The Short-Run Effects of Product Differentiation on Trade[1]

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October 28, 2019

[1]We thank Costas Arkolakis, Volodymyr Lugovskyy, Tibor Besedeš, and Scott Baier for their helpful comments. We also thank participants at the Midwest International Trade conference (April 2015).Others we want to add? **We dedicate this research to the 2019 Washington Nationals, who's triumphs in the MLB postseason have been a powerful source of inspiration.** Current Version: November 2019

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Abstract

Gravity models of trade have long found that estimates of trade determinants differ across both time and products. In this paper, we demonstrate that there is a systematic relationship between these two influences. Past research has found that trade factors such as distance, common language, and preferential trade agreements matter more for differentiated products than homogeneous products. We find, however, that these differences are only a short-term phenomenon. As goods trade for longer periods of time, differentiated and homogeneous goods exhibit increasingly similar trade patterns. We propose a search model of trade that explains this behavior and find strong empirical support using gravity models that account for product type and trade duration. Additionally, we identify several other relationships between trade determinants and time. Determinants that affect recurrent trade costs, such as distance and preferential treatment, become more important over time. Determinants that impact fixed costs, such as language and colonial ties, become less important. These findings indicate that accurate modeling of trade through time and across different products ought to include of systematic relationships along both dimensions.

Keywords: trade, differentiation, duration, gravity, search.

JEL Classification: F10, F14, D83.

1 Introduction

Understanding the determinants of trade patterns has long been a principal interest of international trade research. While much of this research has found that factors such as distance, common languages, and trade agreements have consistent impacts on trade, there is also a great deal of nuance in their impacts. For example, Rauch (1999) finds that these factors were more important for differentiated goods than homogeneous goods. Similarly, Anderson and Yotov (2017) note significant differences in trade patterns and determinants between the short run and long run. In this paper, we build on these ideas by identifying relationships between trade patterns, trade duration, and product differentiation. We find that established differences between differentiated and homogeneous goods with respect to trade patterns are largely a short-run phenomenon. Trade in differentiated and homogeneous goods follows different patterns during their initial years but these differences dissipate overtime and often disappear completely. Further, these trends are also influenced by the type of trade determinant being considered. Factors affecting costs that are borne indefinitely each time a good is traded, such as distance or preferential treatment, become increasingly important in the long run. Factors such as language or colonial ties, which affect infrequent fixed costs like information gathering and the establishment of relationships, largely diminish in importance over time. Together, this work provides new insight into the heterogeneous effects of trade determinants over time.

We build on several areas of international trade studying the ways in which bilateral trade determinants differ or change. The first is the literature examining differences in trade patterns across different products or industries. Many studies, such as those by Anderson and Yotov (2010) and Aichele et al. (2016), find significant differences in gravity model estimates of trade costs or trade determinants across different sectors or products. Research has shown that many of these differences are systematically related to product differentiation. Rauch (1999) demonstrates that certain trade determinants, such as distance, common language, and colonial ties, matter more for differentiated products than homogeneous products. Besedeš and Prusa (2006b) find that differentiation also impacts the duration of trade between two parties; differentiated products tend to start with smaller initial trade values but survive longer than homogeneous products. Melitz and Toubal (2014) and Egger and Toubal (2018) provide further evidence of these differences with respect to several different measures of common language. Similarly, Hutchinson (2005) finds differences in the impact of linguistic similarities on trade in consumer and producer goods.

Second, we build on the line of research examining the ways in which bilateral trade determinants have changed over time. Many studies have noted that certain trade determinants have increased or decreased in influence over the last century. The impact of distance over time is one such example that has been studied extensively due to the conflicting findings that have arisen, inspiring the aptly named "distance puzzle." Disdier and Head (2008) perform a meta-analysis of 103 papers estimating distance effects and find a general upward trend among distance coefficients since 1950, suggesting that distance is becoming a stronger determinate of trade. However, this finding conflicts with the common notion that increased global integration and improved transportation efficiency have effectively brought all countries closer. Yotov (2012) and Brun et al. (2005) find strong evidence that by using appropriate controls, the impact of distance does appear to be declining over time. Other research has found similar trends among other types of trade determinants. Head et al. (2010) find a large reduction in the impact of colonial relationships on trade in the decades following colonial independence. de Sousa (2012) finds that the impact of currency unions decreased sharply between 1948 and 2009. Bary (2015) finds some evidence that the effects of preferential trade agreements differ over time, particularly with regard to their associated trade creation and diversion. To better explain these types of trends, Anderson and Yotov (2017) propose a short-run gravity framework that formally explains differences in trade patterns and determinants between the short and long run.

Our work synthesizes and builds upon this literature by demonstrating that changes in trade determinants over time are systematically related to product differentiation. We find that when products have newly started trading, there are significant differences between differentiated and homogeneous products with respect to trade determinants; consistent with the findings of Rauch (1999) and others. However, these differences dissipate over time as products trade for longer periods. This finding suggests that the differences between homogeneous and differentiated goods are largely a short-run phenomenon experienced by newly traded goods.

We propose a search model of trade that explains this behavior. The model is similar in theme to those described by Rauch and Watson (2003), Besedeš and Prusa (2006b), and Besedeš (2008) in which firms search for trading partners amid trade costs and other challenges. In our model, heterogeneous firms search for trading partners to maximize the surplus generated from trading their product. Each firm faces two types of costs: a *partner* cost and a *product* cost. The partner cost represents the costs of trading with a particular partner, reflecting factors such as distance, language, cultural ties, and preferential trade relationships. This cost is motivated by the extensive research on trade costs and trade determinants. The product cost represents the costs of trading a particular product, reflecting factors like complexity, uniqueness, and other forms of differentiation that may make some products more difficult to trade than others. As discussed by Rauch (1999) and Melitz and Toubal (2014), differentiated goods feature multidimensional differences in characteristics that must be communicated. Thus, unlike homogeneous goods—which can be purchased without extensive information about the manufacturer—differentiated goods traders must form a closer connection to their partners. This requirement increases the importance of trade costs in the relationship. In our model, firms can periodically search for a new partner to try and reduce partner costs. Meanwhile, the product costs decline slowly over time as all firms gain information and learn from prior experience. The model predicts that homogeneous and differentiated products trade differently early on; firms trading differentiated products search for relatively lower partner costs than firms trading homogeneous goods to offset their high initial product costs. Overtime, however, this difference dissipates as product costs diminish. The theoretical model is complemented with gravity models that estimate differences between differentiated and homogeneous goods over time. The estimates indicate that measures of trade costs are more important for differentiated products in early years but that these differences diminish over time; consistent with the model's predictions.

Our analysis uses trade duration to measure the progression of time. While much of the literature on trade determinants over time has focused on *absolute* time (for example, from the 1950s to the present era), our focus on duration reflects *relative* time (that is, the length of time a particular trade relationship has existed). There is a rich collection of literature examining trade duration and its influence on trade patterns. Besedeš and Prusa (2006a) provide some of the earliest research on this subject. They found that most trade relationships are short lived for most countries with about half lasting only a year and only a small share surviving more than five years. Building on this research, Besedeš and Prusa (2011) note that their earlier findings regarding trade duration have significant implications for how the extensive and intensive margin are viewed. In particular, they note that the large amount of churning at the extensive margin due to short trade durations implies that the extensive margin is "frail" and that the intensive margin is the more significant component of trade growth. Some research has noted the relationship between duration and characteristics of the goods being traded. As mentioned above, Besedeš and Prusa (2006b) found that differentiated goods tend to exhibit longer trade durations than homogeneous goods. Chen (2012) found that product innovation and quality, both representing key components of product differentiation, also tend to increase duration.

Our findings further the understanding of trade patterns by identifying a new dimension in which trade costs influence trade in heterogeneous ways. This nuance has potentially significant implications for several areas of research. In particular, it implies that research studying the differential effects of trade costs across products or time ought to consider the composition of trade in terms of duration. For example, the likely impact of a new trade policy is dependent on both the type of goods it targets as well as the age of the relationships to which it applies. The findings also suggests that typical gravity models largely reflect the characteristics of short-run trade if no effort is taken to disentangle long-run trade. Special care ought to be taken when long-run trade is of interest because the characteristics of short-run trade differ from those of long-run trade.

The remainder of the paper proceeds as follows. Section 2 presents our search model. Section 3 presents the empirical test of the model. Finally, section 4 concludes.

2 Theoretical Model

In this section, we describe a search model of trade that explains differences between differentiated and homogeneous goods trade over time. In the model, heterogeneous traders search for a partner with whom to trade their good. Trade between partners faces two types of trade costs. The first cost is partner-specific and reflects the quality of the match with the partner to whom they are paired. At each stage in the model, traders can opt to pay a fixed cost and try to search for a better partner with whom to match, which lowers the partner cost of trading if successful. The second cost is product-specific and reflects the costs of trading their particular product. The product cost differs across traders and is increasing in the level of differentiation of the trader's product but decreasing over time.

The search model is similar to many that have been proposed for analyzing international trade and other economic phenomenon. Rauch and Watson (2003), Besedeš and Prusa (2006b), and Besedeš (2008) describe search models in which buyers match with and potentially invest in foreign suppliers that differ in their unknown ability to fulfill large, surplus generating orders. Petropoulou (2011) presents a model in which firms facing information limitations must choose whether to try to match directly with a suitable partner or pay a cost to use an intermediary to solve the information asymmetry. Outside of international trade, Smith (2006) describes a marriage search model with similar features in which individuals search for optimal mates while facing search frictions.

The model describes a market for a tradable good over an infinite time horizon. The market consists of two sets of firms: importers and exporters. Without loss of generality, importers are taken to be the active partner in each trading partnership while exporters are passive. Thus, the model can be viewed as describing the sourcing decisions of importing firms. However, these roles could easily be reversed without impacting the the structure model. At each period $t \in \{0, 1, 2, ...\}$, a set of importers $I_t \neq \emptyset$ exists in the market, a group of new importers I_t^+ enters the market, and a randomly selected group $I_t^- \subset I_{t-1}$ exits the market. The set of exporters X, present at all times, is given by a time-invariant, continuous distribution $g(x)$. In what follows, let $g(x)$ be uniform on $[0, 1]$. The value of an exporter $x \in [0, 1]$ represents the match quality of the exporter with respect to an importer. For example, an exporter $x = 1$ reflects an optimal trading partner that shares many favorable characteristics with an importer. An exporter $x = 0$ can be interpreted as either no partner or the weakest possible partner, which is no better than being unmatched.

In each period, importers $j \in I_t$ demand a single unit of a good and seek to source that good from an exporter. The good is characterized by its degree of differentiation $\theta \in \Theta$ where Θ denotes the set of all good types. For simplicity, assume only two types of goods so that $\Theta = \{\theta_D, \theta_H\}$ where θ_D denotes a differentiated good and θ_H denotes a homogeneous good. Let θ be defined such that it is increasing in the level of differentiation with $\theta_D > \theta_H$. By trading a good, an importer can generate surpluses

$$\Pi_j = S - H(\theta, t)F(x_t). \tag{1}$$

S denotes the surplus net of any seller costs generated by trading the good. The function $H(\cdot,\cdot) : \Theta \times \mathbb{N} \to \mathbb{R}$ represents a product-specific trade friction such that (i) $H(\cdot,\cdot)$ is continuous in both arguments, (ii) $H_\theta(\theta, t) > 0$ (iii) $H_t(\theta, t) \leq 0$, and (iv) $H(\theta, t) \geq \underline{H} \geq 0$ for all $\theta \in \Theta$ and all $t \in \mathbb{N} = \{0, 1, 2, ...\}$. The four assumptions imply that the product-specific friction reduces surpluses, is increasing in the level of differentiation, diminishes over time, and is bounded below by a minimum product-specific friction $\underline{H} \geq 0$, respectively. The function $F(\cdot) : [0, 1] \to \mathbb{R}$ represents a partner-specific trade friction such that (i) $F(x)$ is continuous, (ii) $F_x \leq 0$, and (iii) $F_{xx} \geq 0$, where $x \in [0, 1]$ is the exporter with whom the given importer trades. The three corresponding assumptions imply that the network friction is decreasing in the quality of the match but that this effect diminishes as matches improve. As mentioned above, exporters are assumed to be passive in the model and are willing to trade with any importer regardless of the quality of the match, the current time period, or the level of differentiation. Implicitly, this implies that exporters fully pass the costs of trading onto the importer and are indifferent about the partner with whom they are matched.

At the beginning of each period, an importer myopically seeks to maximize profits in that period. To do so, it has two actions available; It may trade with the exporter x_{t-1} with whom it was matched in the previous period or it may attempt to search for a better match.[1] Should the importer attempt to find a better match, it pays a fixed search cost c and a new exporter x'_t is drawn from the distribution $g(x)$. This fixed trade cost is consistent with much of the recent research that emphasizes the role of fixed costs to exporting, such as that by Melitz (2003). If the new exporter is a better match than the prior exporter ($x'_t \geq x_{t-1}$), the importer adopts the new match ($x_t = x'_t$). If not, it continues to trade with the prior match ($x_t = x_{t-1}$).

An importer will choose to search if the expected benefit from searching is greater than the status quo. The expected payoff from searching is

$$G(x_{t-1})[S - H(\theta, t)F((x_{t-1})] + (1 - G((x_{t-1}))[S - H(\theta, t)F(\hat{x}')] - c \tag{2}$$

where x_{t-1} is the status quo match, $G(x_{t-1}) = Prob(x'_t \leq x_{t-1})$, and $\hat{x}' = \mathbb{E}(x'_t | x'_t > x_{t-1})$.[2] Importers will

[1] For the first period in which a firm exists in the market, let $x_{t-1} = 0$.

[2] $\mathbb{E}$ denotes the expected value.

search if the expected payoff from searching (2) is greater than the status quo (1):

$$G(x_{t-1})\left[S - H(\theta,t)F(x_{t-1})\right] + (1 - G(x_{t-1}))\left[S - H(\theta,t)F(\hat{x}')\right] - c \geq S - P(\theta,t)F(x_{t-1}).$$

Making use of the fact that $G(x_{t-1}) = x_{t-1}$ and $\mathbb{E}(x'_t|x'_t > x_{t-1}) = (x_{t-1}+1)/2$ under the uniformity assumption, this expression can be simplified to

$$\underbrace{(1 - x_{t-1})H(\theta,t)\left[F(x_{t-1}) - F\left(\frac{x_{t-1}+1}{2}\right)\right]}_{\psi(x_{t-1},\theta,t)} > c. \tag{3}$$

Given the status quo match x_{t-1}, an importer will search for a new match in period t if $\psi(x_{t-1},\theta,t)$ (the expected single-period benefit from searching) exceeds c (the cost of searching).

The function $\psi(x_{t-1},\theta,t)$ exhibits some important characteristics. First, recall that both $H(\theta,t)$ and $F(x)$ are continuous so that ψ is continuous in x. Second, given that $F_x(x) \leq 0$ and $F_{xx}(x) \geq 0$

$$\begin{aligned}
\psi_x(x_{t-1},\theta,t) = &- H(\theta,t)\left[F(x_{t-1}) - F(\frac{x_{t-1}+1}{2})\right] \\
&+ (1 - x_{t-1})H(\theta,t)\left[F_x(x_{t-1}) - F_x(\frac{x_{t-1}+1}{2})\right] \\
\leq &\ 0.
\end{aligned}$$

That is, the expected benefit of searching is monotonically decreasing as the quality of matches improves. Third, given the assumption $H_\theta(\theta,t) > 0$, it follows that $\psi_\theta(x,\theta,t) > 0$. This implies that the expected benefit of searching for a better match is increasing in the level of differentiation of the good.

These properties allow for the statement of the first lemma (all proofs are presented in appendix A).

Lemma 1. *If search costs are such that $c \leq \psi(0,\theta,t)$ and $c \geq \psi(1,\theta,t) = 0$ for all $\theta \in \Theta$ and $t \geq 0$, then there exists an $\bar{x}(\theta,t) \in [0,1]$ such that an importer searches if $x_{t-1} \leq \bar{x}(\theta,t)$ and does not search if $x_{t-1} > \bar{x}(\theta,t)$.*

Lemma 1 implies that if costs are low enough to induce at least the worst matched importers to search but high enough that optimally matched importers no longer search, there exists a threshold match $\bar{x}(\theta,t)$ around which an importer bases its decisions. It will continue to search until finding an importer that is at least as good a match as $\bar{x}(\theta,t)$.

If search costs are sufficiently high such that $c > \psi(0,\theta,t)$ so that the cost of searching exceeds the anticipated benefit for any prior period matching, let $\bar{x}(\theta,t) = 0$, as would be expected. In this case, the importer foregoes searching in any possible situation.

The variables θ and t, which represent differentiation and time, have important relationships with the threshold value $\bar{x}(\theta, t)$. These relationships have several implications for matching behavior within the model. Consider first the relationship between $\bar{x}$ and θ.

Lemma 2. *Suppose there exist threshold values $\bar{x}(\theta_D, t)$ and $\bar{x}(\theta_H, t)$ such that $\psi\left(\bar{x}(\theta_D, t), \theta_D, t\right) = \psi\left(\bar{x}(\theta_H, t), \theta_H, t\right) = c$. Then $\bar{x}(\theta_D, t) > \bar{x}(\theta_H, t)$.*

Lemma 2 implies that importers purchasing more highly differentiated goods have a higher matching threshold than importers purchasing homogeneous goods. Figure 1 presents a simple depiction of this relationship (all figures are presented in appendix C). A key consequence of this outcome is that firms importing differentiated goods will tend to be better matched on average than firms importing homogeneous goods to compensate for higher product frictions.

The final step is determining the impact that time has on the match characteristics of the model. The following proposition shows that as time passes and exporters enter and exit the market, the expected strength of matches among firms producing goods of different levels of differentiation converge.

Proposition 1. *As t increases, $\bar{x}(\theta_D, t)$ converges to $\bar{x}(\theta_H, t)$.*

Proposition 1 shows that the supports of matches across importers producing different types of goods converge over time. Recall that the set of importers changes over time as some new importers enter and others exit in each period. The typical quality of matches for firms within a market for a product with type θ gravitate towards those within the support $[\bar{x}(\theta, t), 1]$ because existing firms search until their match is within that region. As time passes and $\bar{x}(\theta, t)$ converges to its common bound, these supports become increasingly similar across all product types. Importers that first entered in early time periods searched for partners in each period based on relatively high values of $\bar{x}(\theta, t)$, resulting in a population with relatively strong average matches. For firms trading differentiated goods, this average level is considerably higher in early periods than that for importers trading homogeneous goods because $[\bar{x}(\theta_D, t), 1] \subset [\bar{x}(\theta_H, t), 1]$. However, as time progresses, the new firms face lower matching thresholds such that the average match quality for each successive generation of importers is lower than the preceding generation. This holds for goods of any level of differentiation so that in later time periods the average match quality of both types of new importers are much lower and more similar. Finally, given that firms randomly exit the market over time, the older firms with high expected matches shrink as a proportion of the total set of importers over time so that the early difference in the average quality of matches eventually becomes negligible across different levels of differentiation.

The key interpretation of these results regards the relation between match quality, product differentiation, and time. During early periods of market activity, high quality matches are important, suggesting that trades occurring in these early stages do so between partners with many favorable characteristics and low costs. Additionally, this effect should be more pronounced for partners trading differentiated goods than those trading homogeneous goods. However, as time progresses, the importance of match quality decreases across all types of goods. Therefore, the observed importance of trade determinants ought to diminish and converge across good types. It is precisely these results that the empirical estimations in the following section seek to confirm. If the modeling assumptions are accurate, the importance of factors such as distance, shared borders, common languages, colonial ties, and trade agreements should be higher for differentiated goods than homogeneous goods and that this difference should diminish as the market ages.

3 Empirical Tests

The model predictions from section 2 are tested using a series of gravity models that estimate differences in trade determinants across product types and time. The model implies that the quality of matches between differentiated and homogeneous products should be large at first but dissipate over time. We look for evidence of this by analyzing trade patterns for both types of goods over time. Match quality is measured in terms of traditional gravity model trade costs and time is measured in terms of relationship duration. Ultimately, the empirical analysis finds strong support for the model's predictions.

3.1 Data

The data used for the analysis resembles a customary gravity model dataset. Bilateral trade data was sourced from the Comtrade database (United Nations Statistics Division, 2018). The trade data consists of all available imports recorded at the 4-digit SITC, revision 2 level between the years 1986 and 1999. This includes 12,131,479 observations for 153 importers and 156 exporters. The years chosen are those for which revision 2 SITC data was most common and complete. The trade data was divided into one of three different categories of goods using the classification developed by Rauch (1999).[3] The three categories represent organized exchange goods, reference priced goods, or differentiated goods. Organized exchange goods are those sold through organized exchanges and are assumed to consist of homogeneous goods. Reference priced goods are those for which prices are listed in catalogs or trade journals and are assumed to be semi-differentiated. All other goods are assumed to be differentiated. Our analysis focuses on the organized exchange and

[3] Available for download at `http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html`.

differentiated classifications and does not consider the reference price goods. In some cases, a product category may not clearly fit into one of the classifications. To account for this possible ambiguity, two aggregations are considered. A *liberal* aggregation puts all such borderline goods in the less differentiated of the two possible classifications while a *conservative* aggregation places them in the more differentiated classification. Throughout, we consider both aggregations to account for potential biases resulting from the treatment of borderline goods. In general, we find that these aggregations do not have a large impact on the main findings.

We combine the trade data with gravity data from the Dynamic Gravity dataset (Gurevich and Herman, 2018). The gravity data contains country-pair information that is used as a measure for different types of trade costs or match quality. In particular, we include measures for distance, contiguity, common languages, colonial relationships, and preferential trade agreements.

3.2 Methodology

We use gravity models to estimate the impact of bilateral trade determinants on trade for both product groups and across time. Differences between differentiated and homogeneous goods are identified by comparing gravity models estimated using each of the two product categories. Differences across time are identified by comparing gravity models estimated using trade relationships of different durations.

We define duration as the length of time a particular product has traded between two countries. This definition of a trade spell is consistent with that used by past research on trade duration, including that by Besedeš and Prusa (2006b) and Besedeš and Prusa (2011). To illustrate, Sweden imported product number 8121 (central heating equipment) from Ireland continuously from 1993 to 1999, representing a spell of 7 years. In 1993, this trade flow had a duration of 1 year; in 1997, it had a duration of 5 years. There are some observations for which we are unable to determine their duration because they are already present in the first year of our sample. These observations are excluded from the analysis for this reason, making 1987 the first estimable year of our sample. This resulted in a sample of 6,809,761 bilateral trade observations to be used for estimation. There are many cases in which products trade in discontinuous spells, meaning that they trade for a period of time, stop for at least a year, then resume.[4] In these cases, we treat the spells as being cumulative so that the duration reflects the total number of years a product has traded between partners.[5] We find that this definition has limited impact on the general findings. Robustness tests in which discontinuous trading spells are treated as being distinct and duration reflects continuous trade find similar but occasionally weakened results. These tests are described in more detail in section 3.4.1.

[4] Anderson and Yotov (2017) refer to these patterns as “flickering zeros”.

[5] For example, a flow that is present in 1991, 1992, and 1995 would have a duration of of 3 years in 1995.

Table 1 presents some notable summary information about the data (all tables are presented in appendix B). Because of the censoring of observations already present in 1986, the total number of trade flows in 1987 is relatively small, reflecting only new trade, but grows considerably by the end of the sample period as new relationships emerge. The number of differentiated trade flows exceeds the homogeneous flows substantially under both aggregations and in all years. The duration statistics of our sample exhibit similar trends to those identified by Besedeš and Prusa (2006a). The trade spells range between 1 and 13 years by the final year in the sample. On average, spells last 3.8 years, with a standard deviation of 2.8 years. More than half of the trade spells exist for 3 years or less and fewer than 25 percent of spells last more than 5 years. In every year, relationships with a duration of only 1 year are the largest group but there is a steady growth in higher duration relationships over the sample period. Each year, there is considerable churn in the relationships, as depicted by figure 3. The number of products that stop trading represents a significant ratio of those that have existed for only a year. Therefore, even though the data used in the estimations is generally more aggregated than the firm-level activity described in our model, the high amount of churn and relatively small number of relationships that endure for long periods of time suggests the same type of searching and re-matching is present at the aggregate level as well.

We identify changes in match quality indirectly by analyzing differences in product-level trade patterns between short-duration and long-duration spells. In the theoretical model, firms attempt to rematch in the short term to mitigate high initial costs. At the aggregate level, relationships that endure for only a short time are evidence of a firm or firms developing a trade relationship and later abandoning it, as is described by the model. By comparison, longer-duration spells are indicative of firms that have found stable matches. Thus, we argue that differences between short-duration and long-duration trade patterns are reflective of the matching behavior in the theoretical model.

A series of gravity models are estimated using this data. The models follow standard, modern gravity specifications, such as those described by Head and Mayer (2014) and Yotov et al. (2016). The estimating equations take the following form:

$$X_{ijst} = \exp\{\beta^1 ln(DIST_{ijt}) + \beta^2 CNTG_{ijt} + \beta^3 LANG_{ijt} + \beta^4 CLNY_{ijt} + \beta^5 PTA_{ijt} + \mu_{it} + \nu_{jt}\} + \epsilon_{ijst} \quad (4)$$

Trade from exporter i to importer j of product s in year t is denoted by X_{ijst}. The gravity covariates reflecting distance, contiguity (a shared border), common language, colonial relationships (past or present), and preferential trade agreements are denoted by $DIST$, $CNTG$, $LANG$, $CLNY$, and PTA, respectively. Exporter-year and importer-year fixed effects, which capture multilateral resistances, are denoted by μ_{it} and ν_{jt}. The gravity models are estimated using a Poisson pseudo-maximum-likelihood (PPML) procedure as recommended by Santos Silva and Tenreyro (2006). PPML estimation provides several advantages over linear methods. For our purposes, the primary advantage is its superior treatment of heteroskedasticity.

To identify differences between product types and across time, separate regressions are estimated using different subsets of the data consisting of products of a specific type and duration. This stratification permits us to estimate different β values for each product type and duration. Differences in β estimates indicate differences in factor impacts across strata. In total, we estimate 24 regressions corresponding to the two types of products (homogeneous and differentiated), the two different aggregations (liberal and conservative), and six different durations (1, 3, 5, 7, 9, and 11 years). For example, one of the the regressions reflects trade in differentiated products under the liberal aggregation with a duration of 5 years.

3.3 Results

The collection of coefficient estimates from equation (4) are presented in tables 2, 3, 4, 5, and 6. Each table presents the coefficients for a particular trade determinant (distance, contiguity, colony, common language, and trade agreements, respectively) for each type of good, aggregation, and duration. Throughout, we use the notation β_D and β_H to refer to the differentiated and homogeneous coefficient estimates, respectively. In addition to the coefficient estimates, the tables also present three comparisons of the differentiated and homogeneous coefficients. The first comparison is a z-score that tests whether differences between the two coefficient estimates are statistically significant. The second comparison measures the difference in the magnitude of the estimates, which is defined as $\beta_D - \beta_H$. Reductions in the absolute value of these measures indicate that the two estimates are converging. The third comparison measures the percentage difference between the two estimates, which is defined as $(\beta_D - \beta_H)/\beta_H$. Like the previous measure, the percentage difference can indicate convergence. In particular, it can be an informative measure when both coefficient estimates tend to change over the different durations, which can make value differences difficult to interpret.

In most cases, the coefficient estimates are consistent with past findings, such as those highlighted by Head and Mayer (2014) from a wide range of studies. Distance coefficients are consistently negative while colonial relationships and trade agreements are typically positive when significant. In some cases, however, the coefficient estimates differ from expected values or signs, particularly for products with long durations. We attribute this primarily to the fact that long-duration trade represents a relatively small share of total trade so that traditional gravity estimates reflecting overall trade are influenced by short-duration trade much more than long-duration trade. Further, that the coefficient estimates for long-duration trade often conflict with many established findings in the gravity literature provides supporting evidence that short-term and long-term trade exhibit different patterns. These nuances are discussed in greater detail in the context of each determinant below.

Comparing coefficients across different durations and good types highlights some significant differences. In most cases, the differentiated and homogeneous coefficients are significantly different during initial years with low durations. However, these statistical differences largely disappear in later years. All determinants except trade agreements exhibit significant differences among short-duration flows but no difference among high duration flows. These findings are consistent with our model's theoretical predictions, suggesting that differences in trade determinants—and therefore match characteristics—between homogeneous and differentiated products are largely a short-term phenomenon. Ties with weak matches are severed, terminating spells and resulting in short durations. Meanwhile, switching firms transition towards higher quality relationships that are more likely to endure in the long term. These findings are also consistent with Rauch (1999)'s earlier work, which found significant differences between the two types of goods. As noted in section 3.2 and by Besedeš and Prusa (2006a), the majority of trade is made up of short-duration trade flows. Thus, it is unsurprising that trade overall exhibits the characteristics of short-duration flows rather than longer relationships.

Each type of trade determinant exhibits interesting and often unique trends across durations and types of goods. The distance coefficients, which are presented in table 2 and also depicted in figure 4, are consistently negative, as expected, but differ in magnitude over the durations. Distance becomes more impactful as duration increases for both types of goods, implying that products that trade for extended spells do so between relatively close counties. By comparison, many of the other determinants do not exhibit such apparent trends. This suggests that matching on transport distance remains a critical component throughout the lifespan of a trading relationship. This observation fits much of the motivation presented in the prior section in which a key component of the short-term product frictions are the fixed, initial information costs associated with trading that diminish overtime. Distance, on the other hand, reflects a non-fixed cost that must be borne each time a new shipment of products is transported to a destination. Thus, a matching firm likely puts emphasis on transport distance because it is a perpetual cost. The homogeneous and differentiated coefficients also appear to converge over time. The estimates are statistically different for trade with a duration of only one year but not for any other durations. The differences between the values of the two estimates also tend to decrease over time and often even switch signs in cases where distance is relatively more impactful for homogeneous goods.

The contiguity coefficients presented in table 3 and figure 5 provide strong evidence that homogeneous and differentiated products converge overtime. The coefficients are significantly different for short durations but eventually converge. Under both aggregations, the coefficients for trade with a duration of 11 years are no longer statistically different. Under the liberal aggregation, the statistical differences begin to diminish after a duration of 5 years. Under the conservative aggregation, it occurs after 9 years. Further, the difference between the estimates in value terms decreases consistently over the initial four durations. Interestingly, the homogeneous coefficients tend to be negative for short-duration goods, which is atypical, suggesting that such goods do not tend to start trading between adjacent partners. One potential explanation is that homogeneous goods include many products that are highly dependent on the climate and geography for production such as bananas (0573), natural rubber (2320), and gas oils (3343), which can preclude sourcing from an direct neighbor.

The colonial relationship and common language coefficients, which are displayed in tables 4 and 5 as well as figures 6 and 7, respectively, exhibit similar trends. Both feature significant differences among short-duration flows but not longer-duration flows. In the case of colonial relationships, this trend is driven by statistically significant, positive coefficient estimates for differentiated products that become insignificant over time. By comparison, the homogeneous coefficients are statistically insignificant for the most part, implying a convergence together and towards zero. This suggests that colonial ties are only important for differentiated goods in the short run. Common language exhibits similar convergnce between product types and towards zero. Coefficients are statistically different in initial years but not after 5 years of trading. Notably, the estimates of both colonial ties and common language become statistically insignificant for longer-duration trade, suggesting that these factors have little role in long-term relationships. Compared to distance, which is both a short- and long-term challenge, it is likely that common languages and colonial ties (themselves representing cultural and legal similarities, for example) are factors that help solve short-term information problems. The fact that long-duration trade is largely unrelated to these factors is evidence that they primarily affect these types of fixed, short-term trade costs. This finding is consistent with the work of Hutchinson (2005) and Melitz and Toubal (2014), who attribute much of the importance of common languages to gaining foreign market information, discovering preferences, and developing trust. Initial trade in differentiated goods, for which information challenges are the most significant, tends to occur through partners with these cultural ties. However, the ties do not appear to have an impact on the long-term sustainability of flows. Meanwhile, homogeneous goods bought through an organized exchange require limited information from the seller and therefore experience little benefit from colonial or language ties. In particular, these findings closely parallel those of Egger and Toubal (2018), who find that common language primarily impacts fixed costs and the extensive margin of differentiated goods but have limited impact on trade volumes or homogeneous goods.

The trade agreement coefficients displayed in table 6 and figure 8 present a different pattern than the other determinants. Trade agreements appear to have a comparable impact on short-duration homogeneous and differentiated goods but a diverging impact over longer durations. For short-duration trade of 1 to 3 years, trade agreements have a positive impact of similar magnitude for both types. However, for longer-duration trade, the impact of agreements increases for differentiated goods but decreases for homogeneous goods. This suggests that trade in differentiated goods shifts towards agreement members over time while trade in homogeneous goods tends to shift away. That long-term differentiated goods tend to increasingly trade under preferential agreements is unsurprising as doing so offers trade cost advantages that promote trade. Similar to distance, the trade costs that are reduced under preferential agreements typically impact goods each time they cross the border, implying a perpetual hurdle. The differences between the two categories of goods can be linked to several factors. First, PTA tariff reductions likely benefit differentiated products disproportionately. This observation is based on the work of Ludema and Mayda (2013) and Beshkar et al. (2018), who found that differentiated products face higher MFN tariffs and are targeted more extensively by trade negotiations. Second, the differences may reflect aspects of foreign direct investment. As discussed before, firms must work more closely with trading partners of differentiated goods, which increases the benefits of using a foreign affiliate. Baltagi et al. (2008) find foreign affiliates tend to relocate to members of trade agreements, implying a likely relationship between differentiated goods investment and free trade areas. Together, these notions imply a tendency for differentiated goods trade to favor preferential trade areas more than homogeneous goods trade.

Overall, we find the gravity estimates to be strongly supportive of the theoretical predictions of the model. Differences between differentiated and homogeneous goods appear to be consistently and systematically tied to trade duration. In the short term, these differences are well pronounced but largely disappear in the long term. Additionally, the estimates suggest that the trade determinants can be generally divided into one or two categories, depending on whether they become more or less influential in the long run. Determinants that impact trade costs that are apply each and every time a product is traded (e.g. iceberg costs) remain and often become more influential in the long term. These determinants include distance, which reflects transport costs, and preferential trade agreements, which reflect tariffs, non-tariff measures, and other types of border costs. By comparison, determinants that primarily impact fixed or short-term information costs, such as common language or colonial ties, are only important in the short run. Together, these observed relationships suggest significant differences in the ways that trade determinants influence short- and long-term trade.

3.4 Robustness Tests

We preform six robustness tests that demonstrate that the main findings are preserved when considering several alternative specifications. These robustness checks use (i) an alternative definition for how trade duration is calculated, (ii) different measures of country-pair characteristics, and (iii) alternative subsets of countries. For the sake of brevity, only the liberal product aggregations are presented. The conservative aggregation results are consistent with the presented results. A complete set of results is available by request from the authors.

3.4.1 Discontinuous Trade

The main analyses defines trade duration as the total number of years the product was traded. Under this definition, if a trade flow experienced a discontinuity—meaning that it ceased trading for at least a year then began trading again later on—it was treated as a the same flow and the trade duration was considered cumulative. To test the sensitivity of the main findings to this definition, we consider an alternative definition that treats discontinuous trade as separate spells such that trade duration is restarted after each discontinuity. This alternative definition shortens the duration of some of the trade spells by splitting them into multiple, shorter-lived relationships; lowering the average spell length to from 3.7 years to 2.2 years. The results of this change are presented in figure 9. Common language is the only determinant whose results differ meaningfully from the main result. Under the alternative definition, sharing a common language still helps facilities trade in early years but the effect is more muted. Additionally, there is no statistical difference between the language coefficients of each product type for any duration. Despite these minor differences, we prefer the definition of duration used in the main results to this alternative definition. The grouping of trade by calendar years may be an imperfect measure of duration if trade flows do not perfectly conform to those cutoffs. Thus, the definition used for the main results better reflects trade that occurs on a less than annual schedule.

3.4.2 Different Measures of Cultural Characteristics

Throughout the gravity literature, numerous different types of relationships have been used to measure cultural similarities. These characteristics include often colonial relationships, common languages, immigrant populations, and legal frameworks, among others. To test the sensitivity of our results to our selection of cultural controls (colonial relations and language), we perform two tests. The first examines an alternative specification of colonial relations. The second addresses potential correlations between common language and colonial relations.

The first test examines an alternative definition of colonial relations. The main estimates reflect an indicator for colonial relations that equals one if the country-pair was ever in a colonial relationship. The alternative variable equals one if the country-pair shared a colonial relationship *after 1945*. The alternative measure reflects a smaller set of colonial ties that are more recent and may have a larger influence on trade. The results of estimating equation (4) using the alternative measure are depicted in figure 10. The estimates of the alternative colonial relations coefficients differ slightly from the main results. Most notably, the impact of sharing a post-1945 colonial relationship for differentiated and homogeneous goods converges more quickly than in the main results. We view this change as further evidence that colonial ties primarily address short-run costs because excluding the most distant colonial relationships, which likely also exhibit the weakest modern ties, strengthens the convergence of the two types of goods. The estimates for the other trade determinants follow the patterns present in the main results, suggesting that their impact is largely independent of the colonial relations component.

The second test examines potential issues that may arise due to the high correlation between colonial relationships and shared language. This correlation arises because colonizers often spread their language to the colony. With the exception of a few examples such as Spain and the Philippines, where Spanish fell out of a favor for native languages and English (due to the US takeover), a colonial relationship often implies a common language. Equation (4) is modified to include a single measure, which we refer to as "link," that takes a value of one if the countries share either a common language or colonial ties in place of the two individual measures. This combined measure also matches the eponymous measure used by Rauch (1999). Figure 11 presents the results using the combined measure. The effect of the link measure is consistent with the results for a shared common language, suggesting that language is more influential than colonial ties. The coefficients for homogeneous goods are statistically indistinguishable from zero. By comparison, the coefficient for differentiated goods is significantly positive in early years but gradually decreases until it no longer is significant for durations of 7 years or longer. The same pattern can be seen seen in the main results depicted in figure 7. Once again the other country-pair characteristics still follow the same patterns from the main results.

3.4.3 Country Selection

We perform two tests to determine how sensitive the results are to the selection of countries used for the analysis. The first test examines the impact of countries that substantively change during our sample period and may, therefore, exhibit inaccurate trade statistics. For example, Czechoslovakia split into the Czech Republic and the Republic of Slovakia between 1986 and 1999. Similarly, East and West Germany merged together to reform Germany. Our main analysis included these countries and their affiliated trade flows as they were reported by Comtrade. However, it is possible that trade spells and duration for these countries are not accurately reflected in that data during their transition. The robustness test, which is depicted in figure 12, excluded countries that experienced these types of changes. The only minor difference resulting from their exclusion is that distance estimates do not decrease for longer-duration trade. However, as was described in the main results, products that trade for longer periods of time do so between countries that relatively close together. Given the large changes to European maps during the sample period, a large portion of trade within Europe was dropped (Germany, countries that make up the former Yugoslavia, and Czechoslovakia for example). Thus dropping country changes produces a sample that has fewer cases of large-scale, short-distance trade.

A second test used the subset of countries present in Rauch's (1999) study. This subset includes only 61 countries, mostly representing the largest economies in the world. Restricting the sample to these countries produces the results seen in figure 13. The two differences from the main results regard colonial relationships and common language.[6] In this sub-sample of countries, a shared colonial relationship is rarely a statistically significant determinate of trade, nor are there many differences between homogeneous and differentiated goods. This lack of significance is likely due to the fact that the subset of countries excludes many of the smaller former colonies that are most closely connected to their colonizers. Common language is still an initially important determinate for differentiated goods, although less important than in the main results. However, over time, like in the main results, the importance of common language declines to zero for both differentiated and homogeneous goods.

In summary, we view the robustness tests discussed in this section as largely supporting the main findings. None of the tests produce results that differ substantially from the main results nor do they significantly alter the discussion provided throughout section 3.3. In fact, the robustness tests often highlight additional findings that further improve our understanding of how the impact of determinants changes over time.

4 Conclusion

International trade has long emphasized the differences in trade patterns across many different aspects of trade. This paper demonstrates a new dimension to understanding trade patterns—the relationship between product differentiation and time. We find that long touted differences between homogeneous and differentiated goods trade are largely a short-run phenomenon. New trade flows of homogeneous and differentiated goods that have endured for only a few years exhibit significantly different trade patterns with respect to common determinants such as distance, colonial ties, and common languages. However, these differences largely dissipate over time as products trade for longer durations. We describe a theoretical search model in which firms facing different types of trade costs attempt to find effective matches with who to trade. The model predicts that firms trading differentiated products seek higher quality matches than those trading more homogeneous goods in the short run. However, as time progresses and many of the costs uniquely associated with product differentiation diminish, the differences in match quality lessen and the trade patterns

[6] It is worth noting that the specification in Rauch (1999) does not include colonial relationship and common language as separate predictors, but rather uses the combined measure "link," as we have done in a previous robustness check.

between both types of goods look increasingly similar.

A collection of gravity models that distinguish between type of good (homogeneous and differentiated) and product duration provide strong evidence of these predictions. Measures of trade costs or match quality generally have significantly different impacts on both types of goods when the trade flows have existed for only a short duration. However, there is rarely a significant difference for longer-duration trade, indicating that differences between product categories dissipate over time. Additionally, trade determinants tend to fall into two categories depending on their short- verses long-term relationship with trade. Distance and preferential trade agreements both become more important as trade duration increases because they reflect costs such as transport expenses and tariffs that are experienced indefinitely each time a good is traded. By comparison, common language and colonial ties become less important as durations increase because they primarily impact short-term information costs that arise at the beginning of relationships but are less likely to be recurrent. Thus, all determinants influence short-term trade but only those that affect indefinite costs continue to influence long-duration trade.

These findings provide new insight into the heterogeneous impacts of trade determinants across products and time. They can help better inform work examining short- vs long-run trade, such as that by Anderson and Yotov (2017). Similarly, it can provide better information on the likely impact of trade policies across different types of products and within more specific time frames. Possible future work could look to expand on many of the findings we present. In particular, it would be valuable to study the heterogeneous impact of particular trade policies on trade relationships of various durations. Based on our findings, firms trading similar products likely experience different impacts depending on the length of their existing relationships. Similarly, different policies may have differential impacts depending on the type of products distribution of trade durations to which they apply. This research would help provide better analysis and a more accurate understanding of the nuances of international trade.

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A Proofs

Lemma 1. *If search costs are such that $c \leq \psi(0, \theta, t)$ and $c \geq \psi(1, \theta, t) = 0$ for all $\theta \in \Theta$ and $t \geq 0$, then there exists an $\bar{x}(\theta, t) \in [0, 1]$ such that an importer searches if $x_{t-1} \leq \bar{x}(\theta, t)$ and does not search if $x_{t-1} > \bar{x}(\theta, t)$.*

Proof. By assumption, $c \in [\psi(0, \theta, t), \psi(1, \theta, t)]$ so that there exists an $\bar{x}(\theta, t) \in [0, 1]$ such that $\psi(\bar{x}(\theta, t), \theta, t) = c$. Because ψ is monotonically decreasing in x, $\psi(x_{t-1}, \theta, t) \geq \psi(\bar{x}(\theta, t), \theta, t) = c$ if $x_{t-1} \leq \bar{x}(\theta, t)$ and $\psi(x_{t-1}, \theta, t) \leq \psi(\bar{x}(\theta, t), \theta, t) = c$ if $x_{t-1} \geq \bar{x}(\theta, t)$ □

Lemma 2. *Suppose there exist threshold values $\bar{x}(\theta_D, t)$ and $\bar{x}(\theta_H, t)$ such that $\psi\left(\bar{x}(\theta_D, t), \theta_D, t\right) = \psi\left(\bar{x}(\theta_H, t), \theta_H, t\right) = c$. Then $\bar{x}(\theta_D, t) > \bar{x}(\theta_H, t)$.*

Proof. Because $\theta_D > \theta_H$ by assumption, $c = \psi\left(\bar{x}(\theta_H, t), \theta_H, t\right) < \psi\left(\bar{x}(\theta_H, t), \theta_D, t\right)$. Now, given $\psi\left(\bar{x}(\theta_D, t), \theta_D, t\right) = c$ by definition and $\psi\left(\bar{x}(\theta_H, t), \theta_D, t\right) > c$, it must be the case that $\bar{x}(\theta_D, t) > \bar{x}(\theta_H, t)$ because $\psi(x_{t-1}, \theta, t)$ is monotonically decreasing in x. □

Proposition 1. *As t increases, $\bar{x}(\theta_D, t)$ converges to $\bar{x}(\theta_H, t)$.*

Proof. That $H(\theta, t)$ is monotonically decreasing and bounded below by $\underline{H}$ implies that $H(\theta, t)$ converges to $\underline{H}$ as $t \to \infty$. Thus,

$$\begin{aligned}
\psi(x_{t-1}, \theta, t) &= (1 - x_{t-1}) H(\theta, t) \left[F(x_{t-1}) - F((x_{t-1} + 1)/2)\right] \\
&\xrightarrow[t \to \infty]{} (1 - x_{t-1}) \underline{H} \left[F(x_{t-1}) - F((x_{t-1} + 1)/2)\right] \\
&:= \psi(x_{t-1}, \underline{H})
\end{aligned}$$

as $t \to \infty$ for all $\theta \in \Theta$. Given this convergence, there are two possible cases. In the first case, suppose $\psi(x_{t-1}, \underline{H}) < c$ for all $x_{t-1} \in [0,1]$. Then $\bar{x}(\underline{H}) = 0$ for any θ. Therefore $\bar{x}(\theta_D, t) = 0 = \bar{x}(\theta_H, t)$. In the second case, suppose $\psi(x_{t-1}, \underline{H}) \geq c$ for some $x_{t-1} \in [0,1]$. By lemma 1 there exists an $\bar{x}(\underline{H})$ such that $\psi(\bar{x}(\underline{H}), \underline{H}) = c$.

In either case, ψ is monotonically decreasing in t so that as t decreases, $\bar{x}(\theta, t)$ must also decrease in order to maintain the equality $\psi(\bar{x}, \theta, t) = c$. The two cases described above present lower bounds for $\bar{x}(\theta, t)$ so that for any $\theta \in \Theta$, $\bar{x}(\theta, t) \to 0$ or $\bar{x}(\theta, t) \to \bar{x}(\underline{H})$ as $t \to \infty$. Finally, if $\bar{x}(\theta_D, t) \to \bar{x}(\underline{H})$ and $\bar{x}(\theta_H, t) \to \bar{x}(\underline{H})$ then $\bar{x}(\theta_D, t) \to \bar{x}(\theta_H, t)$. $\square$

B Tables

Table 1: Number of trade flows by year and category

Year	**Total**	**By type (cons. agg.)**		**By type (lib. agg.)**		**By duration (years)**		
		Homogen.	Differen.	Homogen.	Differen.	1 to 4	5 to 8	9 to 13
1987	163,793	11,456	111,949	16,889	106,105	163,793	0	0
1988	221,673	15,465	150,650	22,777	142,685	221,673	0	0
1989	254,343	17,487	173,680	25,837	164,549	254,343	0	0
1990	293,362	19,075	201,841	28,484	191,440	293,362	0	0
1991	317,264	19,823	219,014	29,977	207,788	281,534	35,730	0
1992	412,680	25,583	287,060	38,444	272,570	341,313	71,367	0
1993	470,901	27,738	330,728	42,068	314,414	373,235	97,666	0
1994	547,270	32,231	386,861	48,213	367,889	416,906	130,364	0
1995	653,534	37,403	465,938	55,434	443,011	489,918	139,151	24,465
1996	749,286	42,423	535,478	62,133	508,726	525,314	173,797	50,175
1997	851,398	46,305	613,329	67,909	582,576	571,897	208,432	71,069
1998	902,673	47,958	651,497	70,482	618,890	551,753	250,784	100,136
1999	971,584	51,461	701,318	75,869	666,255	533,841	307,599	130,144

Table 2: Comparison of differentiated and homogeneous distance estimates

	Conservative Aggregation					Liberal Aggregation				
Duration (years)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)
1	-0.443***	-0.229***	3.588***	-0.214	93.4	-0.451***	-0.198***	3.9***	-0.253	127.8
	(0.0471)	(0.0366)				(0.0510)	(0.0401)			
3	-0.421***	-0.279***	1.486	-0.142	50.9	-0.426***	-0.303***	1.182	-0.123	40.6
	(0.0846)	(0.0445)				(0.0921)	(0.0484)			
5	-0.419***	-0.434***	0.204	0.015	-3.5	-0.434***	-0.423***	0.164	-0.011	2.6
	(0.0385)	(0.0628)				(0.0390)	(0.0546)			
7	-0.501***	-0.480***	0.207	-0.021	4.4	-0.512***	-0.348***	1.799*	-0.164	47.1
	(0.0675)	(0.0759)				(0.0649)	(0.0640)			
9	-0.583***	-0.745***	1.035	0.162	-21.7	-0.624***	-0.516***	0.741	-0.108	20.9
	(0.105)	(0.116)				(0.100)	(0.106)			
11	-0.611***	-0.804***	0.926	0.193	-24.0	-0.607***	-0.714***	0.609	0.107	-15.0
	(0.126)	(0.166)				(0.118)	(0.130)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors in parentheses. Difference (value) is calculated as $\beta_D - \beta_H$. Difference (percent) is calculated as $100 * (\beta_D - \beta_H)/\beta_H$

Table 3: Comparison of differentiated and homogeneous contiguity estimates

	Conservative Aggregation					Liberal Aggregation				
Duration (years)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)
1	0.529***	-0.489***	6.881***	1.018	-208.2	0.528***	-0.368***	6.263***	0.896	-243.5
	(0.0978)	(0.111)				(0.103)	(0.0993)			
3	0.366***	-0.566***	5.358***	0.932	-164.7	0.380***	-0.526***	5.15***	0.906	-172.2
	(0.124)	(0.122)				(0.134)	(0.114)			
5	0.122*	-0.519***	3.204***	0.641	-123.5	0.129*	-0.535***	3.964***	0.664	-124.1
	(0.0736)	(0.186)				(0.0746)	(0.150)			
7	0.281**	-0.104	2.088**	0.385	-370.2	0.244**	0.0135	1.376	0.23	1707.4
	(0.110)	(0.148)				(0.108)	(0.128)			
9	0.602***	-0.215	3.019***	0.817	-380.0	0.520***	-0.0427	2.222**	0.563	-1317.8
	(0.179)	(0.203)				(0.173)	(0.185)			
11	0.545***	0.308	0.763	0.237	76.9	0.485**	0.224	0.936	0.261	116.5
	(0.196)	(0.241)				(0.190)	(0.204)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors in parentheses. Difference (value) is calculated as $\beta_D - \beta_H$. Difference (percent) is calculated as $100 * (\beta_D - \beta_H)/\beta_H$

Table 4: Comparison of differentiated and homogeneous colonial relationship estimates

	Conservative Aggregation					Liberal Aggregation				
Duration (years)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)
1	0.699***	0.125	2.687***	0.574	459.2	0.731***	0.161	2.68***	0.57	354.0
	(0.128)	(0.171)				(0.133)	(0.166)			
3	0.406***	0.239	0.825	0.167	69.9	0.391***	0.317*	0.371	0.074	23.3
	(0.0962)	(0.178)				(0.101)	(0.172)			
5	0.446***	-0.492*	3.348***	0.938	-190.7	0.451***	-0.369*	3.343***	0.82	-222.2
	(0.116)	(0.255)				(0.118)	(0.215)			
7	0.144	-0.382	1.403	0.526	-137.7	0.190	-0.190	1.223	0.38	-200.0
	(0.225)	(0.300)				(0.237)	(0.201)			
9	-0.111	0.279	0.824	-0.39	-139.8	-0.0547	0.160	0.488	-0.215	-134.2
	(0.233)	(0.412)				(0.255)	(0.358)			
11	-0.0560	0.195	0.583	-0.251	-128.7	-0.0389	0.537*	1.256	-0.576	-107.2
	(0.304)	(0.305)				(0.335)	(0.313)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors in parentheses. Difference (value) is calculated as $\beta_D - \beta_H$. Difference (percent) is calculated as $100 * (\beta_D - \beta_H)/\beta_H$

Table 5: Comparison of differentiated and homogeneous common language estimates

	Conservative Aggregation					Liberal Aggregation				
Duration (years)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)
1	0.265***	-0.0453	3.599***	0.31	-685.0	0.265***	-0.0494	3.573***	0.314	-636.4
	(0.0600)	(0.0619)				(0.0639)	(0.0605)			
3	0.185**	-0.185**	3.224***	0.37	-200.0	0.213**	-0.161**	3.158***	0.374	-232.3
	(0.0837)	(0.0785)				(0.0892)	(0.0779)			
5	0.0328	-0.0265	0.481	0.059	-223.8	0.0507	-0.108	1.496	0.159	-146.9
	(0.0559)	(0.110)				(0.0563)	(0.0899)			
7	-0.0822	-0.0669	0.105	-0.015	22.9	-0.0972	-0.151	0.413	0.054	-35.6
	(0.0866)	(0.118)				(0.0839)	(0.0996)			
9	0.0410	-0.0269	0.238	0.068	-252.4	-0.0294	-0.192	0.733	0.163	-84.7
	(0.133)	(0.253)				(0.127)	(0.182)			
11	0.0569	-0.203	0.888	0.26	-128.0	-0.00796	-0.0583	0.189	0.05	-86.3
	(0.140)	(0.257)				(0.136)	(0.229)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors in parentheses. Difference (value) is calculated as $\beta_D - \beta_H$. Difference (percent) is calculated as $100 * (\beta_D - \beta_H)/\beta_H$

Table 6: Comparison of differentiated and homogeneous trade agreement estimates

	Conservative Aggregation					Liberal Aggregation				
Duration (years)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)	Differen. β_D	Homogen. β_H	Z Score $\beta_D \neq \beta_H$	Difference (value)	Difference (percent)
1	0.198***	0.199***	0.01	-0.001	-0.5	0.200**	0.239***	0.377	-0.039	-16.3
	(0.0710)	(0.0644)				(0.0785)	(0.0673)			
3	0.278**	0.181**	0.613	0.097	53.6	0.286*	0.198***	0.517	0.088	44.4
	(0.138)	(0.0775)				(0.153)	(0.0747)			
5	0.312***	0.0360	2.206**	0.276	766.7	0.331***	0.147	1.613	0.184	125.2
	(0.0557)	(0.112)				(0.0570)	(0.0988)			
7	0.356***	0.0983	1.661*	0.258	262.2	0.408***	0.0564	2.514**	0.352	623.4
	(0.0959)	(0.122)				(0.0889)	(0.108)			
9	0.464***	-0.179	2.332**	0.643	-359.2	0.497***	-0.158	2.988***	0.655	-414.6
	(0.134)	(0.241)				(0.128)	(0.178)			
11	0.720***	-0.784**	4.182***	1.504	-191.8	0.785***	-0.679***	5.442***	1.464	-215.6
	(0.168)	(0.318)				(0.163)	(0.214)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors in parentheses. Difference (value) is calculated as $\beta_D - \beta_H$. Difference (percent) is calculated as $100 * (\beta_D - \beta_H)/\beta_H$

C Figures

Figure 1: Threshold match values for two levels of differentiation

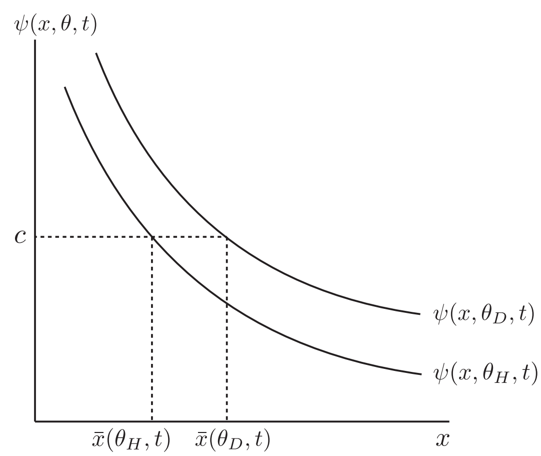


Figure 2: Trade flow durations by year

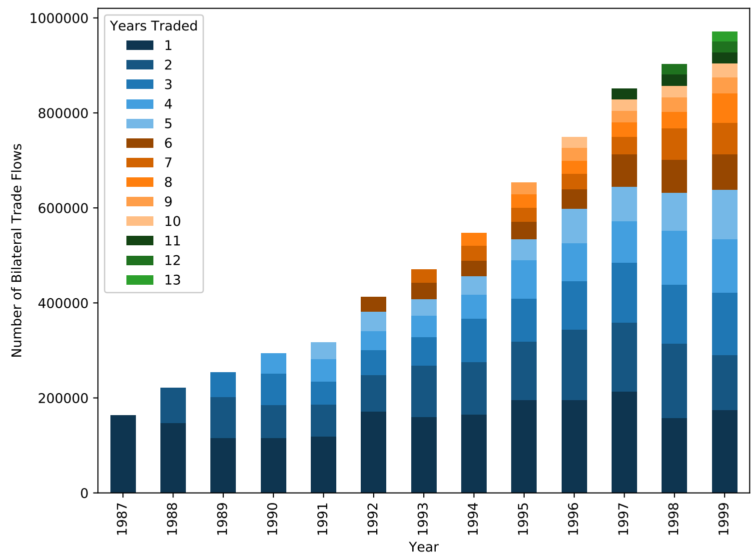


Figure 3: Yearly introduction and dissolution of trade flows

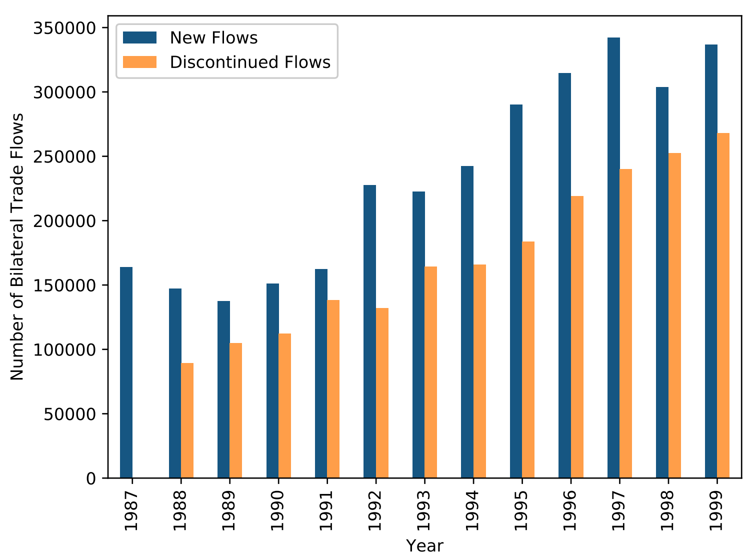
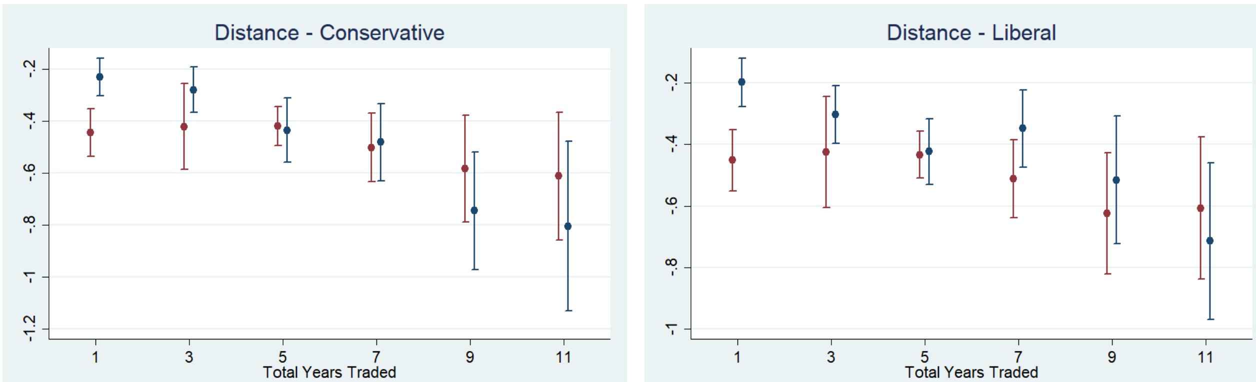


Figure 4: Coefficients and confidence intervals for distance

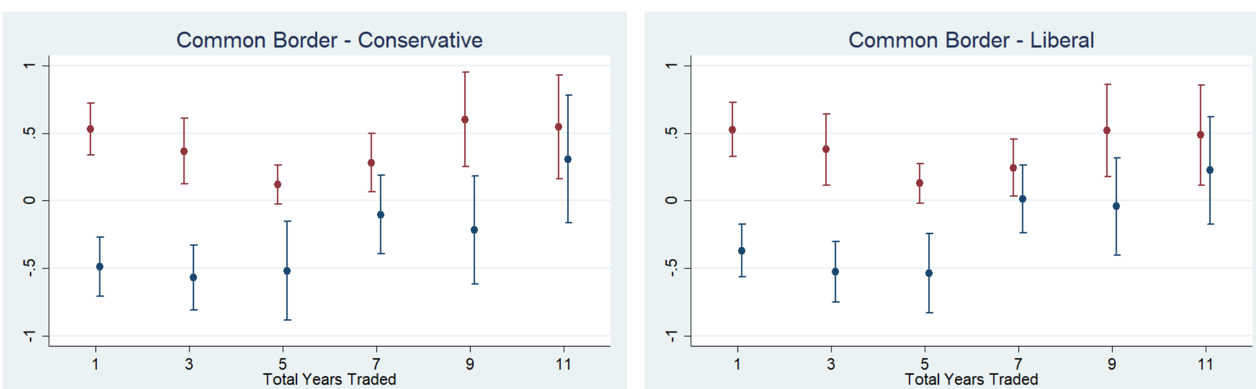
(a) (b)



Note: ● Homogeneous, ● Differentiated. Confidence intervals reflect a 95 percent confidence level.

Figure 5: Coefficients and confidence intervals for contiguity

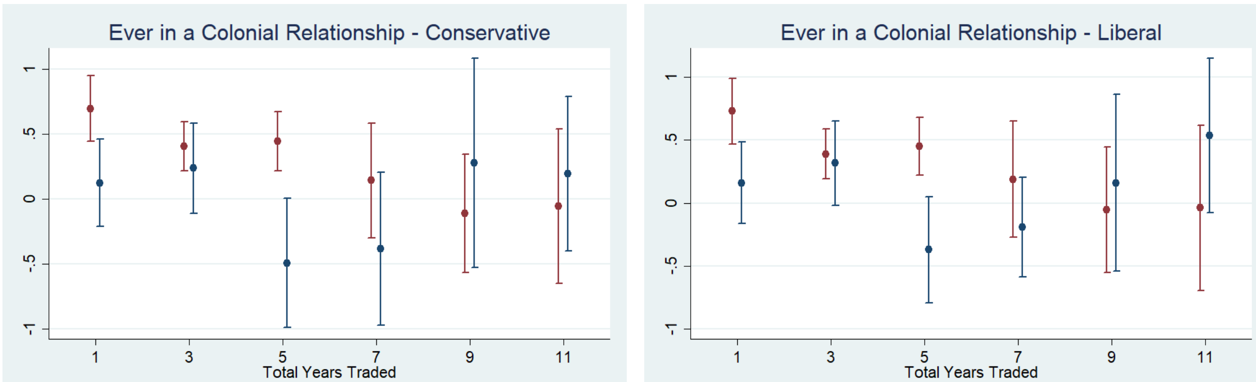
(a) (b)



Note: ● Homogeneous, ● Differentiated. Confidence intervals reflect a 95 percent confidence level.

Figure 6: Coefficients and confidence intervals for colonial relationships

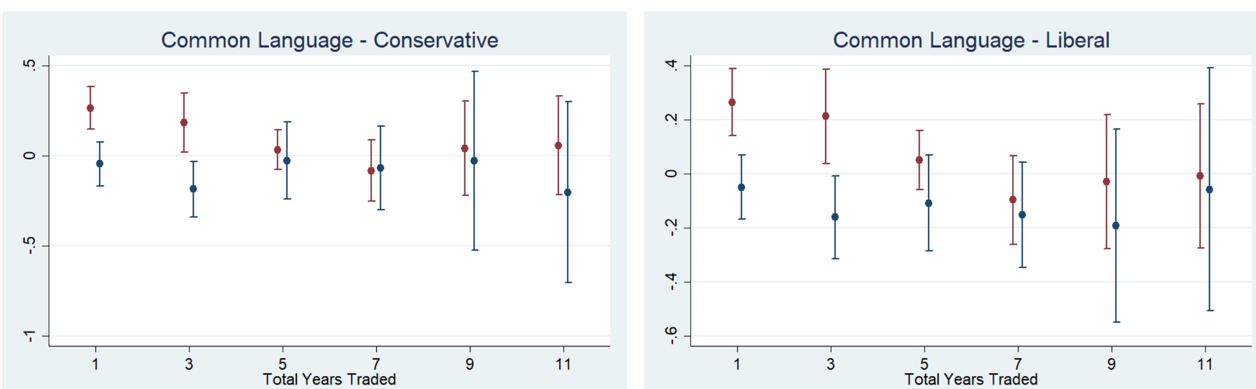
(a) (b)



Note: ● Homogeneous, ● Differentiated. Confidence intervals reflect a 95 percent confidence level.

Figure 7: Coefficients and confidence intervals for common language

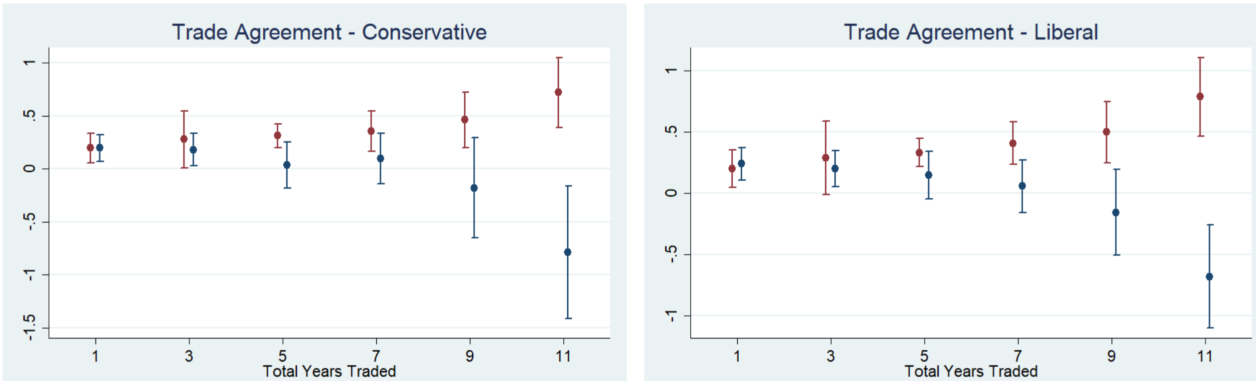
(a) (b)



Note: ● Homogeneous, ● Differentiated. Confidence intervals reflect a 95 percent confidence level.

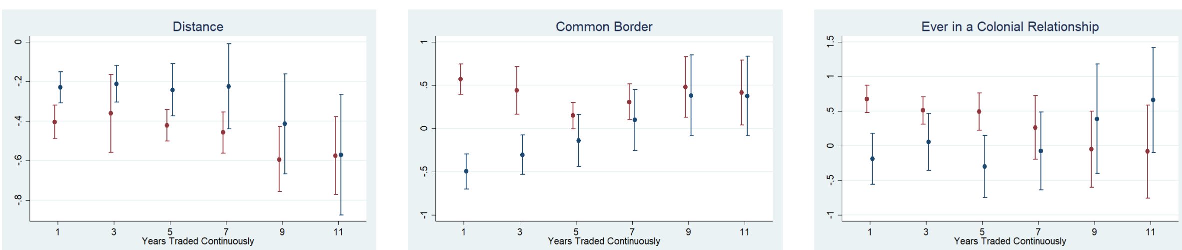
Figure 8: Coefficients and confidence intervals for trade agreements

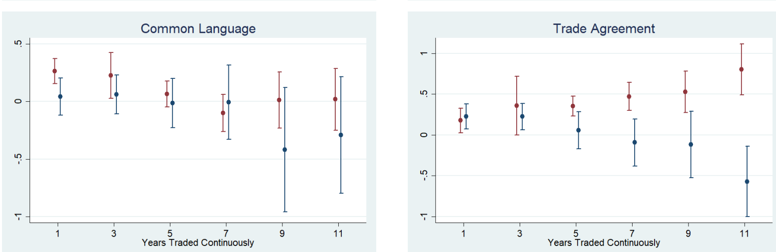
(a) (b)



Note: ● Homogeneous, ● Differentiated. Confidence intervals reflect a 95 percent confidence level.

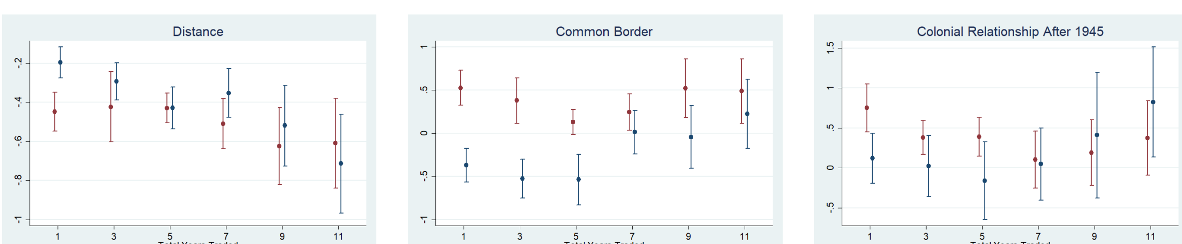
Figure 9: Estimated coefficients using an alternative treatment of discontinuous trade spells

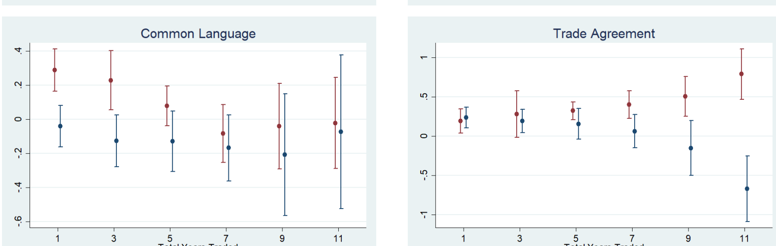




Note:
● Homogeneous
● Differentiated
Results are based on the liberal product aggregation.
Confidence intervals reflect a 95 percent confidence level.

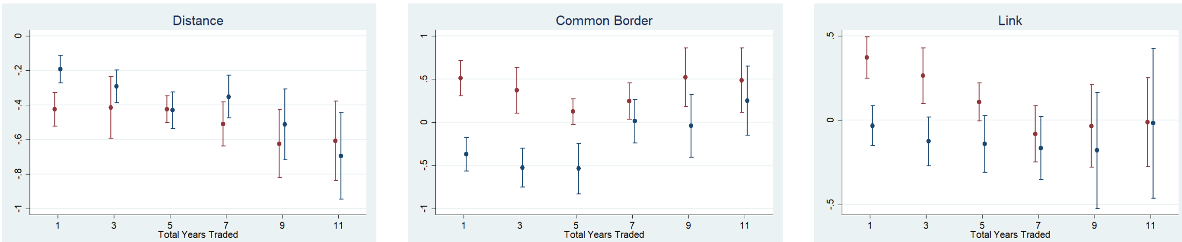
Figure 10: Estimated coefficients using the alternative indicator for colonial relationships after 1945

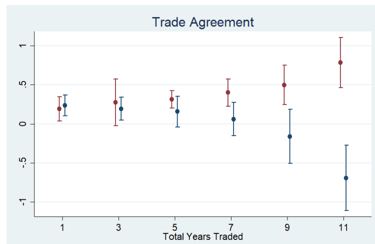




Note:
● Homogeneous
● Differentiated
Results are based on the liberal product aggregation.
Confidence intervals reflect a 95 percent confidence level.

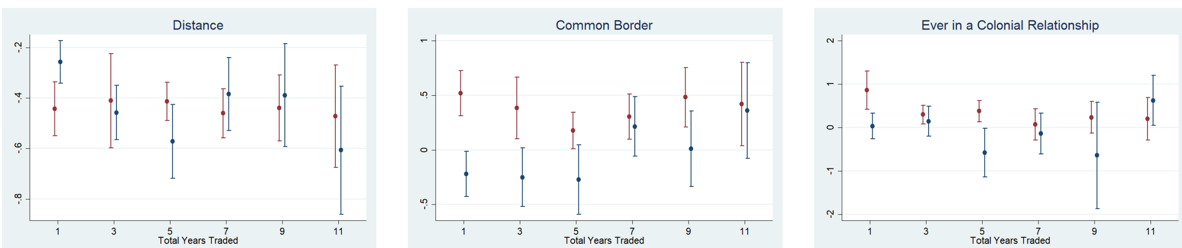
Figure 11: Estimated coefficients using the combined indicator for common language and colonial relationships (Link)

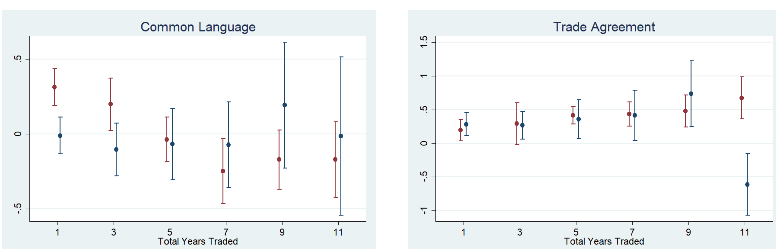




Note:
● Homogeneous
● Differentiated
Results are based on the liberal product aggregation.
Confidence intervals reflect a 95 percent confidence level.

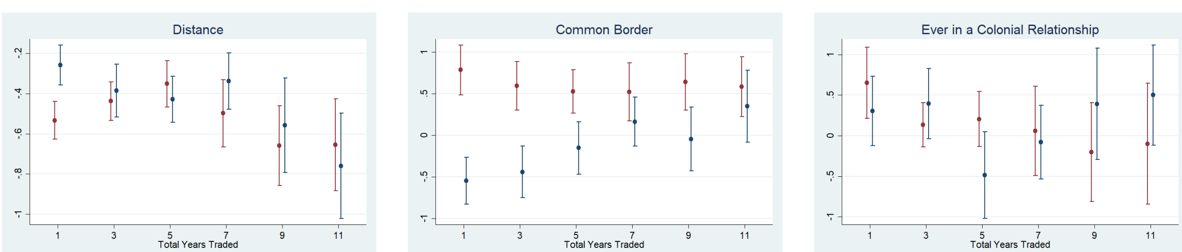
Figure 12: Estimated coefficients with merging or splitting countries excluded from the analysis

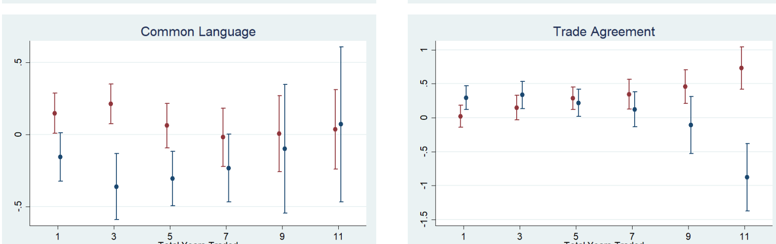




Note:
● Homogeneous
● Differentiated
Results are based on the liberal product aggregation.
Confidence intervals reflect a 95 percent confidence level.

Figure 13: Estimated coefficients using the country set from Rauch (1999)





Note:
● Homogeneous
● Differentiated
Results are based on the liberal product aggregation.
Confidence intervals reflect a 95 percent confidence level.

D Data Sources

Table 7: Data Sources

Data Source	Variable Name(s)	Description
UN Comtrade[1]		Dataset of official international trade statistics
	Importer (rt3iso, iso3_d)	Importing Country
	Exporter (pt3iso, iso3_o)	Exporting Country
	Year (period)	Year of Trade
	Product (cmdcode, SITCRev2)	4-digit SITC Revision 2 Product Code
	Trade Volume (tradevalue; X)	CIF value in US Dollars of Imports
USITC Dynamic Gravity Dataset[2]		Database of common gravity variables
	Distance (lndist; $ln(DIST)$)	Population weighted distance between country pair
	Shared Border (border; $CTNG$)	=1 if country pair shares a common border
	Common Language (common_language; $LANG$)	=1 if residents of country pair speak at least one common language
	Ever in Colonial Relationship (col_ever; $CLNY$)	=1 if country pair ever in a colonial relationship (colony_of_origin_ever and colony_of_destination_ever)
	Colonial Relationship after 1945 (col_45; $CLNY$)	=1 if country pair in a colonial relationship af 1945 (colony_of_origin_after45 and colony_of_destination_after45)
	Preferential Trade Agreement (agree_pta; PTA)	=1 if country pair is in at least one active preferential trade agreement
Rauch Product Classification[3]		Excel file of Rauch (1999) product classification
	Product (sitc4)	4-digit SITC Revision 2 product code
	Liberal Classification (lib)	=n if differentiated good, =w if homogenous good; liberal aggregation
	Conservative Classification (con)	=n if differentiated good, =w if homogenous good; conservative aggregation

1. Available at https://comtrade.un.org/data 2. Available at https://www.usitc.gov/data/gravity/dataset.htm
3. Available at https://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html#Rauch
Replication instructions and files are hosted on Ryan Lee's github page: https://github.com/rlee1390/ShortRun-Differentiation-Paper-Code