Trade Effect of E-commerce agreements: Gravity Model Estimation

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Abstract

With the rapid growth of e-commerce, understanding the impact of e-commerce agreements on international trade is crucial. In this study, we examine this relationship using panel data from the OECD ICIO tables and the TAPED dataset. Our research employs a structural gravity model that includes three fixed effects: country pair, exporter year, and importer year. To deal with statistical challenges such as zero trade flows and heteroscedasticity inherent in trade data, we use the PPML estimator for estimation. After analyzing the results, our findings suggest a significant positive impact of e-commerce agreements on bilateral trade flows. Moreover, we employ a staggered difference-in-differences analysis to identify the causal effect while controlling for interventions that occur over different time periods. The results show a tendency for trade flows to increase following the implementation of an e-commerce agreement. These findings underscore the critical role of e-commerce agreements in facilitating international trade.

1 Introduction

In recent decades, the global economy has rapidly progressed due to digitalization. This wave of digitalization has significantly changed the traditional framework of international trade, creating new economic opportunities. Trade in services has surged, with digital platforms enabling cross-border delivery. The free flow of data and digital content across borders has also increased substantially.

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Simultaneously, countries have been discussing and implementing policies related to e-commerce and other forms of digital trade. Figure 1 illustrates the number of country pairs engaged in e-commerce agreements from 2000 to 2020. As shown, there has been a significant increase in e-commerce agreements over the years. This upward trend can be attributed to nations' efforts to facilitate digital economic integration and establish unified rules for digital trade.

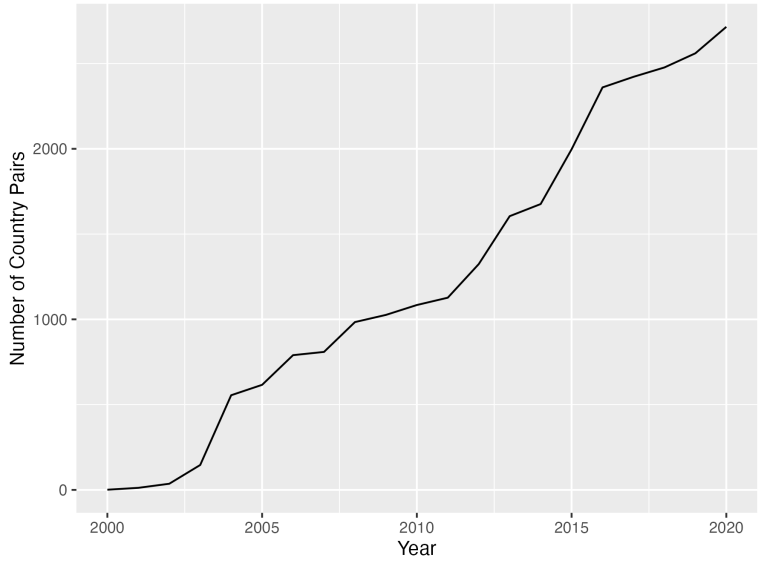

Figure 1: The cumulative number of country pairs entering into e-commerce agreements, 2000-2020 (Source: Author's calculations based on TAPED dataset)

These e-commerce agreements typically include provisions for liberalizing cross-border data flows, accepting electronic signatures, allowing electronic payments and consumer protection measures. By developing such digital trade rules, the agreements aim to reduce barriers and create an environment conducive to e-commerce.

International agreements concerning e-commerce have the potential to enhance digital trade and accelerate economic growth. However, their actual impact on trade flows remains an important empirical question. This study aims to reveal the actual impact of e-commerce agreements on international trade flows. Evaluating their effectiveness can provide valuable insights for policymakers to further improve digital trade policies and negotiations.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature on e-commerce agreements and international trade. Section 3 outlines the theoretical framework underpinning the empirical analysis. Section 4 describes the empirical strategies employed, including the gravity model specification and the dataset used. Section 5 presents and discusses the estimation results. Finally, Section 6 concludes with a summary of key findings and policy implications.

2 Literature review

2.1 Effects of Regional Trade Agreements

A number of papers, including Baier and Bergstrand (2017), provide empirical evidence that regional trade agreements significantly increase trade volume. This is because it minimizes growth instability, expands productive capacity, and reduces the vulnerability of certain sectors to shocks (Kpodar and Imam 2016). This is often influenced by a number of factors, including the level of economic development, the nature of institutions, cultural norms, and the imposition of tariffs (Urata and Okabe 2014). The implementation of FTAs has led to an increase in real incomes in the manufacturing sector of more than 5% in some countries and improved efficiency in global manufacturing trade (Anderson and Yotov, 2016). FTAs will increase bilateral trade volume by about 100% on average over the next decade (Baier and Bergstrand, 2007).

2.2 Effects of Digital Trade Agreements

On the other hand, to the author's knowledge, few papers have analyzed the effects of digital trade agreements. As with traditional regional trade agreements, regional digital trade agreements have the potential to influence bilateral trade, multilateral trade, and the economies of contracting parties (Christensen et al., 2013; Van der Marel et al., 2016; Duval, Utoktham, and Kravchenko, 2018). Ma et al. (2022) is one of the few papers that quantitatively analyzes the effects of digital trade agreements. The paper shows that the effects of digital trade agreements are negligible with respect to trade in goods. On the other hand, with respect to trade in services, the paper shows that the effect of digital trade agreements is significant and contributes to the promotion of trade in services. However, the inclusion of

the value of trade in goods as a control variable in the regression analysis of the trade in services is puzzling.

3 Theoretical framework

The gravity equation, first introduced by Tinbergen (1962), is a foundational model in international economics used to analyze and predict bilateral trade flows between countries. This model explains the trade volumes between two countries based on their economic sizes and geographic factors like distance, tariffs, and transportation costs that impede trade.

The gravity equation has been derived from various microeconomic foundations, including monopolistic competition (Anderson, 1979), Heckscher-Ohlin theory (Bergstrand, 1985), and the Ricardian framework (Eaton and Kortum, 2002). This section briefly outlines the derivation of the gravity equation following the approach of Anderson and van Wincoop (2003).

Consider a world consisting of n countries, each producing a unique differentiated good that is traded internationally. We assume iceberg transportation costs as commonly used in trade literature.

Household preferences across countries are modeled using a constant elasticity of substitution (CES) utility function:

$$U_j = \left(\sum_{i=1}^{n} \alpha_i^{\frac{1-\sigma}{\sigma}} x_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where x_{ij} is the consumption of good i in country j, p_{ij} is the price, $\alpha_i > 0$ is the preference parameter, and $\sigma > 1$ is the elasticity of substitution.

Consumers maximize the utility subject to their budget constraint:

$$\sum_{i=1}^{n} p_{ij} x_{ij} = E_j \tag{2}$$

where E_j is the total expenditure in country j.

Solving this problem yields the demand for good i by consumers in country j:

$$X_{ij} = \frac{(\alpha_i p_i T_{ij})^{1-\sigma}}{\sum_{i=1}^{n} (\alpha_i p_i T_{ij})^{1-\sigma}} E_j \tag{3}$$

where X_{ij} is the value of bilateral trade, p_i is the factory-gate price of good i, and $T_{ij} \geq 1$ is the iceberg transport cost.

Imposing market clearing conditions $Y_i = \sum_{j=1}^{n} X_{ij}$ leads to the gravity equation:

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{T_{ij}}{\Pi_i P_j} \right)^{1-\sigma}. \tag{4}$$

where Y is total world production, and Π_i and P_j are the multilateral resistance terms (Anderson and van Wincoop, 2003) defined as:

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{T_{ij}}{P_j} \right)^{1-\sigma} \frac{E_j}{Y} \right)^{\frac{1}{1-\sigma}}, \tag{5}$$

$$P_j = \left(\sum_{i=1}^{n} \left(\frac{T_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y} \right)^{\frac{1}{1-\sigma}}. \tag{6}$$

4 Empirical strategies and data

4.1 Model

In our empirical analysis, we employ the following equation:

$$X_{ijt} = \exp\left(\beta EC_{ijt} + \gamma_{ij} + \gamma_{it} + \gamma_{jt}\right) \varepsilon_{ijt} \tag{7}$$

where X_{ijt} represents the value of trade between exporter i and importer j in year t and EC_{ijt} is a binary variable that takes the value of 1 if countries i and j have entered into force an e-commerce agreement in year t, and 0 otherwise. The coefficient β represents the effect of e-commerce agreement and is the focus of our analysis. γ_{ij}, γ_{it}, and γ_{jt} represent the exporter-importer fixed effects, exporter-year fixed effects, and importer-year fixed effects, respectively, and ε_{ijt} denotes the error component.

To compare with FTAs without e-commerce agreements, we also consider a model with the interaction between e-commerce agreements and FTAs.

$$X_{ijt} = \exp\left(\beta_1 FTA_{ijt} EC_{ijt} + \beta_2 FTA_{ijt} \overline{EC}_{ijt} + \gamma_{ij} + \gamma_{it} + \gamma_{jt}\right) \varepsilon_{ijt} \tag{8}$$

where $\overline{EC}_{ijt} \equiv 1 - EC_{ijt}$ is a binary variable that takes the value of 0 when $EC_{ijt} = 1$, and 1 when $EC_{ijt} = 0$. β_1 represents the effect of FTA with an e-commerce provision and β_2 represents the effect of no e-commerce FTA.

To extend the analysis, we estimate the time series trend of trade flows for each country pair i, j by the equation:

$$X_t = \exp(\alpha + \beta t) u_t. \tag{9}$$

The estimated trend is then included in the control variables of the model described earlier.

We also used the staggered differences-in-differences (Sun and Abraham, 2021) to estimate the dynamic treatment effects of e-commerce agreements on bilateral trade flow.

$$X_{ijt} = \exp\left(\sum_{e}\sum_{\ell}\delta_{e\ell}\mathbb{1}\{s_{ij}=e\}\mathbb{1}\{t-s_{ij}=\ell\} + \gamma_{ij} + \gamma_{it} + \gamma_{jt}\right)\varepsilon_{ijt} \tag{10}$$

where $s_{ij} \equiv \min\{t\colon EC_{ij}=1\}$ represents the year in which the country pair i, j first entered into the e-commerce agreement. The coefficient estimator $\hat{\delta}_{e\ell}$ is DID estimator for the cohort-specific average treatment effect on the treated (CATT) ℓ periods from initial treatment. This method allows us to compare the outcomes of countries before and after they enter into e-commerce agreements, while also accounting for the staggered timimg of these agreements across country pairs.

Following Mayer et al. (2019), the estimation also includes an equation for the trade share π_{ijt}, defined as the ratio of X_{ijt} to the total trade flow of the importing country j:

$$\pi_{ijt} = \exp\left(\beta EC_{ijt} + \gamma_{ij} + \gamma_{it} + \gamma_{jt}\right)\varepsilon_{ijt}. \tag{11}$$

Throughout the entire estimation, we use the Poisson Pseudo Maximum Likelihood (PPML) estimator, proposed by Silva and Tenrenryo (2006), to address statistical challenges such as zero trade flows and heteroscedasticity inherent in trade data.

4.2 Data

A panel data set comprising 76 countries from 2000 to 2020 was utilized. E-commerce information was obtained from the TAPED (Trade Agreement Provisions on Electronic Commerce and Data) dataset (Burri et al., 2022), while trade figures were sourced from the OECD ICIO (Inter-Country Input-Output) tables (OECD, 2023).

TAPED is a comprehensive source of information on e-commerce, encompassing over 340 trade agreements since 2000.

In contrast, the ICIO is a comprehensive database for analyzing inter-industry linkages in the global economy. In addition to inter-country trade

volumes and inter-industry transactions, the database contains information on trade in services, domestic trade, and trade in intermediate and final goods. Consequently, ICIO can be used to assess the impact of e-commerce from multiple perspectives. However, one limitation of the ICIO is the limited number of countries included in the data. Summary statistics are shown in Table 1.

Table 1: Summary Statistics

	Mean	Std.Dev	Min	Max	N
Exports	20488.32	462755.4	2.98×10^{-4}	34492746.0	124509
Trade shares	0.0130	0.0903	5.81×10^{-10}	0.934	124509
FTA	0.285	0.452	0	1	124509
E-commerce	0.189	0.391	0	1	124509

5 Estimation results

5.1 Results on Exports

First, we examine the results of the regression analysis with export value as the dependent variable. The results are shown in table 2.

Model (1) shows that Free Trade Agreements (FTAs) have a significant positive impact on exports. Countries participating in FTAs experience an increase in exports of about $(\exp(0.1169) - 1) \times 100 \approx 12.40\%$. This result is consistent with previous empirical studies.

The result of model (2) indicates the impact of FTAs, while still statistically significant, is smaller than the models that do not control for trends. Specifically, exports from countries participating in FTAs are estimated to increase by about $(\exp(0.0282) - 1) \times 100 \approx 2.86\%$. This suggests that ignoring the trend may lead to an overestimation of the effect of FTAs and could potentially lead to misinterpretation.

In model (3), agreements that include e-commerce provisions were found to have a significant positive impact on exports. Counties that entered into such agreements experienced an increase in exports of about $(\exp(0.0439) - 1) \times 100 \approx 4.49\%$. However, model (4), which controls for trends, shows a significant negative effect.

Model (5) confirms that FTAs with e-commerce provisions have a significant positive impact on exports. Countries that have FTAs that include e-commerce clauses experience about $(\exp(0.1151) - 1) \times 100 \approx 12.20\%$ a increase in exports. However, traditional FTAs without e-commerce provisions have larger coefficients. In model (6), the coefficients decreased similarly to the other models controlling for trends, but the effect of e-commerce FTAs having smaller effects remained unchanged.

5.2 Results on Trade shares

Next, the results of the regression analysis with trade share as the dependent variable are examined. The results are shown in table 3.

In model (1), it has been demonstrated that free trade agreements (FTAs) have a considerable positive impact on trade share, with countries that have signed FTAs experiencing an expansion of $(\exp(0.2107) - 1) \times 100 \approx 23.45$ percentage points in their trade share.

In model (3), it has been established that agreements that include provisions related to e-commerce have a significant positive impact on trade share, with countries that have signed such agreements showing an increase of $(\exp(0.1483) - 1) \times 100 \approx 15.09$ percentage points in their trade share.

The results of model (5) indicate that FTAs including e-commerce provisions have a positive impact on trade share. Countries participating in such FTAs experience a $(\exp(0.2188) - 1) \times 100 \approx 24.46$ percentage points increase in trade share. Moreover, in contrast to the regression results for export value, the regression coefficients were estimated to be larger than those for FTAs that did not include e-commerce provisions.

As in the regression results for export value, the regression coefficients are smaller in models (2), (4), and (6), which take into account the trend.

Table 2: Regression Analysis Results on the Impact of FTAs and E-commerce agreements on Exports

Dependent Variables: Export						
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
FTA	0.1169***	0.0282***				
	(0.0195)	(0.0071)				
E-commerce chapter			0.0439***	-0.0180**		
			(0.0157)	(0.0083)		
FTA with an e-commerce provision					0.1151***	0.0253***
					(0.0195)	(0.0071)
No e-commerce FTA					0.1384***	0.0628***
					(0.0277)	(0.0100)
log(Trend)		1.134***		1.139***		1.134***
		(0.0072)		(0.0071)		(0.0073)
Fixed-effects						
Exporter-Importer	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-Year	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	124,509	124,509	124,509	124,509	124,509	124,509
Squared Correlation	0.99994	0.99996	0.99994	0.99996	0.99994	0.99996
Pseudo R^2	0.99941	0.99968	0.99941	0.99968	0.99941	0.99968
BIC	14,719,267.9	8,004,484.0	14,793,649.6	8,005,455.2	14,716,082.7	7,996,383.8

Clustered (Exporter-Importer) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: Regression Analysis Results on the Impact of FTAs and E-commerce agreements on Trade Share

Dependent Variables: Trade share						
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
FTA	0.2107***	0.0327***				
	(0.0204)	(0.0087)				
E-commerce chapter			0.1483***	0.0214***		
			(0.0165)	(0.0065)		
FTA with an e-commerce provision					0.2188***	0.0332***
					(0.0208)	(0.0087)
No e-commerce FTA					0.1690***	0.0302**
					(0.0282)	(0.0121)
log(Trend)		1.042***		1.044***		1.042***
		(0.0159)		(0.0156)		(0.0159)
Fixed-effects						
Exporter-Importer	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-Year	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Year	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	124,509	124,509	124,509	124,509	124,509	124,509
Squared Correlation	0.99919	0.99968	0.99918	0.99968	0.99919	0.99968
Pseudo R^2	0.92124	0.92242	0.92120	0.92242	0.92124	0.92242
BIC	196,531.7	195,203.6	196,545.3	195,204.2	196,541.5	195,215.3

Clustered (Exporter-Importer) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4: Staggered Difference-in-Differences Estimation on the Impact of E-commerce agreements on Trade Share

Dependent Variables:	Trade share
Model:	(1)
Variables	
ATT	0.1510***
	(0.0165)
Fixed-effects	
Exporter-Importer	Yes
Exporter-Year	Yes
Importer-Year	Yes
Fit statistics	
Observations	124,508
Squared Correlation	0.99927
Pseudo R^2	0.92132
BIC	201,115.8

Clustered (Exporter-Importer) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

5.3 The Staggered DID results

Here we present the results of the Staggered DID estimation. The staggered difference-in-differences approach leverages the staggered timing of trade agreement ratification across different country pairs, rendering it particularly well-suited for this analysis. By comparing the change in trade shares for country pairs that entered agreements in a given year to the change for those that had not yet done so, we can isolate the causal effect of the agreements while flexibly controlling for time-invariant bilateral factors as well as time-varying exporter and importer characteristics.

The results, reported in Table 4, reveal a positive and statistically significant average treatment effect on the treated (ATT) of 0.1510. This implies that, after accounting for unobserved heterogeneity through exporter-importer pair fixed effects, exporter-year fixed effects, and importer-year fixed effects, country pairs that entered into trade agreements with e-commerce provisions experienced an average increase of approximately (exp(0.1510) −

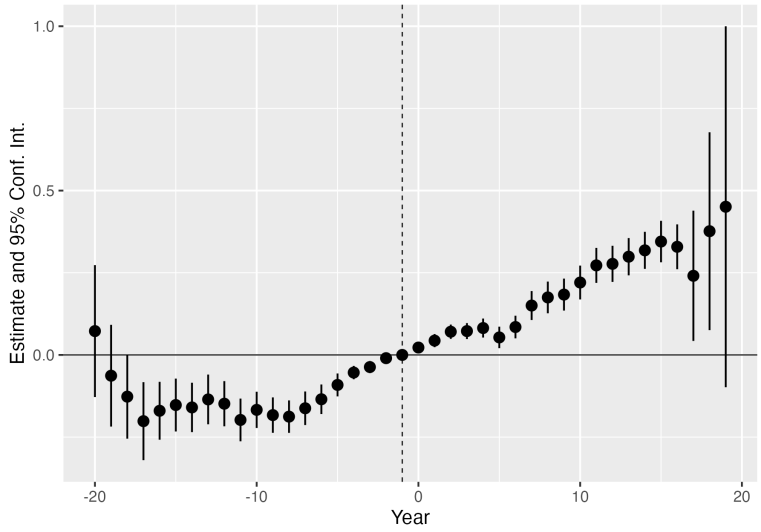

Figure 2: Dynamic Effects of E-commerce agreements on Trade share

1) $\times$ 100 $\approx$ 16.2 percentage points in their trade share relative to those that did not implement such agreements.

Figure 2 presents the dynamic treatment effect estimates over time. The x-axis represents the year, with negative values indicating pre-treatment periods and positive values representing post-treatment periods. The y-axis depicts the estimated treatment effect. As evident from the plot, following the implementation of e-commerce agreements, a distinct upward trend emerges. The treatment effect estimates gradually increase over the post-treatment years, indicating that the intervention becomes more effective over time.

6 Conclusion

This study employed a structural gravity model and panel data from 2000 to 2020 to examine the impact of e-commerce agreements on international trade flows. The key findings and conclusions can be summarized as follows:

E-commerce agreements have a significant positive impact on bilateral trade flows. Countries that enter into such agreements tend to experience an increase in exports and trade shares with their partner countries.

The staggered difference-in-differences analysis provides evidence of a

causal effect of e-commerce agreements on trade flows. Trade shares tend to increase following the implementation of an e-commerce agreement, while controlling for interventions that occur over different time periods.

In comparison to traditional free trade agreements that lack e-commerce provisions, those that include an e-commerce chapter have a more pronounced impact on trade share. This indicates that contemporary agreements that include an e-commerce chapter can potentially facilitate further trade promotion.

The findings indicate that e-commerce agreements play a significant role in promoting international trade and economic integration in the digital age. As e-commerce continues to grow, such agreements can facilitate the establishment of unified rules, the reduction of barriers, and the creation of an environment conducive to digital trade. Policymakers should consider these benefits when negotiating and implementing e-commerce agreements as part of their broader trade policies.

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