The Gravity of Experience*

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Abstract

In this paper, we establish the importance of experience in international trade in reducing unmeasured trade costs and facilitating bilateral trade. We find a strong role for experience, measured in years of positive trade, for both aggregate and sectoral bilateral trade. In an augmented gravity framework, with a very comprehensive set of fixed-effects and trend variables, we find that a 1% increase in experience at the country-pair level increases bilateral exports by 0.417% and reduces trade costs by 0.105%. Non-parametric estimates imply that nine years of experience is equivalent to a country-pair joining a preferential trading area. We show that experience matters more for country-pairs that are distant, non-contiguous, do not share a common language, lack colonial links, and legal ties to one another. Subsequently, we construct microfounded measures of trade costs and show how these decline with the accumulation of experience. Our results are consistent with experience reducing the bilateral unmeasured variable costs of trade and experience shared across firms and industries.

JEL Classification: F10, F14

Keywords: Gravity model; Dark trade costs; Experience; Extensive and intensive margin

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1 Introduction

The gravity model analyzing bilateral exports between country-pairs has traditionally been used to understand the role of trade costs. However, the underlying importance, the persistence, and heterogeneous incidence of various gravity variables for trade flows remain poorly understood (Head and Mayer, 2013). Multiple studies have identified a persistent and even rising role for gravity variables for cross-border trade such as distance, borders, language, and colonial ties (Disdier and Head, 2008; Egger and Lassmann, 2012; Head, Mayer and Ries, 2010; Head and Mayer, 2014). To reconcile the persistent effects of such gravity variables, prior work often alludes to informational and contracting costs, cultural differences, and the importance of business and social networks in overcoming informal barriers to international trade (Greif; 1994; Rauch, 1999; Chaney 2014). Head and Mayer (2013), drawing on the analogy of dark matter, coin the term 'dark trade costs' and argue that these gravity variables capture some unmeasured and unknown sources of resistance.[1]

In this paper, we introduce a new perspective on trade costs. We take as given that there are some unobserved or 'dark' trade costs, some of which are captured by traditional gravity variables, while others are embedded in the error term. We show that a key factor driving the decline in such bilateral trade costs is the cumulative experience in exports. When a country starts exporting to a new destination, a large component of trade costs is related to the novelty and uncertainty of selling in an unfamiliar environment, identifying customer preferences, engaging with foreign shipping agents, customs officials or consumers, and navigating an uncharted legal and regulatory context (see Anderson and van Wincoop, 2004; Kneller and Pisu, 2011). Experience from repeated local interaction can be effective in gaining familiarity, acquiring information, and building contacts. In turn, this reduces trade costs and expands bilateral trade flows.

We first measure dark trade costs as the ratio of predicted bilateral exports (from a standard gravity specification) to actual bilateral exports. The extent to which actual trade falls short of

[1]Head and Mayer (2013) show that 72% − 96% of the trade costs associated with distance and borders are attributable to the dark sources (read unknown) sources of resistance. Some papers attempt to directly incorporate these forces through networks (Rauch and Trindade, 2002), immigration links (Bastos and Silva, 2012), contractual enforcement problems (Anderson and Marcouiller, 2002), corruption (Dutt and Traca, 2010), learning (Allen, 2014 and Chaney, 2014), or bilateral trust (Guiso, Sapienza and Zingales, 2009).

predicted trade can be seen as a variable that includes unmeasured dark trade costs, and other idiosyncratic reasons why trade is higher/lower than expected. In a non-parametric specification, we show that these unmeasured dark trade costs decline consistently with experience measured by 58 dummy variables, each capturing the number of years the origin has been exporting to the destination.

Our core empirical specification augments the bilateral gravity equation to account for the role of experience, measured at the bilateral level. We measure experience in two ways: the number of years of strictly positive exports and the cumulated value of past exports. At the bilateral level, we have sufficient variation in experience, both across countries and over time, which allows us to measure experience precisely and identify its importance in lowering trade costs and increasing trade.[2]

Experience is, of course, an endogenous variable. Interpreting the estimates of experience as causal in the gravity setting requires that experience at the country-pair level is exogenous to unobserved bilateral trade costs. This is challenging in our context since omitted variables affect both the current value of trade and our experience measures. We account for these challenges by using demanding specifications that include country-year fixed effects, country-pair fixed effects, and, additionally, country-pair specific trends. Our baseline specification is a difference-in-difference specification, where we rely on variation in experience within country-pairs over time to identify the coefficient. We find an elasticity of trade with respect to experience of 0.417 for the OLS specification and 0.576 for the Poisson Pseudo-Maximum Likelihood (PPML) specification.[3] The OLS (PPML) estimates imply that for a country-pair at the median level of experience (6 years of positive trade), an additional year of trade increases bilateral exports by 6.5% (9.9% for PPML). For countries in the 75th percentile of experience (19 years of positive trade), an additional year of trade increases bilateral trade by 1.8% (2.8% for PPML) so we have diminishing returns to experience.

[2] Data on bilateral trade are consistently available from 1948. By contrast, firm-level trade data on export experience are usually confined to exporters from a single country and are available only for a few years. For instance, Roberts and Tybout (1997) use 9 years of data from Colombia, Albornoz et al (2012) use 5 years of data from Argentina, Timoshenko (2015) uses 10 years of data from Colombia, Fernandes and Tang (2015) use 6 years of data for China. With firm-level data, there are also censoring and selection issues.

[3] This is equivalent to a 0.105% decline in trade costs.

Incorporating lagged dependence, our OLS estimates imply that a 1% increase in experience reduces unmeasured trade costs by 0.05% in the short-run and by 0.07% in the long-run.

We also show that experience matters more for country-pairs that are geographically distant, non-contiguous, lack colonial ties, and do not share a common language or a common legal system. Country-pairs that lack such ties are also ones that have higher unobserved trade costs. To the extent that experience reduces trade costs, experience plays a stronger role in facilitating bilateral trade.

The use of aggregated bilateral trade data does not allow us to account for composition effects, which could bias our results on the role of experience in increasing trade. Sectors with a lower elasticity with respect to distance could be trading more over time due to specialization. To control for this possibility, we run our augmented gravity equation using country-product-level data at the 4-digit level of disaggregation. We deploy multiple fixed-effects that allow us to control for a plethora of omitted variables. This allows us to account for composition effects, control for product-specific taste shifters in the destination, productivity improvements in particular sectors reflecting comparative advantage in the origin, and even time-varying bilateral trade costs. Consistently, we find that in the most demanding specifications, experience measured in terms of years of positive trade has a strong influence on exports. Experience measured as past cumulated trade has a negative impact on bilateral exports once we account for exporter-importer-industry fixed effects (identification relies on variation in experience within pair-industries over time.)

Motivated by our empirical findings for bilateral trade, we decompose the effect of experience on bilateral exports into an effect on the extensive (number of products at the 6-digit level) and on the intensive (average exports per product) margins of trade. Within a standard Melitz-Chaney heterogeneous firm model, this allows us to understand whether exports reduce fixed and/or variable costs of trade and whether experience is shared across firms. We find a positive effect of experience on the extensive margin and a negative but insignificant effect on the intensive margin. Such a finding suggests a) experience is shared across firms since the extensive margin adjusts, and b) that experience reduces the bilateral variable costs of trade since the intensive margin does not change. Next, we measure bilateral trade costs relative to domestic trade costs directly using the methodology in Head and Ries (2001) and show that experience reduces these trade costs, especially the non-tariff component, which corresponds more closely to unmeasured trade costs. Finally, we use a new structural gravity methodology from Agnosteva, Anderson and Yotov (2019) to construct Unexplained Trade Barriers (UTBs) and relate this to experience, demonstrating that these unexplained trade barriers decline with bilateral export experience.

Our paper contributes to the trade costs and gravity literature in three ways. First, even after controlling for sunk trade costs, we find a role for experience in bridging "unmeasured" trade costs within the gravity framework. We show that experience matters most for country-pairs that are remote - those who are geographically distant, do not share borders, a common language, colonial links, etc. This channel introduces a dynamic aspect to trade costs, as these barriers are overcome over time with accumulated experience. Second, experience enables countries to expand trade primarily along the extensive margin by enabling exports of a larger set of products. Third, we provide evidence that the effects of experience are shared among exporters and non-exporters, which complements the recent literature focusing on the role of networks and search in export decisions (Eaton, Eslava, Krizan, Kugler and Tybout, 2012; Chaney, 2014).

The remainder of the paper is organized as follows. Section 2 augments the traditional gravity specification with experience at the bilateral level; Section 3 presents our empirical estimates at the bilateral level utilizing a series of identification strategies and placebo tests; Section 4 shows estimates with 4-digit sectoral data; Section 5 relates experience to trade costs, both indirectly by examining the margins of trade and directly by using microfounded measures of trade costs; Section 6 concludes.

2 Gravity Equation

We estimate the following gravity equation for exports from origin o to destination d at time t, the current workhorse for estimating the importance of trade costs for bilateral trade.

$$\ln X_{od,t} = \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \theta \ln \tau_{od,t} + e_{od,t} \tag{1}$$

$\mu_{o,t}$ and $\mu_{d,t}$ are exporter and importer-year dummies that capture output/expenditure in the exporting- and the importing-country, respectively, and the two multilateral trade resistance terms. The parameter $-\theta$ is the elasticity of bilateral exports with respect to trade costs $\tau_{od,t}$. Finally, $e_{od,t}$ is an error term. Several theoretical frameworks support the gravity specification. For instance, Anderson and van Wincoop (2003) in a model where goods are differentiated by origin deliver the following expression for exports $X_{od,t}$ from country o (exporter/origin) to country d (importer/destination) in time t,

$$X_{od,t} = \frac{Y_{o,t}E_{d,t}}{Y_t}\left(\frac{\tau_{od,t}}{P_{d,t}\Pi_{o,t}}\right)^{-\theta} \tag{2}$$

Here $\theta = \sigma - 1$ where σ is the elasticity of substitution among goods from different countries, $Y_{o,t}$ is the value of production in origin, $E_{d,t}$ is expenditure in destination, $P_{d,t}$ and $\Pi_{o,t}$ are the multilateral trade resistance terms, Y_t is world output and $\tau_{od,t}$ are bilateral trade costs. Other microfounded gravity models yield a similar equation with varying interpretations of θ. It equals the parameter in the Pareto distribution of firm productivity in Chaney (2008) and the parameter governing the dispersion of labor requirements across goods and countries in Eaton and Kortum (2002). As is standard, $\ln \tau_{od,t}$ is specified in terms of bilateral gravity variables, as shown below.

$$\ln \tau_{od,t} = \sum_{m=1}^{M} \gamma_m z_{od,t}^m \tag{3}$$

where $z_{od,t}^m$ are the M gravity variables and γ_m are parameters. Substituting (3) into (1) yields an estimable specification

$$\ln X_{od,t} = \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + e_{od,t} \tag{4}$$

To the extent that many terms in $z_{od,t}^m$ capture time-invariant bilateral trade costs, all specifications include bilateral time-invariant fixed effects. This also reduces endogeneity concerns related to variables included in $z_{od,t}^m$ such as membership in a preferential trading arrangement. Our estimating equation becomes

$$\ln X_{od,t} = \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + \varepsilon_{od} + e_{od,t} \tag{5}$$

where all time-invariant pair-specific gravity variables including distance, contiguity, shared language and legal systems, and colonial links are subsumed in ε_{od}.

Helpman, Melitz, and Rubinstein (2008) and Haveman and Hummels (2004) highlight the prevalence of zero bilateral trade flows. For the bilateral data, 39% of all possible bilateral trade flows show a zero value. Unobserved trade costs can endogenously create zeros, and taking logs removes them from the sample, creating selection bias. Santos Silva and Tenreyro (2006) also show that a log-linear specification of the gravity model in the presence of heteroskedasticity leads to inconsistent estimates. We follow them and use the Poisson Pseudo-Maximum Likelihood (PPML) to estimate the following equation

$$X_{od,t} = \exp\left[\alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + \varepsilon_{od}\right] * e_{od,t} \tag{6}$$

We estimate these equations using data on bilateral trade flows from IMF's *Direction of Trade Statistics* DOTS. The data covers trade flows from 208 exporters to 208 importers over the time period 1948-2006.

2.1 'Dark' Trade Costs and Experience

We first estimate equations (5) and (6) within a standard specification without any measures of export experience. We include four time-varying bilateral variables in $z_{od,t}$. Multilateral market access is captured with a dummy variable that takes the value 1 if both trading partners are members of the GATT/WTO and 0 otherwise. Bilateral preferential trade arrangements are captured by a dummy variable which takes the value 1 if both trading partners are members in a preferential trade arrangement (PTA) and 0 otherwise. Data on WTO membership and PTAs are from the CEPII and updated via the WTO website (www.wto.org). Unilateral preferential access is in terms of the Generalized System of Preferences (GSP) where trade preferences are granted on a non-reciprocal basis by developed countries to developing countries. We code a dummy variable as 1 if the importing county grants a GSP to the exporter. GSP data are from the WTO website. We also use a dummy variable that captures co-membership in a currency union. Currency union data are from Andrew Rose's website.

We estimate (5) and (6) and predict bilateral trade as $\widehat{X}_{od,t}$, which captures the effect of all measured trade costs—including time-invariant bilateral trade costs—on bilateral trade. Next, we calculate the ratio $\frac{\widehat{X}_{od,t}}{X_{od,t}}$, which shows the extent to which predicted trade falls short of actual trade, and we take it as a proxy for unmeasured trade costs. We take the log of this expression and regress it on a complete set of 58 dummy variables, one for the number of years of strictly positive trade between a country-pair, with 0 years of experience as the omitted category.[4] Such a non-parametric specification of experience is flexible in that it makes no functional form assumption, captures depreciation in experience, and allows for diminishing returns in experience.

Figure 1A plots the coefficient estimates for each of the years of experience along with error bars as ± 2 standard deviations for the OLS specification; Figure 1B plots it for the PPML specification. For both specifications, we observe a consistent and significant decline in this proxy for dark trade costs with experience. The R^2 is 0.31 (0.33) for the OLS (PPML) specification, so the number of years of positive trade explains 31-33% of the decline in unmeasured trade costs across countries over time.

Within a bilateral pair, residuals sum to zero. Experience (necessarily) monotonically increases over time. This, in turn, implies that positive residuals (the extent to which actual trade exceeds predicted trade) tend to appear late in a trading relationship. This is not an artifact of trade increasing over time as the specification employs country-year fixed effects. Given that bilateral experience for a country-pair is highly correlated with country-year fixed effects for dyads in an unbroken trading relationship, this suggests that what we observe is the initiation of new trading relationships that start off small and gain momentum over time.

[4] We use such a two-step process for ease of interpretation. The log of this expression measures the negative of the residuals of the gravity equation.

2.2 Experience Measures in the Gravity Specification

A recent literature examines the role of export experience of firms in international trade. Exporting to a new geographic market entails the discovery of (i) the cheapest, most reliable transport; (ii) the best way to get goods through customs, (iii) the right partner for distributing and promoting the goods locally, or (iv) the preferences and dispositions of customers. Although firms may engage in pre-entry research, experience is a vital element of this discovery process, with prior experience in a destination facilitating a reduction in fixed (some of which may be sunk) and variable trade costs.[5] The initial contact with a new market environment unavoidably raises unexpected challenges that push the firm to find quick, imperfect solutions. Experience with the local reality helps the firm gain familiarity and find better, cheaper solutions for future shipments, thereby lowering trade costs. Artopoulos et al. (2013) interview exporters and find that the biggest obstacle to exports is the lack of information about foreign distributors and uncertainty about demand for products. Similarly, Kneller and Pisu (2011) use survey data to identify barriers to exports and show that the best predictor of whether a particular firm identifies an export barrier as relevant is explained almost exclusively by the number of years the firm has been exporting.

Eaton et al. (2012) and Freund and Pierola (2010) emphasize learning in a destination country, where producers encounter costs to find new buyers or new products and uncover idiosyncratic costs. In contrast, in Albornoz et al. (2012), uncertainty is not destination-specific, and firms learn about export profitability as a whole. Allen (2014) models a search process to acquire market information. Das, Roberts and Tybout (2007) and Schmeiser (2012) model entry costs and show that previous export status affects export supply responses. These papers may differ in terms of whether export experience facilitates learning about trade costs or distribution network costs, or demand preferences in the destination market, but they all highlight the role of export experience for export supply decisions.

Multiple empirical papers link firm exports to experience, measured as the number of years of export presence (Meinen, 2015; Ruhl and Willis, 2017; Berman, Rebeyrol, and Vicard, 2018;

[5] While large sunk costs have been used to explain why only few firms enter export markets and account for persistence in exporting, it fails to account for short-lived trading relationships (see Besedes and Prusa, 2006.)

Timoshenko, 2015; Bastos, Dias and Timoshenko, 2016). Others use more flexible specifications that include multiple categorical variables for each year of past firm export presence (e.g., Roberts and Tybout, 1997). Therefore, our first measure of experience is simply the number of years of strictly positive bilateral exports from origin to destination, which corresponds to the export age measure in the firm-level literature.

In the IO literature, learning-by-doing is measured as past cumulated output (lagged by a year) with variable and marginal costs declining with experience in production (e.g., Levitt, List and Syverson, 2013). Therefore, as a second measure we measure experience as the cumulated value of past exports. The advantage of the time-based measure of experience is that it is less prone to measurement error (we use multiple datasets to confirm that there was positive bilateral trade between each country-pair in each time period) and is not influenced by the unit value of exports. A disadvantage is that the time-based measure of experience does not distinguish between small and large shipments. Past cumulated value of exports distinguishes between small and large shipments, captures the intensity of experience, and has more variation that aids in identification. However, it is prone to measurement errors (different datasets report a different value of bilateral trade; agencies use different lower bounds for recording a shipment that varies across data sources) and is influenced by the unit value of exports. Experience based on past cumulated exports would also be influenced by changes in the sectoral composition of a country's exports, both in terms of comparisons across countries and its evolution in time, creating potential spurious variation.[6]

Our two experience measures are given by

$$E^{time}_{od,t} = \sum_{\tau=1}^{t} I_{od,t-\tau};\ E^{value}_{od,t} = \sum_{\tau=1}^{t} X_{od,t-\tau}$$

where $I_{od,t} = 1$ if there are strictly positive exports from o to d at time t, and 0 otherwise. We use the DOTS database to construct the experience measures. To attenuate concerns regarding measurement error for $E^{time}_{od,t}$, we confirmed zero trade flows using an alternate dataset from the

[6]Subsequently, we analyze disaggregated trade flows between countries at the four-digit level where changes in composition and unit values are less of a concern.

Correlates of War (COW) Project (Barbieri, Keshk and Pollins, 2012).[7]

We have 1,105,862 observations spanning 29,783 country-pairs. $E_{od,t}^{time}$ takes values from 0 to 58, with a mean of 11.6 years of experience and a median of 6 years. In our sample, 5% of country-pairs have zero experience over the entire time period while 5.6% of country-pairs trade for exactly one year. At the other extreme, 23% of country-pairs exhibit continuous trade over the years in our sample, so 77% of country-pairs experience at least one break in trading experience. We have very few instances where there is a pause in experience and trade never restarts. Instead, 70% of country-pairs stop and restart trade over the time period of our sample. Of these breaks in experience, 43% are for exactly one year, while 82% are for less than 5 years. Overall, we have rich variation in experience, including country-pairs that trade continuously, pairs with multiple breaks in experience, most of which span 1-5 years, and therefore, multiple instances where trade stops and restarts. Given the skewed nature for both experience measures and a spike at zero, we follow Card and DellaVigna (2020) and use the inverse hyperbolic sine (arcsin) of the experience measure. The arcsin function closely parallels the natural logarithm function (accounting for skewness) and is well defined at 0.[8] [9]

We use the experience measures one at a time, given the high multicollinearity between the two variables (correlation equals 0.93). Therefore, the experience-adjusted specification for trade costs becomes

$$\ln \tau_{od,t} = \sum_{m=1}^{M} \gamma_m z_{od,t}^m - \lambda \ln E_{od,t} \tag{7}$$

where $E_{od,t} \in \left\{ E_{od,t}^{time}, E_{od,t}^{value} \right\}$.

[7] In constructing the experience variable, we coded all countries that were formerly part of the Soviet Union, Czechoslovakia and Yugoslavia as new countries and set experience to zero in their first year of trade after 1992. The exceptions are trade with the Soviet Union which was merged with Russia and with West Germany which was merged with Germany. These choices, while reasonable since exporters plausibly faced a new environment, may create measurement error in experience. Our results are robust to dropping these countries.

[8] $\operatorname{arcsin} h(z) = \ln\left(z + \sqrt{\left(1+z^2\right)}\right)$. For $z \geq 2$, $\operatorname{arcsin}(z) \approx \ln(z) + \ln(2)$, but $\operatorname{arcsin}(0) = 0$. In the estimating equations, we denote it as ln for the sake of exposition.

[9] $E_{od,t}^{time}$ for country-pairs with continuous trade for 58 years from 1948-2006 will be perfectly collinear with their country-year fixed-effects.

With aggregate trade, two assumptions underlie our estimation specification. First, we are giving equal weight to all years of past trade, so we do not allow for the depreciation of experience or "forgetting." It is plausible that after some years of zero trade, experience is reset to zero. We evaluate this by implementing a semi-parametric specification where we enter each of the $I_{od,t}$ separately, allowing for both depreciation in experience and a flexible functional form for experience (instead of taking the log of the past cumulated indicator variables for positive trade).[10] Second, experience at the bilateral level is an aggregation of firm-level experience. Experience, in addition to benefiting the firm, is also likely to be shared among networks of firms (Chaney, 2014; Eaton et al., 2012; Koenig 2009; Iacovone and Javorcik, 2010). Prior work shows that experience acquired historically by some exporters contributes to increased familiarity by fellow exporters and even crosses over to non-exporters (Clerides, Lach and Tybout,1998). We evaluate the sensitivity of our results by measuring whether experience is shared across firms directly with disaggregate 4-digit trade data and indirectly examining how experience differentially affects the extensive vs. intensive margins of trade.

Substituting (7) into (1) yields an estimable specification for the gravity equation that accounts for the effect of experience.

$$\ln X_{od,t} = \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + \theta\lambda \ln E_{od,t} + \varepsilon_{od} + e_{od,t} \tag{8}$$

The coefficient $\theta\lambda$ is the experience elasticity of trade with respect to experience measure with $0 < \theta\lambda < 1$ implying a positive but diminishing role of experience for bilateral trade.

[10] We also followed Levitt, List and Syverson, 2013 and directly estimated a retention parameter for experience. We estimated the gravity equation along with experience at time t by accumulating according to a perpetual-inventory process:

$$E_{od,t}^{time} = I_{od,t-1} + \delta E_{od,t-1}^{time}$$

where δ parametrizes the fraction of experience that is retained from one period to the next (our specifications assume $\delta = 1$, indicating complete retention). We estimated this equation and the gravity equation jointly using non-linear least squares and obtained estimates of δ ranging from 0.905 to 0.995. These estimates are substantively close to 1.

3 Experience and Bilateral Exports With Aggregate Data

3.1 Baseline Results

Our baseline specification in equation (8) uses exporter-year and importer-year fixed effects which absorb any effects that are particular to changes in variables at the exporter-year and the importer-year level. Similarly, the inclusion of unobserved dyadic effects captures all time-invariant bilateral costs. It also helps us with concerns that any exporter, importer, or pair-specific shocks that affects both the onset of trade (hence our experience measure) and trade today, would lead to an upward bias in our coefficient on experience. In such a difference-in-difference specification, we rely on variation in experience within country-pairs for identification. Columns 1-4 of Table 1 show results with $E^{time}_{od,t}$ while Columns 5-8 use $E^{value}_{od,t}$ as the measure of experience.

Column 1 of Table 1 shows that the experience elasticity of trade is 0.345 for experience measured in years. This estimate implies that for a country-pair with the median level of experience (6 years of positive trade), an additional year of trade increases bilateral exports by 6.49%. For countries in the 75th percentile of experience (19 years of positive trade), an additional year of trade increases bilateral trade by only 1.88%, indicating both depreciation of experience and diminishing returns to experience for bilateral trade.

The estimate in Column 1 with time-invariant dyadic effects is a difference-in-difference estimate whose reliability hinges on the common trends assumption - that bilateral trade between two country-pairs would have evolved similarly in the absence of different levels of experience. A common reason for the failure of the common trend assumption is the presence of individual or group-specific trends. Therefore, we add pair-specific linear time-trends, one for every country-pair in Column 2. Such a specification accounts not only for all time-invariant characteristics at the dyadic level but also for any unobserved country-pair specific variables that evolve in a linear fashion. For instance, if we believe that measured trade barriers between country-pairs decline in a gradual fashion (e.g., elimination of tariffs after joining a trading arrangement happens only gradually), these should be accounted to some extent, though not entirely, by the pair-specific trends.[11] We estimate

$$\ln X_{od,t} = \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + \theta\lambda \ln(E_{od,t}) + \varepsilon_{od} + \varepsilon_{od} * t + e_{od,t} \tag{9}$$

Column 2 estimates the experience elasticity of trade as 0.417, a slight increase in the coefficient of experience. The introduction of pair-specific trends means that these trend terms absorb much of the variation in experience for countries with a long history of trade. Identification, therefore, relies on country-pairs for which we have either short periods of positive trade or where we observe start-stop patterns in experience. Given the diminishing returns to experience, with the trend terms, we should observe a stronger role for experience measured in terms of years of positive trade.

Next, following Oliviero and Yotov (2012) and Eichengreen and Irwin (1998), we include the lagged dependent variable as an additional regressor. Such a variable accounts for slow-moving unobserved dyadic influences on trade, which would not be captured by the country-pair fixed effects. More importantly, as Eichengreen and Irwin (1998) argue in the context of bilateral trade and Roberts and Tybout (1997) emphasize for firm-level supply decisions, such a lagged dependent variable would capture sunk costs of trade that can be associated with persistent increases in the volume of trade rather than a decline in unmeasured trade costs as we argue here. If all unmeasured trade costs are sunk, our experience measure should not matter once we account for the lagged dependence. However, sunk costs do not preclude the existence of recurring unmeasured trade costs that also drive export supply decisions. For instance, we can think of sunk costs as adapting the domestic production process to serve particular destinations, while recurring costs could include the distribution and marketing costs in the destination.

Our estimating equation becomes

$$\ln X_{od,t} = a \ln X_{od,t-1} + \alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M} \theta\gamma_m z_{od,t}^m + \theta\lambda \ln(E_{od,t}) + \varepsilon_{od} + e_{od,t} \tag{10}$$

Such specification with a lagged dependent variable also allows us to distinguish between the short

[11] The trend is calculated over all observations including the observations where there is no trade between a country-pair.

vs. long-run effect of experience. The long-run experience elasticity of trade is given by $\frac{\widehat{\theta\lambda}}{(1-\widehat{a})}$.

Columns 3 (without pair-specific trends) and 4 (with pair-specific trends) in Table 1 show that the coefficient on the lagged dependent variable is both statistically and substantively significant. The (short-run) coefficient on experience declines significantly in the presence of the lagged dependent variable while the long-run experience elasticity of trade equals 0.243 in Column 3 and 0.285 in Column 4, comparable to the estimates in Columns 1 and 2.[12]

We set $\theta = 4$ consistent with the literature's interpretation as elasticity of substitution minus one (Anderson and van Wincoop, 2003), the Pareto shape parameter (Chaney, 2008) or the parameter governing the dispersion of labor requirements across goods and countries (Eaton and Kortum, 2002). From Column 4, our short-run estimate of $\theta\lambda^{time} = 0.18$ which implies $\lambda^{time} = 0.05$ so a 1% increase in experience leads to a decline in trade costs by 0.05% in the short-run. In the long-run, a 1% increase in experience reduces trade costs by 0.07%, which is economically substantive. For the rest of the paper, we use these coefficient estimates as our benchmark estimates.[13]

Given the functional form assumptions embedded in the estimates in Columns 1-4, we next adopt a semi-parametric approach and estimate equation (10) but replace $\ln(E_{od,t}^{time})$ with a complete set of 58 dummy variables, one for the number of years of strictly positive trade. This specification is flexible in that it makes no functional form assumption, captures depreciation in experience, and allows for diminishing returns in experience. With 0 years of trade as the omitted category, each coefficient captures the cumulated impact of experience on bilateral trade for a country-pair relative to a country-pair with zero experience. The coefficient estimates (and 95% confidence intervals) for the experience dummies are plotted in Figure 2, with the number of years of experience shown on the horizontal axis. With one lag of the dependent variable, we can only identify coefficients for

[12] The Least Squares Dummy Variables estimator is inconsistent in the presence of lagged dependent variables (the Nickell bias). From Nickell (1981), $\lim(\widehat{a} - a) = \frac{(1+a)}{(T-1)}$ where $\widehat{a}$ is the estimate of the lagged dependent variable, N is the number of country-pairs and T is the number of time periods. At the median value of $T = 39$ across country-pairs, the bias is quite minimal. For instance, if $a = 0.7$, then the bias is -0.04 which is not very high. We also estimated specifications without pair-specific fixed effects in the Appendix to the paper. The coefficient on $E_{od,t}^{time}$ equals 0.315 close to the estimate in Column 1 of Table 1.

[13] In Section 5, we show that experience increases the extensive margin of trade but not the intensive margin. The results are consistent with experience shared across exporters and reducing the variable costs of trade. To the extent that entry by new exporters takes time, we would expect that the long-run effect to be larger than the short-run effect .

2-58 years of experience.

Figure 2 illustrates three findings. First, experience has an insignificant impact on bilateral trade for the first three years. This mirrors the firm-level export literature findings that there are many short-lived entry and exit of exporters initially. After that, all the experience dummies are positive and significant. Second, in terms of magnitude, the coefficient estimates imply a very strong role for experience. For a country-pair with the median level of experience (6 years of positive trade), an additional year of trade increases bilateral exports in the long-run by 4.6%. Ten years of experience increase bilateral trade by 32% in the short-run and by 68% in the long-run, compared to a country-pair that has yet to initiate trade. Another way to think of the magnitude is that 9 years of experience is equivalent to a country-pair joining a preferential trading area, while 7 years of experience is equivalent to sharing a common currency.[14] Third, the relationship seems approximately log-linear, which supports using the log of the experience variable.

Columns 5-8 use $E_{od,t}^{value}$ as the experience measure. We obtain a positive and significant coefficient on experience measured as cumulated past trade in all specifications. The coefficient declines substantially when we add the pair-specific trend terms or the lagged dependent variable as a regressor (compare Columns 6 and 7 to Column 5).[15] In the presence of the pair-specific trends (compare Columns 7 and 8), adding the lagged dependent variable does not affect the magnitude of the coefficient. A plausible interpretation is that the trend term and the lagged dependent variable capture similar dynamics in pair-specific bilateral trade.

Overall, we find that experience as measured in terms of number of years of positive exports matter strongly for bilateral trade, especially in more demanding specifications that account for a comprehensive set of fixed effects, sunk costs of trade, and hysteresis in trade.[16]

[14] We base these comparisons on estimates for PTA and common currency areas from Head and Mayer (2014).

[15] To reduce multicollinearity, when we include the lagged dependent variable, we cumulate the past value of trade to period $t-2$ so that $E_{od,t}^{value} = \sum_{\tau=2}^{t} X_{od,t-\tau}$.

[16] Our experience variable is right-censored at 58 years of continuous trade. To account for the right-censoring, we added a dummy variable for all censored observations. Including this dummy does not change the sign, significance, or magnitude of the estimates. We also used an alternative dataset from the Correlates of War (COW) Project that tracks bilateral trade from 1870-2006 (Barbieri, Keshk and Pollins, 2012). Relying on this data to construct experience may mitigate the right-censoring concern. However, the COW data, by going further back in time, requires fairly strong assumptions about shifts in country identities through division, unification, and emergence from colonial rule. Of more concern is the fact that COW provides trade data on former colonies in Asia, Africa and Latin America only

3.2 Accounting for Zeros and Heteroskedasticity

Unobserved trade costs can endogenously create zeros, and taking logs removes them from the sample, creating selection bias. Therefore, we deploy a Poisson pseudo-maximum-likelihood (PPML) specification that takes into account the information contained in the zero trade flows. It simultaneously controls for the problem of inconsistent estimates arising from heteroskedasticity in the log-linear specification of the gravity model (Santos Silva and Tenreyro, 2006).

For PPML specification, with the bilateral exports measured in levels, we estimate

$$X_{od,t} = \exp\left[\alpha_{o,t}\mu_{o,t} + \alpha_{d,t}\mu_{d,t} - \sum_{m=1}^{M}\theta\gamma_m z_{od,t}^m + \theta\lambda\ln\left(E_{od,t}\right) + \varepsilon_{od}\right] * e_{od,t} \tag{11}$$

Including lagged dependent variables in a PPML specification raises various estimation issues. In a standard Poisson model, the conditional mean is required to remain positive. As Blundell et al. (2002) point out, the functional form of the lagged dependent variable in the exponential function becomes critical. In our context, if we use levels of the lagged dependent variable, then it can potentially lead to an explosive series and issues of convergence. Alternately, if we use a log-transformation of the lagged dependent variable, then the problem of zeros in the trade matrix persists. The use of the lagged log-transformation with Poisson will continue to drop a substantial fraction of zeros (though not all).[17] A final option is to use the inverse hyperbolic transformation of the lagged dependent variable, but this creates convergence issues. For instance, in a specification with pair-effects plus pair-specific trends, PPML does not converge.[18] Therefore, we estimate (11)

when they become independent. In contrast, the DOTS data provides data for these countries prior to colonization. Therefore, experience constructed on the basis of COW data is also not free of measurement error. When we use the COW based measure of experience in terms of number of years of positive trade, the coefficient on experience is 0.261 (without pair-specific trends) and 0.219 (with pair-specific trends).

[17] For instance, the OLS specification in Columns 3 and 4 of Table 1 with lagged dependent variable, the number of observations equals 568,562. In a corresponding Poisson specification, the number of observations equals 616,524. In both, we fail to take into account the zeros in the trade matrix.

[18] The PPML estimator with lagged dependent variables is biased. While this bias in the Least Squared Dummy Variable approach used in Table 1 goes to zero for large number of time periods, this is no longer the case with Poisson estimation. Wooldridge (2005) highlights the initial conditions problem in dynamic models. Dynamic panel models require additional assumptions about the relationship between the initial observations ("initial conditions") on trade in levels and the pair-specific fixed effects. Unlike linear models with lagged dependent variables where first-differencing (e.g., Arellano-Bond) eliminates these unobserved time-invariant terms, there are no known transformations in the

without lagged dependent variables. In an Appendix to the paper, we report results with various specifications for the lagged dependent variable as an additional regressor.

Column 1 in Table 2 shows that the experience elasticity of trade (measured in terms of years of trade) is 0.516 so that unmeasured trade costs decline by 0.13% for a 1% increase in experience. The estimate implies that for a country-pair at the median level of experience (6 years of positive trade), an additional year of trade increases bilateral exports by 9.86%. For countries in the 75th percentile of experience (19 years of positive trade), an additional year of trade increases bilateral trade by only 2.83%, again indicating diminishing returns to experience. Adding pair-specific trends in Column 2, increases the elasticity of trade for experience marginally to 0.576.[19] In Columns 3 and 4, with experience measured as cumulated past exports, the coefficient again increases substantially compared to the estimates in Table 1.

3.3 Placebo Tests

Next, we carry out a series of placebo tests where we replace export experience with experience measures that should not matter for bilateral trade. First, we examined whether the *importing* experience of country o from d matters for *exports* from o to d. To the extent that trade costs are symmetric and information flows easily across bilateral ties, import experience may be highly collinear with export experience and may also matter for bilateral exports. However, it should matter less than export experience. Row 1 of Table 3 uses the OLS specification in equation (10) with comprehensive dummies and shows that while importing experience measured in terms of imports by o from d matters, the coefficient is approximately one-fifth of that on export experience in Columns 4 and 8 of Table 1.[20]

Second, we assigned each exporter's experience in a particular destination to the alphabetical neighbor of the exporter from the same region. Row 2 shows insignificant coefficients on the placebo

Poisson model that eliminates the unobserved fixed effects.

[19] Our estimates are not directly comparable with firm-level evidence on the importance of export experience since much of the literature focuses on export participation decisions (e.g., Roberts and Tybout, 1997; Timoshenko, 2015; Meinen, 2015; Iacovone and Javorcik, 2010). At the same time, much of our findings are consistent with this literature - that export experience matters even when accounting for sunk costs.

[20] If we include both export and import experience, then only export experience matters.

experience measures. In Row 3, we assign the experience of the origin to the alphabetical neighbor of the destination from the same region. Again, we obtain insignificant coefficients on the placebo experience measures. Overall, these placebo tests demonstrate that it is the experience of the exporter in the destination that really matters for bilateral exports.

Finally, our experience measure may simply be a proxy for deeper integration between country-pairs such as harmonization of worker, product and environmental standards, IP regulations, tax rules, etc. In fact, recent preferential trading arrangements increasingly emphasize these issues over formal trade barriers. As such, experience may be unrelated to unobserved pair-specific trade costs. To examine this, we replace the dependent variable with a measure of bilateral FDI stock from CEPII, available for a single year 2004.[21] We find a strong *negative* role for experience (see Row 4 of Table 3). To the extent that export experience facilitates bilateral trade by reducing trade costs, our finding is consistent with the contention that FDI and exports are substitutes for serving a particular destination.

3.4 Heterogeneous Effect of Experience

In our baseline specification, standard gravity variables such as distance are absorbed in the country-pair dummies. To the extent that these gravity variables are proxies for unobserved trade costs, we should also expect a higher coefficient on experience when countries are remote in the sense that they are geographically distant, non-contiguous, do not share a common language, or have past colonial links. This would also support our contention that the mechanism by which experience matters is via overcoming trade costs. We examine this by estimating our model for sample splits based on each gravity variable. All splits are based on binary gravity variables except distance. For distance, we split the sample into four sub-samples based on the quartiles of distance.

Table 4 shows that experience is significant for non-contiguous but insignificant for contiguous country-pairs. For the other gravity variables, experience has a bigger coefficient for dyads that do not share a colonial relationship, do not share a common language, or a common law legal system.

[21] In this cross-section, we include only exporter and importer fixed-effects, and a standard set of bilateral gravity variables.

The effect of experience is monotonic in distance - experience has a bigger impact in countries that are more distant from each other. Overall, our results are in line with our contention that experience matters more for countries that are remote as measured by standard gravity variables. The third column tests whether the coefficient on experience is significantly larger in Column 1 compared to Column 2 for each sub-sample split. Except for contiguity, we find that the coefficient for experience is significantly higher when the variable takes the value 0. For distance, we cannot reject the null that the coefficients are significantly different for the neighboring quartiles. But comparing quartile 1 to quartile 3, we find these coefficients to be significantly different.

The last column in Table 4 introduces an interaction term of experience with each gravity variable, allowing us to test whether the impact of experience changes significantly for different values of the gravity measures. We obtain a positive and significant coefficient for experience interacted with distance and a negative and significant coefficient for experience interacted with a dummy for contiguity so that experience matters more for more distant and non-contiguous countries. A second way to interpret these interaction terms is that distance matters less for country-pairs with accumulated export experience. Similarly, not sharing borders is less of an impediment to trade when country-pairs have a long history of export experience. Essentially, exogenous trade barriers based on geography matter less with cumulated experience.

4 Experience and Bilateral Exports With Disaggregate Data

The use of aggregate bilateral trade data does not allow us to account for composition effects or changes in unit values, which could bias our results on the role of experience in increasing trade. This is especially the case for our experience measure based on cumulated past trade. Moreover, it is also not feasible to distinguish whether export experience facilitates learning about trade costs or demand preferences in the destination market. With disaggregate data, we are relatively more immune to composition effects, and use a richer set of fixed-effects that enables us to mitigate endogeneity concerns and distinguish the channels through which export experience matters.

We estimate a sectoral gravity equation with bilateral commodity trade data from NBER-UN available at the 4-digit SITC Rev 2 level of disaggregation. The NBER-UN 4-digit export data starts in 1962 and covers 98% of world trade. A significant product reclassification was undertaken in 1983 (from SITC Rev 1 to SITC Rev 2). Given that this reclassification may induce measurement error, we use data only from 1984 onward for estimation. Even though we lack rich firm-level trade data to accurately measure firm export experience for a large set of destinations, the 4-digit commodity trade data are a reasonably good compromise. It allows us to exploit variation in experience within country-pairs across industries and over time to identify the effect of experience. It also allows us to construct multiple measures of experience - at the industry-country-pair level, as well as destination-specific experience across sectors.[22]

As before, we construct two experience measures at the industry-specific, country-pair level as

$$E_{od,t}^{k,time} = \sum_{\tau=1}^{t} I_{od,t-\tau}^{k}; E_{od,t}^{k,value} = \sum_{\tau=1}^{t} X_{od,t-\tau}^{k}$$

where $I_{od,t-\tau}^{k}$ is a dummy that equals one for strictly positive exports from o to d in industry k at time t and $X_{od,t-1}^{k}$ is the value of exports from o to d in industry k. We use the arcsin transformation for both experience measures. In a subset of specifications, for each origin-destination pair, we include experience of the exporter o in d at time t in exactly the same way using the DOTS data

$$E_{od,t}^{time} = \sum_{\tau=1}^{t} I_{od,t-\tau}; \; E_{od,t}^{value} = \sum_{\tau=1}^{t} X_{od,t-\tau}$$

Anderson and van Wincoop (2004) derive a gravity equation for bilateral industry trade, where trade costs vary at the industry-pair-year level. Here proper accounting for the multilateral resistance terms requires the inclusion of exporter-industry-year and importer-industry-year fixed effects. We

[22] The NBER-UN data set includes data provided they exceed $100,000 per year with some trade flows included below this cutoff. Unlike in the DOTS data, there is no information on zero flows ruling out the PPML specification. Even if we assume that all missing trade values are zero, PPML estimation is computationally infeasible given the number of fixed effects that we use.

therefore estimate

$$\ln X^k_{od,t} = a \ln X^k_{od,t-1} + \alpha_{ok,t}\mu^k_{o,t} + \alpha_{dk,t}\mu^k_{d,t} + \varepsilon_{od} - \sum_{m=1}^{M} \theta\gamma_m z^m_{od,t} + \theta\lambda_1 \ln\left(E^k_{od,t}\right) + \theta\lambda_2 \ln\left(E_{od,t}\right) + e^k_{od,t} \tag{14}$$

where $E^k_{od,t} \in \left\{E^{k,time}_{od,t}, E^{k,value}_{od,t}\right\}$ and $E_{od,t} \in \left\{E^{time}_{od,t}, E^{value}_{od,t}\right\}$. As before, we present results with experience measured in terms of time and value separately. $\mu_{ok,t}$ captures all exporter-industry-year shocks including productivity shocks and industry-specific export promotion policies that affect the comparative advantage of country o in industry k; $\mu_{dk,t}$ captures all importer-industry-year shocks including industry-specific trade costs in the destination and time-varying preference shocks of destination d in industry k. In an even more demanding specification, we replace ε_{od} in the above equation with time-varying country-pair dummies ($\varepsilon_{od,t}$) which absorb all time-varying bilateral trade costs. Identification then relies on variations in experience within the same country-pair across industries and over time. We use two-way clustering with standard errors clustered on country-pair and 4-digit industry.

Column 1 in Table 5 finds a strong effect of industry-specific bilateral experience (measured in years of positive trade) with a 1% increase in experience raising 4-digit bilateral trade by 0.034%. Alternately, an extra year of experience raises bilateral trade at the 4-digit level by 1% when evaluated at the median level of experience (3 years). Column 2 adds the aggregate experience measure $E^{time}_{od,t}$. Here the coefficient on experience measured as number of years of trade at the bilateral level is positive but marginally insignificant. Bilateral industry-specific experience continues to positively influence bilateral trade. Column 3 adds time-varying bilateral fixed effects ($\varepsilon_{od,t}$) which absorb all bilateral trade costs at the country-pair level as well as the aggregate experience term $E^{time}_{od,t}$. Identification relies exclusively on variation in experience across industries and within industries over time for bilateral pairs. The coefficient $\theta\lambda^{time}_1$ is estimated as 0.035, substantively unchanged. Finally, it is possible that country d has a preference for goods from industry k produced by country o and our experience measure may simply reflect such preferences. Therefore, we control for exporter-importer-industry fixed effects (ε^k_{od}) so identification relies on variation in experience within pair-industries over time. We estimate

$$\ln X^{k}_{od,t} = a \ln X^{k}_{od,t-1} + \alpha_{ok,t}\mu^{k}_{o,t} + \alpha_{dk,t}\mu^{k}_{d,t} + \varepsilon_{od,t} + \varepsilon^{k}_{od} + \theta\lambda_1 \ln\left(E^{k}_{od,t}\right) + e^{k}_{od,t} \tag{15}$$

Column 4 shows that in such a specification, the coefficient on experience measured in terms of years of positive trade increases to 0.041.

Columns 5-8 measure experience in terms of cumulated past trade at the industry-bilateral level. Experience again increases bilateral trade. However, in the most demanding specification that also includes exporter-importer-industry fixed effects, the coefficient on experience is negative. A plausible interpretation is that experience in terms of past trade has a positive effect across industries, while the within estimate in Column 8 reflects regression to the mean. Finally, if we include all four experience measures (not shown) then the coefficients on $E^{k,time}_{od,t}$, $E^{k,value}_{od,t}$ and $E^{time}_{od,t}$ are positive and significant providing evidence that experience at the bilateral level also matters for 4-digit trade. The coefficient on $E^{value}_{od,t}$ is negative and significant, similar to Column 6.

Overall, we are able to confirm that our results for experience measured in years are not driven by composition effects and that experience matters with a rich set of fixed effects.

5 Trade Costs and Experience

Next, we turn our attention to understanding the mechanisms by which experience promotes bilateral trade. Our contention is that experience allows exporters to learn about trade costs, especially unobserved trade costs (unobserved to the econometrician) in the destination market. We evaluate this in three ways. First, we decompose bilateral exports into an extensive and intensive goods margin and draw on a standard Melitz-Chaney model to infer the mechanism by which experience reduces trade costs. Second, we use data on intra and international trade and the method of tetrads from Head and Ries (2001) and Jacks, Meissner and Novy (2011) to infer trade costs and relate it to experience. Third, we use the structural gravity methodology of Agnosteva, Anderson and Yotov (2019) to estimate what they call Unexplained Trade Barriers (UTBs) and examine its relationship with experience.

5.1 Extensive and Intensive Margins of Exports and Experience

We analyze the effect of experience on the bilateral extensive and intensive product margins of international trade. Chaney (2008) provides closed-form solutions of how declines in variable and fixed bilateral trade costs affect the two margins, assuming firm productivity follows a Pareto distribution. Examining the coefficient on experience for the two margins allows us to infer whether experience reduces the fixed vs. variable costs of trade and whether experience is shared.

Following Dutt, Mihov and Van-Zandt (2013), we decompose bilateral exports $X_{od,t}$ as the product of an extensive margin ($N_{od,t}$), defined as the number of products traded, and an intensive margin ($\overline{x}_{od,t}$), defined as the volume of exports per product so that

$$X_{od,t} = N_{od,t} * \overline{x}_{od,t} \tag{16}$$

Interpreting each product as a firm allows us to map our empirical findings to the Chaney (2008) model.

In Chaney (2008), a reduction in either fixed or variable costs leads to more entry into a bilateral export market and thus increases the extensive margin. A reduction in *fixed* costs reduces the intensive margin: the increase in entry does not affect export sales of incumbents and the average exports per firm is brought down since new entrants enter at a smaller scale than incumbents. A reduction in *variable* costs increases the export revenues of incumbents, but this is counteracted by entry of new firms with lower productivity. When productivity follows a Pareto distribution, the two cancel out so the intensive margin is unaffected by a change in variable costs.

If experience reduces bilateral trade costs, the effect on each margin will depend upon a) whether experience is shared across sectors/firms and b) whether experience reduces the fixed or variable costs of trade. In a scenario where experience is not shared, and experience reduces only the fixed costs of trade of incumbents, neither the extensive nor the intensive margin is affected by experience. Alternately, if experience reduces variable trade costs, but experience is not shared, we should expect no adjustments in the extensive margin along with an increase in the intensive margin. Here the number of products exported should remain unaffected as potential entrants do not benefit from experience of other firms while incumbent firms increase their exports, raising export per product. Hence, the extensive margin increases with experience only if experience is shared. If experience is shared and reduces only the fixed costs of trade, the intensive margin should decline (there is no impact on exports of incumbent firms but the new entrants enter at a smaller scale reducing export per product). Finally, if experience is shared and reduces the variable costs of trade, the impact on the intensive margin is zero under the Pareto distribution assumption.

UNCTAD's COMTRADE provides data on bilateral trade between pairs of countries at the Harmonized System 6-digit (HS-6) level of disaggregation. The HS-6 data spans 5,017 product categories, for the time-period 1988-2006 for 183 importers and 248 exporters. For each year, COMTRADE covers more than 99% of all world trade and allows us to decompose total exports into an extensive and an intensive margin. The advantage of this data over the UN-NBER 4-digit data is that it is available at a higher level of aggregation. Therefore, we estimate equation (10) with two lags of the dependent variable and a comprehensive set of fixed effects, decomposing bilateral exports into an extensive and an intensive margin.

Columns 1-3 in Table 6 show the effect of experience $E_{od,t}^{time}$ on the two margins of trade and bilateral trade for our baseline specification that includes country-year dummies and dyadic fixed effects. We see that experience increases the extensive margin and bilateral trade while it has a negative but insignificant impact on the intensive margin of trade. Columns 4-6 show similar results when the specification also includes pair-specific trends.

The increase in the extensive margin indicates experience is shared across 6-digit sectors. The fact that the intensive margin remains unaffected is consistent with experience reducing the variable costs of trade. Overall, these results are consistent with a mechanism where export experience is shared across firms/sectors and experience reduces the variable costs of trade.

5.2 Unmeasured Trade Costs and Experience: Method of Tetrads

Head and Ries (2001) and Jacks, Meissner and Novy (2011) use microfounded gravity equations to express bilateral trade costs as a function of observable international trade and intranational trade data that can be tracked over time. Such a trade cost measure encapsulates tariffs, transport costs, and the dark trade cost components related to networks, information costs, and familiarity with customs and destination markets.

Following Novy (2007), we compute a tariff equivalent of the geometric average of trade costs from origin to destination and destination to origin, $T_{od,t}$.[23] The expression is given by

$$T_{od,t} = \left(\frac{\tau_{od,t}\tau_{do,t}}{\tau_{oo,t}\tau_{dd,t}}\right)^{\frac{1}{2}} - 1 = \left(\frac{X_{oo,t}X_{dd,t}}{X_{od,t}X_{do,t}}\right)^{\frac{1}{2\theta}} - 1 \tag{17}$$

where $X_{oo,t}$ and $X_{dd,t}$ is intra-national trade in the origin and destination, respectively. τ_{od} denotes bilateral trade costs if $o \neq d$ and domestic trade costs if $o = d$. Data on this measure of trade costs are from World Bank Trade Cost Database, which uses COMTRADE data and gross output data to provide both sectoral and aggregate trade cost measures.[24]

Since we are concerned mainly with dark trade costs, we used a second measure that captures non-tariff bilateral costs by excluding measured bilateral tariffs ($t_{od,t}$ and $t_{do,t}$) between country-pairs. Following Anderson and van Wincoop (2004), non-tariff bilateral cost $T_{od,t}^{non-tariff}$, which includes all additional costs other than tariffs involved in trading goods bilaterally rather than domestically is calculated as

$$T_{od,t}^{non-tariff} = \left(\frac{(1+T_{od,t})}{\sqrt{(1+t_{od,t})\,(1+t_{do,t})}}\right) - 1 \tag{18}$$

Given that these measures are symmetric, we take logs and regress them on both export and import experience of origin to destination, measured in years of positive trade. As the trade cost measure nets out multilateral resistance components, these regressions do not have to include additional fixed effects to control for multilateral resistance.

Column 1 in Table 7 includes the standard time-invariant gravity variables from Head and Mayer (2014). We find that experience of origin in the destination and of destination in the origin reduces bilateral trade costs inclusive of tariffs. Moreover, the two coefficients are of similar magnitude and

[23]Details on the derivation can be found in an online Appendix to the paper.

[24]The dataset as well as a user note with the derivation of the different measures of trade costs used in this analysis can be found in: https://www.unescap.org/resources/escap-world-bank-trade-cost-database. The data uses $\theta = 7$ to construct the trade cost measures. Data spans 1996-2006 for 177 countries.

sign. Column 2 uses the trade cost measure excluding tariffs $T_{od,t}^{non-tariff}$. Here we find that the magnitude of the decline in trade costs with experience is 23% higher as compared to the estimates in Column 1. Columns 3 and 4 add pair-specific fixed effects to absorb all time-invariant bilateral costs and one lag of the dependent variable to account for slow-moving time-varying bilateral costs.[25] Columns 5 and 6 add pair-specific trends. This increases the magnitude of the coefficient estimates, with a bigger coefficient estimate when the trade cost measure excludes tariffs. In the short run, a 1% increase in export experience reduces overall trade costs (trade costs excluding tariffs) by 0.02% (0.03%) and by 0.04% (0.05%) in the long-run. These magnitudes are very similar to the ones from Column 4 in Table 1, where a 1% increase in experience implies that trade costs decline by 0.05% in the short-run, and by 0.07% in the long-run.[26]

5.3 Trade Costs from Structural Gravity and Experience

One of the issues with the tetrads approach used above is that bilateral trade costs include error terms due to mismeasured bilateral trade flow data. Therefore, we adopt the methodology of Agnosteva, Anderson and Yotov (2019), who rely on a structural gravity model to estimate what they call Unexplained Trade Barriers (UTBs). UTBs are computed as the difference between trade barriers inferred from pair fixed effects and from bilateral distance, contiguity, colonial linkages, common language, and common law.[27] While they apply their methodology to inter vs. intra provincial trade within Canada, we use their methodology for international vs. intranational trade. Data for this are from Larch and Yotov (2016), which covers 69 exporter and importers for the period 1986-2006.

We regress this variable on our 58 experience dummies for the year 2006, the final year of our sample. Figure 3 shows that bilateral unexplained trade barriers decline continuously with experience. At the median level of experience, a one year increase in positive trade reduces unexplained

[25] In a specification without the lagged dependent variable and pair fixed effects we estimate a coefficient if -0.016 for "Experience of origin in destination" and -0.015 as the coefficient on "Experience of destination in origin" both of which are statistically significant.

[26] Adding experience measures in terms of cumulated past exports makes interpretation of the trade cost terms difficult. Therefore, we only considered experience measured in terms of number of years.

[27] Details on the derivation of UTB are shown in the online Appendix.

trade barriers by 0.13%, a magnitude comparable to our estimates in Table 1.

Overall, both methodologies show that trade costs decline with experience. The margin decomposition shows that our findings are consistent with experience being shared across firms, with experience reducing the variable costs of trade, leading to an increase in the extensive margin and an insignificant impact on the intensive margin.

6 Conclusion

The persistent influence of borders, distance, and other gravity variables in the presence of a rapid decline in transportation and communication costs has been highlighted in multiple papers. This led Head and Mayer (2013) to invoke a cosmological metaphor of dark trade costs. In this paper, we take these dark trade costs as given and demonstrate the importance of export experience in overcoming such costs. We show that cumulated experience, especially as measured in terms of the number of years of positive exports, reduces such unmeasured trade costs, both for bilateral trade between country-pairs and for sectoral trade at the industry-country-pair level. At the bilateral level, we estimate an elasticity of bilateral trade with respect to our measure of experience of 0.180. This implies that 1% increase in experience reduces trade costs by 0.05% in the short-run and by 0.07% in the long-run. Our non-parametric estimates imply that 9 years of experience is equivalent to a country-pair joining a preferential trading area, while 7 years of experience is equivalent to sharing a common currency. Recognizing the endogeneity of experience, we employ multiple identification strategies, placebo tests, account for zeros in the trade matrix, and demonstrate the heterogeneous impact of experience for different values of standard gravity variables. Subsequently, we construct microfounded measures of trade costs and show how these decline over time with the accumulation of experience. Our results are consistent with experience reducing the bilateral unmeasured variable costs of trade and with experience shared across firms and industries.

Our work complements a burgeoning firm-level literature that examines the role of experience in firm-level exporting decisions. Our estimates are not directly comparable with firm-level evidence on the importance of export experience since much of the literature focuses on export participation decisions. At the same time, our findings are consistent with this literature - that export experience matters even when accounting for sunk costs, that experience is shared, and that experience matters more in countries that are remote (e.g., geographically distant). We recognize that there are interesting dynamics at the firm level, (e.g., Eaton et al., 2012) that we are unable to capture. Simultaneously, existing firm-level datasets span relatively fewer years, so measuring experience accurately at the firm-level remains an ongoing challenge.

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Table 1: Experience and Bilateral Exports: OLS Estimates

	(1) OLS No trend	(2) OLS Trend	(3) OLS No trend	(4) OLS Trend	(5) OLS No trend	(6) OLS Trend	(7) OLS No trend	(8) OLS Trend
Experience as years ($E_{od,t}^{time}$)	0.345***	0.417***	0.116***	0.180***				
	(0.012)	(0.015)	(0.011)	(0.019)				
Experience as past trade ($E_{od,t}^{value}$)					0.065***	0.025***	0.013***	0.014***
					(0.002)	(0.002)	(0.001)	(0.001)
Both in GATT/WTO	0.115***	0.009	0.048***	0.006	0.127***	0.006	0.051***	0.052***
	(0.030)	(0.029)	(0.017)	(0.021)	(0.030)	(0.029)	(0.016)	(0.017)
PTA	0.568***	0.124***	0.286***	0.112***	0.519***	0.140***	0.271***	0.263***
	(0.030)	(0.027)	(0.015)	(0.018)	(0.029)	(0.027)	(0.015)	(0.015)
GSP	0.151***	0.241***	0.010	0.122***	0.157***	0.236***	0.010	0.013
	(0.041)	(0.041)	(0.021)	(0.028)	(0.040)	(0.041)	(0.021)	(0.022)
Currency Union	0.237***	0.252***	0.168***	0.191***	0.222***	0.292***	0.167***	0.171***
	(0.070)	(0.064)	(0.034)	(0.041)	(0.068)	(0.063)	(0.033)	(0.034)
$\ln X_{od,t-1}$			0.522***	0.368***			0.522***	0.521***
			(0.003)	(0.003)			(0.003)	(0.003)
Exporter-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair specific trends	No	Yes	No	Yes	No	Yes	No	Yes
Observations	642,993	642,993	568,562	568,562	642,993	642,993	568,562	568,562
R-squared	0.85	0.89	0.90	0.92	0.85	0.89	0.90	0.92

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (time) measures experience as the number of years of strictly positive bilateral exports; Experience (value) measures experience as cumulated past value of bilateral exports

Table 2: Experience and Bilateral Exports: PPML Estimates

	(1) PPML No trend	(2) PPML Trend	(3) PPML No trend	(4) PPML Trend
Experience as years ($E_{od,t}^{time}$)	0.516***	0.576***		
	(0.067)	(0.070)		
Experience as past trade ($E_{od,t}^{value}$)			0.432***	0.133***
			(0.036)	(0.014)
Both in GATT/WTO	-0.124	-0.256***	-0.047	-0.229***
	(0.081)	(0.072)	(0.056)	(0.067)
PTA	0.295***	0.087***	0.224***	0.075***
	(0.035)	(0.026)	(0.027)	(0.025)
GSP	-0.136**	-0.291***	-0.123***	-0.277***
	(0.064)	(0.051)	(0.048)	(0.050)
Currency Union	0.021	0.040	0.003	0.043
	(0.039)	(0.031)	(0.029)	(0.030)
$\ln X_{od,t-1}$				
Exporter-year fixed effects	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes
Pair specific trends	No	Yes	No	Yes
Observations+	1,103,056	1,103,080	1,104,802	1,103,083
R-squared	0.86	0.87	0.86	0.87

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1;
Experience as years measures experience as number of years of strictly positive bilateral exports;
Experience as past trade measures experience as cumulated past value of bilateral exports.
+ We use the ppmlhdfe command in STATA which drops singleton observations. This accounts for changes in the number of observations in the PPML specification

Table 3: Placebo Tests

Specification	Coefficient on experience	Coefficient on Placebo variable (experience as years of positive trade)	Coefficient on Placebo variable (experience as past trade)
1. Import experience of exporter		0.051***	0.003**
		(0.011)	(0.001)
2. Assign experience to alphabetical neighbor of exporter from same region		0.001	0.001
		(0.011)	(0.001)
3. Assign experience to alphabetical neighbor of importer from same region		0.008	0.001
		(0.008)	(0.001)
4. FDI stock as dependent variable	-0.095***		
	(0.029)		

Standard errors in parentheses are clustered on country-pair: * significant at 10%; ** significant at 5%; *** significant at 1%. All specifications, except FDI specification, use the experience measures one at a time, include one lag of the dependent variable with country-year and country-pair dummies, and pair-specific trends (Columns 4 and 8 of Table 1). The FDI specification uses experience (time) is a cross-section, in an OLS specification with exporter and importer fixed effects.

Table 4: Variation of Coefficient on Experience across Model Specifications

Split On Gravity Variable	Coefficient on experience (time) [Gravity variable = 0]		Coefficient on experience (time) [Gravity variable = 1]		t-test for equality of coefficients	Interaction of experience (time) & gravity variable
Contiguity	0.187***		0.291		-0.48	-0.164***
	(0.019)		(0.216)			(0.038)
Colonial relationship	0.181***		0.145***		1.88**	0.023
	(0.019)		(0.068)			(0.026)
Common language	0.187***		0.155***		1.48*	0.005
	(0.022)		(0.041)			(0.020)
Common law	0.194***		0.090**		5.03***	0.007
	(0.021)		(0.052)			(0.027)
Distance	0.109***	0.125***	0.235***	0.261***		0.028***
	(0.037)	(0.040)	(0.042)	(0.046)		(0.009)

Standard errors in parentheses are clustered on country-pair; * significant at 10%; ** significant at 5%; *** significant at 1%; All specifications include the lagged dependent variable, exporter-year, importer-year, country-pair fixed effects and pair-specific trends. All splits are based on binary variables except for distance; for distance we split the sample into four ranges corresponding to quartiles. Column 3 tests the equality of coefficients in the sub-samples; Column 4 shows the coefficient on the interaction between experience and each gravity measure.

Table 5: Experience and Bilateral Trade at 4-digit Level: Experience as Number of Years of Positive Trade

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry specific bilateral experience as years ($E_{od,t}^{k,time}$)	0.034***	0.034***	0.035***	0.041***				
	(0.001)	(0.001)	(0.001)	(0.004)				
Industry specific bilateral experience as past trade ($E_{od,t}^{k,value}$)					0.450***	0.450***	0.447***	-0.471***
					(0.007)	(0.007)	(0.006)	(0.009)
Bilateral experience across industries as years ($E_{od,t}^{time}$)		0.051						
		(0.034)						
Bilateral Experience across industries as past trade ($E_{od,t}^{value}$)						-0.016***		
						(0.002)		
Both in GATT/WTO	-0.068***	-0.068***			-0.072***	-0.072***		
	(0.017)	(0.017)			(0.017)	(0.017)		
Preferential trading arrangement	0.011**	0.011**			0.012**	0.011**		
	(0.005)	(0.005)			(0.005)	(0.005)		
GSP	-0.071***	-0.071***			-0.073***	-0.074***		
	(0.013)	(0.013)			(0.013)	(0.013)		
Common currency	0.008	0.008			0.006	0.005		
	(0.007)	(0.007)			(0.007)	(0.007)		
$\ln X_{od,t-1}^{k}$	0.743***	0.743***	0.748***	0.356***	0.733***	0.733***	0.739***	0.355***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Exporter-industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	NA	NA	Yes	Yes	NA	NA
Pair specific trends	Yes	Yes	NA	NA	Yes	Yes	NA	NA
Pair-year fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Pair-industry fixed effects	No	No	No	Yes	No	No	No	Yes
Observations	4,428,247	4,428,247	5,229,697	5,070,233	4,428,247	4,428,247	5,229,697	5,070,233
R-squared	0.88	0.88	0.88	0.92	0.88	0.88	0.88	0.92

Two way clustered standard errors on country-pair and 4-digit industry; *** p<0.01, ** p<0.05, * p<0.1; Industry specific bilateral experience measures experience as number of years of positive or cumulated value of past bilateral exports in same in same 4-digit industry; Bilateral experience across industries measures experience measure based on aggregate bilateral trade.

Table 6: Experience and Margins of Trade: OLS Estimates

	(1) Extensive Margin	(2) Intensive Margin	(3) Bilateral Exports	(4) Extensive Margin	(5) Intensive Margin	(6) Bilateral Exports
Experience as years ($E_{od,t}^{time}$)	0.086***	-0.027	0.059*	0.090***	-0.026	0.064*
	(0.017)	(0.029)	(0.031)	(0.018)	(0.030)	(0.032)
Both in GATT/WTO	0.219***	-0.059	0.160***	0.220***	-0.059	0.161***
	(0.032)	(0.046)	(0.049)	(0.034)	(0.048)	(0.052)
PTA	-0.108***	0.166***	0.058*	-0.109***	0.164***	0.055
	(0.021)	(0.032)	(0.034)	(0.023)	(0.034)	(0.036)
GSP	-0.064*	0.108	0.045	-0.064*	0.110	0.046
	(0.036)	(0.074)	(0.078)	(0.038)	(0.078)	(0.082)
Currency Union	-0.082***	0.128***	0.046	-0.084***	0.125***	0.041
	(0.024)	(0.035)	(0.032)	(0.026)	(0.037)	(0.033)
$\ln X_{od,t-1}$	0.070***	0.222***	0.292***	0.070***	0.222***	0.292***
	(0.002)	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)
Exporter-year fixed effects						
Importer-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pair specific trends	No	No	No	Yes	Yes	Yes
Observations	192,042	192,042	192,042	192,042	192,042	192,042
R-squared	0.96	0.81	0.92	0.96	0.81	0.92

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (Years) measures experience as number of years of strictly positive bilateral exports; Extensive margin is measured as the number of 6-digit product exports; Intensive margin is measured as the average exports per product.

Table 7: Trade Costs and Experience (Tetrads Method)

	(1) All trade costs	(2) Trade costs excluding tariffs	(3) All trade costs	(4) Trade costs excluding tariffs	(5) All trade costs	(6) Trade costs excluding tariffs
Experience of origin in destination ($E_{od,t}^{time}$)	-0.126***	-0.155***	-0.013***	-0.020***	-0.024***	-0.027***
	(0.004)	(0.005)	(0.004)	(0.003)	(0.005)	(0.003)
Experience of destination in origin ($E_{do,t}^{time}$)	-0.127***	-0.158***	-0.014***	-0.019***	-0.026***	-0.027***
	(0.004)	(0.006)	(0.004)	(0.003)	(0.005)	(0.003)
Both in GATT/WTO	0.044***	0.092***	-0.035***	-0.024***	-0.034***	-0.024***
	(0.010)	(0.012)	(0.006)	(0.004)	(0.006)	(0.005)
Preferential trading arrangement	-0.321***	-0.294***	-0.021***	-0.042***	-0.022***	-0.044***
	(0.018)	(0.018)	(0.005)	(0.004)	(0.005)	(0.004)
GSP	-0.031***	0.010	0.001	0.001	0.001	0.001
	(0.009)	(0.010)	(0.002)	(0.002)	(0.003)	(0.002)
Both in Currency Union	0.013	-0.032	-0.034***	-0.030***	-0.039***	-0.035***
	(0.037)	(0.037)	(0.010)	(0.009)	(0.010)	(0.009)
Distance (log)	0.199***	0.200***				
	(0.007)	(0.008)				
Contiguity	-0.270***	-0.321***				
	(0.042)	(0.047)				
Colonial relationship	-0.456***	-0.381***				
	(0.033)	(0.036)				
Common language	0.068***	0.031**				
	(0.013)	(0.015)				
Common law	-0.079***	-0.114***				
	(0.019)	(0.021)				
Lagged trade costs			0.399***	0.467***	0.398***	0.470***
			(0.009)	(0.007)	(0.009)	(0.007)
Pair fixed effects	No	No	Yes	Yes	Yes	Yes
Pair specific trends	No	No	No	No	Yes	Yes
Observations	74,889	57,705	49,553	65,790	49,553	65,790
R-squared	0.40	0.41	0.95	0.95	0.99	0.99

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Data are symmetric as are all variables except experience; Experience is measured as both number of years of strictly positive bilateral exports and strictly positive bilateral trade. This table reports results from the Method of Tetrads.

Figure 1A: Dark Trade Costs and Experience (OLS Estimates)

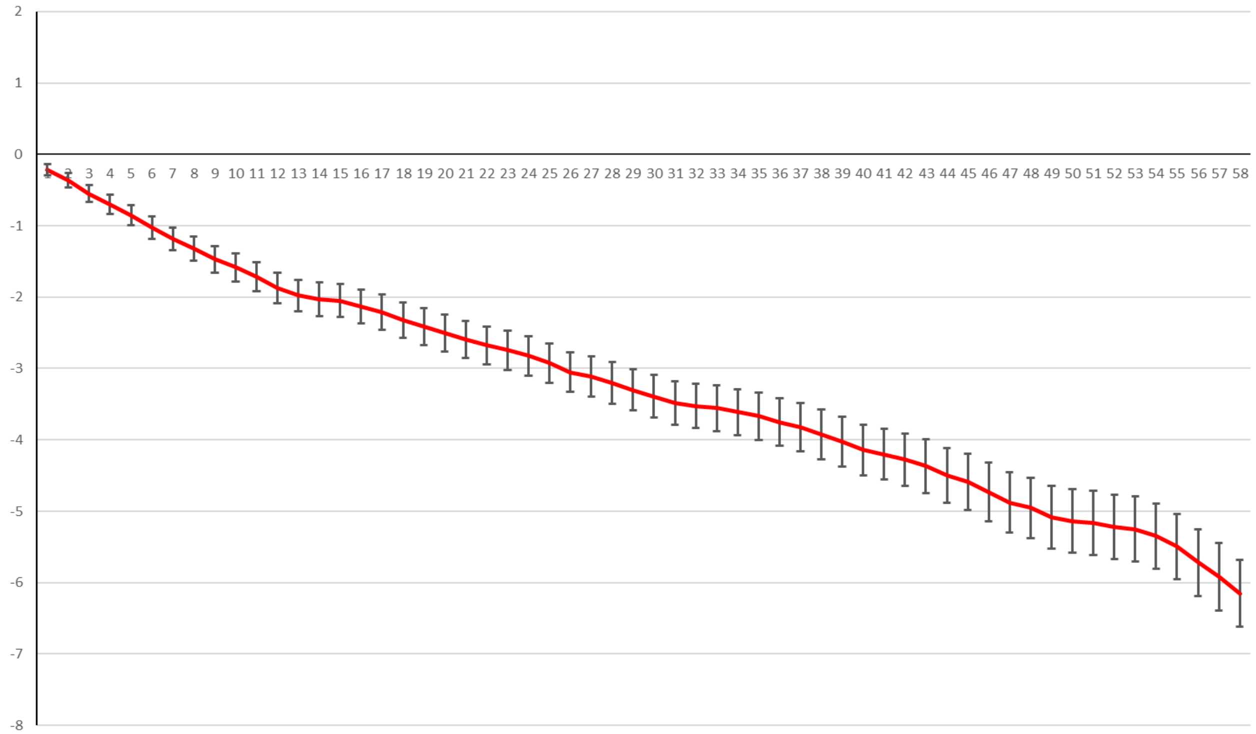

Figure 1B: Dark Trade Costs and Experience (PPML Estimates)

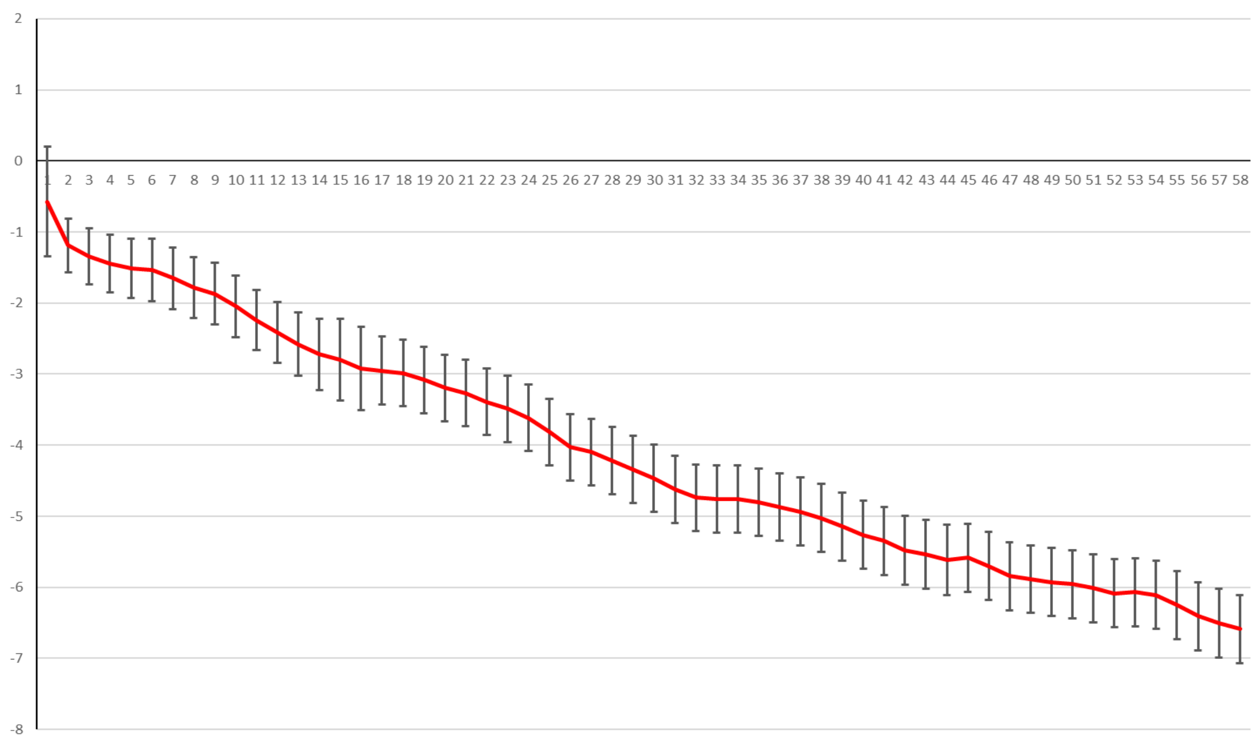

Figure 2: Experience Dummies and Bilateral Trade

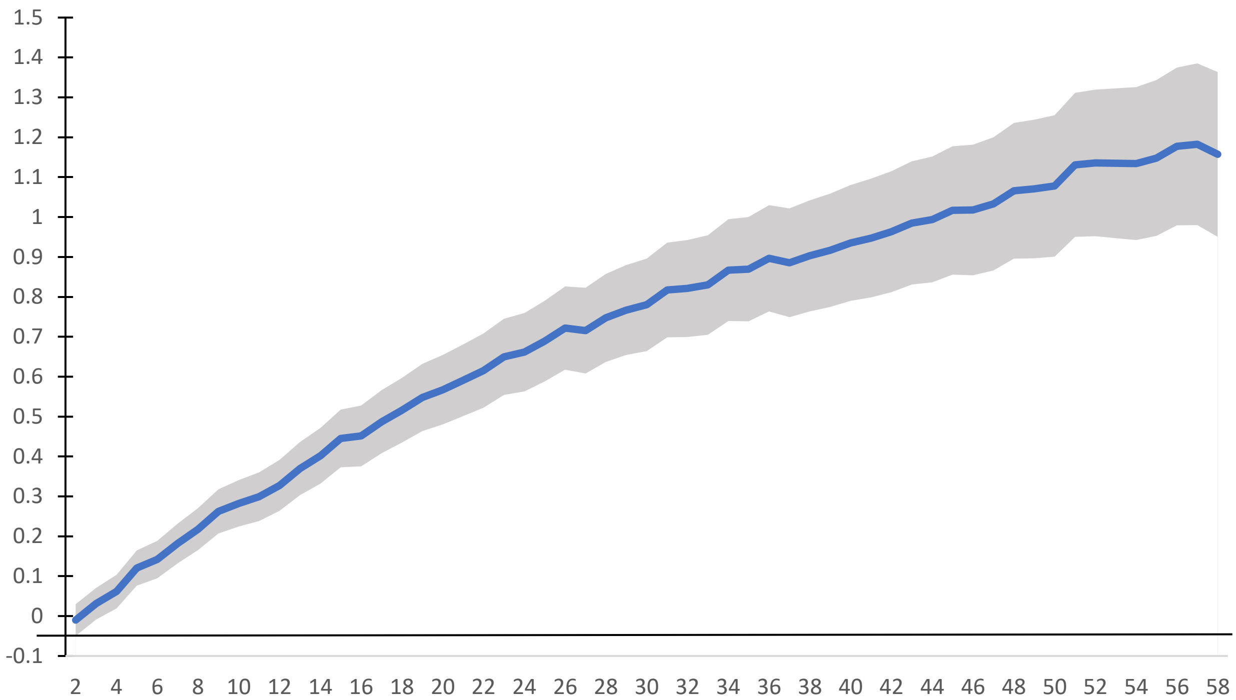

Figure 3: Unexplained Trade Barriers and Experience