for this study, districts with outer limits bordering the La Plata River and the Argentine Sea were not considered. Regarding the distribution of border districts with service agreements during the period 2006-2013, those with geographical adjacency to Brazil, Paraguay, and Uruguay were selected[3], resulting in a total of 41 neighboring districts.

Population and population density per district were collected from the Gridded Population of the World (GPW) dataset. This source provides quinquennial estimates (2000, 2005, 2010), and linear interpolation is used for the intermediate years. Data on border crossings were obtained from the Ministry of the Interior of Argentina[4], which reported a total of 70 land border crossings (affecting 42 districts) and 54 river border crossings (affecting 32 districts).

Figure 1. Nighttime light maps for Argentina, selected years



(Source) own elaboration based on NOAA.

and 0.64 km² at the latitude of Buenos Aires City (Ciaschi, 2021).

3) On December 7, 2005, the Mercosur Services Protocol came into effect (Organización de los Estados Americanos. (sp.). Protocolo de Montevideo 2004. Accessed on February 26, 2023, from http://www.sice.oas.org/trade/mrcsr/montevideo/pmontevideo_s.asp).

4) Ministerio del Interior. (s.f.). Entrada y salida del país. Gobierno de Argentina. Accessed on March 3, 2023, from https://www.argentina.gob.ar/interior/migraciones/entrada-y-salida-del-pais.

B. Empirical strategy

The paper employs a generalized differences-in-differences model to analyze the impact of international borders and trade integration agreements on the economic development of the 503 Argentine districts between 1992 and 2013. Our parsimonious baseline estimation equation to explain subnational income per capita is the following:

$$Luzpc_{it} = \beta_0 + \gamma_1 (Border_i) + \beta_2 (Border_i * TA_{it}) + \phi(X_{it}) + \text{EF} + \mu_{it}, \quad (1)$$
$$i = 1, ..., \text{N district}; \; t = 1992, ..., 2013$$

where $Luzpc_{it}$ represents the difference in the logarithm of per capita luminosity between years t and t-1 (a proxy for economic growth), $Border_i$ is a dummy variable taking the value 1 if district i has an international border and 0 else, TA_{it} is a dummy variable taking the value 1 if the district shares a border with a country with whom a trade service agreement exists in the year t (this dummy taking the value 1 from the year 2006 for districts with borders with Brazil, Paraguay, and Uruguay), and 0 else. X_{it} is a vector of control variables (population density and latitude). EF represents the fixed effects for year and district, as specified. Finally, μ_{it} is the error term.

The paper also provides an analysis of the border effect and the integration effect on inequality in Argentina. It is estimated based on the standard deviation of night luminosity in district i and year t. The standard deviation is a commonly used measure in inequality analysis. Intuitively, the higher the standard deviation, the higher the inequality observed in the data (Ciaschi, 2021; González, Cantero, & Szyszko, 2022; Mendez & Santos-Marquez, 2021; Montalvo, Reynal-Querol, & Muñoz, 2021; Seminario & Palomino, 2022; Valenzuela Vega, 2022). In the context of measuring economic inequality through satellite night luminosity, the standard deviation refers to the variation in night luminosity among different pixels within a district. Therefore, the standard deviation does not directly measure inequality between households or individuals, but rather the inequality in the distribution of night luminosity within each district. In this way, the paper provided two of the most important dimensions of economic development (growth and inequality). Our parsimonious baseline estimation equation to explain subnational inequality is the following:

$$stdev(luz)_{it} = \beta_0 + \gamma_1 (Border_i) + \beta_2 (Border_i * TA_{it}) + \phi(X_{it}) + \text{EF} + \mu_{it}, \quad (2)$$
$$i = 1, ..., \text{N district} \; ; \; t = 1992, ..., 2013$$

where stdev$(luz)_{it}$ represents the difference in the logarithm of the standard deviation of night

luminosity between years *t* and *t-1* (a proxy for economic inequality), $Border_i$ is a dummy variable taking the value 1 if district *i* has an international border and 0 else, TA_{it} is a dummy variable taking the value 1 if the district shares a border with a country with whom a trade service agreement exists in the year *t* (this dummy taking the value 1 from the year 2006 for districts with borders with Brazil, Paraguay, and Uruguay), and 0 else. X_{it} is a vector of control variables (population density and latitude). EF represents the fixed effects for year and district, as specified. Finally, μ_{it} is the error term.

IV. Results and Robustness Checks

A. Results - Economic growth

Table 1 presents the results of various estimated specifications for the economic growth of Argentine districts[5]. In our preferred specification in column (1), vector of control variables (latitude and population density) and fixed effects control for a substantial amount of unobserved heterogeneity[6]. In this specification can be observed that the coefficients "Border" ($Border_i$) and "Service Agreement" (TA_{it}) are statistically significant. These results suggest that an international border has a negative (reducing) effect, while the existence of a service agreement has a positive (increasing) effect on the economic growth of districts with international borders.

With all available controls in column (2), it is observed that districts with international borders exhibit a per capita night luminosity growth rate 0.585 percentage points lower than districts without borders. Assuming an elasticity of 0.3[7] between light intensity and regional GDP, this result implies a reduction of 0.18 percentage points in the regional GDP growth rate for districts with borders compared to those without. On the other hand, it was found that bordering districts that share a service agreement with neighboring countries experience an increase in the luminosity growth rate of 0.136 percentage points, resulting in a 0.04 percentage point increase in the regional GDP growth rate compared to bordering districts without a service agreement with Mercosur. These results allow quantifying the costs of borders and the benefits of trade integration agreements, such as Mercosur. Consequently, it can be inferred that districts

5) The computational work was conducted using the 'felm()' command from the 'lfe' package in the RStudio software. This command enables the fitting of linear models with multiple group fixed effects.

6) When district fixed effects are included, any district-specific omitted variable that remains constant over time is controlled for. Similarly, any year-specific omitted variable that is constant across districts is controlled for through the year fixed effect.

7) Henderson, Storeygard, and Weil (2012) demonstrate a positive elasticity of 0.3 between the growth of nighttime light intensities and GDP at the country level for a sample of over 100 low and middle-income countries. This finding was corroborated by Hodler and Raschky (2014).

located in the border area that share a service agreement with neighboring countries may be less affected by the international border than those that do not share an integration agreement.

Table 1. *Growth and Borders in Districts of Argentina (1992-2013)*

Night lights per capita	Difference of logarithms	
	(1)	(2)
Border	-0.609*** (0.042)	-0.585*** (0.038)
Service agreement	0.135* (0.040)	0.136* (0.049)
Latitude		0.018*** (0.003)
Population density		0,000*** (0,000)
District - year EF	yes	yes
Observations	10.427	10.427
Adjusted R^2	0.443	0.537

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01.

B. Robustness checks - Economic growth

In this section, different variations of the estimation of equation 1 are presented to check the sensitivity of the results. Various techniques were applied, including the inclusion of the dependent variable in different scales (linear or logarithmic) and the inclusion and exclusion of different-level fixed effects. The findings suggest that the conclusions derived from this investigation remain unaffected by the scale of measurement employed for the dependent variable or the incorporation of fixed effects.

A slight modification of the luminosity variable is also attempted to avoid the loss of observations with a value of 0 when transforming to logarithms. The results show that this modification does not have a significant impact on the obtained results. Additionally, the exclusion of districts near the upper limit of the luminosity scale is evaluated. The results indicate that observations reaching the maximum value on this scale (63) do not have a substantial impact on the results. Therefore, it is concluded that the results presented in this study are robust to several variations.

Table 2 presents the results of the new specifications to evaluate the effect of the international border on the growth of Argentine districts during the period 1992-2013. The first column reports the results for the dependent variable in logarithms, while the second column incorporates a fixed effect by province. In the third column, a fixed effect by province and year is added.

The fourth column adds a small constant (0.001) to avoid the loss of observations with a luminosity value of zero when transformed into logarithms, following the recommendation of Hodler and Raschky (2014). Finally, in the fifth column, districts of the Buenos Aires City (Federal Capital) and capital cities of the provinces are excluded to avoid potential contamination effects on the results.

Overall, columns 1 to 5 of Table 2 show that Argentine districts with international borders have a lower per capita growth rate of night luminosity compared to districts without borders. With the exception of model (1), the Agreement of Service variable is statistically significant, and its coefficients are larger when controlling for provinces (columns 2 and 3).

The regression and robustness analysis yield results consistent with the works of Adam et al. (2021) and Brülhart et al. (2019). It is demonstrated that cities near the borders grew less than more distant cities. However, districts belonging to a border region show fewer difficulties in growing if there is a trade agreement with the neighboring country. Nevertheless, in this study, it is observed that the benefit of a service agreement is smaller than that exposed by Adam and colleagues, and therefore, it only partially compensates for the negative effect of the international border on income.

Table 2. *Growth and Borders in Districts of Argentina (1992-2013). Different Specifications*

Night lights per capita	Logarithms	Difference of logarithms			
	(1)	(2)	(3)	(4)	(5)
Border	-0.579***	-0.589***	-0.591***	-0.575***	-0.667***
	(0.039)	(0.041)	(0.040)	(0.039)	(0.038)
Service agreement	0.057	0.571***	0.579***	0.113**	0.133**
	(0.038)	(0.074)	(0.097)	(0.038)	(0.036)
Latitude	0.016***	0.032**	0.031**	0.017***	0.020***
	0.003	(0.010)	(0.010)	(0.003)	(0.003)
Population density	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
District - year FE	yes			yes	yes
Province FE		yes			
Province - year FE			yes		
Observations	10,944	10,467	10,467	10,563	10,028
Adjusted R^2	0.856	0.458	0.477	0.518	0.537

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01.
Equation (1): Dependent variable in logarithm.
Equations (2) and (3): Fixed effect by province.
Equation (4): A small constant (0.001) was added to include rural areas in the analysis.
Equation (5): Buenos Aires City and capital cities of the provinces are excluded.

Table 3 presents the results of the specifications for the border effect on the growth rate

according to the quantity and type of formal border crossings[8]. The coefficients of the variable "Border" are significant and negative for all specifications. The variable "Service Agreement" is positive and statistically significant in column (2) when the number of land border crossings per district is included as a control variable.

Table 3. *Growth and Borders in Districts of Argentina (1992-2013) According to the Number and Type of Border Crossings*

Night lights per capita	Difference of logarithms	
	(1)	(2)
Border	-1.329*** (0.049)	-0.266*** (0.043)
Service agreement	0.066 (0.036)	0.151** (0.039)
Latitude	0.009*** (0.003)	0.016*** (0.003)
Population density	0.000*** (0.000)	0.000*** (0.000)
River Crossings	0.597*** (0.025)	
Land Crossings		-0.827*** (0.054)
District-year FE	yes	yes
Observations	10,427	10,427
Adjusted R^2	0.561	0.548

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01.

The different types of border crossings yield contrasting results. The number of river crossings per district has a positive effect on the dependent variable, while the number of land crossings shows a negative impact. That is, an increase of one unit in the number of river crossings in a district is related to a 0.597% increase in the growth rate of that district (or a 0.18% increase in the GDP growth rate). In contrast, an increase of one unit in the number of land crossings in a district is associated with a 0.827% reduction in the growth rate of that district (or a 0.25% reduction in the GDP growth rate).

Based on the results obtained, it can be concluded that river border crossings have a positive impact on the local economy, as their presence is associated with an increase in the growth rate of a district. On the other hand, the presence of land border crossings is associated with

8) Argentina.gob.ar. (s.f.). Pasos internacionales. Accessed on February 26, 2023, from https://www.argentina.gob.ar/pasos-internacionaless. It relates to the impact of available infrastructure, as some border crossings are not operational. For example, the Barra Bonita (Barra Bonita"") River crossing (Arg-Br) has been out of service since 2010, and the Alicia-San Antonio ("Alicia-San Antonio") crossing (Arg-Br) has also remained inactive since 2011.

a decrease in the growth rate. In this regard, river transportation presents itself as a more economical alternative than land transportation for integration between countries and for the economic development of regions near rivers. The lower costs of river transportation compared to land transportation are an advantage to consider for public policy planning and business decisions in the region.

C. Results - Inequality

Regarding the model considering the dimension of inequality among the Argentine districts (equation 2), Table 4 presents the same specifications as the economic growth model, but using the standard deviation of nightlight luminosity. Regarding the variable "Border", the results show few variations compared to the economic growth model. However, there is a decrease in the magnitude of the negative effect on the dependent variable.

The results of all specifications indicate that districts with international borders have a lower standard deviation of night luminosity, suggesting less dispersion around the mean luminosity and, therefore, lower inequality compared to districts without borders. On the other hand, it is observed that border districts sharing a service agreement with the neighboring country have a higher dispersion around the mean luminosity, indicating greater inequality compared to border districts without a service agreement with Mercosur.

Table 4. *Inequality and Borders in Districts of Argentina (1992-2013)*

Standard deviation of night lights	Difference of logarithms	
	(1)	(2)
Border	-0.427*** (0.031)	-0.419*** (0.031)
Service agreement	0.062* (0.030)	0.064* (0.030)
Latitude		-0.003 (0.002)
Population density		0.000*** (0.000)
District - year FE	yes	yes
Observations	10,311	10,311
Adjusted R^2	0.375	0.377

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01

D. Robustness checks - Inequality

Table 5 presents the results of the new specifications for the border effect on inequality in the districts of Argentina for the period 1992-2013. Column (1) shows the results for the dependent variable in logarithms, while column (2) presents the fixed effect by province and column (3) includes the fixed effect by province and year. In column (4), districts from the Buenos Aires City and capital cities of the provinces are excluded, and in column (5), Values below the 5th percentile and above the 95th percentile of the luminosity distribution are excluded.

Table 5. *Inequality and Borders in Districts of Argentina (1992-2013) Different Specifications*

Standard deviation of night lights	Logarithms	Difference of logarithms			
	(1)	(2)	(3)	(4)	(5)
Border	-0.428***	-0.076***	-0.070***	-0.500***	-0.311***
	(0.030)	(0.018)	(0.017)	(0.032)	(0.025)
Service agreement	0.043	0.036	-0.001	0.059*	0.032
	(0.030)	(0.032)	(0.033)	(0.030)	(0.024)
Latitude	-0.004	-0.026***	-0.026***	-0.006**	-0.010***
	(0.002)	(0.004)	(0.004)	(0.002)	(0.002)
Population density	0.000***	0.000***	0.000***	0.000***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
District - year FE	yes			yes	yes
Province FE		yes			
Province - year FE			yes		
Observations	10,853	10,311	10,311	9,914	9,454
Adjusted R^2	0.866	0.079	0.120	0.386	0.492

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01
Equation (1): Dependent variable in logarithm.
Equations (2 and 3): Fixed effect by province.
Equation (4): Buenos Aires City and capital cities of the provinces are excluded.
Equation (5): Values located below the 5th percentile and above the 95th percentile of the luminosity distribution are excluded.

Columns (1) to (5) show that districts with international borders have a lower standard deviation of night luminosity compared to the dispersion among districts without international borders. The coefficients exhibit a noticeable reduction in columns (2), (3), and (5) compared to column 2 of Table 2, while the magnitudes are higher in columns (1) and (4). In column (4), the "Service Agreement" variable has a positive and significant effect. By excluding districts from the Buenos Aires City and capital cities of the provinces from the analysis, it is observed that border districts that share a service agreement with the neighboring country exhibit higher

dispersion in night luminosity compared to districts without an agreement.

Table 6 presents the results of the specifications for the border effect on the standard deviation, according to the number and type of formal border crossings. It is observed that the coefficients of the variable "Border" are significant and negative in all specifications. Additionally, the "Services Agreement" variable is statistically significant and negative in column (1) when the number of river border crossings per district is included as a control variable. It is important to note that the results diverge between columns regarding the types of border crossings, showing that the number of river crossings per district has a positive effect on the dependent variable, while the number of land crossings has a negative effect. According to this result, an increase in river crossings in a district is related to higher dispersion in night luminosity (i.e., greater inequality), while an increase in land crossings in a district is associated with lower dispersion in night luminosity (i.e., lower inequality).

Table 6. *Inequality and Borders in Districts of Argentina (1992-2013) According to the Number and Type of Border Crossing*

Standard deviation of night lights	Difference of logarithms	
	(1)	(2)
Border	-0.921*** (0.040)	-0.148*** (0.035)
Service agreement	0.017 (0.029)	0.077** (0.029)
Latitude	-0.009*** (0.002)	-0.005* (0.002)
Population density	0.000*** (0.000)	0.000*** (0.000)
River Crossings	0.403*** (0.021)	
Land Crossings		-0.703*** (0.043)
District-year FE	yes	yes
Observations	10,311	10,311
Adjusted R^2	0.400	0.393

(Source) Own elaboration based on NOAA, IGN, and GPW.
Note. Standard errors are reported in parentheses.
P-values of the two-sided t test are reported with asterisks, with *p<0.1, **p<0.05, and ***p<0.01.

In summary, we analyzed the relationship between international borders and inequality in the districts of Argentina between 1992 and 2013. We found that districts with international borders have a lower standard deviation of night luminosity compared to the dispersion among districts without international borders, and the presence of service agreements with neighboring countries may affect this relationship. Additionally, we found that the number and type of

border crossings can also influence inequality, with river crossings associated with higher inequality and land crossings associated with lower inequality. These findings have important implications for public policy in the region.

V. Conclusions

This study aimed to address the question of whether international borders and trade agreements can explain regional differences in Argentina. An econometric model of differences-in-differences was used to measure the effect of the presence of an international border and a trade integration agreement on economic development in Argentine districts, including economic growth and inequality. The identification strategy leveraged the deepening of the Mercosur agreement with respect to the trade in services protocol in 2005, as well as the varying degrees of proximity of districts to the international border with member countries. The estimations were based on an annual panel covering 503 Argentine districts from 1992 to 2013. To measure economic development, night luminosity maps provided by the National Oceanic and Atmospheric Administration (NOAA) of the United States were used, as there is no disaggregated data on per capita income at the district level in Argentina.

The results indicate that international borders negatively impact the economic growth of border districts, while trade integration agreements favor such growth. It was also observed that river border crossings have a positive impact on the local economy, as they are associated with an increase in the growth rate, whereas the presence of land border crossings is associated with a decrease in the growth rate. In this regard, fluvial transportation emerges as a more cost-effective alternative than land transportation for cross-border integration and economic development of regions near rivers, which could be considered in public policy planning and business decisions in the region.

In relation to inequality, it was found that districts with international borders have a lower standard deviation of night luminosity in relation to the dispersion among districts without international borders, and that the presence of service agreements with the neighboring country may affect this relationship. Additionally, it was found that the number and type of border crossings can also influence inequality, with river crossings being related to greater inequality and land crossings to lesser inequality.

The Northern Argentina (NGA) has consistently exhibited slower development compared to other regions within the country. Given that NGA districts share borders with Mercosur member countries, this paper posits that Argentina has the potential to mitigate these disparities through the expansion of trade agreements. This underscores an often overlooked aspect: the nation's trade policy can potentially contribute to the reduction of regional disparities. Thus,

a clear finding of the paper is that trade policy plays a central role in development.

Several future research directions can be suggested based on the findings of this study. First, understanding the determinants that affect economic development in border regions could be explored, for example, by analyzing how improvements in infrastructure, such as the construction of new roads, bridges, and ports, can affect cross-border trade and, consequently, economic growth. Secondly, it would be interesting to assess the long-term effects of trade agreements on the Argentine economy and border regions. In relation to this, one could examine whether these agreements have led to greater production specialization and, consequently, increased international competitiveness. Additionally, investigating how public policies can support small and medium-sized enterprises in border regions to leverage the opportunities presented by trade agreements and compete in the international market could be explored. Lastly, the relationship between economic development and environmental sustainability in Argentine border regions could be examined. In particular, evaluating whether cross-border trade has had negative impacts on the environment and how public policies can be designed to minimize these effects and promote sustainability could be explored.

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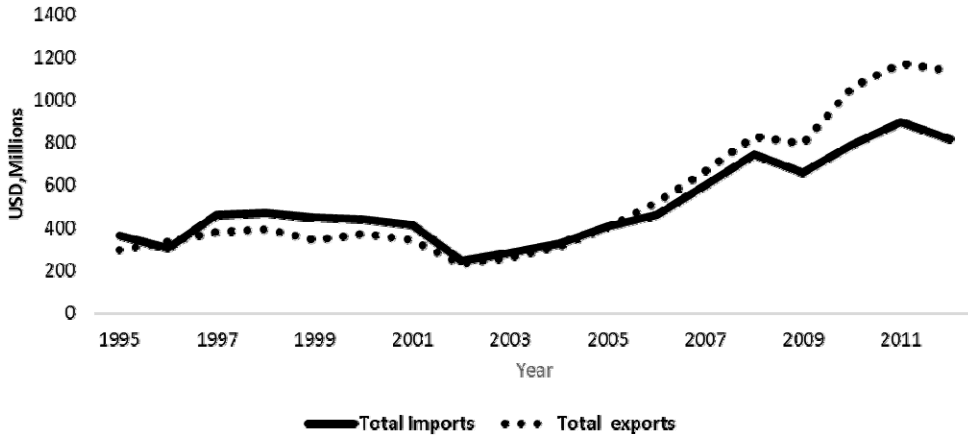
Appendix

Table A1. *Districts with International Borders*

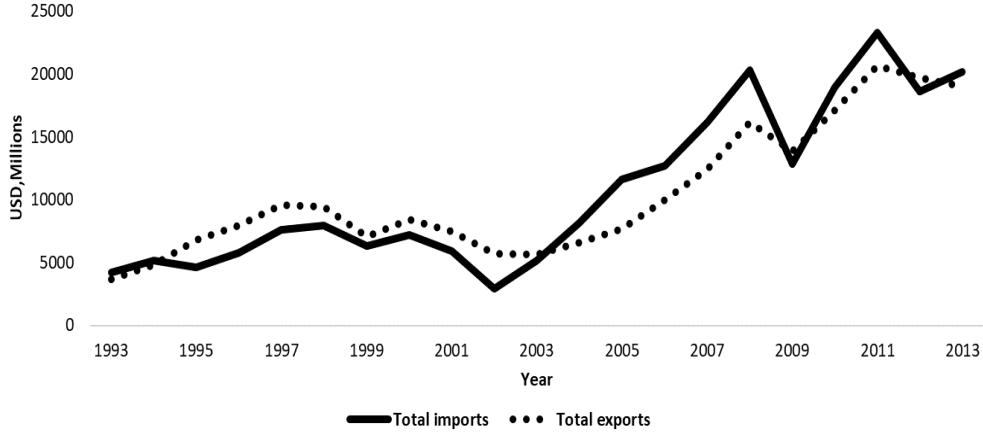
Province	District	Stretch	Services Agreement
Catamarca	Antofagasta de la Sierra	Argentina - Chile	NO
Catamarca	Tinogasta	Argentina - Chile	NO
Chaco	Bermejo	Argentina - Paraguay	YES
Chubut	Cushamen	Argentina - Chile	NO
Chubut	Futaleufú	Argentina - Chile	NO
Chubut	Languiñeo	Argentina - Chile	NO
Chubut	Tehuelches	Argentina - Chile	NO
Chubut	Río Senguer	Argentina - Chile	NO
Corrientes	General Alvear	Argentina - Brasil	YES
Corrientes	Paso de los Libres	Argentina - Brasil	YES
Corrientes	San Martín	Argentina - Brasil	YES
Corrientes	Santo Tomé	Argentina - Brasil	YES
Corrientes	General Paz	Argentina - Paraguay	YES
Corrientes	Ituzaingó	Argentina - Paraguay	YES
Corrientes	San Cosme	Argentina - Paraguay	YES
Corrientes	San Miguel	Argentina - Paraguay	YES
Corrientes	Berón de Astrada	Argentina - Paraguay	YES
Corrientes	Itatí	Argentina - Paraguay	YES
Corrientes	Monte Caseros	Argentina - Uruguay	YES
Entre Ríos	Concordia	Argentina - Uruguay	YES
Entre Ríos	Islas del Ibicuy	Argentina - Uruguay	YES
Entre Ríos	Uruguay	Argentina - Uruguay	YES
Entre Ríos	Colón	Argentina - Uruguay	YES
Entre Ríos	Federación	Argentina - Uruguay	YES
Entre Ríos	Gualeguaychú	Argentina - Uruguay	YES
Entre Ríos	Isla	Argentina - Uruguay	YES
Formosa	Bermejo	Argentina - Paraguay	YES
Formosa	Formosa	Argentina - Paraguay	YES
Formosa	Laishi	Argentina - Paraguay	YES
Formosa	Pilagás	Argentina - Paraguay	YES
Formosa	Pilcomayo	Argentina - Paraguay	YES
Formosa	Patiño	Argentina - Paraguay	YES
Formosa	Ramón Lista	Argentina - Paraguay	YES
Jujuy	Rinconada	Argentina - Bolivia	NO
Jujuy	Santa Catalina	Argentina - Bolivia	NO
Jujuy	Yavi	Argentina - Bolivia	NO
Jujuy	Susques	Argentina - Chile	NO
La Rioja	General Lamadrid	Argentina - Chile	NO
La Rioja	Vinchina	Argentina - Chile	NO
Mendoza	Las Heras	Argentina - Chile	NO
Mendoza	San Carlos	Argentina - Chile	NO

Figure A1. Foreign trade of services, Argentina with Mercosur (1995-2013)



(Source) Own elaboration data based on the Organisation for Economic Cooperation and Development (OECD)

Figure A2. Foreign trade of goods, Argentina with Mercosur (1993-2013)



(Source) Own elaboration data based on theWorld Integrated Trade Solution (WITS).