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International and Domestic Border Effects in China: Multilateral Resistances, Trade Substitution Patterns and Linguistic Differences

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International and Domestic Border Effects in China: Multilateral Resistances, Trade Substitution Patterns and Linguistic Differences*

Zilong Li†

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Abstract

I conduct a comprehensive analysis of China's international and domestic border effects. My results confirm the negative impact of administrative borders on exports. In my analysis, I account for multilateral resistance terms, which were omitted in previous relevant studies. My findings show that this omission underestimates both international and inter-provincial border effects while overstating the gap between them. I find a negative relationship between international and inter-provincial border effects, driven by provinces reducing inter-provincial trade as they increase international or intra-provincial trade. This substitution effect can, however, be mitigated through the coordinated growth of both international and intra-provincial exports. In the last step, I develop a linguistic distance metric to compare language gaps between Chinese provinces and between provinces and foreign partners, showing that linguistic differences mediate the negative impact of provincial borders on inter-provincial trade flows.

Keywords: Border effects; National border; Provincial border; Multilateral resistances; Substitution effect.

JEL: F14, F15, F40

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1 Introduction

This study examines border effects in China by comparing: (1) international trade and inter-provincial trade, and (2) intra-provincial trade and inter-provincial trade. Unlike studies that focus on trade between bordering and non-bordering countries or regions (Lawless et al., 2019), this approach examines the relative preference for domestic versus international trade. What I refer to as the border effect is often called "home bias", meaning that more trade occurs domestically than internationally. This phenomenon is evident not only in goods trade but also in service transactions (Chen et al., 2022; Broocks and Studnicka, 2024). In this paper, I aim to answer the following questions: (1) How large are the international and inter-provincial border effects in China in recent years, and which of them is larger? (2) What explains the observed border effects in China? In particular, I focus on the role of multilateral resistance terms, spatial aggregation, the interaction of border barriers and linguistic proximity in shaping these effects.

The gravity framework is a widely recognized model in international economics due to its accessibility, flexibility, and strong theoretical foundations. However, most applications have overlooked domestic trade flows, which contradicts gravity theory's recognition of trade frictions affecting both domestic and foreign goods. This omission may contribute to unresolved puzzles in international economics. For instance, it contributes to the so-called "distance puzzle" - the observation that the negative effect of geographical distance on international trade flows is larger than expected and has not diminished over time, despite advances in technology, transportation, and communication (Yotov, 2012; Yotov, 2022). Yotov (2022) identifies fifteen advantages of incorporating domestic trade data alongside international trade data when estimating the gravity equation. These benefits include improved alignment with theoretical frameworks, enhanced identification of country-specific trade policy effects, resolution of trade-related puzzles, and more.

Analyzing border effects is no exception. As emphasized by Yotov (2022), it requires considering at least two levels of trade flows, depending on the specific topic under investigation. For instance, when examining the international border effect, structural estimations require data on both international trade flows and internal trade flows to be consistent with theoretical foundations. Therefore, the use of multiple levels of trade data represents a natural advancement in gravity estimation, which constitutes the first contribution of the current paper. To date, most studies on border effects focus on either international or intra-national border effects independently (McCallum, 1995; Wei, 1996; Wolf, 2000; Anderson and van Wincoop, 2003; Xing and Li, 2011) with only a few studies jointly estimating both international and domestic border effects. This is largely due to the greater data requirements involved.[1] The main advantage of this approach is to enable a direct comparison of domestic and international trade barriers (Fally et al., 2010; Coughlin and Novy, 2013; Hong, 2013; Hayakawa, 2017). Interestingly, the majority of studies applying joint estimation find that the domestic border effect is larger than the international border effect (Fally et al., 2010; Coughlin and Novy, 2013), suggesting that trade barriers within a country can be more substantial than across countries.[2] In the current study, I also employ joint estimation, but with several key innovations.

First, the data I use is considerably more extensive and up-to-date compared to previous studies on China. Second, previous studies using similar data have omitted multilateral resistance terms (MRTs henceforth) due to technical limitations (Coughlin and Novy, 2013; Hong, 2013) or have included them under highly limited data conditions (Hayakawa, 2017). In contrast, I employ the method proposed by Baier and Bergstrand (2009), manually controlling for multilateral resistance terms (MRTs), and adapt it to align with the structure of the joint estimation model. My analysis shows that excluding MRTs introduces substantial bias in the estimation of border effects. This approach not only enhances the robustness of my results but also offers a valuable methodology for future researchers aiming to accurately estimate border effects.

Second, following Coughlin and Novy (2021), I test the heterogeneous border effects and the role of spatial aggregation for China. Although the international border effects in China might be associated with economic size, they remain robust and significantly negative across specifications, which aligns with the cross-country trade frictions. Nevertheless, the impact of spatial aggregation on the domestic border effect is limited, indicating that the domestic border effect in China arises from genuine frictions.

Third, I offer new evidence on the source of border effects by focusing on the relationship between international and inter-provincial border effects. I find that a decrease in international border effects is accompanied by a corresponding increase in inter-provincial border effects. Further, I explore the mechanism behind this association by analyzing three tiers of export flows of Chinese provinces. Prior research highlights the positive relationship between international trade openness and the increase of domestic trade (Xing and Whalley, 2014; Li et al., 2022a), while I find a more nuanced dynamic, in which international and intra-provincial exports may substitute for inter-provincial exports and exacerbate the international and inter-provincial border barriers. Moreover, I uncover that the simultaneous growth of international export and intra-provincial export mitigates the substitution of inter-provincial export.

[1] For instance, Coughlin and Novy (2013) include trade flows between US states and foreign countries, between US states, and within a single state, to estimate the country border effect as well as the state border effect.

[2] However, a larger international border effect than the domestic one has also been observed (Hayakawa, 2017).

Fourth, I construct a more refined measure for the language gap, rather than relying on the common-language dummies as it is frequently done in border-effects literature (Evans, 2003; Coughlin and Novy, 2013; Hong, 2013; Dincer and Tekin, 2020). To do so, I calculate the linguistic distance between Chinese provinces, as well as between Chinese provinces and foreign partners. In addition, I account for the fact that the language can be different within a single Chinese province by calculating the population-weighted linguistic distance. This method fits better with the joint estimation and prevents the drawbacks of employing common language dummies or other measures derived from them.

The Chinese economy has experienced rapid development since its entry into WTO in 2001. One notable outcome of this progress is the remarkable growth in trade as presented in Panel (a) of Figure 1. This can be attributed, in part, to the central government's implementation of various measures aimed at streamlining administration and decentralizing power. However, the devolution of central power leads to the concentration of local government power, thus forming local protection which impedes domestic transactions and imposes large domestic barriers (Young, 2000; Poncet, 2003). In recent years, China's foreign export growth has gradually slowed down as Panel (b) of Figure 1 demonstrates. Consequently, China is now emphasizing a shift from an external-oriented economy to an internal-oriented one. In 2022 China implemented an initiative of forming a "National Unified Market", seeking to boost the internal circulation of its economy, coordinate the domestic and international markets, and break down local protectionism and market segmentation.[3] Therefore, jointly analyzing the external and internal barriers faced by China and elaborating on their relation is crucial for policy implication under this context.

(a) Export volume (b) Export growth

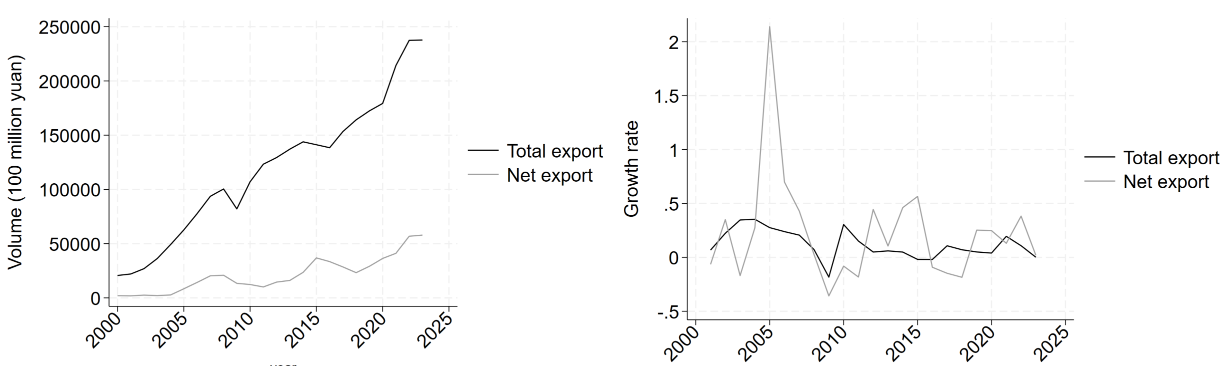

Figure 1: Export and net export of China (2001-2023)

Note: export data sourced from National Bureau of Statistics

[3] See Central Committee of the Communist Party of China & State Council (2022).

The remainder of this paper is structured as follows. A detailed review of the literature, including how my work relates to or differs from existing studies, is presented in Section 2. The data description and empirical model are provided in Sections 3 and 4 respectively. Section 5 presents the baseline results, then Section 6 elaborates on the explanation of observed results. The final section concludes.

2 Literature review

The border effect puzzle, also known as the home bias puzzle, is deemed as one of the six major mysteries in the area of international economics (Obstfeld and Rogoff, 2000). This puzzle has been studied since the seminal paper by McCallum (1995) who finds a significantly negative impact of the US-Canada border on trade volumes between US states and Canadian provinces. Building on McCallum's findings, several papers (e.g., Helliwell, 1996; Anderson and Smith, 1999; Anderson and van Wincoop, 2003) have sought to refine the gravity model to re-evaluate the magnitude of the border effects.

Subsequent studies have expanded their focus to examine border effects in other economies, such as the OECD countries (Wei, 1996), the EU (Chen, 2004) and specific nations like France and Germany (Helble, 2007). Beyond physical trade, the border effect extends to digital trade and online services (Fan et al., 2018; Chen et al., 2022). For example, Broocks and Studnicka (2024) analyze online video consumption based on the gravity framework and find a significant preference among Netflix users for domestic content. Furthermore, administrative borders within a country, such as sub-national borders, have garnered significant attention and are found to hinder domestic trade (Wolf, 2000; Hillberry and Hummels, 2003; Xing and Li, 2011).

Some studies have jointly examined international and domestic border effects, along with market segmentation. Coughlin and Novy (2013) estimate inter-state trade, intra-state trade, as well as trade between US states and foreign countries. They find that domestic trade barriers are higher for the US, similar to findings by Fally et al. (2010) for Brazil and by Hong (2013) for China. However, due to technical issues, neither Coughlin and Novy (2013) nor Hong (2013) control for MRTs, which, as Baldwin and Taglioni (2006) describe, constitutes a "gold medal mistake" in gravity estimations.[4] Hayakawa (2017) refines this joint estimation by incorporating cross-country inter-regional trade flows to study border effects between Chinese and Japanese regions. This inclusion allows to control for MRTs

[4] Feenstra (2002) recommends including importer and exporter fixed effects as one of the most common methods to account for MRTs. However, applying fixed effects in the framework of Coughlin and Novy (2013) or Hong (2013) creates perfect collinearity between the international border dummy and the fixed effect. Under this framework, foreign countries are always considered as importers but never as exporters, while the international border dummy variable takes the value of one for trade between US states and foreign countries and zero for inter-state or intra-state trade.

through fixed effects. However, cross-country inter-regional trade flow data remains exceptionally rare and, when available, is generally restricted to a single country and a limited number of trade partners (e.g., between China and Japan). This limitation makes it challenging to derive generalizable and extensive trade patterns. In this study, I use the approach of Baier and Bergstrand (2009) to control for MRTs and adapt it to a data framework similar to that of Coughlin and Novy (2013). This approach may be helpful for future studies that wish to include MRTs but lack cross-country inter-regional trade data.

Studies have also emphasized the source of the border effects. Evans (2003) shows that the language gap, and local trust level could explain partly the observed border effect. Coughlin and Novy (2013) suggest that supplier co-location, and lower trust-related "contracting costs" with local partners, business or immigration networks all contribute to the border effect in the US. Turrini and van Ypersele (2010) contend that legal costs induced by judicial asymmetries contribute to border effects and market segmentation in France. Xu and Fan (2012) emphasize that improving the business environment could reduce domestic border effects in China. Additionally, some studies suggest that the large border effects observed may be artifacts of geographical aggregation (Llano-Verduras et al., 2011). Coughlin and Novy (2021) highlight the role of spatial aggregation and sample composition in shaping the observed border effects.[5] They recommend that future border-effect studies account for these factors. On the contrary, Li et al. (2022a) argue that the internal border effects in China arise more from heterogeneity related to slowly-changing fundamentals (such as social networks and differences in industry structure) and unchangeable fundamentals (such as geographical barriers) rather than from aggregation bias or statistical artifacts, making the domestic border effect robust and resistant to decline (Nitsch and Wolf 2013; Felbermayr and Gröschl 2014).

Previous research indicates that international trade can enhance inter-provincial trade in China (Xing and Whalley), but it may also crowd out the latter (Li et al., 2022b). However, whether the international border effect influences the domestic border effect (or vice versa) requires further discussion. I contribute to the literature by examining the co-movement between domestic and international border effects and elucidating the underlying mechanisms.

Many border-effect studies rely on the common-language dummy to explain the observed border effect (Evans, 2003; Coughlin and Novy, 2013).[6] Incorporating the linguistic distance is not uncommon in gravity model analysis (Melitz and Toubal, 2014; Tie and Meng, 2020; Liu et al., 2020). However,

[5]While they have no doubt that the international border effects exist, albeit the spatial aggregation pushes them to zero, they argue that the domestic border effects could potentially be statistical artifacts.

[6]The common language dummy has several limitations: (1) it assumes equal linguistic gaps between languages, (2) it only reflects trade patterns between regions with a shared language, (3) it overlooks internal language diversity, and (4) it cannot distinguish between intra-provincial and inter-provincial pairs (assigning a value of one to both).

to the best of my knowledge, it has rarely been used in border effect analysis, especially within a joint estimation framework that requires linguistic distance data both across and within borders. Some studies examining the impact of linguistic or dialectical differences on domestic trade and immigration in China use ordinal linguistic distance, which is derived from a binary condition that determines whether two locations belong to the same language (or dialect) branch or the same sub-level language (or dialect) branch (Liu et al., 2015; Gao et al., 2019; Liu et al., 2020). In contrast, I use the Levenshtein linguistic distance to directly quantify language gaps within provinces, between provinces, and between provinces and other countries.

To summarize, the current research adds to the literature by providing an alternative way to include MRTs within the joint estimation framework of border effects. It emphasizes the roles of MRTs, explores the impacts of spatial aggregation on the border effects in China, examines the relationship between international and domestic border effects, and revisits the language effect with a more refined measurement.

3 Data

In this section, I present the data used in the current study, which includes trade data, linguistic distance data, and supplementary information.

3.1 Domestic trade

Acquiring domestic trade volume data is challenging for many countries due to the lack of direct statistics, and China is no exception. However, internal trade flows can be calculated using Input-Output Tables, a method that has been employed by studies such as Poncet (2003). Unlike Poncet (2003), who used the provincial Input-Output Tables to estimate trade from individual Chinese provinces to the rest of the country, I utilize the Multi-regional Input-Output Tables (MRIO) to calculate the bilateral trade between and within Chinese provinces. The dataset covers the years 2010, 2012, 2015, and 2017. The MRIO for 2010 is compiled by Liu et al. (2014).[7] The MRIO for 2012, 2015 and 2017 are obtained from the Carbon Emission Accounts and Datasets (CEADs) database.[8] The MRIOs provide comprehensive input and output data for each sector and province. Using this data, I calculate both inter-provincial

[7] Key Laboratory of Regional Sustainable Development Modeling, China Academy of Sciences. (2014). China 30-Province Inter-regional Input-Output Table of 2010.

[8] `https://www.ceads.net/`. MRIO data is not available annually, resulting in gaps between years. The most recent dataset available is 2017.

and intra-provincial exports for each sector, along with the total exports between provinces.

3.2 International trade

International trade data consists of exports from mainland Chinese provinces to more than 200 countries and regions. This information is sourced from the Sectoral Trade Database of the EPS China Data Platform and China Customs. To ensure comparability with intra-national trade, I collect sector-specific trade flows and then aggregate the flows for selected sectors. I focus on overlapping sectors identified in both the MRIO and Customs statistics.

3.3 Linguistic distance

The linguistic distance is calculated using the Normalized and Divided Levenshtein Distance (LDND), a refined form of the Levenshtein Distance (Bakker et al., 2009). LDND represents the minimum steps required to turn a phonetic transcription of a word in one language to that in another language. A larger linguistic distance denotes a lower degree of similarity. I compute the LDND between languages and dialects using data from the Automated Similarity Judgment Program (ASJP) database. The ASJP database provides over 10,000 languages or dialects' word lists, which enables me to calculate the linguistic distance not only between China and foreign countries but also between Chinese provinces and foreign countries, between Chinese provinces, and within individual provinces. Consequently, it is consistent with my three levels of export data. The calculation of population-weighted LDND requires data on the population of county-level administrative units of Chinese provinces and the dialect area distribution of these counties. For the former, I refer to *Tabulation on the 2010 Population Census of the People's Republic of China by County* (NBS, 2011). For the latter, I employ the dialect area distribution by Liu et al. (2015).

3.4 Other data

I employ the great circle distance between the capital of each location. The latitude and longitude data required for calculating the it are from the *World Urbanization Prospects: The 2018 Revision* (United Nations, 2018) and an R package "worldcities". I use *Statistical Table of Administrative Divisions of the People's Republic of China* (Ministry of Civil Affairs, 2018) to gather the geographical area of each province, which is necessary for calculating the intra-province distance.[9] The GDP data for all foreign countries comes from the World Bank, while the GDP data for Chinese provinces is obtained from the statistical yearbooks.

Table 1 presents the summary statistics for the variables used in this paper. The final dataset comprises 25,005 observations.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Export$_{ijt}$	25,005	16.69	3.602	2.833	28.38
International$_{ij}$	25,005	0.849	0.358	0	1
Local$_{ij}$	25,005	0.005	0.070	0	1
Distance$_{ij}$	25,005	8.665	0.931	3.805	9.899
Exporter GDP$_{it}$	25,005	26.26	0.876	22.74	27.92
Importer GDP$_{jt}$	25,005	24.74	2.154	17.28	30.60
Linguistic Distance$_{ij}$	25,005	93.35	16.79	0	106.3
Weighted Linguistic Distance$_{ij}$	25,005	94.22	14.73	0	106.3

The statistics are for the sample used in jointly estimating international and intra-national border effects of Table 4. The export volume, exporter GDP, importer GDP, distance are in logs.

4 Empirical analysis

In this section, I present the baseline model derived from the theoretical framework outlined in Coughlin and Novy (2013) and subsequently expand it by integrating MRTs into the structure.

4.1 Baseline model

I estimate the following baseline model.

$$z_{ijt} = \beta_0 + \beta_1 Dis_{ij} + \beta_2 Inter_{ij} + \beta_3 Local_{ij} + \beta_4 GDP_{it} + \beta_5 GDP_{jt} + \epsilon_{ijt} \quad (1)$$

The dependent variable is the export volume from a Chinese province i to its importers j in a given year t. On the right-hand side, the model includes five independent variables along with an error term: geographic distance Dis_{ij}, two border dummies, the output of the exporter GDP_{it}, and the output of the importer GDP_{jt}. The dummy variable $Inter_{ij}$ differentiates between international and domestic export

[9] Following Nitsch (2000), the internal distance at the province level is calculated by dividing the area by π and taking the square root.

flows. The *Local* dummy takes the value of one for intra-provincial export flows and zero otherwise. In this setup, inter-provincial export serves as the reference category. Consequently, β_2 and β_3 estimate the international and inter-provincial border effect respectively. I first test the international and inter-provincial border effects separately. In the second step, I proceed to jointly estimate these two effects.

Based on this framework I propose the following hypotheses:

Hypothesis 1 Holding everything else equal, inter-provincial export dominates international export.

Hypothesis 2 Holding everything else equal, intra-provincial export dominates inter-provincial export.

4.2 Modified model: controlling for MRTs

As discussed earlier, the data framework used in Coughlin and Novy (2013) makes it infeasible to include fixed effects, meaning that MRTs are not accounted for in their study and in some subsequent studies (Hong 2013). The recognized importance of MRTs in the gravity literature highlights the need to address this oversight. While Hayakawa (2017) accounts for MRTs by using fixed effects, his approach relies on the inclusion of international cross-regional trade flows, which are not often available. To address this issue, I introduce the method proposed by Baier and Bergstrand (2009), which employs a Taylor expansion to obtain the first-order approximation of the non-linear MRTs.[10] Additionally, I adapt Baier and Bergstrand's approach to align with the frameworks of both Coughlin and Novy (2013) and my own.

Specifically, I apply the Taylor approximation to each of the bilateral trade cost variables to derive their MRTs-adjusted versions. For instance, consider the geographical distance:

$$Dis^*_{ij} = Dis_{ij} - \frac{1}{N_i}\sum_i Dis_{ij} - \frac{1}{N_j}\sum_j Dis_{ij} + \frac{1}{N_i}\frac{1}{N_j}\sum_i\sum_j Dis_{ij} \tag{2}$$

The second and third terms in right hand side capture the multilateral distances faced by importers and exporters, respectively, and are positively correlated with bilateral trade volumes. The final term denotes average global trade cost, reflecting the overall resistance to trade across all regions.[11] Similar procedures are applied to other bilateral trade cost variables. This approach ensures that the MRTs remain exogenous, thereby preventing bias in the estimation of trade costs.

However, the international border dummy is an exception. Applying this method directly to it is

[10] This method, as noted by Magerman et al. (2016), addresses the practical issue of estimating certain variables under fixed effects.

[11] Following the recommendation of Baier and Bergstrand (2010), the simple average is used instead of GDP weighted average introduced in Baier and Bergstrand (2009) to avoid endogeneity.

challenging given the current data framework, where the exporters are Chinese provinces. For example, consider exports from Beijing to Japan: Beijing serves as the exporter, while Japan is the importer. From Beijing's perspective, the presence of borders between it and other importers (e.g., Shanghai, South Korea) may influence its bilateral export patterns with Japan, making it essential to account for exporter-specific MRTs. Conversely, from Japan's perspective, as all exporters in this sample are Chinese provinces, there is invariably an international border between Japan and each exporter. Therefore, when calculating the MRTs-adjusted international border dummy, importer-specific MRTs should not be included.

5 Baseline results

Table 2 shows my baseline results of the international border effect. The first thing to note is that the international border dummy consistently shows a significantly negative coefficient across all specifications. Taking column (1) as an example, the coefficient of -2.764 indicates that international export is 93.7 percent smaller than inter-provincial one. Column (2) adds random effects, as used by Coughlin and Novy (2013), resulting in only a slight reduction in the magnitude of the international border coefficient. However, as noted earlier, the first two columns do not control for MRTs. To address this, in column (3), I follow and modify the method of Baier and Bergstrand (2009) (hereafter referred to as BB) and calculate the MRTs-adjusted bilateral trade cost variables. The coefficient of interest declines to -3.958, implying that international exports are about 98.1 percent smaller than inter-provincial exports after controlling for MRTs. In other words, the omission of MRTs leads to an underestimation of the international border effect.

For the inter-provincial border effect, as shown in Table 3, the $Local_{ij}$ dummy has a significantly positive coefficient, indicating that the intra-provincial export is substantially larger than inter-provincial export. For instance, in column (2), where I include year-specific importer and exporter fixed effect,[12] the coefficient is 4.196, suggesting that the intra-provincial export is around 65 times larger than inter-provincial export. Since column (2) fully accounts for MRTs via fixed effects, I compare its results with those generated using the BB method in column (4). These two methods yield very close results, highlighting the efficiency of the BB approach.

Table 4 shows the results of the joint estimation of the two border effects, allowing the comparison of the magnitude of provincial and international border effects in China. The first two columns which do not

[12] The collinearity problem only arises with the international border dummy, allowing the use of fixed effects in this context.

Table 2: International border effect

	(1)	(2)	(3)
$\text{International}_{ij}$	-2.764***	-2.817***	-3.958***
	(0.077)	(0.078)	(0.041)
Distance_{ij}	-0.634***	-0.645***	-0.356***
	(0.036)	(0.037)	(0.089)
GDP_{it}	1.895***	1.841***	1.750***
	(0.023)	(0.023)	(0.026)
GDP_{jt}	0.960***	0.971***	0.995***
	(0.010)	(0.011)	(0.010)
Constant	-48.404***	-47.233***	-50.014***
	(0.762)	(0.773)	(0.753)
OLS	Y	-	-
RE	-	Y	-
BB	-	-	Y
Observations	24,882	24,882	24,882
Adjusted R-squared	0.750	-	0.741

Dependent variable: log export volume. Robust standard errors are in parentheses and clustered by trade pair. Year fixed effects are included in all specifications. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Inter-provincial border effect

	(1)	(2)	(3)	(4)
Local_{ij}	4.267***	4.196***	4.282***	4.210***
	(0.142)	(0.188)	(0.150)	(0.147)
Distance_{ij}	-0.385***	-0.428***	-0.385***	-0.423***
	(0.037)	(0.033)	(0.038)	(0.040)
GDP_{it}	1.065***	-	1.110***	1.014***
	(0.034)		(0.036)	(0.033)
GDP_{jt}	0.850***	-	0.850***	0.903***
	(0.025)		(0.025)	(0.024)
Constant	-25.953***	24.164***	-27.122***	-28.533***
	(1.178)	(0.234)	(1.236)	(1.109)
OLS	Y	-	-	-
Fixed effects:				
Exporter-year	-	Y	-	-
Importer-year	-	Y	-	-
RE	-	-	Y	-
BB	-	-	-	Y
Observations	3,783	3,783	3,783	3,783
Adjusted R-squared	0.764	0.891	-	0.765

Dependent variable: log export volume. Robust standard errors are in parentheses and clustered by trade pair. Year fixed effects are included in all specifications. *** p<0.01, ** p<0.05, * p<0.1.

account for the MRTs, display similar coefficients for both effects.[13] However, the incorporation of MRTs in column (3) results in notable differences in the estimates of both border effects. These results indicate that exports from a Chinese province to another country are approximately 98.3 percent smaller than exports to another Chinese province. Similarly, exports from a Chinese province to another province are around 98.7 percent smaller than exports within the same province. In this framework, Chinese provinces can trade not only within their own borders and with other provinces but also with international partners. This highlights the critical role of multilateral trade costs in shaping both the international and provincial border effects. Consequently, omitting MRTs leads to an underestimation of both international and inter-provincial border effects, and exaggerates the differences between them. Notably, once MRTs are incorporated, the gap between these two effects becomes statistically insignificant, a stark contrast to the results in the first two columns.

Table 4: International and inter-provincial border effect

	(1)	(2)	(3)
$\text{International}_{ij}$	-2.777***	-2.830***	-4.099***
	(0.077)	(0.078)	(0.041)
Local_{ij}	3.871***	3.875***	4.355***
	(0.293)	(0.297)	(0.313)
Distance_{ij}	-0.628***	-0.639***	-0.334***
	(0.036)	(0.037)	(0.089)
GDP_{it}	1.884***	1.831***	1.734***
	(0.023)	(0.023)	(0.026)
GDP_{jt}	0.958***	0.968***	0.993***
	(0.010)	(0.011)	(0.011)
Constant	-48.112***	-46.968***	-49.394***
	(0.763)	(0.773)	(0.751)
$\lvert International_{ij}\rvert = \lvert Local_{ij}\rvert$	[0.00]	[0.00]	[0.41]
OLS	Y	-	-
RE	-	Y	-
BB	-	-	Y
Observations	25,005	25,005	25,005
Adjusted R-squared	0.758	-	0.749

Dependent variable: log export volume. Robust standard errors are in parentheses and clustered by trade pair. Year fixed effects are included in all specifications. The $\lvert International_{ij}\rvert = \lvert Local_{ij}\rvert$ is the corresponding F-test with p-values reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

As Coughlin and Novy (2021) suggest, border effect results are not directly comparable across different

[13] I also estimate specifications that include the exporter's distance to the nearest port or a dummy variable representing coastal provinces. This is because coastal provinces may import from inland provinces for subsequent foreign export. The results are robust and available upon request.

countries (e.g., comparing the international border coefficients of the US and China) due to underlying heterogeneity. Therefore, I limit my comparison to general findings and focus specifically on studies related to China. As depicted in Table 5, my findings align with prior research in demonstrating that both international and intra-national borders significantly hinder trade. In addition, before controlling for MRTs as shown in row 3, the estimated coefficients are comparable to those of Hong (2013).[14] However, after incorporating the MRTs in the last row, both border effects increase in absolute terms, indicating that the omission of MRTs biases the border coefficients towards zero. Regarding the relative magnitude of these two types of border effects, the inclusion of MRTs narrows the gap between inter-provincial and international border effect. In other words, the absolute magnitudes of international and intra-national border effects are not statistically different from each other.

Table 5: Comparing results with related literature

Studies	Countries	International dummy	Own-region dummy	MRTs	Partners and periods
Coughlin and Novy (2013)	US	-1.1	2.05	-	50 countries 1993, 1997, 2002
Hong (2013)	China	-2.15	4.15	-	top 10 partners 2007
This paper	China	-2.78	3.87	-	200+ partners 2010, 2012, 2015, 2017
This paper	China	-4.10	4.36	Yes (BB)	200+ partners 2010, 2012, 2015, 2017

Reference groups are the inter-state trade for the US and inter-provincial trade for China.

6 Determinants of border effects

In this section, I aim to investigate the factors explaining the observed border effects beyond the MRTs discussed earlier. Coughlin and Novy (2021) suggest that domestic border effects could be driven by spatial aggregation, as larger regions are systematically associated with smaller border effects. Following their recommendation, I first explore the heterogeneous border effects and the composition effects that depend on the size of spatial entities. This analysis seek to determine if the patterns observed in China are similar to those found in the case of the US.

Second, various factors influencing border effects and its heterogeneity—such as social networks, legislative differences, language gaps, infrastructure and economic size—have been discussed in the literature (Combes et al., 2005; Turrini and van Ypersele, 2010; Coughlin and Novy, 2013; Coughlin and

[14] My data framework closely resembles the one in Coughlin and Novy (2013) and Hong (2013), with the former focusing on the US. Thus, comparing my findings to Hong's results for China is more appropriate.

Novy, 2021). However, the relationship between international and domestic border effects, as well as the mechanisms underlying this association, remain a significant are of concern. This section specifically examines how these two border effects influence one another. Finally, I revisit the role of language in shaping border effects, providing a more nuanced analysis of its impact.

6.1 Heterogeneous border effects: spatial attenuation and sample composition

I begin by estimating border effects for each province individually. As illustrated in Panel (a) of Figure 2, the international border effect exhibits a clear pattern, with inland provinces displaying significantly higher international border barriers compared to coastal provinces. This results in a "west-large, east-small distribution", indicating that provinces further from the coast face greater challenges related to international trade. Conversely, the distribution of inter-provincial border effects appears to follow an inverse or ambiguous pattern (Panel (b)).

(a) International border effect (b) Inter-provincial border effect

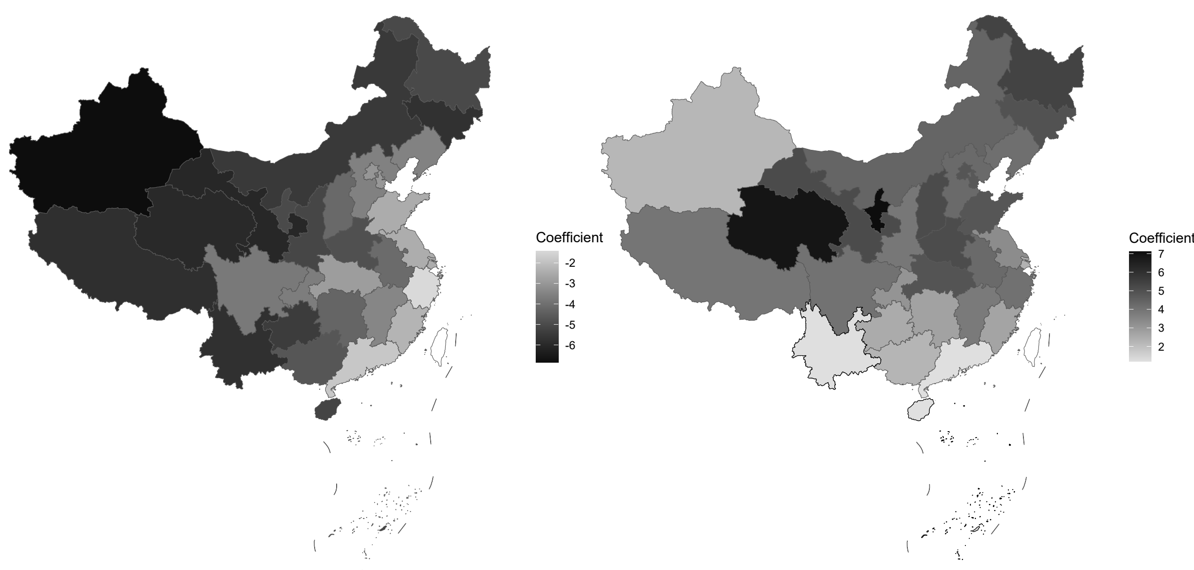

Figure 2: Border effect by provinces (4 years)

Note: blank regions indicate a lack of data. Provinces outlined in solid black exhibit an insignificant inter-provincial border effect. I report 90% confidence intervals. The robust standard errors are clustered at the importer-exporter pair.

The international border effects are always significant and range from -1.42 to -6.85 across the provinces, while the inter-provincial border effect ranges from 1.20 to 7.10, with Yunnan and Hainan exhibiting insignificance. In Figures 3 and 4, I plot the individual border effects against economic size to see whether as Coughlin and Novy (2021) suggest, larger economies exhibit smaller international and domestic bias. As shown in Figure 3, larger provinces tend to have smaller international border effects, consistent with the findings of Coughlin and Novy (2021).

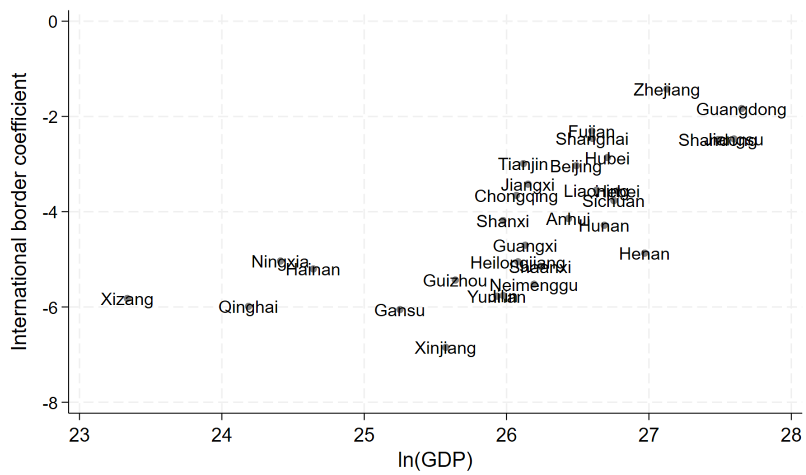

Figure 3: Plot of international border effect against economic size

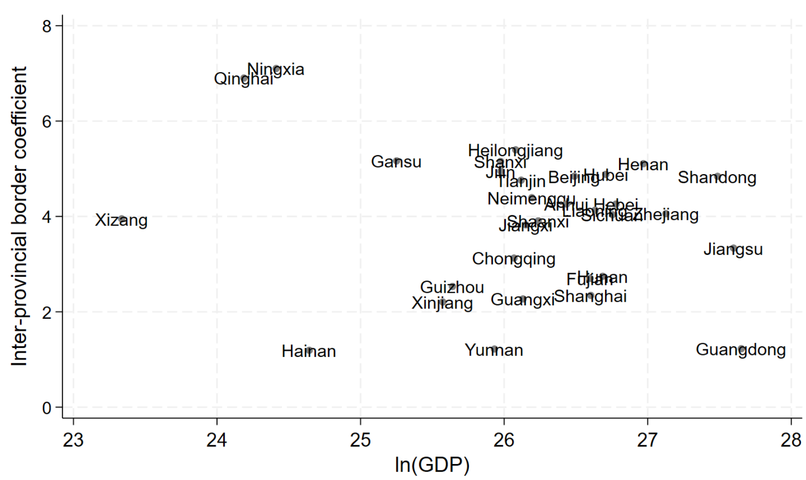

Figure 4: Plot of inter-provincial border effect against economic size

However, unlike the US, no Chinese province exhibits a positive international border effect. Conversely, as presented in Figure 4, the inter-provincial border effect does not demonstrate a clear relationship with economic size. For all provinces, the coefficients are always positive, indicating a robust and negative impact of provincial border on exports. In Coughlin and Novy (2021), some states individually have positive international and domestic border effects, while in the case of China, each of the international and provincial borders impedes trade.

To examine the precise relationship between border effects and economic size, rather than relying solely on scattered plots, I regress the yearly provincial border effect coefficients on log GDP, with the results presented in Table 6. Interestingly, the correlation between GDP and international border coefficients becomes negative after accounting for provincial fixed effects and is significant with robust standard errors but insignificant with bootstrapped standard errors, contradicting the trend shown in Figure 3. For the inter-provincial border effect, the negative correlation remains insignificant regardless of whether robust or bootstrapped standard errors are applied. This result is consistent with the findings shown in Figure 4. These indicate that the relationship between border effects and economic size in China is more intricate compared to the case of the U.S. in Coughlin and Novy (2021).[15]

Table 6: Association between border effect coefficients and economic size

Dependent variable	Coeff. $Inter_{it}$		Coeff. $Local_{it}$	
	(1)	(2)	(3)	(4)
GDP_{it}	-1.794	-1.294	-1.096	-0.788
	(0.894)**	(0.564)**	(0.724)	(0.732)
	[1.122]	[0.843]	[0.927]	[0.952]
Observations	123	109	123	109
Adjusted R-squared	0.873	0.887	0.855	0.832

Robust standard errors are in parentheses. Bootstrapped standard errors based on 1,000 valid replications are in brackets. All specifications include year fixed effect and province fixed effect. Columns (2) and (4) drop the observations in which certain provinces exhibit insignificant inter-provincial border effects. *** p<0.01, ** p<0.05, * p<0.1.

Furthermore, following Coughlin and Novy (2021), I examine the sample composition effect by sequentially removing provinces from the sample. Starting with the largest province, I estimate the border effect for the remaining sample, then remove the next largest province, and repeat this process iteratively. This approach allows me to assess how sensitive the border effect is to the exclusion of economically dominant units.

[15] In Table 6 of Coughlin and Novy (2021), similar estimations show that economic size reduces the border effect without additional covariates included. The relationship becomes statistically insignificant after including additional control variables, although the sign of the correlation remains unchanged. They use robust standard errors. Here, I additionally employ bootstrapped standard errors for robustness.

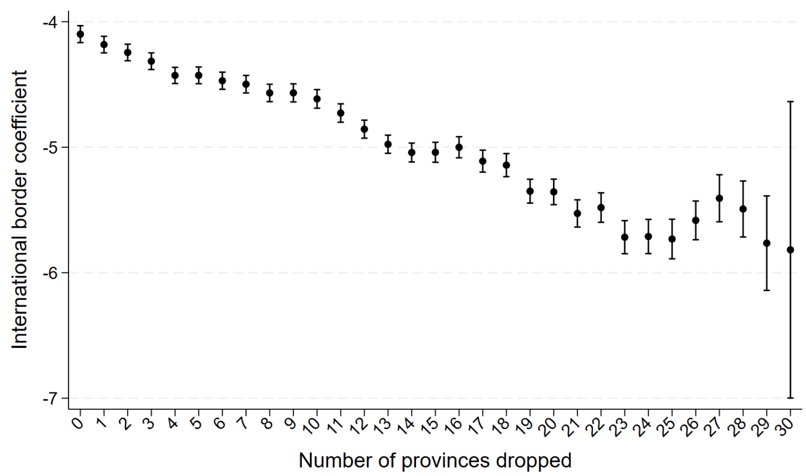

Figure 5: International border effects estimated by sequentially dipping larger provinces from the regressions

Note: 90% confidence intervals are used. The robust standard errors are clustered at the importer-exporter pair.

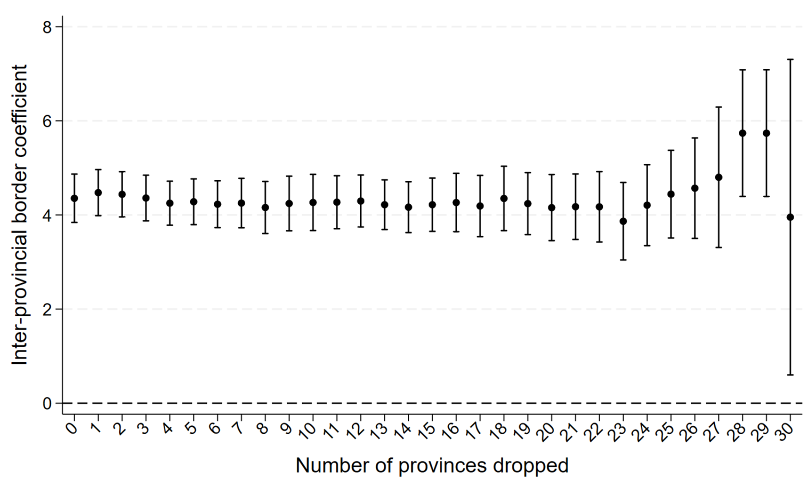

Figure 6: Inter-provincial border effects estimated by sequentially dipping larger provinces from the regressions

Note: 90% confidence intervals are used. The robust standard errors are clustered at the importer-exporter pair.

As illustrated in Figure 5, the coefficients across all specifications remain significantly negative, while the magnitude progressively diminishes as economically larger provinces are excluded. This trend shows a potential sample composition effect influencing China's international border effect, consistent with findings by Coughlin and Novy (2021). In contrast, as shown in Figure 6, the sample composition effect has minimal impact on China's inter-provincial border effect. Only in the final few specifications, after removing the majority of observations, a slight upward trend occurs.

In summary, spatial aggregation and sample composition might influence China's international border effect, while their impact on the inter-provincial border effect appears more limited. Notably, unlike the US, both types of border effects show a consistently negative impact on trade within China, though the strength of these effects varies in magnitude. Despite the possible impact of spatial attenuation on the international border effect, as noted by Coughlin and Novy (2021), the existence of this effect remains plausible due to persistent trade frictions, like tariffs. Conversely, China's inter-provincial border effect is likely driven by genuine frictions, consistent with the findings by Li et al. (2022a), who show that the inter-provincial border effect estimated from industry-level trade data is closely aligned with that from aggregated data. Therefore, it is worth exploring more fundamental factors behind border effects in the following sections.

6.2 Association between international and inter-provincial border effects

In this section, I analyze the relationship between international and inter-provincial border effects to investigate whether the international border effect can explain the inter-provincial border effect, and vice versa. This interplay is rarely explored in the literature, yet it is likely that these two effects influence each other. As shown in Figure 2, provinces with higher international border barriers tend to exhibit lower, or even insignificant, provincial border effects. Meanwhile, some inland and coastal provinces, which have smaller international border effects, show a more pronounced provincial border effect.

Based on this observation, I estimate Equation 1 to generate the international and inter-provincial border effect coefficients for each province and each year, resulting in a total of 123 coefficients for each border dummy.[16] These coefficients are then used to estimate the following Equation 3:

$$Coeff, Local_{it} = \beta_0 + \beta_1 Coeff, Inter_{it} + \beta_3 GDP_{it} + \gamma_i + \gamma_t + \epsilon_{it} \tag{3}$$

where $Coeff, Local_{it}$ and $Coeff, Inter_{it}$ denote the coefficients of $Local_{ij}$ and $Inter_{ij}$ of province i during year t, respectively. This specification aims to explore the association between international and inter-provincial border effects. Since economic size can potentially influence the estimation of both types of border effects as Coughlin and Novy (2021) argue, I include provincial GDP as a control variable in line with their theoretical framework. Additionally, I include province fixed effect γ_i and year fixed effect γ_t to absorb confounding factors.

As shown in Table 7, there is a significantly positive correlation between the border effects: a smaller international border effect (larger *International* coefficient) is associated with stronger preferences for own-province trade (larger *Local* coefficient). This suggests a potential substitution effect between international and inter-provincial exports. As barriers to international trade decrease, provinces may shift their focus towards exporting to foreign markets, reducing their engagement in inter-provincial trade, since the former becomes more profitable or accessible. Therefore, the inter-provincial border effect is significantly affected by the international border effect.

Table 7: Association between international and inter-provincial border effect

Specification	(1)	(2)	(3)	(4)
Coeff, Inter_{it}	0.493	0.484	0.443	0.434
	(0.102)***	(0.112)***	(0.147)***	(0.150)***
	[0.168]***	[0.177]***	[0.212]**	[0.213]**
GDP_{it}	-	-0.227	-	-0.226
		(0.626)		(0.655)
	-	[0.798]	-	[0.798]
Observations	123	123	109	109
Adjusted R-squared	0.881	0.879	0.855	0.853

Dependent variable: $Coeff, Local_{it}$. Robust standard errors are in parentheses. Bootstrapped standard errors based on 1,000 valid replications are in brackets. All specifications include year fixed effect and province fixed effect. Columns (3) and (4) drop the observations in which certain provinces exhibit insignificant inter-provincial border effects. *** p<0.01, ** p<0.05, * p<0.1.

In order to explain the observed association, I further analyze the underlying mechanism. I calculate

[16] No data is available for Xizang in 2010, resulting in 31*4-1=123 observations in total. This approach is similar to the methodology used by Coughlin and Novy (2021), who regress the border dummy coefficients—derived from estimating either the international or domestic border effects—against measures of infrastructure and economic size, which they identify as determinants of the border effect. In contrast, I obtain the coefficients by jointly estimating both border effects within a single model, and focus on how each effect influences the other.

the total volume of three tiers of exports for each province and each year (international, inter-provincial and intra-provincial exports), and estimate the association between them. As presented in Table 8, the results in columns (1) and (4), show a negative and insignificant association between international exports and inter-provincial exports, whereas a significantly positive correlation exists between international and intra-provincial exports. This result provides an explanation for the finding in Table 7: as provinces become more dependent on international exports, the international border effect diminishes. Simultaneously, as intra-provincial exports increase with increased international exports, the level of participation in inter-provincial trade may decline, resulting in reduced trade with other provinces and leading to an increase in the inter-provincial border effect. In other words, enhancing international exports without reducing internal barriers might lead to a larger inter-provincial border effect.

This does not imply that engaging in international exports or developing intra-provincial exports necessarily harms inter-provincial exports or exaggerates the border effects. Rather, as demonstrated in column (3), when both international and intra-provincial exports increase simultaneously, it can mitigate the substitution effect on inter-provincial exports. Therefore, for policymakers, the key is to reduce inter-provincial trade barriers and coordinate efforts with both international and intra-provincial exports.

Table 8: International, inter-provincial, intra-provincial exports of China

Dependent variable	Inter-provincial$_{it}$			Intra-provincial$_{it}$		
	(1)	(2)	(3)	(4)	(5)	(6)
International$_{it}$	-0.229	-	-2.255**	0.128**	-	-1.231**
	(0.140)		(0.892)	(0.058)		(0.509)
Intra-provincial$_{it}$	-	-0.730***	-2.779***	-	-	-
		(0.179)	(0.894)			
Inter-provincial$_{it}$	-	-	-	-	-0.271***	-1.502***
					(0.066)	(0.492)
International$_{it}$ *Intra-provincial$_{it}$	-	-	0.085**	-	-	-
			(0.036)			
International$_{it}$ *Inter-provincial$_{it}$	-	-	-	-	-	0.053**
						(0.021)
GDP$_{it}$	2.028***	3.024***	3.064***	1.507***	2.108***	2.044***
	(0.366)	(0.459)	(0.333)	(0.188)	(0.214)	(0.207)
Constant	-22.546***	-34.948***	17.888	-16.380***	-22.276***	7.994
	(8.175)	(8.826)	(21.978)	(5.066)	(4.698)	(13.314)
Observations	123	123	123	123	123	123
Adjusted R-squared	0.940	0.949	0.952	0.983	0.986	0.987

Robust standard errors are in parentheses. Year and province fixed effects are added in specifications. All export volumes and GDP are in logs. *** p<0.01, ** p<0.05, * p<0.1.

6.3 Linguistic distance

Beyond the interplay between international and intra-national border effects, what other fundamental factors might explain these border effects? Could language barriers play a significant role?

Incorporating the language gap in the trade costs function is crucial for several reasons. Linguistic disparities create trade barriers, as trading partners not sharing a common language must invest time and resources, such as hiring interpreters, to facilitate communication. Hence, the language barrier is likely to be one of the explanations for the border effects. Nevertheless, as mentioned in previous sections, the most commonly used linguistic measure-the common language dummy- is not suitable for this study. To address this limitation, I calculate two comprehensive measures of linguistic distance (LD henceforth) within Chinese provinces, between Chinese provinces, as well as between Chinese provinces and foreign partners.

The first measure is a simplified version based on the most widely spoken language (or dialect) in each province. The second measure is a population-weighted version using the population distribution of language (or dialect) of areas within each province. As before, I jointly estimate the border effects but take into consideration the effects of LD.

Table 9 displays the results of the joint regression. Column (1) displays the baseline results without considering LD, columns (2) and (3) incorporate LD and population-weighted LD respectively. It is clear that LD has a significantly negative impact on exports. However, interpreting the coefficient for LD is somewhat challenging due to the less intuitive nature of its units. Taking column (2) as an example, the coefficient -0.019 can be interpreted as that trade pairs with a language distance of 100, have, on average, around 19 percent lower trade compared to trade pairs that have no linguistic gap.[17] The inclusion of LD does not significantly impact the coefficient of the international border effect, suggesting that the international border effect arises from sources other than language barriers or operates through alternative channels. However, it causes the coefficient for $Local_{ij}$ to decrease substantially, from 4.355 in column (1) to 3.353 in column (2). This suggests that language differences, and perhaps cultural factors they embody, partially mediate the observed inter-provincial border effect.

[17] For instance, LD_{ij} between Jinan Mandarin of Shandong province and Armenian of Armenia is 100.

Table 9: International and intra-national border effect: the role of language

Specification	(1)	(2)	(3)
International$_{ij}$	-4.099***	-4.096***	-4.097***
	(0.041)	(0.041)	(0.041)
Local$_{ij}$	4.355***	3.353***	3.866***
	(0.313)	(0.344)	(0.340)
LD$_{ij}$	-	-0.019***	-0.013***
		(0.004)	(0.004)
Constant	-49.939***	-49.594***	-49.798***
	(0.761)	(0.758)	(0.761)
LD type	-	unweighted	weighted
Observations	25,005	25,005	25,005
Adjusted R-squared	0.749	0.750	0.750

Dependent variable: log export volume. All specifications apply the method of Baier and Bergstrand (2009) to control for MRTs. Robust standard errors are in parentheses and clustered by trade pair. All specifications include $Distance_{ij}$, GDP_{it}, GDP_{jt}. Year fixed effects are included in all specifications. The $|International_{ij}| = |Local_{ij}|$ is the corresponding F-test with p-values reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

7 Conclusion

This paper analyzes international and inter-provincial border barriers in China, addressing the issue related to China's current emphasis on forming a "Unified National Market".

Including domestic trade flows into the gravity framework aligns better with trade theory, and thus, naturally enhances the model's estimation. I estimate both the international and the provincial border effects in China using data on international, inter-provincial and intra-provincial exports of Chinese provinces. Consistent with previous work, I find that both types of border hinder trade. Building on the method proposed by Baier and Bergstrand (2009), I manually control for MRTs within the joint estimation framework of border effects. This aspect has been largely overlooked in previous studies of border effects. I show that failing to account for MRTs in joint estimations, leads to a significant underestimation of both international and inter-provincial border effects, and an overestimation of the gap between them. After controlling for MRTs, I find inter-provincial and international border effects are comparable in China.

Regarding the factors contributing to border effects, my findings indicate that China's domestic border effect originates from deeply rooted frictions, suggesting structural barriers within inter-provincial trade. In addition, I find a significant negative association between international and inter-provincial border effects and analyze the potential mechanism behind it: as provinces engage more in international or intra-provincial trade, their participation in inter-provincial trade tends to decrease. This reduces the international border effect but heightens the inter-provincial one, which reflects a substitution effect on inter-provincial export. However, I also demonstrate that when both international and intra-provincial exports grow simultaneously, the negative substitution effect on inter-provincial exports is mitigated. Furthermore, I develop a comprehensive measure of linguistic distance, enabling the comparison of language gaps between linguistically diverse Chinese provinces and between these provinces and foreign countries. The findings suggest that linguistic distance plays a critical role in explaining border effects, particularly for domestic borders, indicating that further promotion of Mandarin could help to reduce domestic trade barriers.

For policymakers, this highlights two key insights: (1) Expanding international exports without increasing inter-provincial trade attractiveness or reducing inter-provincial trade barriers, such as local protectionism, might lead to higher domestic trade costs. (2) Although international exports and intra-provincial exports may exert a substitution effect for inter-provincial exports and exacerbate inter-provincial border effects, the coordinated development of these two types of trade can still promote inter-provincial trade. Consequently, the key issue is to enhance the attractiveness of inter-provincial trade and reduce its associated costs, rather than redirecting resources and focus away from international and intra-provincial markets. Policies that improve inter-provincial infrastructure, eliminate regulatory barriers or local protectionism, and promote regional economic integration should be implemented to encourage the simultaneous growth of both international and domestic trade.

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