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Article

The Impact of the Pacific Alliance on Trade Creation and Trade Diversion in the COVID-19 Period: A Robust Econometric Analysis

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Abstract: (1) Background: The COVID-19 pandemic severely disrupted global trade, posing challenges for regional trade agreements such as the Pacific Alliance, comprising Chile, Colombia, Mexico, and Peru. This study investigates the Pacific Alliance's impact on trade creation and diversion during the pandemic, exploring how regional cooperation mitigated trade disruptions. (2) Methods: A quantitative approach utilizing econometric models, including ordinary least squares, Poisson pseudo-maximum likelihood, and the Heckman selection model, was employed. The gravity model of trade was applied to bilateral trade data from 1948 to 2021, incorporating COVID-19-specific variables to assess trade dynamics. (3) Results: The analysis revealed significant trade creation within the Pacific Alliance during the pandemic, with intra-bloc trade strengthening despite global disruptions. However, evidence of trade diversion from non-member countries was mixed and inconclusive. (4) Conclusions: The Pacific Alliance demonstrated resilience during the COVID-19 period, fostering regional trade creation and cushioning the impact of global trade shocks. While trade diversion remains uncertain, the study highlights the critical role of regional trade agreements in stabilizing trade flows during global crises, offering valuable insights for future policy and regional cooperation strategies.

Keywords: Pacific Alliance; trade creation; trade diversion; COVID-19 impact; regional trade agreements; gravity model of trade; econometric analysis; intra-bloc trade; Latin American trade; global trade disruption



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1. Introduction

Over the centuries, government officials, academicians, and politicians have recognized the pivotal role of international trade in shaping the global economy. For instance, Jain (2023, pp. 6–7) argues that the economies of China, India, Brazil, Russia, and South Africa have experienced economic development and thus have grown substantially thanks to global commerce. This aligns with Akash et al. (2023, p. 23), who posit that globalization, driven by financial integration and increased FDI (foreign direct investment), can accelerate growth in developing economies; however, this growth is accompanied by complex dynamics that require careful management and policy considerations to ensure sustainable economic development.

In light of these challenges, regional trade agreements (RTAs) have become a key focus for policymakers and academics. Ruta (2023, p. 32) notes that RTAs strike a balance between protectionism and globalization, providing a framework that reduces trading costs and accelerates growth, especially in developing economies. Contrary to initial concerns, RTAs not only boost trade among members by 40% but also benefit non-members by reducing costs across the board due to their non-discriminatory provisions.

Nonetheless, RTAs present multifaceted outcomes; Vebiyanto and Atmanti (2023, p. 155) reveal through a gravity model analysis that FTAs (free trade agreements) can have varying impacts on member states' welfare, with benefits occurring when trade creation

exceeds diversion. [Vebiyanto and Atmanti's \(2023\)](#) research analysis of ASEAN's FTAs showed positive trade creation for ACFTA and AIFTA, negative impacts on intra-regional trade for AJCEP and AANZFTA, and export trade diversion for AKFTA. These outcomes highlight the need for nuanced policies, continuous evaluation of integration impacts, support for affected domestic sectors, and enhanced FTA utilization.

1.1. The Pacific Alliance RTA

The Pacific Alliance (PA) is a regional trade bloc established in 2011 by Chile, Colombia, Mexico, and Peru, with a framework agreement effective as of July 2015 and a trade protocol starting in May 2016 ([Ministry of Foreign Relations of Colombia 2024](#)). Its primary aim is to foster regional integration, reduce trade barriers, and promote economic cooperation, enhancing global competitiveness through a unified market.

In terms of economic indicators, the PA represents over 37% of Latin America's GDP and 52% of its trade, making it a key player in regional and global trade ([Pacific Alliance 2022](#)). With over 225 million people, the PA leverages a vast network of trade agreements with Asia, Europe, and North America.

In addition to eliminating tariffs on over 96–98% of goods traded within the bloc, the PA focuses on harmonizing regulatory frameworks, facilitating cross-border investments, and promoting cooperation in areas such as education, innovation, and technology ([Cracau and Durán Lima 2019](#), p. 49). Its long-term goal is to boost economic growth, increase competitiveness, and position its member states as a hub for international trade, especially in the Asia–Pacific region ([Saco 2019](#), p. 174).

Through partnerships with over 59 observer countries and regional blocs, the PA continues to attract foreign investment and enhance its role in the global economy ([Ceron et al. 2022](#), p. 3). [Rodríguez et al. \(2023, p. 2\)](#) found that China's importance for PA trade has grown significantly over 30 years, with Chile and Peru's trade-to-GDP ratios rising to 10–15% by 2019. By prioritizing economic integration and cooperation, the PA aims to improve citizens' living standards while offering a model for regional collaboration in the 21st century.

1.2. The Global Trade Shock Caused by COVID-19

The literature highlights the significant disruptions to global supply chains and the uneven trade shock caused by the COVID-19 pandemic. The Bank of England's analysis, as noted by [Rosie and Gabija \(2021\)](#), identified three key trends: service trade declined more sharply than goods trade, the impact varied across countries, and shipping costs surged. In 2020, global trade contracted by 8.9%, marking the steepest decline since the financial crisis. Shipping costs rose by 350%, and service trade dropped over 20%, while goods trade experienced a milder decline. Container shortages worsened the situation, complicating global commerce.

[Kimura and Zen \(2023\)](#) examined the impact of the COVID-19 pandemic on trade, transport, mobility, and e-commerce in five ASEAN member states—Indonesia, Malaysia, Singapore, Thailand, and Vietnam—along with Japan. Despite governments' efforts to deploy stimulus measures totaling USD 642 billion across the region to mitigate economic impacts, ASEAN economies contracted sharply in 2020, with Vietnam being the sole exception that maintained growth ([Kimura and Zen 2023](#), pp. 1–2). Nonetheless, the authors highlight digitalization as an emerging resilience factor, with e-commerce playing a pivotal role in economic adaptation. As a policy recommendation, they propose establishing a cross-border e-commerce regional cooperation mechanism to enhance the e-commerce revenues of small- and medium-sized enterprises (SMEs) in select ASEAN economies, such as Thailand ([Kimura and Zen 2023](#), pp. 94–95).

[Ridley et al. \(2023, pp. 2446–48\)](#) found that labor-intensive sectors, especially in the U.S. and Brazil, were hit hardest by supply-side disruptions, but demand-side effects from recession had a larger impact, with projected trade losses in the billions. [Gagnon et al. \(2023, pp. 9–11\)](#) argued that the pandemic's economic fallout severely affected poorer

nations, with manufacturing and export-oriented economies faring better than those reliant on services like tourism. These findings highlight the need for tailored policy responses to build resilience in varying economic contexts, including those in Colombia, Mexico, Chile, and Peru within the EMDE LAC group (Emerging Market and Developing Economies of Latin American Countries).

Also, [Mena et al.](#)'s (2022, pp. 87–88) study explores the complex factors influencing international trade resilience during crises like the COVID-19 pandemic. It highlights how globalization, logistics capabilities, healthcare preparedness, and income levels bolstered resilience, while strict government responses and high death tolls had negative effects. The researchers stress the relevance of these findings for business managers making sourcing decisions and policymakers shaping trade and development strategies. The study also underscores the need for equitable access and robust logistics infrastructure to foster resilient export economies.

1.3. Role of RTAs in Mitigating Trade Disruptions

[Barbero et al.](#) (2021, pp. 15–16) examined the impact of COVID-19 on global trade, using a PPML estimator and data from 68 countries. They found that the pandemic negatively affected trade flows, particularly in countries with RTAs. Government responses also worsened trade, especially when exporting and importing countries with RTAs had similar income levels.

However, many studies suggest RTAs buffer against global trade shocks. [Kpodar and Imam](#) (2015, pp. 5, 29–30) found that RTAs reduce growth volatility due to enhanced policy credibility, coordination, and reduced conflict risk. Countries prone to shocks are more likely to join RTAs with partners exhibiting less volatile growth, further stabilizing trade. During COVID-19, trade within RTAs showed resilience, with deeper agreements providing more stability ([Nicita and Saygili](#) 2021, p. 13). RTAs, like those in the EU, Chile, and South Korea, helped trade recover faster than non-RTA partners ([Zuev et al.](#) 2023, p. 83).

Nonetheless, RTAs have been found to produce both trade creation and trade diversion effects, with varying impacts across different agreements and commodities. Studies using gravity models and Poisson pseudo-maximum likelihood (PPML) estimation on annual data from 38 countries covering six RTAs in the Western Hemisphere for the years 1986–2005, have shown that most RTAs in the Western Hemisphere exhibit significant trade creation, except for NAFTA and LAIA ([Muhammad and Yucer](#) 2009, pp. 11, 15).

In Asia, AFTA has demonstrated trade creation effects in machinery trade, while the EU has shown similar effects in agricultural commodities ([Urata and Okabe](#) 2010, p. 9). However, partial-scope RTAs and those among developing countries from the NAFTA and MERCOSUR tend to cause trade diversion, as measured by the impacts of various types of RTAs involving 67 countries for 20 commodities during 1980–2006 ([Urata and Okabe](#) 2010, pp. 6, 9).

Analysis of RTAs in Sub-Saharan Africa, Asia, and Latin America revealed that while all are intra-bloc trade-creating, some are net trade-creating (ECOWAS and SAPTA) and others are net trade-diverting (AFTA, CAN, MERCOSUR, and SADC) ([Coulibaly](#) 2004, pp. 2–3). In summary, the trade impacts of RTAs on individual members vary, with no clear evidence of universal net trade creation effects across all members.

1.4. Gap in the Literature and Justification for the Study

While there is substantial research on trade creation, trade diversion for RTAs, and the pandemic's overall impact on trade, little attention has been given to the specific effects on regional trade blocs like the PA during COVID-19. This gap presents an opportunity to explore the pandemic's impact on trade dynamics within the PA.

This study fills this gap by conducting a comprehensive empirical analysis of the PA's response to COVID-19, focusing on trade creation and diversion effects.

1.5. Main Objective

The aim of the study is to assess the extent of trade creation and trade diversion within the PA during the COVID-19 era, and to explore the role of regional cooperation in mitigating the pandemic's impact on trade. By examining these dynamics, the study contributes valuable insights into the functioning of regional cooperation mechanisms during times of crisis, potentially informing future policy decisions and economic integration strategies.

1.6. Specific Research Objectives

- To analyze the impact of COVID-19 on intra-bloc trade among PA members.
- To evaluate whether the pandemic led to significant trade diversion from non-member countries.
- To explore the economic and policy factors that contributed to trade creation and diversion during the COVID-19 pandemic.

1.7. Hypotheses

Hypotheses 1. *The PA facilitated significant trade creation among its member states during the COVID-19 period.*

Hypotheses 2. *The COVID-19 pandemic led to trade diversion from non-member countries to PA members.*

Hypotheses 3. *The regional cooperation within the PA mitigated the adverse effects of the pandemic on intra-bloc trade flows.*

1.8. Contributions of the Study

First, this study contributes to the growing literature on RTAs and global crises by providing empirical evidence on how the PA responded to a global trade disruption. The novelty lies in examining both trade creation and diversion during the COVID-19 pandemic, an unexplored topic in the context of the PA.

And second, the study, under a positivist philosophy with a deductive approach and an explanatory research design, employs an augmented gravity model, utilizing a robust set of econometric models, including ordinary least squares (OLS), PPML, and Heckman selection models (HSMs), to analyze the impact of the PA on trade flows during the COVID-19 pandemic. By including COVID-19-specific variables and analyzing bilateral trade data from both member and non-member countries, the study offers a comprehensive assessment of trade creation and diversion within the PA.

1.9. Structure of the Paper

The remainder of this paper is structured as follows. Section 2 outlines the methodology, covering research design, data collection, and econometric models for analyzing trade creation and diversion. Section 3 presents the empirical findings and interpretations. Section 4 discusses the results in relation to the hypothesis, literature, and policy implications. Finally, Section 5 summarizes key findings, highlights contributions, acknowledges limitations, and proposes future research directions.

2. Methodology

The study aims to investigate the extent of trade creation and diversion within the PA during COVID-19 while assessing regional cooperation's role in mitigating the pandemic's impact. A quantitative research approach is used, applying econometric models to analyze bilateral trade flows within the PA and between member and non-member countries.

The structured methodological framework is based on the gravity model of trade, using secondary data from the CEPII database, with key variables such as GDP, distance, and COVID-19-specific factors. The analysis spans multiple time periods to examine pre-pandemic, pandemic, and long-term trade effects. Following [Saunders et al. \(2009, p. 108\)](#),

the methodology includes research philosophy, approach, design, choices, data collection, and econometric techniques.

2.1. Research Philosophy

This study frames itself within positivism, as it seeks to objectively analyze observable phenomena, specifically trade flows within the PA through the application of statistical and econometric models. Positivism aligns with the quantitative nature of this research (Masuku 2024, p. 706), as it relies on empirical data and aims to test hypotheses related to trade creation, trade diversion, and the impact of COVID-19. By applying a positivist approach, the study ensures that the findings are based on measurable outcomes and can be generalized to broader trade patterns within regional trade agreements.

2.2. Research Approach

To be consistent with the research philosophy, the present study follows a deductive research approach, which tests existing trade theories in the PA context during COVID-19. Hypotheses derived from established trade theories are validated or refuted using empirical data, ensuring a systematic, evidence-based approach. This approach ensures that the research is systematic, moving from theory to data collection and analysis and, ultimately, to conclusions based on empirical evidence (Saunders et al. 2009, pp. 124–25).

Other possible research approaches include the inductive approach, which builds theories based on observed data and patterns, and the abductive approach, which combines elements of deduction and induction to explore and generate plausible explanations for observed phenomena. While the inductive approach is well suited for exploratory studies or when existing theories are insufficient, it lacks the structured framework of testing hypotheses (Saunders et al. 2009, p. 126). Similarly, the abductive approach is valuable for generating new theoretical insights but may introduce greater subjectivity in inference (Kistruck and Slade Shantz 2022, p. 1480).

The deductive approach is preferred for this study because it aligns with the goal of systematically testing established trade theories in the context of the PA. This method ensures rigor and reproducibility, allowing for a focused analysis of trade creation and diversion while providing clear validation or refutation of hypotheses. By grounding the research in tested frameworks, this approach strengthens the reliability and generalizability of the findings.

2.3. Methodological Choice

In concatenation with the research approach, this study adopts a mono-method quantitative approach by focusing solely on quantitative data (Saunders et al. 2009, pp. 151–52) and using econometric models such as OLS, PPML, and the HSM. The quantitative approach is well suited for testing hypotheses related to the causal relationships outlined in the study, ensuring that the results are both robust and generalizable, particularly in examining the role of regional cooperation in mitigating trade disruptions during global crises. Other studies and working papers, such as those by Murad et al. (2024, p. 380), Shahriar et al. (2019, pp. 23–24), and Piermartini and Teh (2005, pp. 1–3), have also employed a mono-method quantitative approach in economic modeling for trade policy.

2.4. Research Design

In alignment with the methodological choice, the research employs a quantitative strategy with an explanatory research design to analyze the causal relationships between trade creation, trade diversion, and the COVID-19 pandemic within the PA. Using the gravity model of trade as the core analytical framework, the study examines bilateral trade flows between PA members and non-member countries. By applying econometric models such as those mentioned in Section 2.3, this approach explains how regional cooperation influences trade during global disruptions, providing robust and generalizable insights into trade patterns and the resilience of intra-bloc trade.

The explanatory research design focuses on determining causal relationships between variables (Saunders et al. 2009, p. 140). This study is specifically interested in understanding how the COVID-19 pandemic and regional cooperation within the PA influence trade creation and trade diversion. This research is not only looking for relationships but is also testing hypotheses derived from established trade theories based on the gravity model of trade to explain why and how these effects occur. This design is ideal for answering the why behind observed patterns, such as whether the pandemic caused an increase in intra-bloc trade or a shift away from non-members.

2.5. Time Horizon

This study adopts a longitudinal time horizon, analyzing trade flows over multiple periods to capture changes in trade creation and trade diversion within the PA before, during, and after the COVID-19 pandemic. The chosen timeframes—2008–2014 (7 years before the framework agreement went into force), 2015–2021 (7 years when the framework agreement was in force and the pandemic hit), and an extended period from 1948 to 2021—allow for a comprehensive analysis of how trade patterns have evolved over time. This longitudinal approach aligns with the study’s aim to investigate the causal effects of the pandemic on trade dynamics, offering insights into both short-term disruptions and long-term trends in regional cooperation and trade resilience. It is important to highlight that the dataset was up to December 2021 when this study started.

2.6. Data Collection and Data Sources

The study relies on secondary data from the CEPII—Centre d’Études Prospectives et d’Informations Internationales—database (Conte et al. 2023), which offers comprehensive global trade data, covering bilateral trade flows and geographic and economic indicators. The initial dataset encompasses a total of 252 countries and 4,699,296 observations. The dataset spans from 1948 to 2021, allowing for an analysis of both the pre-PA RTA period (2008–2014) and when the period when the PA RTA was in effect (2015–2021). The key dependent variable is the bilateral trade flow (*trade_flow_imf_o*), as reported by the exporter.

In addition to the established variables in the CEPII dataset, the study introduced novel variables aimed at capturing the dynamics of trade creation or trade diversion, inspired by the framework proposed by Bacchetta et al. (2012, p. 109):

- *both_in_pa*: This binary variable takes the value of 1 if both the exporter (i) and importer (j) are members of the PA at time t, and 0 otherwise.
- *one_in_pa*: A binary variable assigned the value of 1 if the importer (i) belongs to the PA while the exporter (j) does not, and 0 otherwise.
- *covid_world*: This dummy variable is set to 1 if the year of the trade is equal to or greater than 2020 for all countries i and j in the dataset, signifying the onset of the global COVID-19 pandemic.
- *covid_pa*: Similarly, this dummy variable assumes a value of 1 if the year of the trade is equal to or greater than 2020, and either the exporter (i) or the importer (j) belongs to the PA regional trade block.

Out of the initial 87 variables, several independent control variables are selected and incorporated:

- *gdp_o* and *gdp_d*: GDP of the exporting and importing countries, respectively, to account for the economic size of the trading partners (log-current thousands of USD).
- *dist*: Geodesic distance between the most populated cities of the trading countries, capturing the influence of geographic proximity on trade flows (km).
- *contig*: A binary variable indicating whether the countries share a common border.
- *pop_o* and *pop_d*: Population of the exporting and importing countries (in thousands).
- *comlang_off*: A binary variable indicating whether the trading countries share a primary or common official language.
- *comcol*: A binary variable indicating if the countries share a common colonizer after 1945.

- `wto_o` and `wto_d`: Binary variables indicating whether the exporter and importer are members of the World Trade Organization (WTO).
- `rta_coverage`: Indicates whether the RTA covers goods only or goods and services. Coverage of the trade agreement. 0 = “no trade agreement”, 1 = “goods only”, 2 = “services only”, 3 = “goods and services”, bilateral.
- `year`: Conventional year of trade.
- `country_id_o`: Variable identifying each exporting country.
- `country_id_d`: Variable identifying each importing country.
- `col_dep_ever`: Dummy variable equal to 1 if pair ever was in a colonial or dependency relationship (including before 1948).
- `col_dep`: Dummy variable equal to 1 if pair is currently in a colonial or dependency relationship.

These variables enable a comprehensive analysis of the trade patterns within the Pacific Alliance and its relationships with non-member countries, particularly in the context of regional cooperation and global trade disruptions during the COVID-19 pandemic.

2.7. Data Analysis Techniques

To be consistent with all the former choices of this section, the study employs a series of econometric models to analyze the impact of trade creation, trade diversion, and the COVID-19 pandemic impact on trade flows within the PA. The primary analytical framework is based on the gravity model of trade, which is widely used to explain bilateral trade patterns by accounting for the economic size of countries and the distance between them, among other extended variables. To ensure robustness, the following data analysis techniques are applied using the R programming software (version RStudio 2023.06.1+524):

OLS with Fixed Effects: This model is used to estimate the effects of key variables such as `both_in_pa`, `one_in_pa`, `covid_world`, and `covid_pa` on trade flows, controlling for country-specific factors by incorporating fixed effects for exporters and importers. This approach accounts for unobserved heterogeneity and provides baseline estimates for trade creation and trade diversion.

PPML: To address the limitations of OLS, particularly when dealing with zero trade flows and heteroskedasticity, the PPML model is applied. This technique provides more reliable estimates by accommodating the large number of zero trade flows that often occur in bilateral trade data.

HSM: To account for sample selection bias, the HSM is employed. This model helps ensure that the observed trade flows are not biased due to the possibility that some trade pairs may be systematically excluded from the sample due to zero trade. The Heckman model corrects the mentioned issue by estimating both the probability of trade occurring (selection equation) and the trade flow (outcome equation), ensuring unbiased estimates.

2.7.1. Reconciling Conflicting Estimation Approaches in Gravity Models

The application of alternative estimation techniques in gravity models reveals nuanced differences that arise from distinctive methodological approaches to handling trade flow data complexities. The PPML and HSM estimators each address specific econometric challenges inherent in international trade analysis, as follows:

Treatment of Zero Trade Flows

PPML incorporates zero trade observations naturally, as it operates in levels rather than logarithms (Santos Silva and Tenreyro 2006, p. 653). This inclusion avoids sample selection bias, which can arise when zeros are excluded, as in OLS models (Haveman and Hummels 1999, p. 31). Conversely, the HSM addresses zero trade flows through a two-stage process: a selection equation to model the likelihood of positive trade and an outcome equation for trade volumes (Shepherd et al. 2019, p. 55). While the HSM’s separate treatment of selection and volume allows for distinct data-generating processes, it assumes a correlation between selection and outcome error terms. This assumption may not hold in

all cases, particularly if the factors influencing the likelihood of trade (selection equation) differ significantly from those affecting trade volumes (outcome equation), leading to potential biases in the estimation of trade determinants.

Heteroskedasticity and Distributional Assumptions

PPML effectively handles heteroskedasticity by ensuring consistency under a multiplicative error term framework (Santos Silva and Tenreyro 2011, p. 222). This robustness makes it particularly suitable when trade data exhibit variance proportional to the mean. In contrast, the HSM does not inherently address heteroskedasticity and is more sensitive to the structure of the error terms, meaning error terms in the selection and outcome equations are correlated, which can impact its reliability when heteroskedasticity is present; in other words, the HSM assumes homoscedasticity and requires correction for selection bias (Bendig and Hoke 2022, pp. 34–36).

Fixed Effects and Multilateral Resistance Terms

PPML seamlessly accommodates fixed effects, which are essential for controlling for unobserved heterogeneity and multilateral resistance terms in gravity models (Fally 2015, pp. 81–82). The HSM, while theoretically extendable to fixed effects, encounters practical limitations such as the incidental parameters problem, which can lead to biased estimates when the number of fixed effects grows relative to the sample size (Shepherd et al. 2019, p. 58).

Efficiency vs. Bias Trade-Offs

The two estimators diverge in how they balance efficiency and bias. PPML's simplicity and minimal data distribution requirements make it a preferred workhorse for trade models. However, it assumes the same data-generating process for zero and positive trade flows, which the HSM explicitly models separately, potentially offering insights into different underlying mechanisms of trade participation versus trade volume (Helpman et al. 2008, pp. 11–17).

These differences underscore the importance of choosing an appropriate estimator based on the data characteristics and research objectives. This study leverages both models together with the OLS model to ensure robustness, providing a comprehensive view of trade determinants while highlighting the methodological trade-offs inherent in their application.

Finally, all models are estimated with robust standard errors to correct for potential heteroskedasticity. This combination of econometric techniques ensures a comprehensive analysis of the causal relationships between trade flows and the key factors of interest—trade creation, trade diversion, and the COVID-19 pandemic—while providing accurate and reliable results.

2.8. Model Specification and Interpretation of Coefficients

The econometric analysis is based on the gravity model of trade, specified to capture the effects of key variables such as trade creation, trade diversion, and the impact of the COVID-19 pandemic on trade flows within the Pacific Alliance. The baseline gravity equation is specified as follows:

$$\text{Trade Flow}_{ij,t} = \beta_0 + \beta_1 \text{both_in_pa}_{ij,t} + \beta_2 \text{one_in_pa}_{ij,t} + \beta_3 \text{covid_world}_t + \beta_4 \text{covid_pa}_{ij,t} + \beta_5 \text{gdp_o} + \beta_6 \text{gdp_d} + \beta_7 \text{dist}_{ij} + \beta_8 X_{ij,t} + \varepsilon_{ij,t}$$

where

- $\text{Trade Flow}_{ij,t}$ is the bilateral trade flow from country i to country j at time t .
- $\text{both_in_pa}_{ij,t}$ is a binary variable indicating whether both countries are members of the PA, used to measure trade creation.
- $\text{one_in_pa}_{ij,t}$ is a binary variable indicating whether only the importer is a Pacific Alliance member, used to measure trade diversion.

- $covid_world_t$ is a dummy variable for the global COVID-19 pandemic (1 for trade flows during 2020 or later).
- $covid_pa_{ij,t}$ captures the specific effect of the pandemic on trade involving Pacific Alliance members.
- gdp_o and gdp_d represent the GDP of the exporting and importing countries, respectively.
- $dist_{ij}$ is the geographic distance between the two countries.
- $X_{ij,t}$ represents a set of control variables for exporting and importing countries, respectively, including the following:
 - pop_o and pop_d : population.
 - $comlang_off$: shared language.
 - col_dep_ever : ever were in a colonial or dependency relationship.
 - wto_o and wto_d : membership WTO membership.
 - $rta_coverage$: whether the RTA covers goods only or goods and services.
 - $contig$: both countries are contiguous (borders).
 - $comcol$: countries share a common colonizer post-1945.
- $\epsilon_{ij,t}$ is the error term.

The control variables β_5 through β_8 (GDP, distance, and others) are expected to behave as typical in gravity models, where GDP is positively associated with trade flows, while geographic distance and other barriers negatively impact trade. This model specification allows for the comprehensive analysis of the causal effects of both regional integration and the COVID-19 pandemic on trade flows, while the interpretation of the coefficients provides insights into the dynamics of trade creation, diversion, and pandemic-related resilience.

2.9. Validity and Reliability

This study ensures internal validity by utilizing a large dataset from the CEPII database and applying robust econometric models such as OLS, PPML, and the HSM, which help minimize biases in the estimation process. The inclusion of essential control variables, such as GDP, distance, and other relevant factors, further enhances the validity by controlling for potential confounding variables. Regarding external validity, the findings are generalizable to other RTAs, as the gravity model of trade is a widely accepted framework in international trade research, allowing the results to be applicable beyond the PA. In terms of reliability, the study benefits from the use of well-established and reliable secondary data sources, ensuring that the results are reproducible. Additionally, the consistent application of fixed effects across the OLS and PPML models to account for country-specific characteristics contributes to the stability and robustness of the findings.

In summary, this study follows a positivist research philosophy with a deductive approach, using a quantitative research strategy to investigate the causal relationships between trade creation, trade diversion, and the impact of the COVID-19 pandemic within the PA. The research employs an explanatory research design, leveraging large-scale secondary data from the CEPII database and analyzing it through robust econometric models, including OLS, PPML, and the HSM. These models, grounded in the gravity model of trade, provide a comprehensive examination of trade patterns before and during the pandemic. By utilizing a longitudinal time horizon, the study captures both short-term and long-term trends, ensuring rigorous analysis. This methodological approach, aligned with the research onion framework by [Saunders et al. \(2009\)](#), ensures that the study is both robust and reliable, providing valuable insights into the resilience of regional trade agreements like the Pacific Alliance during global economic disruptions.

3. Results

This section presents the empirical findings of the study, addressing the key research aim regarding the trade creation and trade diversion effects within the PA during the COVID-19 period. The results address how RTAs within the PA influenced intra-bloc trade and whether the pandemic led to significant trade diversion from non-member countries.

The analysis uses the econometric models outlined in the methodology: OLS with fixed effects, PPML with fixed effects, and the HSM. These models offer insights into the causal relationships between trade flows, regional cooperation, and the pandemic, testing the study's hypotheses on trade creation and diversion. The results focus on the significance, direction, and magnitude of these effects, considering the pandemic's impact on global and regional trade.

3.1. Data Patterns and Model Assumptions

Before presenting the results, it is important to check data features and model assumptions. Figure 1 shows similar trade patterns among PA countries from 1948 to 2021. However, individual analysis 7 years before the agreement reveals diverse patterns. For example, global and Mexican trade patterns were similar, but other PA countries saw a decline between 2011 and 2012 within the 2008–2014 period (see Figure 2).

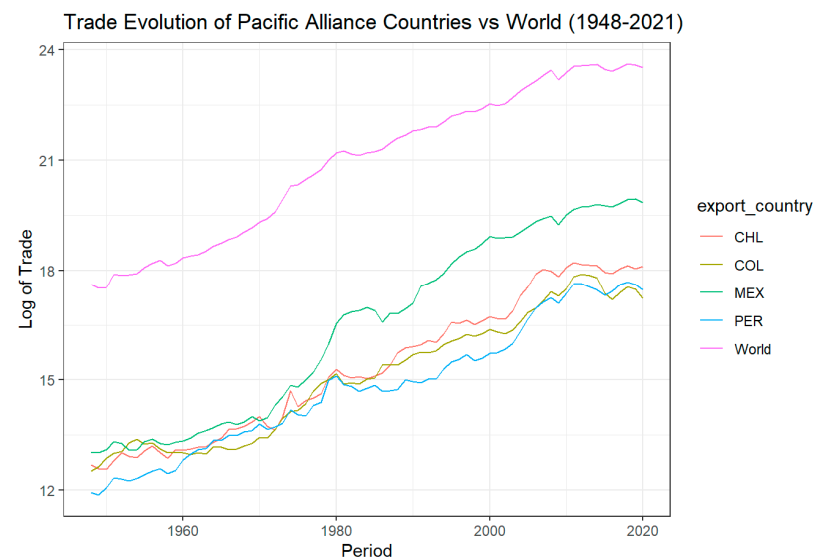


Figure 1. World and PA trade evolution; trade is in log scale.

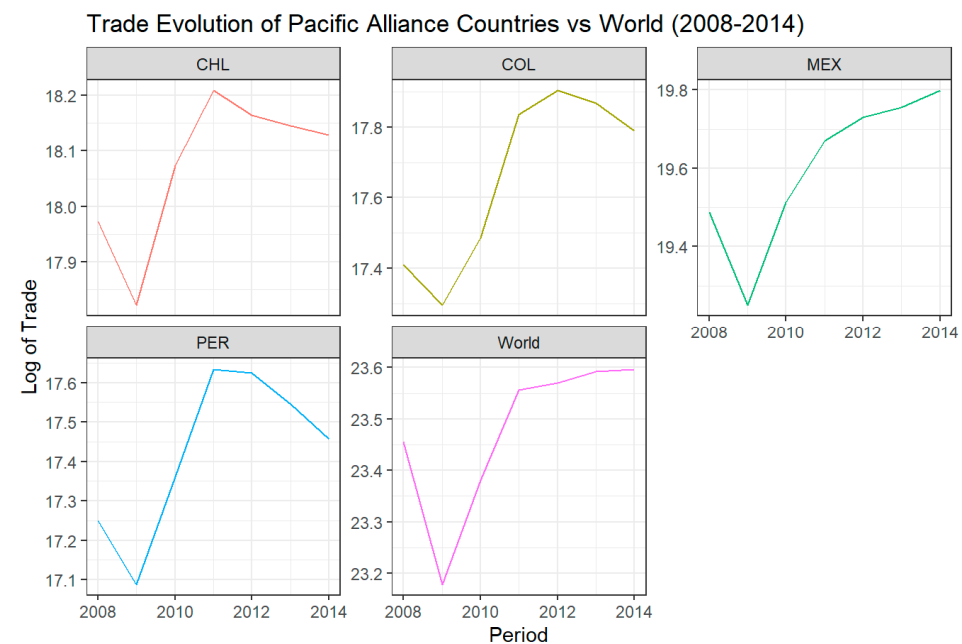


Figure 2. World and PA trade evolution before the PA RTA; trade is in log scale.

After the PA agreement framework and trade protocol took effect, an interesting pattern emerged (see Figure 3) during 2015–2021. All PA countries, except Mexico, saw significant trade growth until 2018. However, during the COVID-19 pandemic, trade declined for all except Chile, which saw a notable increase. This trend raises questions about trade creation, diversion, and COVID-19’s impact on the PA. A deeper investigation using the gravity trade model is needed to better understand these dynamics.

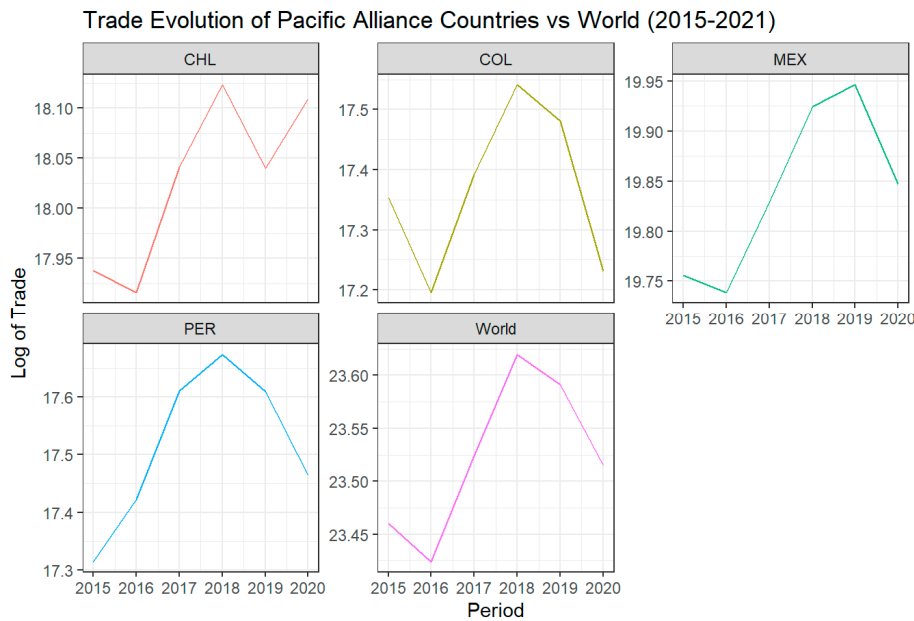


Figure 3. World and PA trade evolution after the PA RTA; trade is in log scale.

3.2. Correlation Matrix of the Basic Intuitive Gravity Model of the Dataset

Before proceeding with the correlation matrix of the basic variables from the intuitive gravity model, stringent measures were taken to exclude zero and missing values from the dataset. This meticulous approach ensures the integrity of the dataset and aligns with best practices in empirical research methodologies.

The correlation output in Figure 4 reveals the pairwise associations among key variables—trade_{flow_imf_o}, dist, gdp_o, and gdp_d.

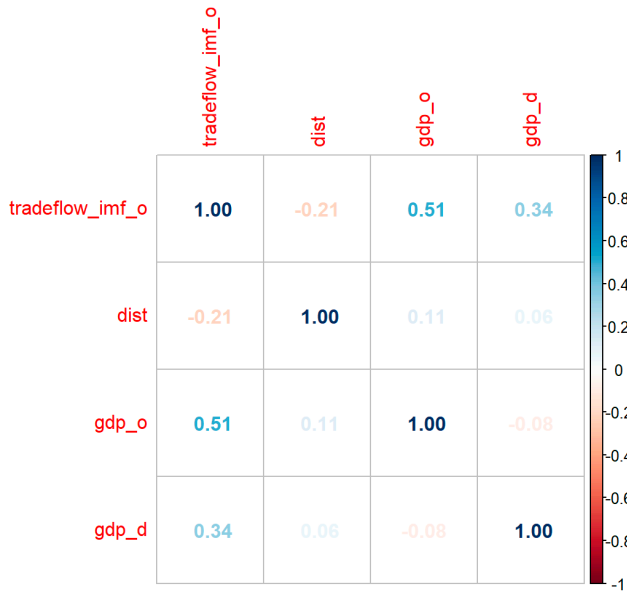


Figure 4. Correlations of basic intuitive gravity model for the whole dataset from 1948 to 2021.

From Figure 4, the following can be interpreted:

- `trade_flow_imf_o` and `dist` (-0.2119914): A negative correlation indicates that trade flows decrease as the distance between trading partners increases.
- `trade_flow_imf_o` and `gdp_o` (0.5059407): A positive correlation suggests that as the exporting country's GDP rises, trade flows increase.
- `trade_flow_imf_o` and `gdp_d` (0.3421216): Similarly, as the importing country's GDP grows, trade flows also increase.

3.3. Heteroscedasticity

An important issue to address is heteroscedasticity, as it affects the reliability of coefficient estimates, violating the basic OLS assumptions (see Figures 5 and 6), where black circles represent each data observation and the red line represents the line of best fit. Therefore, a robust regression model with clustered standard errors (`stata s.e. type`) was constructed using the `estimat` package in R (Blair et al. 2024). The three basic OLS assumptions outlined by Shepherd et al. (2019, p. 28) are as follows:

- The errors e_{ij} must have a mean of zero and be uncorrelated with each of the explanatory variables (the orthogonality assumption).
- The errors e_{ij} must be independently drawn from a normal distribution with a given (fixed) variance (the homoskedasticity assumption).
- None of the explanatory variables are a linear combination of other explanatory variables (the full rank assumption).

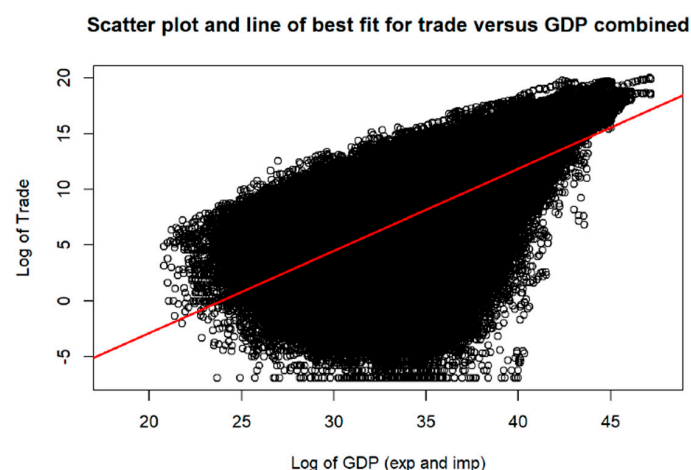


Figure 5. Heteroscedasticity issue between the trade and GDP variables (both in log scales).

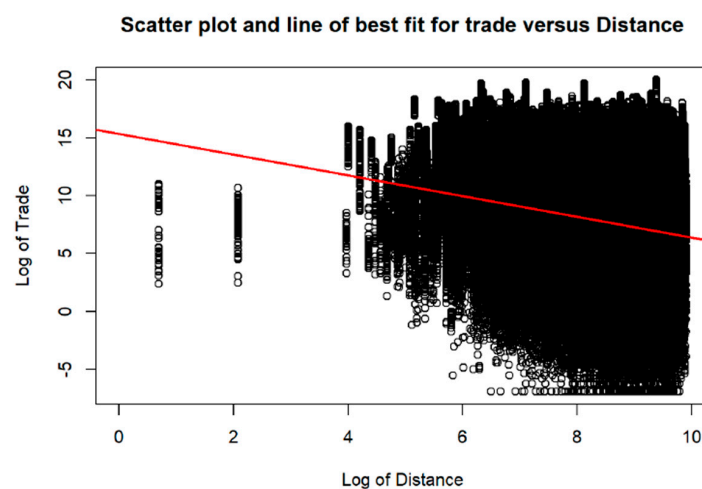


Figure 6. Heteroscedasticity issue between the trade and distance variables (both in log scales).

3.4. OLS Without Fixed Effects

Based on the data visualization, OLS with robust standard errors addresses OLS assumption violations and accounts for error correlation within groups. In gravity models, errors often correlate among country pairs, requiring clustering by country pair to avoid underestimated standard errors (Moulton 1990, p. 334). Following Anderson and van Wincoop (2003, pp. 183–84), distance is used as a clustering variable, incorporating border effects, as it is consistent for both trade directions.

The results of the OLS with robust standard errors are shown in Table 1 for all periods studied.

Table 1. OLS gravity model with robust standard errors.

	2008–2014	2015–2021	1948–2021
(Intercept)	−17.05 *** (0.58)	−19.70 *** (0.52)	−11.18 *** (0.48)
log(dist)	−1.50 *** (0.04)	−1.51 *** (0.03)	−1.51 *** (0.03)
log(gdp_o)	1.18 *** (0.02)	1.27 *** (0.02)	1.08 *** (0.01)
log(gdp_d)	0.86 *** (0.01)	0.92 *** (0.01)	0.78 *** (0.01)
contig	0.67 *** (0.14)	0.56 *** (0.13)	0.43 *** (0.11)
comlang_off	0.85 *** (0.11)	0.69 *** (0.10)	0.78 *** (0.10)
col_dep_ever	0.75 *** (0.22)	0.70 *** (0.18)	1.08 *** (0.27)
comcol	1.31 *** (0.15)	1.37 *** (0.13)	1.04 *** (0.13)
pop_o	−0.00 (0.00)	−0.00 *** (0.00)	0.00 (0.00)
pop_d	0.00 *** (0.00)	0.00 ** (0.00)	0.00 *** (0.00)
wto_o	1.01 *** (0.14)	1.05 *** (0.14)	−0.42 *** (0.06)
wto_d	0.22 * (0.09)	0.14 (0.09)	−0.85 *** (0.06)
rta_coverageGoods and Services	0.13 * (0.06)	0.34 *** (0.06)	0.33 *** (0.06)
both_in_pa	0.48 ** (0.16)	0.30 * (0.13)	0.57 *** (0.14)
one_in_pa	0.17 (0.13)	0.22 (0.12)	0.23 * (0.11)
rta_coverageServices		−0.54 (0.28)	−0.69 * (0.28)
covid_world		−0.07 *** (0.02)	−0.41 *** (0.03)
covid_pa		0.02 (0.05)	0.28 *** (0.08)

Table 1. *Cont.*

	2008–2014	2015–2021	1948–2021
nobs ¹	27,929	33,071	108,843
Adjusted R ²	0.75	0.74	0.72
statistic	854.82	950.63	861.69
p-value	0.00	0.00	0.00
se_type	stata	stata	stata

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. ¹ The number of observations in the OLS model differs from the original dataset due to the exclusion of NA values and the dropping of observations with zero trade flows when log-transforming the dependent variable. This reduction in sample size occurs as OLS estimation in R performs complete case analysis, omitting any rows with missing or undefined values. Note: Numbers within parentheses relate to the coefficient standard errors.

3.5. OLS with Fixed Effects by Importer and Exporter

A robust method for estimating the theoretical gravity model uses fixed-effects estimation within a panel data framework for each country. By grouping terms for exporters and importers, this approach provides reliable estimates for gravity models. It applies to various trade scenarios, spanning from the Ricardian model proposed by [Eaton and Kortum \(2002, pp. 1745–46\)](#) to the heterogeneous firms model introduced by [Chaney \(2008, pp. 1712–15\)](#). Two new variables, exp and imp, were created from the CEPII dataset, representing exporting and importing countries, respectively. The resulting model is shown in Table 2.

Table 2. OLS gravity model with fixed effects by importer and exporter.

	2008–2014	2015–2021	1948–2021
(Intercept)	23.57 *** (1.14)	20.29 *** (1.28)	17.56 *** (1.35)
log(dist)	−1.84 *** (0.04)	−1.78 *** (0.04)	−1.64 *** (0.03)
contig	0.17 (0.12)	0.21 (0.12)	0.14 (0.10)
comlang_off	0.76 *** (0.13)	0.76 *** (0.10)	0.65 *** (0.11)
col_dep_ever	1.07 *** (0.21)	0.94 *** (0.17)	1.30 *** (0.25)
comcol	0.99 *** (0.15)	1.21 *** (0.13)	1.17 *** (0.13)
pop_o	0.00 *** (0.00)	0.00 *** (0.00)	0.00 *** (0.00)
pop_d	0.00 *** (0.00)	0.00 (0.00)	0.00 *** (0.00)
wto_o	0.17 (0.15)	−0.58 (0.71)	1.03 *** (0.05)
wto_d	0.02 (0.09)	−0.24 (0.46)	0.75 *** (0.06)
rta_coverageGoods and Services	0.19 (0.12)	0.25 * (0.10)	0.26 *** (0.08)
both_in_pa	0.78 ** (0.26)	0.91 *** (0.21)	1.14 *** (0.27)
one_in_pa	0.20 (0.61)	0.88 (0.55)	0.66 (0.55)

Table 2. *Cont.*

	2008–2014	2015–2021	1948–2021
rta_coverageServices		0.14 (0.42)	0.27 (0.37)
covid_world		−0.03 (0.02)	0.10 *** (0.02)
covid_pa		−0.09 (0.05)	0.14 (0.08)
nobs	29,734	34,034	114,465
Adjusted R ²	0.83	0.83	0.80
df.residual	2418.00	2855.00	3083.00
se_type	stata	stata	stata

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. This is a truncated output where all exporting and importing countries were excluded. Numbers within parentheses relate to the coefficient standard errors.

3.6. Poisson Pseudo-Maximum Likelihood Estimator

Moreover, this research addresses the issue of heteroskedasticity in the gravity model of trade, as shown by scatter plots (Figures 5 and 6) and the Breusch–Pagan test on the robust OLS and fixed-effects models. For example, test results for the 1948–2021 data are presented in Table 3.

Table 3. Studentized Breusch–Pagan test conducted on the 1948 to 2021 dataset.

Model	BP	df	<i>p</i> -Value
OLS_robust_model_total_period	7599	17	2.2×10^{-16}
robust_model_fix_effects_total_period	16,677	369	2.2×10^{-16}

Hence, Santos Silva and Tenreyro (2006, p. 653) suggest the PPML estimator as an alternative to address parameter bias in the presence of heteroskedasticity. Therefore, a fixed-effects gravity model using the PPML estimator with robust clustered standard errors, clustered by distance, was implemented using the gravity package in R by Woelwer et al. (2023). Unlike OLS, the Poisson model accommodates NA and zero observations, offering a more comprehensive approach. The results are shown in Tables 4–6 for the periods 2008–2014, 2015–2021, and 1948–2021, respectively.

Table 4. PPML estimator with robust clustered standard errors (2008–2014).

Predictors	Estimate	Std. Error	z Value	Pr(> z)
(Intercept)	17.73	0.26	66.97	0.00
dist_log	−0.76	0.01	−55.62	0.00
contig	0.59	0.02	25.16	0.00
comlang_off	0.17	0.03	4.99	0.00
col_dep_ever	0.02	0.05	0.40	0.69
comcol	0.31	0.07	4.25	0.00
pop_o	0.00	0.00	5.13	0.00
pop_d	0.00	0.00	3.48	0.00
wto_o	0.41	0.11	3.74	0.00
wto_d	0.19	0.10	1.91	0.06
rta_coverageGoods and Services	0.19	0.06	3.23	0.00
both_in_pa	0.20	0.11	1.87	0.06
one_in_pa	−0.07	0.16	−0.43	0.67

Note: This is a truncated output where all exporting and importing countries were excluded.

Table 5. PPML estimator with robust clustered standard errors (2015–2021).

Predictors	Estimate	Std. Error	z Value	Pr(> z)
(Intercept)	16.24	0.52	31.51	0.00
dist_log	−0.74	0.01	−58.56	0.00
contig	0.59	0.02	24.95	0.00
comlang_off	0.05	0.04	1.43	0.15
col_dep_ever	0.06	0.05	1.30	0.19
comcol	0.41	0.06	6.63	0.00
pop_o	0.00	0.00	2.74	0.01
pop_d	0.00	0.00	2.53	0.01
wto_o	−0.14	0.25	−0.54	0.59
wto_d	0.16	0.28	0.56	0.57
rta_coverageGoods and Services	0.24	0.04	5.97	0.00
rta_coverageServices	−1.50	0.16	−9.48	0.00
both_in_pa	0.18	0.10	1.75	0.08
one_in_pa	0.75	0.17	4.43	0.00
covid_world	−0.06	0.02	−2.53	0.01
covid_pa	−0.06	0.12	−0.54	0.59

Note: This is a truncated output where all exporting and importing countries were excluded.

Table 6. PPML estimator with robust clustered standard errors (1948–2021).

Predictors	Estimate	Std. Error	z Value	Pr(> z)
(Intercept)	16.09	0.17	94.20	0.00
dist_log	−0.72	0.01	−80.40	0.00
contig	0.59	0.02	33.16	0.00
comlang_off	0.15	0.02	6.49	0.00
col_dep_ever	0.08	0.03	2.28	0.02
comcol	0.44	0.05	9.11	0.00
pop_o	0.00	0.00	14.72	0.00
pop_d	0.00	0.00	11.82	0.00
wto_o	0.67	0.04	16.33	0.00
wto_d	0.71	0.04	17.23	0.00
rta_coverageGoods and Services	0.08	0.04	2.29	0.02
rta_coverageServices	−1.11	0.13	−8.25	0.00
both_in_pa	0.31	0.07	4.31	0.00
one_in_pa	0.09	0.12	0.69	0.49
covid_world	0.01	0.03	0.45	0.65
covid_pa	−0.05	0.11	−0.42	0.67

Note: This is a truncated output where all exporting and importing countries were excluded.

3.7. Heckman Sample Selection Estimator for Gravity Models

The bilateral trade matrix frequently exhibits zero trade flows, as mentioned in Section 3.5, especially as product disaggregation increases. [Helpman et al. \(2008\)](#) noted that about 50% of aggregate trade data contain zero values. Omitting these zero observations, as in the case of OLS due to the undefined logarithm of zero, raises concerns about sample selection bias and leads to biased and inconsistent estimates. To address this, this study employs ([Heckman 1979](#)) sample selection correction techniques.

Based on the former, [Helpman et al. \(2008\)](#) introduced a gravity model with Heckman correction to improve parameter estimation precision. This study uses the `ssmrob` package ([Zhelonkin and Ronchetti 2021](#)), where the `heckitrob()` function computes robust two-stage estimates. The Heckman correction model, applied to the 1948–2021 period, excludes COVID-19-related variables due to computational limitations, focusing on variables like `both_in_pa` and `one_in_pa` to assess trade dynamics within the PA.

Due to computational limitations, the Heckman correction model was applied only to the 1948–2021 period, excluding variables such as `covid_world` and `covid_pa`. This

period was chosen to explore potential trade creation or diversion within the PA. The analysis focused on the variables `both_in_pa` and `one_in_pa` through separate models to elucidate trade dynamics. Nonetheless, the `heckitrob()` function was selected for its ability to provide robust standard errors, which is critical for ensuring the reliability of the results in the presence of potential outliers or violations of standard assumptions such as homoscedasticity. However, the robust estimation procedures implemented by `heckitrob` are computationally intensive, involving iterative algorithms designed to refine estimates against assumption violations (Zhelonkin and Ronchetti 2021).

Compared to other R packages, the `selection()` function from the `sampleSelection` package (Toomet and Henningsen 2008) and `sampselect()` from the `endogenous` package (Spieker 2016) offer alternative methods for Heckman-style models. While the `selection()` function provides standard maximum likelihood estimation with potentially lower computational demands, it does not support robust or clustered standard errors. Similarly, the `sampselect()` function requires initialization values and advanced econometric techniques beyond the scope of this study. Moreover, none of these R functions currently allow for the inclusion of fixed effects, thereby limiting their methodological adaptability.

Before running the Heckman sample analysis, missing values for trade and distance were removed. Three new variables were generated, including a binary output variable for the probit model and the variable `ent_cost_both`, as suggested by Shepherd et al. (2019, pp. 53–54). Following the last step, once again all missing values were removed from the dataset. The results for `both_in_pa` and `one_in_pa` are shown in Tables 7 and 8, respectively.

Table 7. Heckman sample selection estimator for gravity model (`both_pa` variable).

Probit Selection Equation				
	Estimate	Std. Error	t Value	Pr(> t)
(Intercept)	6.453863	0.3111419	20.7400	1.43×10^{-95} ***
log(dist)	−0.481340	0.0347332	−13.8600	1.13×10^{-43} ***
contig	1.035625	0.8072376	1.2830	2.00×10^{-1}
comlang_off	0.033364	0.0686967	0.4857	6.27×10^{-1}
comcol	−0.466047	0.0776893	−5.9990	1.99×10^{-9} ***
both_in_pa	1.140638	0.1813090	6.2910	3.15×10^{-10} ***
ent_cost_both	−0.001963	0.0007541	−2.6030	9.24×10^{-3} **
Outcome Equation				
	Estimate	Std. Error	t Value	Pr(> t)
(Intercept)	17.4105	0.34680	50.200	0.00 ***
log(dist)	−0.7574	0.04868	−15.560	1.38×10^{-54} ***
contig	1.1078	0.07548	14.680	9.03×10^{-49} ***
comlang_off	−0.1074	0.09377	−1.146	2.52×10^{-1}
comcol	−2.0862	0.14828	−14.070	5.88×10^{-45} ***
both_in_pa	1.0762	0.12706	8.470	2.46×10^{-17} ***
IMR1 ¹	−31.5469	2.85005	−11.070	1.78×10^{-28} ***

Signif. codes: 0, *** 0.001, ** 0.01, * 0.05, ‘.’ 0.1, ‘ ’ 1. ¹ IMR1 is the inverse Mills ratio; in this case, it is negative and statistically significant. Note: Heckman selection model/robust 2-step M-estimation. A total of 56,010 observations: 458 censored and 55,552 observed. Sigma 6.670472.

Table 8. Heckman sample selection estimator for gravity model (`one_in_pa` variable).

Probit Selection Equation				
	Estimate	Std. Error	t Value	Pr(> t)
(Intercept)	5.97207	0.2878017	20.7500	1.21×10^{-95} ***
log(dist)	−0.42165	0.0321696	−13.1100	3.00×10^{-39} ***
contig	1.07484	0.7448713	1.4430	1.49×10^{-1}
comlang_off	0.01504	0.0677197	0.2221	8.24×10^{-1}
comcol	−0.49149	0.0763926	−6.4340	1.25×10^{-10} ***

Table 8. Cont.

one_in_pa	0.85682	0.1938428	4.4200	9.86×10^{-6} ***
ent_cost_both	−0.00166	0.0007486	−2.2180	2.65×10^{-2} *
Outcome Equation				
	Estimate	Std. Error	t Value	Pr(> t)
(Intercept)	17.53543	0.36528	48.0100	0.00 ***
log(dist)	−0.77922	0.05078	−15.3400	3.90×10^{-53} ***
contig	1.12611	0.07346	15.3300	4.85×10^{-53} ***
comlang_off	−0.07669	0.08428	−0.9099	3.63×10^{-1}
comcol	−2.17047	0.13884	−15.6300	4.36×10^{-55} ***
one_in_pa	1.30301	0.14504	8.9840	2.62×10^{-19} ***
IMR1 ¹	−26.90169	2.80067	−9.6050	7.58×10^{-22} ***

Signif. codes: 0, *** 0.001, ** 0.01, * 0.05, ‘.’ 0.1, ‘ ’ 1. ¹ IMR1 is the inverse Mills ratio; in this case, it is negative and statistically significant. Note: Heckman selection model/robust 2-step M-estimation. A total of 56,010 observations: 458 censored and 55,552 observed. Sigma 6.670472.

4. Discussion

This study assessed trade creation and diversion within the PA during COVID-19 and examined the role of regional cooperation in mitigating the pandemic’s trade impact. Using econometric models like OLS, PPML, and the HSM, the results provide insights into PA trade dynamics. This section discusses the findings in relation to the literature, highlighting trade creation, mixed evidence for trade diversion, and the stabilizing effects of regional cooperation during the pandemic’s global trade disruption.

4.1. Trade Creation Within the PA

The econometric results confirm trade creation within the PA during COVID-19 until 2021, particularly shown by OLS models and the PPML estimator. For instance, OLS models in Tables 1 and 2 show a significant coefficient for both_in_pa across all periods, with the highest effect during 1948–2021 (0.57, $p < 0.001$ and 1.14, $p < 0.001$), indicating strengthened intra-bloc trade. This aligns with previous studies, such as Ruta (2023) and Fernandes et al. (2021), that argue RTAs reduce costs and harmonize policies to facilitate trade.

Also, PPML models in Tables 4–6 further support trade creation, with a positive coefficient for both_in_pa in the long term (0.31, $p < 0.001$), and statistically significant at the 10% level for 2008–2014 and 2015–2021. These findings, corroborated by Zuev et al. (2023), emphasize RTAs’ role in enhancing trade resilience, especially during crises like COVID-19. All the former findings reinforce the visualization in Figure 1.

In contrast to Vebiyanto and Atmanti (2023), which found mixed FTA results by region, the PA consistently shows trade creation, indicating that deeper integration among its members mitigated global disruptions.

Therefore, H1 (the PA facilitated significant trade creation among its member states during the COVID-19 period) is confirmed. The OLS, PPML, and HSM consistently show statistically significant positive coefficients for both_in_pa during COVID-19, with the most substantial effects seen in the long-term period (1948–2021). These coefficients remained positive and significant in both fixed-effects models and Heckman outcome equations.

4.2. Trade Diversion from Non-Member Countries

The evidence for trade diversion is inconclusive. The OLS models for 2015–2021 show limited support for one_in_pa (0.88, Table 2) but without statistical significance, suggesting trade diversion may not have occurred as expected, consistent with findings by Urata and Okabe (2010). However, the HSM in Table 8 shows trade creation for one_in_pa during 1948–2021 (1.30, $p < 0.001$), exceeding trade creation for both_in_pa (1.14, $p < 0.001$, Table 7).

This nuanced result may be due to global interconnectedness persisting during the pandemic. While the PA fostered intra-regional trade, strong evidence of trade diversion from non-members is lacking, possibly due to global supply chain resilience (Ridley et al. 2023).

4.3. Impact of the COVID-19 Pandemic on Trade

The pandemic had a complex impact on PA trade flows. As expected, the *covid_world* variable in the OLS and PPML models shows a significant negative effect on global trade, with *covid_world* in the PPML model (Table 5) showing a negative impact during 2015–2021 ($-0.06, p < 0.01$), consistent with [Rosie and Gabija \(2021\)](#), who highlight global trade contraction during the pandemic.

Conversely, *covid_pa* presents a nuanced picture. The OLS results (Table 1) show a slight positive but insignificant effect during 2015–2021, possibly explaining Chile's upward trade trend (Figure 3). For 1948–2021, *covid_pa* was statistically significant ($0.28, p < 0.001$). OLS with fixed effects produced mixed, statistically insignificant results.

The PPML results (Tables 5 and 6) suggest that COVID-19 did not significantly disrupt intra-regional trade within the PA, as indicated by the *p*-values. The lack of significance for *covid_pa* in several models suggests that regional cooperation within the RTA helped cushion the pandemic's impact, supporting the hypothesis of trade resilience ([Mena et al. 2022](#)). This resilience likely stems from harmonized trade policies and collective efforts to keep trade channels open during the pandemic crisis.

Therefore, H2 (the COVID-19 pandemic led to trade diversion from non-member countries to PA members) is partially proven. The evidence for trade diversion is mixed. Trade diversion was not consistently observed across all models, particularly in the more recent period (2015–2021), where the results were less conclusive.

4.4. Role of Regional Cooperation in Mitigating Trade Disruptions

The findings from OLS, PPML, and the HSM support the hypothesis that regional cooperation within the PA mitigated the pandemic's trade impacts. The positive and significant coefficient for *both_in_pa* across all models underscores the PA's stabilizing effect, consistent with [Nicita and Saygili \(2021\)](#) and [Kpodar and Imam \(2015\)](#), who found that RTAs reduce volatility during global crises.

Moreover, the Heckman model (Table 7) shows *both_in_pa* as a significant factor in both selection and outcome equations, reinforcing that PA membership enhances trade flow stability during global instability. This highlights RTAs' importance in fostering trade resilience, as confirmed by [Muhammad and Yucer \(2009\)](#), who used gravity models and PPML on six RTAs across 38 countries.

Therefore, H3 (the regional cooperation within the PA mitigated the adverse effects of the pandemic on intra-bloc trade flows) is confirmed. The findings suggest that regional cooperation within the PA helped buffer the impact of the pandemic on intra-bloc trade. The *covid_pa* variable did not show a statistically significant negative effect on trade in all models except the 1948–2021 OLS without fixed-effects model, indicating that the pandemic did not severely disrupt trade within the PA. Additionally, the significant positive coefficients for *both_in_pa* reinforce the idea that regional cooperation helped maintain intra-bloc trade during the global crisis.

5. Conclusions

This study analyzed trade creation, diversion, and regional cooperation within the PA before and during COVID-19, providing insights into how RTAs can mitigate global trade disruptions. The results confirmed significant trade creation within the PA, with intra-bloc trade increasing during the pandemic. Regional cooperation played a critical role in maintaining trade resilience, supporting the hypothesis that the PA mitigated the pandemic's adverse effects on intra-bloc trade.

The evidence for trade diversion from non-members was inconclusive. While the HSM indicated trade creation both within the bloc and with non-members, the OLS and PPML models showed mixed results due to the statistical insignificance of *one_in_pa* in most models, suggesting that trade diversion was not a dominant effect. Nonetheless, the study emphasizes RTAs' stabilizing influence, consistent with the broader literature on their role in fostering trade resilience during global economic instability.

This study provides valuable insights for policymakers, particularly in strengthening regional economic cooperation and mitigating global disruptions like pandemics. The findings highlight the importance of RTAs like the PA in fostering trade resilience and intra-bloc trade creation. By demonstrating that RTAs can buffer external shocks, this research suggests governments should prioritize deepening economic integration within regional blocs. Additionally, it underscores the strategic value of RTAs for small and developing economies, indicating that proactive regional cooperation can help mitigate vulnerability to future crises.

However, the study faced an important limitation, particularly regarding the HSM, which could only be applied to the `one_in_pa` and `both_in_pa` variables due to high computational demands of the `ssmrob` package in R. While these variables could have provided valuable insights into the pandemic's impact on trade flows, their inclusion would have significantly increased the computational load, rendering the estimation process unfeasible with the resources available for this research. Moreover, the exclusion of some COVID-19-specific variables in the Heckman model due to these limitations suggests that further research could benefit from more advanced computational resources to provide a more comprehensive analysis. Additionally, the reliance on secondary data limited the granularity of the findings; therefore, future studies could explore sector-specific trade dynamics within the PA, specifically the main exported commodities by Chile, that could help explain in more detail the pattern in Figure 3. And finally, the time horizon of future studies should be extended to 2022, when COVID-19 restrictions were lifted by governments; this is because the CEPII database was only updated until 2021 at the time of this study.

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