https://doi.org/10.21670/ref.2604182

Articles

South American integration from below: the proposal for a *cross-borderisation* index for Mercosur (2017-2023)

La integración suramericana desde abajo: la propuesta de un índice de *transfronterización* para Mercosur (2017-2023)

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Received on August 5, 2025.
Accepted on April 9, 2026.
Published on April 16, 2026.

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ORIGINAL ARTICLE LANGUAGE: SPANISH.

Abstract

This paper analyses Mercosur's regional integration and examines whether progress has been made and what kind, during the 2017-2023 period. Starting in 2017, with the progressive cycle fully completed, it employs the creation of a *cross-borderisation* index that shows both the heterogeneity of Mercosur's internal and external borders and their evolution over time and their variable geometry, based on the integration of five sub-indices and fifteen indicators. It engages with the specialized literature and verifies whether economic and security variables are indeed the ones that have the greatest impact on integration at the borders. To this end, it proposes a multiple Kendall correlation exercise and a generalized linear model (GLM) that provides an explanatory capacity of over 80% for the cases studied.

Keywords: Latin America, regional integration, Mercosur, *cross-borderisation*.

Resumen

Este trabajo analiza la integración regional de Mercosur y da cuenta de si han existido avances y de qué tipo, en el periodo 2017-2023. Comienza en un año como 2017, con el ciclo progresista finalizado, recurre a la creación de un índice de *transfronterización* que permite mostrar tanto la heterogeneidad de las fronteras internas y externas de Mercosur, como su evolución en el tiempo y su geometría variable, a partir de la integración de cinco subíndices y quince indicadores. Se discute con la literatura especializada y se corrobora si las variables económicas y de seguridad son las que más impactan en la integración que acontece en estas fronteras, para ello se propone un

CITATION: Ríos, J., De la Villa Hervás, I. A. & Gonzalez, J. (2026). South American integration from below: the proposal for a *cross-borderisation* index for Mercosur (2017-2023). *Estudios Fronterizos*, *27*, Article e182. https://doi.org/10.21670/ref.2604182

ejercicio correlacional múltiple de Kendall y un modelo lineal generalizado (MLG) que permite disponer de una capacidad explicativa de más de 80% de la casuística objeto de estudio.

Palabras clave: América Latina, integración regional, Mercosur, *transfronterización*.

Introduction

Latin American regional integration, in general, and South American regional integration, in particular, have been the subject of extensive academic research, especially in the social sciences, where a central focus has been examining and analyzing their unique characteristics, possibilities and obstacles (Preciado, 2018). Broadly speaking, at least four major phases can be identified in the development of Latin American regional integration since the mid-20th century (Cairo, 2023).

First, it is necessary to mention United States Pan-Americanism, beginning with the establishment of the Organization of American States (OAS, 1948) and the theoretical development of the "backyard" concept, closely aligned with Cold War security doctrines, where the primary goal is to advance the Western cause through a binary framework built upon the communism/anti-communism dichotomy. In the Latin American context, this approach coexists with the well-known "closed regionalism" (Van Klaveren, 1997), shaped by ECLAC's influence in the late 1950s and the commitment to an import-substitution industrialization model. Such an approach was unviable in reality and impractical due to a lack of foresight and economic complementarity, the failures of "inward growth", and the proliferation of autarkic dictatorships throughout the 1960s (North, 1990, 2005).

Second, following the end of the Cold War and the exhaustion of this model, a strong commitment to regional integration emerged. Spurred by the Washington Consensus of the late 1980s, with a view toward market globalization and "outward growth" (North, 1990, 2005), the entire regional architecture was redesigned, prioritizing the purely economic and commercial dimension. This was achieved by encouraging and conditioning the proliferation of policies of openness, liberalization and deregulation (Fuentes, 1994), both at the Latin American level and through a pan-regional initiative promoted by the United States, as reflected in the FTAA (Free Trade Area of the Americas) project or the North American Free Trade Agreement (NAFTA) (Cairo, 2023).

This "open regionalism", embodied in the reforms promoted within the Central American Integration System or the Andean Community, found its most ambitious expression in the Southern Common Market (Mercosur, by its acronym in Spanish for *Mercado Común del Sur*), made possible by the democratization processes in Argentina (1983), Brazil (1985), and Uruguay (1985). A Mercosur that, especially in its early stages—spanning the entire 1990s—prioritized economic aspects and legislative harmonization, while also developing a remarkable institutional architecture that, by the 2000s, aspired to create a South American area of economic integration, as well as political integration.

Nevertheless, these objectives were hindered by the lack of enforceability of their decisions, the requirement for unanimity and the absence of comprehensive mechanisms for the transfer of sovereign powers, among other factors. This reality, however, has gradually evolved over the past decade, in parallel with the pursuit of interregional agreements, such as the complex interregional trade agreement with the European Union, signed in late 2024 following negotiations that began in 1999 (Álvarez & Zelicovich, 2020; Ríos Sierra, 2013).

In any case, given that these regional integration schemes have failed to reduce inequality, social exclusion, or poverty—not to mention regional disparities and the plight of vulnerable groups such as women and ethnic minorities—the progressive shift that marked the beginning of the new millennium—driven primarily by Venezuela and Brazil, and supported by Argentina, Ecuador and Bolivia—gave rise to a new phase of Latin American regional integration, known as the post-liberal, post-hegemonic, or post-U.S. alternative (Bouzas et al., 2007; Riggirozzi & Tussie, 2012).

This approach is bolstered not only by a relative convergence of progressive ideologies but also by an economic expansion driven by the commodities boom and the United States' repositioning in the region following the 9/11 attacks, with a focus on the security agenda—particularly in Colombia and later in Mexico—and centered on the Middle East (Cairo Carou, 2018).

From this regional architecture emerged initiatives such as the Bolivarian Alternative for the Peoples of Our America–Peoples' Trade Agreement—sponsored by Venezuela as a form of *petrodiplomacy*—; the Union of South American Nations, which was ultimately undone by its internal tensions and contradictions but aspired to become the largest forum for political and economic intergovernmental cooperation in South America; and, finally, the Community of Latin American and Caribbean States, conceived as a space for regional coordination with a Latin American focus, but which has established itself as the most active and robust of all the aforementioned initiatives, albeit operating at the most superficial and imprecise decision-making level of all (Ríos Sierra, 2017; Sanahuja, 2012).

Throughout this period—and, by extension, following the events of the first decade of the 21st century—the beginnings of a fourth, more integrative phase marked by greater uncertainty and discontinuity have emerged, a phase that began with the exhaustion of the progressive cycle and the break with the post-liberal architecture. Added to these two characteristics are other general ones, such as traditional geopolitical oscillation, the persistence of personalism in Latin American foreign relations, mistrust toward the formation of supranational decision-making spaces, or the return of greater geopolitical unilateralism—fostered by the very circumstances created by COVID-19. A combination of factors has made Latin American regional integration palpable, at least on the surface, with little sign of progress since the end of the pandemic (Katz, 2024; Malamud, 2023; Ríos Sierra, 2020), although this does not diminish its inherent potential for resilience (Briceño Ruiz, 2024; Ruiz Camacho, 2025).

Nevertheless, the analysis of all these factors—which, according to the specialized literature, along with others, account for much of the lack of progress and commitment toward Latin American integration—can hardly be questioned, understood or nuanced unless there is a shift away from the state-centered and static approaches that dominate studies from, among others, the fields of international relations or geopolitics (Saracho López, 2024). In other words, any attempt to gain a deeper understanding of whether or not there has been progress in Latin American regional integration

since the mid-2010s requires new scales, epistemologies and methodologies that—for example, by focusing on the border—shed light on practices that, from the grassroots level, and in a generally invisible way, directly influence the logic of integration and its changing and constantly evolving realities (Fogel, 2008; Laurín, 2010; Lois et al., 2022; Rhi-Sausi & Oddone, 2013; Soto Acosta, 2017; Zapata Morán et al., 2022).

An approach of this nature, in addition to recognizing that the ontological rigidity of borders and their statism at border zones no longer corresponds to the static conceptions of the Cold War, connects with much of this new way of interpreting the significance of securitizing geopolitical codes, as new debates emerge regarding territorialization, borderization and their transformations and reinterpretations (Kolossov & Scott, 2013; Newman, 2006a; Popescu, 2011; Rumford, 2006; Wastl-Walter, 2016). Also regarding the idea of borders as ubiquitous elements that no longer operate as boundaries but rather as diffuse mechanisms of social control (Anderson & O'Dowd, 1999; Balibar, 2002) or their ongoing transformation within a regional architecture geared toward intergovernmental cooperation, which has been partially redesigned in the wake of the COVID-19 pandemic (Aradau & Tazzioli, 2021; Lara-Valencia & Laine, 2022; Lois et al., 2022).

Given all of the above, this study poses several interconnected research questions: Can progress in the regional integration of the Mercosur region be identified during the 2017-2023 period? Are borders an appropriate scale for an empirical analysis to measure the progress of regional integration? Is it feasible to identify the factors that most significantly affect regional integration occurring at these borders? In this regard, the three hypotheses proposed here are consistent and suggest that: *1*) in regional integration—in this case, within Mercosur—despite the apparent degree of statism, there are signs of exchange and progress toward gradual, greater regional integration. Likewise, *2*) specifically regarding the border, methodological tools can be developed that, more precisely, allow for measuring the degree of cross-border exchange and, thereby, identifying trends or dynamics that are generally overlooked at the national level. Finally, in line with the above and with the specialized literature, *3*) it could be inferred that economic and security factors are the ones that most influence the construction of a collaborative network along the border and bottom-up regional integration.

Fulfilling this dual task of characterizing regional integration along Mercosur's borders and measuring it requires extracting statistical data to produce a *cross-borderization* index that complements the regulatory, political and institutional guidelines generally established at the central government level. In other words, an index of this nature allows for the parameterization and longitudinal analysis of the state of exchange at borders that are part of a regional integration process (internally and externally). Furthermore, through an analysis of multiple statistical correlations, it should be possible to identify the aspects that currently have the greatest impact on binational border exchange, which are presumed to be economic and security-related.

To organize this paper, first, a theoretical framework and a review of the current state of the field will be developed. This will be complemented by a methodology for operationalizing the reality of the Mercosur border region and by the creation of a *cross-borderization* index that will analyze its spatiotemporal dynamics, trends of continuity and rupture, and the factors that have the greatest and least impact on its

configuration. The study will conclude with a discussion and evaluation of some of the research findings, aiming to identify both limitations and new avenues of analysis for political science and geography regarding a subject with immeasurable potential for exploration and deeper understanding.

Theoretical discussion

To define border areas as border regions and cross-border regions (Perkmann & Sum, 2002; Scott, 1999), it is necessary to discuss the main trends and variables included in their analysis, as well as the importance of empirical practice and the combination of different contributions in developing a useful theoretical framework. Thus, in the study of regional integration and border processes, it is important to view the border as a dynamic, changing space (Deleixhe et al., 2019; Newman, 2006b; Paasi, 1998; Van Houtum, 2005).

According to Donnan and Wilson (1999) or Kolossov (2005), the border region is understood through the interplay of objective and subjective factors, such that transnational actors who shape economic cycles and the role of borders interact with local actors who, in turn, generate varying degrees of identification and social representations in response to such changes. In other words, there is a dialectical model that interrelates and normalizes categories such as global-local, agency-structure and material-symbolic. The result of this, according to Kolossov himself, in collaboration with Scott (2013), enables the analysis of borders in three ways: as a generator of local memory and identity; as a determinant of the place and the attitudes projected onto the border; and, finally, as a set of community practices that shape the border.

Brunet-Jailly (2005) and Keating (2013) state that the unique and distinctive nature of the border must be understood and explained in terms of the social context. A context that stems from multiscale—vertical—tensions and interactions, as well as those between actors—horizontal—to which are added elements such as cross-border culture, the influence of local actors and the impacts of international trade and the division of labor. Similarly, other studies, such as that by Johnson et al. (2011), focus on the view that the social construction of the border should be understood as a multilevel discursive practice. Thus, it would be a space where national ideologies and their imaginaries overlap and where non-institutional actors politically shape the border apparatus, all of which leads to the unique territorialization of border regions.

In other words, these are dynamic, ever-changing regions that challenge the very essence of the state—specifically, its monopoly on historical construction—and are politically instrumentalized in multifaceted ways. As Sohn (2018) acknowledges, the relationship across both sides of the border generates benefits, incentives and unique capabilities that are not unrelated to national and transnational political and economic flows. This point is highlighted in the work of Hataley and Leuprecht (2018), who empirically demonstrate the importance of factors such as support networks, adaptation to change, economies of scale and political leadership.

Beyond actors and factors, further efforts are needed to systematize and classify borders based on these operationalizable attributes. This approach is evident, among other works, in the study on Latin America proposed by Dilla et al. (2022), which distinguishes between borders that are *1*) customary, where loyalties and forms of cooperation are paramount; *2*) autonomous, which require high mobility and permissiveness for social reproduction; *3*) international, with physical infrastructure to intensify exchange flows; and, *4*) border-related, which connect to the global scale and establish institutions conducive to their functionality.

Altogether, these academic contributions help systematize, characterize, problematize and understand the social and political processes occurring in border regions, specifically the cooperative practices unfolding on both sides of the border. Nonetheless, to further refine the theoretical focus of reflection and discussion, a key element is the impact that so-called securitization has had on border studies. In other words, and in accordance with the premise shared by the so-called Copenhagen School, this involves conceiving of security threats and the response to them as nothing more than the result of eminently discursive processes (Balzacq, 2011; Buzan et al., 1998; Stritzel, 2007; Wæver et al., 1993).

When applied to the study of borders, securitization proves far more complex than a mere tool for asserting border claims, since it is not opposed to cooperation per se. Once again, at the border, this concept is closely linked to a multiscalar representation (Aradau & Van Muster, 2012; Jones & Johnson, 2016), in which non-state actors also play a role: actors noted in theoretical constructs such as security complexes (Buzan, 1983; Buzan & Wæver, 2003), security communities (Kolossov, 2005; Newman, 2010) or hybrid sovereignties (Abrahamsen & Williams, 2009; Prokkola, 2020).

The truth is that, specifically, in the analysis of Latin American regional integration through cross-border regions and the cooperation carried out there, the predominant perspective is purely institutional, focused on the existing frameworks and agencies and on the nature of the cross-border cooperation policies they implement. In this regard, as Dilla et al. (2025) note, state-centered and centralist approaches predominate, whereas initiatives and perspectives focused on border cooperation practices are far fewer. These practices, in any case, are conceived under a clear predominance of the economic and trade agenda and focused primarily on the Andean region or Central America and, to a lesser extent, on Mercosur (Dilla et al., 2025; Marteles Moreno, 2010).

Given all of the above, it would seem both relevant and necessary to develop and propose analytical tools that provide insight into and help address regional integration and cross-border cooperation at and from the border, in terms of openness, exchange, reciprocity and interdependence as they manifest in the Latin American context. A fact that, while accepted in academic literature and its debates, does not exist, strictly speaking, in methodological terms, since researchers often continue to rely on scales and sources of information derived from the national level. This fact alone undermines any semblance of empirical understanding regarding the degree of permeability or cross-border exchange, as observed in analytical tools that are profoundly limited at the subregional level—such as the Global Peace Index, Country Risk Index, Global Food Security Index, Global Health Security Index and Transportation Security Index.

On the other hand, given the limited attention paid to the cross-border perspective, it is equally necessary to move beyond the exclusive focus on the degree of economic openness of borders, operationalized by the Cross-Border Data Index developed by the Global Data Alliance (2023) (Delgado Castresana et al., 2025).

Methodology

Based on the arguments presented so far, a specific objective for demonstrating the border's degree of functionality and dynamism within Mercosur regional integration requires a methodological and analytical approach that moves beyond the prevailing static, state-centric perspective. For this reason, this paper proposes developing a *cross-borderization* index based on the identification of five dimensions and 15 variables, using strictly subnational metrics and border-specific information, to shed light on the border's actual degree of permeability.

These 15 variables are classified into five dimensions, primarily to establish five sub-indices that will subsequently enable the creation of the index. Specifically, reports of interference with sovereignty and the presence of cross-border cooperation instruments constitute the political sub-index. The mobility of people across the border, the flows of goods, capital and services and the type of integrative architecture make up the integration subindex. Third, socioeconomic aspects such as the violent homicide rate, GDP, the Gini coefficient and educational exchanges shape the socioeconomic subindex. For its part, the securitization subindex is based on collaborative actions in the areas of security and defense and the presence of physical border control posts, while the management of joint physical infrastructure, the shared management of natural projects and the shared management of disasters constitute the so-called infrastructure subindex (see Table 1).

Table 1. Development of the *cross-borderization* index

				Initial values			Sum of squared loads (extraction)			Sum of squared loads (rotation)		
	Inicial	Extraction	Component	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
SiJP	1	0.785	1	1.868	37.355	37.355	1.868	37.355	37.355	1.186	37.305	37.305
SiI	1	0.805	2	1.243	24.857	62.212	1.243	24.857	62.212	1.186	23.723	61.028
SiSE	1	0.802	3	1.062	21.232	83.443	1.062	21.232	83.443	1.121	22.416	83.443
SiS	1	0.868	4	0.482	9.647	93.091						
SiI	1	0.913	5	0.345	6.909	100.00						

Extraction method: principal component analysis
Source: created by the authors

Table 2. Identification of variables and dimensions subject to *cross-borderization*

Legal-political dimension	Diplomatic actions regarding interference in sovereignty (ADIS, Spanish acronym for *acciones diplomáticas por intromisión a la soberanía*)
	Types of cross-border cooperation instruments (ICT, Spanish acronym for *instrumentos de cooperación transfronteriza*)
Inclusive dimension	Types of instruments that promote cross-border mobility (IFMT, Spanish acronym for *instrumentos que favorezcan la movilidad transfronteriza*)
	Flows of goods, capital and services relative to GDP (EI)
	Integrative architecture type (TID, Spanish acronym for *tipo de arquitectura integradora*)
Socioeconomic dimension	Violent homicide rate per 100 000 inhabitants (THV, Spanish acronym for *tasa de homicidios violentos*)
	GDP per capita (PIB, Spanish acronym for *producto interno bruto*)
	Gini coefficient (Gini)
	Types of existing educational exchanges (IE, Spanish acronym for *intercambios educativos*)
Security dimension	Joint Police Operations (APC, Spanish acronym for *actuaciones policiales conjuntas*)
	Joint military exercises (EMC, Spanish acronym for *ejercicios militares conjuntos*)
	Presence of physical border control posts (PFCF, Spanish acronym for *puestos físicos de control fronterizo*)
Infrastructure dimension	Type of shared physical infrastructure (IFC, Spanish acronym for *infraestructura física conjunta*)
	Joint projects on natural resources (PCRN, Spanish acronym for *proyectos compartidos sobre recursos naturales*)
	Joint disaster management projects (PCGD, Spanish acronym for *proyectos compartidos sobre gestión de desastres*)

Source: created by the authors

All variables mentioned, operationalized as described in Table 2, were converted to positive scales, considering values on both sides of the border. Subsequently, these indicators were standardized and aggregated into the sub-indices mentioned, which correspond to the five dimensions proposed for analyzing the border. Based on this and using the Organization for Economic Cooperation and Development (OECD) index for the multidimensional study of poverty as a reference, the sub-indices were weighted using principal component analysis.

Once the principal component matrix has been obtained, the method used to determine the final weights of each of the five sub-indices is cumulative aggregation. This is based on the relative weight of the eigenvectors of each component (Equation 1), as has already been used in other index development studies across various social science disciplines (Decancq & Lugo, 2013; Kato et al., 2021; Pérez-Foguet & Giné Garriga, 2011; Slottje, 1991). In this regard, the equation for the subindex weighting method by cumulative aggregation would be as follows:

$$p_i = \sum_{k=1}^{n} \left\{ a_{k,i} \frac{\sqrt{\lambda_k}}{\sum_{j=1}^{n} \sqrt{\lambda_j}} \right\}$$

p_i: total weight of subindex i
$a_{k,i}$: eigenvector of the subindex i in the principal component k
λ_k: eigenvalue of principal component k

$\sum_{j=1}^{n} \sqrt{\lambda_j}$: sum of the square roots of the eigenvalues of all components

Thus, the index is broken down into five distinct yet integrated components that satisfy the requirements of descriptive statistics and control tests and allow validation of the method's application without discarding any of the proposed variables and indicators (see Table 3 and Table 4). The resulting index is calculated using the following weighting formula derived from the eigenvectors:

$$0.22Spol + 0.26Sint + 0.16Ssoce + 0.17Ssec + 0.19Sinfra$$

Table 3. Rotated component matrix

	Component 1	Component 2	Component 3
Legal-political subindex	0.825	-0.024	0.322
Integration subindex	0.851	-0.258	-0.120
Socioeconomic subindex	0.654	0.544	-0.279
Securitization subindex	-0.176	0.903	0.146
Infrastructure subindex	0.038	0.087	0.951

Extraction method: principal component analysis
Rotation method: Varimax with Kaiser normalization (the rotation converged after 6 iterations)
Source: created by the authors

Table 4. Control test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.501
Barlett sphericity test	Approx. Chi-square	59.186
	gl	10
	Sig.	0.000

Source: created by the authors

Based on the above, the cited *cross-borderization* index will enable, as shown below, the assessment of trade levels at Mercosur's internal and external borders. This should, among other things, help identify which of these borders are more or less cooperative; assess the dynamism and evolution of *cross-borderization* over recent years; and, among other aspects, evaluate the impact or restructuring in response to extraordinary situations, such as the pandemic itself. This approach will take the analysis a step further, as—in addition to the above—it seeks to identify, through a final correlational model and by applying the principle of parsimony, the factors that most significantly influence the degree of *cross-borderization* observed in Mercosur for the 2017-2023 period. This

will make it possible to determine whether the impact has the significance attributed to it in the literature—which is largely based on national approaches, such as economic or securitization variables—or whether, on the contrary, other factors have a significant influence on the intergovernmental exchange occurring on both sides of the borders under study.

Development

Based on the data presented in Table 5, several points are worth noting. First, despite the many cross-border initiatives within the Mercosur region—many of which are reinforced by bilateral agreements or other multilateral frameworks—the levels of *cross-borderization* remain modest and heterogeneous. The region's largest economies, such as Argentina, Brazil and Uruguay, exhibit higher levels of trade across their borders than other, much more closed economies, such as Bolivia or Paraguay. In fact, in general, internal trade across Mercosur borders is substantially higher than trade occurring at external borders, as is the case with Colombia, Bolivia and, to a lesser extent, Chile.

Occasionally, the disparity in *cross-borderization* levels reaches 100% between the most open and the most restrictive borders. Therefore, in detail, for the 2017-2023 period, the borders with the highest levels of *cross-borderization* were the Brazil-Paraguay, Argentina-Brazil and Argentina-Uruguay borders, with average levels of 0.600, well above the Mercosur average. Similarly, at the second level are the Argentina-Paraguay and Brazil-Uruguay borders, which also exhibit higher levels of openness than the region's general trend. Conversely, the borders with the highest levels of restrictiveness in cross-border trade—and the widest gaps—are those between Bolivia and Paraguay, Bolivia and Brazil and Bolivia and Argentina, as well as the Brazil-Colombia border, showing a distinct pattern compared to Mercosur's internal borders and maintaining a certain distance from the Argentina-Chile border, which has been normalized by the signing of numerous Mercosur-Chile protocols, in addition to other bilateral agreements (see Figure 1).

Furthermore, there has been a growing trend in *cross-borderization* from 2017 to 2023. For example, while the *cross-borderization* index stood at 0.459 in 2018, it rose to 0.532 by 2023, representing a nearly 20% increase. As expected, and in line with general trends across the continent, the 2020 COVID-19 pandemic constrained cross-border exchange. From 2019 to 2020, the value dropped sharply, from 0.501 to 0.482, although by 2022, signs of recovery were already evident, with a *cross-borderization* index of 0.538.

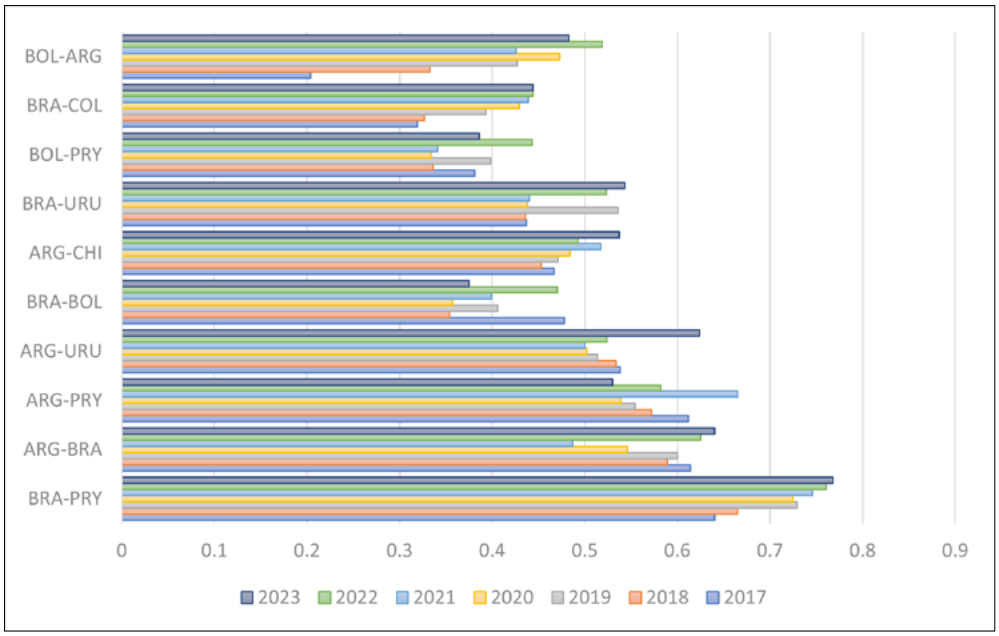
In any case, and despite the substantial differences observed across the ten Mercosur borders studied, there is a growing trend—as mentioned earlier—that may have been partly driven by the momentum gained in recent years by various cooperation initiatives, such as those related to security or the shared management of infrastructure and natural resources. In any case, to shed further light on which elements of cross-borderization have the most direct impact on the index value obtained for each case, it is necessary to use a correlational model that can determine whether, as most of the specialized literature suggests, the economy and security are the two central drivers of subnational collaboration on both sides of the border. Similarly, it is necessary to determine whether other aspects warrant greater attention due to their explanatory power and specific impact on the border.

Table 5. *Cross-borderization* index 2017-2023

	2017	2018	2019	2020	2021	2022	2023
1	Bra-Pry (0.640)	Bra-Pry (0.665)	Bra-Pry (0.729)	Br-Pry (0.725)	Bra-Pry (0.746)	Bra-Pry (0.761)	Bra-Pry (0.768)
2	Arg-Bra (0.614)	Arg-Bra (0.589)	Arg-Bra (0.600)	Arg-Bra (0.546)	Arg-Pry (0.665)	Arg-Bra (0.625)	Arg-Bra (0.640)
3	Arg-Pry (0.612)	Arg-Pry (0.572)	Arg-Pry (0.554)	Arg-Pry (0.539)	Arg-Chi (0.517)	Arg-Pry (0.582)	Arg-Uru (0.620)
4	Arg-Uru (0.538)	Arg-Uru (0.534)	Bra-Uru (0.536)	Arg-Uru (0.502)	Arg-Uru (0.500)	Arg-Uru (0.524)	Bra-Uru (0.543)
5	Bra-Bol (0.478)	Arg-Chi (0.453)	Arg-Uru (0.514)	Arg-Chi (0.484)	Arg-Bra (0.487)	Bra-Uru (0.523)	Arg-Chi (0.537)
6	Arg-Chi (0.467)	Bra-Uru (0.436)	Arg-Chi (0.471)	Bol-Arg (0.473)	Bra-Uru (0.440)	Bol-Arg (0.519)	Arg-Pry (0.530)
7	Bra-Uru (0.437)	Bra-Bol (0.354)	Bol-Arg (0.427)	Bra-Uru (0.438)	Bra-Col (0.439)	Arg-Chi (0.493)	Bol-Arg (0.483)
8	Bol-Pry (0.381)	Bol-Pry (0.336)	Bra-Bol (0.406)	Bra-Col (0.429)	Bol-Arg (0.426)	Bra-Bol (0.470)	Bra-Col (0.444)
9	Bra-Col (0.319)	Bol-Arg (0.333)	Bra-Col (0.393)	Bra-Bol (0.357)	Bra-Bol (0.399)	Bra-Col (0.444)	Bol-Pry (0.386)
10	Bol-Arg (0.204)	Bra-Col (0.327)	Bol-Pry (0.389)	Bol-Pry (0.334)	Bol-Pry (0.341)	Bol-Pry (0.443)	Bra-Bol (0.375)

Source: created by the authors

Figure 1. Geographic distribution of *cross-borderization* in Mercosur, 2017-2023



Source: created by the authors

Based on the above, the variables identified as independent variables in Table 2 were classified as categorical or continuous quantitative. The data identified as categorical correspond to the variables: ADIS, TID, IE, APC and EMC, which have three levels: -1, 0 and 1. The categorical variable PCGD ranges from 0 to 1, with a dichotomous structure added, resulting in a total of seven variables. On the other hand, the variables IFMT, EI, THV, PIB, Gini, PFCF, IFC and PCRN—which are continuous quantitative variables—make up the structure of the dataset along with the aforementioned categorical variables from the analyzed data so that, through a comprehensive correlation analysis, their impact on the dependent variable—which, in this case, is the *cross-borderization* index (DV)—can be determined.

As noted, the hypothesis put forward by most of the specialized literature is that the economic dimension is likely the most important factor in explaining the integration dynamics occurring along the border. Nonetheless, there are other aspects, particularly those related to security, that are also considered in much of the theoretical debate; therefore, a causal relationship can only be determined through a Kendall correlation analysis, as a substitute for what would be a Pearson correlation. This is reflected in Table 6, where the correlation coefficients and *p*-values can be observed, which help determine how many of the variables considered could function on their own as good predictors of *cross-borderization*.

Table 6. Kendall's correlation coefficient with the *cross-borderization* index

Variable	Correlation coefficient	*P*-value
ADIS	-0.0681147	0.4887
ICT	-0.208499	0.0258
IFMT	0.04644366	0.6279
EI	0.5322283	7.522e-11
TID	0.6180259	4.291e-10
THV	0.4645095	1.396e-08
PIB	-0.4876638	2.485e-09
GINI	-0.01554545	0.8572
IE	0.02458647	0.8014
APC	0.3235373	0.0008736
EMC	0.3925286	7.335e-05
PFCF	0.3455411	2.944e-05
IFC	0.2548298	0.003187
PCRN	0.3948616	5.553e-06
PCGD	0.2110645	0.033

Source: created by the authors

In other words, and in order of significance, the variables most strongly correlated with the proposed index would be EI, TID, PIB, THV, PCRN, EMC, PFCF and APC, with the last two showing a lower degree of correlation than the others. For this initial exploratory exercise, to further enhance the explanatory power of this study, a standard linear model (LM) was applied to explore the correlation between the index score (DV) and

the variables considered predictors of *cross-borderization*. Nevertheless, the linear model relies on the assumptions that the errors are normally distributed with constant variance (homoscedasticity) and are independent, and that the response variable is continuous and can take any real value, including negative ones. Additionally, it was deemed necessary to prioritize the principle of parsimony, which is relevant for identifying the independent variables that, taken together, could best predict the dependent variable (DV).

After conducting a second exploratory analysis of the data and initial tests of the linear model, which showed a high R^2, the residuals exhibited substantial heteroscedasticity, despite the response variable being normally distributed. For this reason, the transition to a generalized linear model (GLM) was justified, as it allows the specification of a probability distribution for the dependent variable, such as the Gamma distribution. To this end, a random forest was initially employed to assess the predictive power of the independent variables in the data frame, as shown in Table 7.

Table 7. Improved explanatory power of the model (%IncMSE)

1	EI	19.644058
2	PIB	12.131794
3	TID	12.064573
4	APC	11.566475
5	ITC	11.358887
6	IFC	11.293188
7	PCGD	10.705140
8	EMC	10.676163
9	PCRN	8.453467
10	PFCF	7.627332
11	THV	7.627332
12	GINI	7.133143
13	IFMR	6.177720
14	IE	1.675590
15	ADIS	1.244113

Source: created by the authors

When the random forest dataset and the correlations were considered, the generalized linear model (GLM) showed reproducibility within the gamma function, even though the variables (in the random forest) and THV (in Kendall's *tau*) appeared to be closely related to the value of the *cross-borderization* index, which had a rather negative impact on the homoscedasticity of the residuals. Therefore, after iterating through the different variables, a final model was obtained, defined by the following coefficients, which exhibits adequate parsimony, a low Akaike information criterion (AIC), and a lack of sufficient evidence to reject the null hypothesis of homoscedasticity for the model. That is, the following variables were identified as significant contributors to the model: EI, TID, EMC, APC, IFC, PCRN and PIB, yielding the coefficients shown in Table 8.

Table 8. Table of model coefficients

Variable	Estimated	Standard error	*t*-value	*Pr*(>|*t*|)	Significance
(Intercept)	-1.39008	0.06916	-20.099	<2e-16	***
EI	0.32143	0.07126	4.511	3.00e-05	***
TID1	0.13763	0.04348	3.165	0.002418	**
EMC1	0.1588	0.02724	5.829	2.26e-07	***
APCO	0.1294	0.03038	4.26	7.19e-05	***
APC1	0.21099	0.052	4.057	0.000144	***
IFC	0.16751	0.06778	2.471	0.016270	*
PCRN	0.277	0.04682	5.916	1.62e-07	***
PIB	0.15067	0.05805	2.596	0.011811	*

Source: created by the authors

Table 9. Model statistics

Dispersion parameter	0.006914396
Significant deviation	3.9767 (df = 69)
Residual deviation	0.4793 (df = 61)
AIC	-231.6

Source: created by the authors using results obtained with R software

Table 9 indicates that the model may have a pseudo R^2 of (3.9767 – 0.4793) / 3.9767 ≈ 0.879, suggesting a good fit. Regarding its homoscedasticity, the Breusch-Pagan test found that the values satisfy the assumption of homoscedasticity with the following result: BP = 4.1953, df = 8, *p*-value = 0.8391. Given all of the above, the generalized linear model that predicts the score can be defined by the following equation:

$$\ln(E(Y))=\beta0+\beta1\cdot EI+\beta2\cdot TID1+\beta3\cdot EMC1+\beta4\cdot APC0+\beta5\cdot APC1+\beta6\cdot IFC+\beta7\cdot PCRN+\beta8\cdot PIB$$

Where:
$ln(E(Y))$ is the natural logarithm of the expected value of the dependent variable.
$\beta0$ is the intercept.
$\beta1,\beta2,\ldots,\beta8$ are the estimated coefficients for each predictor variable.

In conclusion, as expected—and in line with the prevailing body of specialized literature—the model would recognize that economic variables have the greatest impact on *cross-borderization*, followed by security variables, and finally by those related to joint management and infrastructure.

Conclusions

Regional integration in Latin America—and, by extension, that within Mercosur—has traditionally faced obstacles and difficulties stemming from the ideologization of foreign relations, the constant geopolitical fluctuations surrounding integration, the tension between ideological affinities and differences, suspicion of any hint of supranationality, or distrust of approaches that seek to go beyond the "unrestricted principle of sovereignty".

Following the progressive era, which spanned from the early 21st century through 2015, no significant progress has been observed in terms of new approaches or revitalized initiatives regarding regional integration. The difficulties that hampered projects such as the Bolivarian Alternative for the Peoples of Our America or the Union of South American Nations do not appear to have been very different from those currently facing the Pacific Alliance or, above all, the Forum for the Progress of South America. Thus, the "open regionalism" initiatives of the 1990s, which were based on a clear economic focus, have proven most enduring and relevant, as demonstrated by Mercosur. Meanwhile, it is true that during the pandemic or under profoundly different administrations—such as those arising from the antagonism between Lula da Silva and Dilma Rousseff versus Jair Bolsonaro, or Cristina Fernández and Alberto Fernández versus Mauricio Macri—progress in integration has continued.

A good indicator of this is the study of cross-border relations, which are often overlooked and rendered invisible by national frameworks and, furthermore, hindered by the lack of analytical tools that enable empirical research applicable to other borders. Thus, based on the *cross-borderization* index proposed in these pages, it is possible to observe the growing trend of intergovernmental cooperation and regional integration in Mercosur, given that this development stems from heterogeneous processes and trends. At the regional level, Brazil and Argentina—and to a lesser extent Uruguay—exhibit more robust forms of *cross-borderization* along their borders. On the other hand, Mercosur's internal borders, including those of Paraguay, also suggest a much higher level of trade than occurs at their external borders, as is the case with Bolivia, Colombia and, to a lesser extent, Chile. Although the trend observed since 2017 has been upward, the pandemic, as expected, imposed significant constraints on *cross-borderization*, which has since recovered following the resolution of the coronavirus health crisis.

On the other hand, to identify which factors have the greatest impact on regional integration along these borders, a significant finding—consistent with what the specialized literature acknowledges but has rarely been empirically demonstrated at the subnational level—points to the economy and security as the primary areas of collaboration. To that end, in an attempt to determine whether other political, institutional or infrastructure variables have a significant impact on cross-border relations, this study concludes that while such variables may contribute to the process, at most, they do not explain the main drivers of cross-border integration, which is clearly centered on economic and security factors.

In any case, as an exploratory exercise—albeit a statistically robust one, given its ability to explain over 80% of the cases studied—the article opens a path that still needs further exploration. This applies both to the application of the index to other integration frameworks, such as the Andean Community and the Central American

Integration System and to the European Union framework, which is built on different rules, such as qualified majority voting, co-decision and the transfer of sovereign powers. Nonetheless, the inclusion of potential control variables that allow for the integration of analytical tools—along with the associated challenge of identifying and systematizing indicators and information sources (for example, through spatial autoregressions and spatial heterogeneity models, or by expanding the temporal scope of analysis)—may be the first steps toward applying this empirical tool to broader analytical levels that shed light on a subject of study—such as this one—with immeasurable possibilities for study and deeper exploration.

Acknowledgments

This contribution is part of the results of the BORES project, Programa estatal de I+D+i del Plan Estatal de Investigación Científica, Técnica y de Innovación 2021-2023, Ministry of Science and Innovation (PID2022-139939NB-I00).

We would like to thank the following individuals for their assistance in organizing the statistical data analyzed in this study: Heriberto Cairo, Jimena Ñáñez, María Lois, Mariano García de las Heras, Mireia Delgado, Pedro Limón, Puerto González, and Sergio González. We would also like to thank Lydia Coronel Yáñez for her editorial work.

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