Depth and Death: Trade Agreements and Trade Duration*

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Abstract

We examine how shallow and deep economic integration agreements affect duration of spells of trade. We build a dynamic model of firm behavior which allows us to characterize duration of trade and the effect of agreements. The model predicts that duration increases in size and length of spells, which is supported by data. The model also predicts that agreements will reduce the hazard of already active spells when an agreement starts, and increase the hazard of spells that start after the agreement. We find empirical support for these predictions as well. Shallow agreements have larger effects than deep agreements.

JEL Codes: F13, F14, F15
Keywords: economic integration, agreements, survival, hazard, trade dynamics

*This paper draws heavily on an earlier paper of ours which was circulated under the title of "Trade Integration and the Fragility of Trade Relationships," which is part of our ongoing research agenda. Some aspects of that manuscript are now described in "Trade Integration and the Fragility of Trade Relationships," while others are contained in this paper.

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1 Introduction

Since the 1970s economic integration agreements (EIAs) have become increasingly common. While prior to the 1970s less than 1% of all country pairs in the world shared an agreement, by the early 2000s that share has increased to more than 20%, as shown in the top left panel of Figure 1. More notably, the share of the value of trade exchanged between trading partners with an agreement has increased from around 15% in the early 1970s to around 55% by the early 2000s. Moreover, in recent years, there has been a growing trend towards deeper trade agreements whose provisions go beyond simple reduction or eliminations of trade barriers such as tariffs, thus fostering deeper economic integration. As Figure 1 shows, while the share of country pairs with a deep agreement (whether newly signed or converted from a shallow agreement) is still relatively low. Such trading partners account for an increasing share of observations and trade, with the share of trade in deep agreements roughly doubling between the early 1970s and early 2000s. Our interest in this paper is to shed new light on the effect of the depth of economic integration agreements on the duration of trade relationships, analyzing the length of active spells of trade at a disaggregated product level.

To do so we combine two distinct data sources. We source trade flow data from the UN Comtrade database taking advantage of the longest available panel, from 1962 to 2005, with data recorded at the 5-digit level of the SITC revision 1 classification. Our data on economic integration agreements are an updated version of the Database on Economic Integration Agreements constructed by Scott Baier and Jeffrey Bergstrand (2007). We use annual trade flow data to create active spells of trade which reflect instances of active trade, exports of a specific product from one source country to a particular trading partner (importer country) over a consecutive number of years, which could be as little as a single year. We define the exporter-importer-product triplet as a trade relationship, while a spell is an instance, possibly lasting several

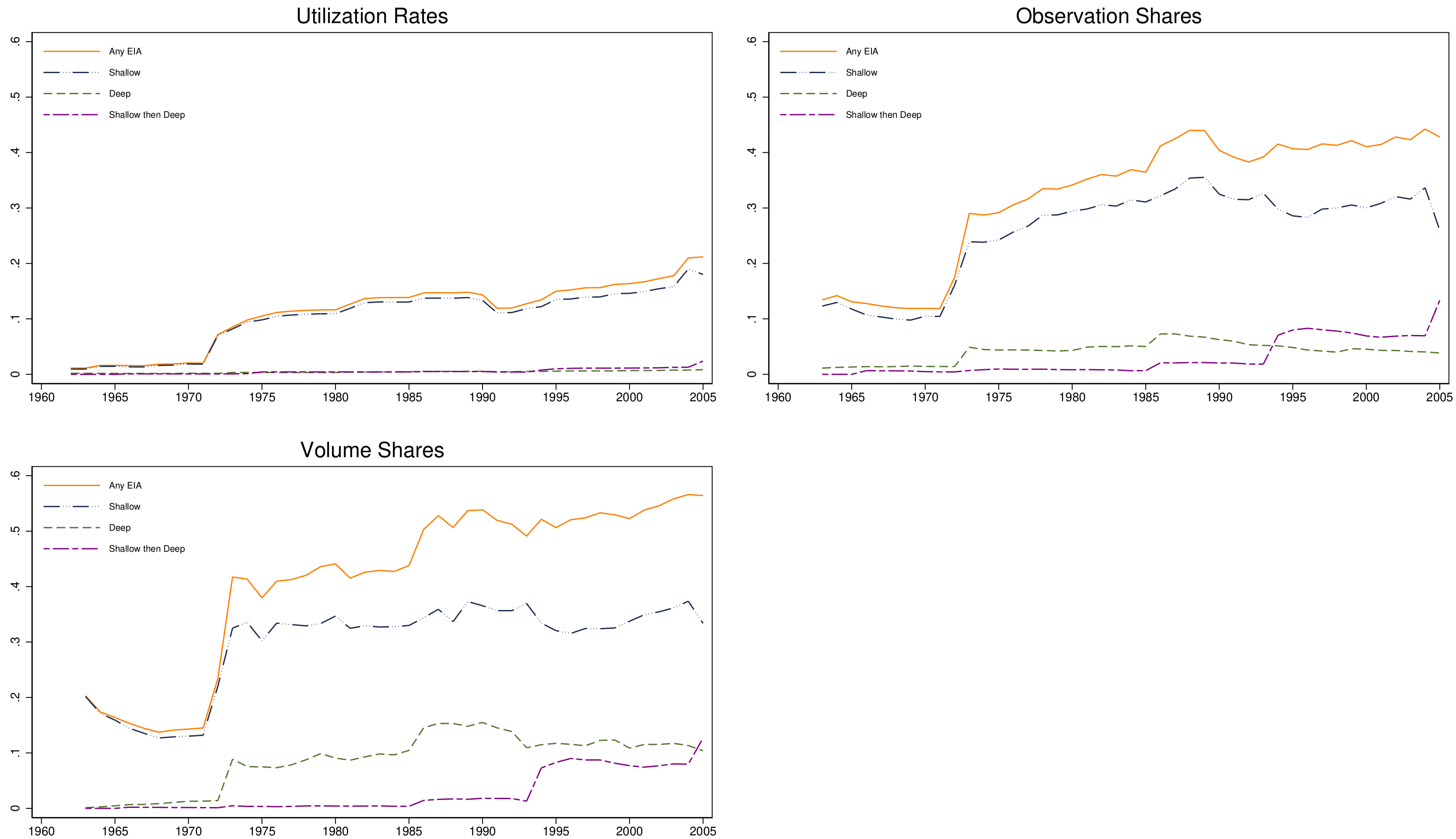

Figure 1: **Growing Relevance of Economic Integration Agreements**

consecutive years, of that relationship being active with positive unidirectional trade taking place. As we show, it is not uncommon to observe multiple spells for a single trade relationship.

To guide our empirical analysis, we develop a dynamic model of international trade which allows us to track the entire evolution of a trade relationship. We do so by combining the heterogeneous firms model of Melitz (2003) with Klepper and Thompson's (2006) model of industry evolution, the former guiding the firm's decision to enter a market and the latter describing the evolution of the trade relationship. As is common in most models of trade with heterogeneous firms, the decision of a firm to enter a market depends on its productivity and the characteristics of the destination market: size, trade barriers, and the competitive environment. In our model, however, the decision to enter a market is only part of the story. Upon entry, we require a firm to match with a possible buyer in the country of destination. If successful, both parties establish a business relation. Using this set-up we are able to track the evolution of trade relationships, which are the aggregation of business relations across the same country of origin and country of destination in a specific product category. Thus, a trade relationship exists due to the activity of at least one exporting firm.

Our parsimonious model delivers a rich set of predictions about the dynamic evolution of disaggregated trade. The first prediction pertains to survival and formalizes by now established results in the duration of trade literature. Trade relationships can and do cease to exist, with the probability of ceasing becoming smaller the longer they are active and the larger in size they are. Buyers in the destination market, however, appear and disappear following a process that is independent of the exporting firm. This independence of the two processes allows for the possibility that the exporting firm re-enters a market and begins exporting to the same destination again after some period of not having exported to that destination. In our data set 55% of all trade relationships are active in multiple distinct spells, each separated by a period of inactivity. Allowing for re-entry of a once abandoned market is a new feature in this literature.

The second prediction revolves around the effect of economic integration agreements. We model shallow agreements as reductions in per-unit costs of trade (tariff rates), while deep agreements are modeled as reductions in fixed costs of trade. Our model's predictions for both are similar. Trade relationships which are already active at the time when an agreement begins benefit from the agreement by becoming less likely to cease (and, therefore, longer in duration). In contrast, trade relationships that begin after the agreement are more fragile: they are more likely to cease.

In our empirical approach we differentiating between shallow and deep economic trade agreements by classifying non-reciprocal preferential trade agreements (NR-PTA), preferential trade agreements (PTA), and free trade agreements (FTA) as shallow trade agreements. These three types of agreements all focus just on removal of direct, or what one might term first-order, trade barriers such as tariffs and quotas, the per-unit costs of trade. Customs unions (CU), common markets (CM), and economic unions (EU) are classified as deep agreements as they affect cross-country interactions beyond trade barriers and affect fixed costs of trade.

We find that both shallow and deep agreements reduce the hazard of trade spells that are active when the agreement starts, as predicted by our model, with the effect being much bigger for shallow agreements. Our model also predicts that the effect of agreements on spells that start after the agreement is to increase the hazard. We also find evidence for this effect, though we have to be careful about the interpretation. The effect on new spells is to increase their hazard, but this effect does not occur in isolation. It occurs in conjunction with the effect of the agreement being in place. The net effect for shallow agreements is a higher hazard, while that for deep agreements is a slightly lower hazard.

We contribute to three main strands of the literature. On the modeling side we make a contribution to the literature dealing with export dynamics. Most of this literature concentrates on the expansion of the geographical coverage of trade as a firm continues to access more distant markets. Chaney (2014), for instance, provides a theory and evidence on the expansion of trade networks and the dynamic evolution of trade frictions. Albornoz, Calvo Pardo, Corcos, and Ornelas (2012) and Defever, Heid, and Larch (2015), using a simpler model of market access, provide evidence that current export relationships influence the decision of where to export next. Complementary to these findings, we provide the first theoretical model able to truly capture the dynamic evolution of existing trade relationships.

Our model is related to a recent set of papers that focus on the destination market, more so than on the firms in the country of origin. Bernard, Moxnes, and Ulltveit-Moe (2018) show that heterogeneity in the characteristics of buyers in the destination market matters for explaining trade relationships. Using highly disaggregated Norwegian data, they find that the extensive margin of the number of buyers plays an important role in explaining the variation in exports at the aggregate level and at the firm level. Carballo, Ottaviano, and Volpe Martincus (2018) use highly disaggregated data from Costa Rica, Ecuador, and Uruguay to show that while most firms serve only very few buyers abroad, the number of buyers and the skewness of sales across them increases with size and accessibility of destinations. Because we assume the process that generates buyers varies across destinations, our model is able to explain some of the results in these papers.

The second strand of literature we contribute to is that dealing with the effects of economic integration agreements. Much effort in this literature has gone to understanding their effects on aggregate trade levels. Baier and Bergstrand (2007) show that economic integration agreements on average double members' trade, while efforts such as Carrère (2006) and Kohl (2013), allow for differences across individual arrangements. A strand of this literature also investigates why countries enter trade agreements (Chen and Joshi 2010; Baldwin and Jaimovich 2012; and Bergstrand, Egger, and Larch 2016). Our related work (Besedeš, Moreno-Cruz, and Nitsch 2024) spans these two strands of the literature. In it we relate the effect of trade agreements, without distinguishing between them, on the formation, growth, and duration of relationships at the aggregate level relating the results to the firm-level models. Our results show economic integration agreements increase duration and growth of incumbent spells, while they reduce duration and growth of post-agreement spells. Agreements also result in an increased number of new spells.

More recent advances in this literature have focused on understanding how different is the effect of deep agreements. Magee (2008) and Roy (2010) show that customs unions have larger effects on aggregate trade than FTAs. Baier, Bergstrand, and Feng (2014) similarly show that deep EIAs have larger effects on aggregate trade while also showing they have larger effects on the extensive and intensive margins. Mattoo, Mulabdic, and Ruta (2022) show that deep trade agreements result in more trade creation and less trade diversion than shallow trade agreements. Díaz-Mora, Garcì-López, and Gonzalèz-Díaz (2022) show that deep trade agreements with substantial provisions on services increase embodied services value added from partner countries more than shallower agreements. Guillin, Rabaud, and Zaki (2023) show that only the deepest trade agreements increase trade in services, while the quality of institutions determines their effect on the intensive and extensive margins. Lee, Mulabdic, and Ruta (2023) use firm-level data from Costa Rica to show that deep regional trade agreements can have positive spillover effects on third countries by increasing the rate of entry of firms that previously exported to one of the agreement's member countries.

The last strand of the literature we contribute to examines duration of trade. This literature, however, mainly documents empirical findings. We provide the first theoretical model able to make predictions about the hazard of a relationship ceasing, thus explaining now standard results in the literature.[1]

2 Theoretical Model

We start our analysis of the dynamic behavior of trade relationships by outlining a theoretical framework that guides our interpretation of empirical results discussed below. We start with a few definitions. There are two countries, origin o and destination d. A *business relation* consists of a firm in country o selling its product to a firm in country d. We refer to firms in the origin country as *sellers (exporters)* and to firms in the destination country as *buyers (importers)*. A *trade relationship* is the collection of all business relations trading in the same product category between origin and destination countries. Finally, a *trade spell* is a realization of a trade relationship or the period of time, in consecutive years, during which the trade relationship is active. Among other things, we are interested in characterizing trade spells.

At the beginning of exporting, a seller identifies potential buyers and bids for a business opportunity to sell its product. Following Klepper and Thompson (2006) we assume potential buyers of a particular product in the destination country appear following a Poisson process with parameter λ. Once a seller successfully contracts with a buyer, the business relation is active for an exogenously determined length of time, z, drawn from the exponential distribution $H(z) = 1 - e^{-z/\mu}$ with mean μ. After period z, the buyer disappears.[2]

The probability that a seller will enter the destination market is θ and the size

[1] See for example Besedeš and Prusa 2006a, 2006b, 2017; Nitsch 2009; Carrère and Strauss-Khan 2017; Görg, Kneller, and Muraközy 2012; and Cadot, Iacovone, Rauch, and Pierola 2013.

[2] A business relation may end from the buyer's side for at least two reasons. First, the buyer may have gone out of business following a random idiosyncratic shock. Second, the seller may have been replaced by a new firm selling the product to the buyer. Although we do not explicitly model this process of creative destruction it can be rationalized along the lines of Klette and Kortum (2004). It is also possible to reconcile the process of arrival of new buyers with a model of advertising similar to Arkolakis (2010).

of the business relation is randomly drawn from a distribution $F(r)$, where r is the revenue of the seller. While most of the results below are independent of the exact form of θ and $F(r)$, we borrow the characterization of these two model parameters from Melitz (2003).

In Melitz (2003) firms are characterized only by their productivity levels, indexed by ϕ. Firms in the origin country selling in the destination country incur per-unit trade costs $\tau > 1$ and must pay fixed exporting costs f_x to set up operations in the destination country.[3] As a result, the probability of a firm entering the destination country depends on the productivity of the firm, the per-unit trade costs, and the set-up costs. We characterize the probability of entering the destination country as $\theta = \theta(\phi, \tau, f_x)$. Only sufficiently productive firms will enter the domestic market and among those, only the most productive firms will export, $\partial\theta/\partial\phi > 0$.

In similar fashion, the size of each firm, described here by its revenue, is a function of the same three parameters presented above, $r = r(\phi, \tau, f_x)$. It follows from the results in Melitz (2003) that more productive firms are larger, $\partial r/\partial\phi > 0$. The distribution of firms' sizes in the destination country is denoted by $F(r)$ with expected value $E[r]$ and variance $var[r]$.

We can model trade liberalization events in two ways, either by reducing per-unit costs, $\tau' < \tau$, or by reducing set-up costs, $f_x' < f_x$. The former approach is akin to having a shallow agreement in place which reduces the most common per-unit cost, the tariff rate exports are subject to. The latter approach would be a consequence of a deep trade agreement which reduces the fixed costs of trading, reducing costs required to setup up sales operations in a foreign country (licensing, translation, satisfying local standards, etc.) As τ or f_x decrease, the productivity cut-off value

[3] All firms that export will also sell in their domestic market. Because we are only looking at business relations across countries, we focus on the fraction of profits and the probability of entry derived from exporting and thus, we only mention the fixed costs of exporting, f_x. Domestic firms that do not export will also have to pay a fixed cost, f_e to set up operations, but we are not concerned with that set of domestic-only firms.

also decreases thereby making it possible for marginally less productive firms to enter the destination market. That is:

$$\frac{\partial \theta}{\partial \tau} < 0 \text{ and } \frac{\partial \theta}{\partial f_x} < 0. \tag{1}$$

Similarly, decreasing τ or f_x increases the revenue and profit margins of firms, resulting in larger firms in equilibrium. Because only the best firms export, a decrease in trade costs expands the distribution of firms in the destination country, such that

$$\frac{\partial E[r]}{\partial \tau} < 0 \text{ and } \frac{\partial E[r]}{\partial f_x} < 0, \tag{2}$$

$$\frac{\partial \text{var}[r]}{\partial \tau} < 0 \text{ and } \frac{\partial \text{var}[r]}{\partial f_x} < 0. \tag{3}$$

Note that our model cannot distinguish between the effects of shallow or deep agreements, which is left to empirics and our data.

2.1 Characterizing trade spells

Define $v_k(t)$ as the probability that a trade spell has exactly k business relations at time t. This probability is distributed according to:[4]

$$v_k(t) = e^{-\theta\rho(t)} \left(\theta\rho(t)\right)^k / k! \tag{4}$$

which is a Poisson distribution with parameter $\theta\rho(t) = \theta\lambda\mu \left(1 - e^{-t/\mu}\right)$. This is the probability that k sellers draw productivities higher than the cutoff and that they had successfully bid for a business opportunity in the destination country. Notice that as time approaches infinity, $\rho(t)$ approaches $\lambda\mu$ and the stationary distribution is $v_k = e^{-\theta\lambda\mu}(\theta\lambda\mu)^k/k!$. In the long run, the probability that a trade spell has exactly

[4]The proofs and several other derivations are in Klepper and Thompson (2006). We also replicate them in the theoretical appendix for completeness.

k business relations is a function of the probability of entry and parameters associated with the process that generates buyers in the destination market. In addition, any trade policy that affects the terms of trade will also affect θ, and as a result trade policy will affect the long term stationary distribution of trade relationships.

2.1.1 Size, Duration, and Survival

A trade spell starts when a business relation was not present in period t and at least one exists in period $t + \Delta t$. Symmetrically, a trade spell ceases to exist when at least one business relation existed in period t and no such relation exists in $t + \Delta t$. The *duration* of a trade spell, $s(t)$, is then defined as the length of time that has elapsed since it was last inactive. In our model, trade spells can appear, disappear, and reappear on various occasions. That is, there is re-entry resulting in multiple spells of the same trade relationship. The possibility of re-entry is a novel feature of our model and usually not found in previous attempts at modeling dynamic behavior of firms, such as Nguyen (2012).

The number of business relations in a trade spell is a function of the duration of the spell. Define $w_k(s(t), t)$ as the probability that a spell with duration s at time t has exactly k active business relations. Then $w_k(s(t), t)$ is distributed Poisson according to:

$$w_k(s(t), t) = e^{-\theta\rho(s)} \left(\theta\rho(s)\right)^k / k! \tag{5}$$

with the mean given by $\theta\rho(s) = \theta\lambda\mu \left(1 - e^{-s/\mu}\right)$, which is increasing in duration of trade, s. Economic integration, by increasing θ, should increase the number of business relations in any given trade relationship.

Denote by $n(t)$ the number of business relations in a trade spell at time t. The size of the trade spell is $y = \sum_0^{n(t)} r$, where $n(t)$ is a random number and each term in the sum is a random draw from $F(r)$. We show in the appendix that the distribution of sizes of all active trade spells has mean

$$E[y] = E[r]\theta\rho(s) \tag{6}$$

and variance

$$\text{var}[y] = E[r^2]\theta\rho(s). \tag{7}$$

The quantities θ, $E[r]$ and var$[r]$ increase when τ decreases, thus:

Result 1 *Holding everything else equal, trade spells in more open trade relationships (with a lower τ) are necessarily larger and have a higher variance when compared to trade relationships with larger trade barriers (large τ).*

Because we have assumed the distribution $H(z)$ is exponential, the arrival of new buyers is independent of the duration of previous relations. Thus, the number of business relations $n(t)$ is enough to explain the probability of exit of a trade spell. In other words, the more business relations there are in a trade spell, the lower the chance of the spell ending in any finite time period.

Result 2 *For any $t, T \in (0, \infty)$, the probability of a trade spell ending by time $(t+T)$ is strictly decreasing in $n(t)$.*

Moreover, both the duration and size of a spell are related to $n(t)$, but in different ways because size is drawn from a distribution that is independent of $n(t)$ and the process that generates buyers. Therefore, the probability of exit will decline with the size of the trade spell, holding duration constant. Likewise, the probability of exit will decline with duration, holding firm size constant.

Result 3 *For any $t, T \in (0, \infty)$, the probability of a trade spell stopping by time $(t + T)$ is decreasing in its size, $y(t)$, and age, $s(t)$.*

2.2 Trade liberalization

Our model provides two important results concerning the effects of trade liberalization on trade relationships: when trade barriers are removed (or reduced) the fraction of firms exporting increases and the average size of the exporting firm increases. Characterizing the dynamic behavior of trade allows us to understand the effects of trade liberalization and to differentiate these effects depending on the timing of the trade liberalization event. In particular, we expect the effects of trade liberalization to differ between trade spells *already in existence* at the time of trade liberalization and *new trade spells* formed after trade liberalization.

Relative to an economic integration agreement, there are three types of spells: (i) those that start and end before the agreement; (ii) those that start before the agreement and are active when the agreement starts, incumbent spells; and (iii) those that start at some point after the agreement itself started. Only the latter two kinds of spells are affected by an agreement.

In our model, trade spells formed before an agreement are different from those formed after the agreement for two reasons. First, business relations already in place experience an increase in their individual size because exporting firms incur lower trade costs, while holding their productivity constant. This will in turn increase duration of those spells. Second, new business relations include marginal firms that are able to export only because their effective costs have been reduced. While standard trade models indicate that the average new business relation is larger due to trade liberalization, separating the old business relations from the new would show that new business relations are, on average, smaller than old ones. In addition, our results above suggest that new trade relations tend to be shorter lived, simply because exporters have not been able to accumulate enough business relations.

The next result summarizes the intuition regarding the effects of trade liberalization on duration of trade spells:

Result 4 *Trade spells that started before the episode of trade liberalization last longer as a result of trade liberalization. Trade spells starting after the episode of trade liberalization have shorter duration than those that began before trade liberalization.*

3 Data

Our theoretical framework yields three sets of results the empirical verification of which is a function of available data. Results 1 and 2 are verifiable only with very detailed firm-level data, which would allow the observation of some form of a business relation. This could be a destination-product pair, or if taken very literally, every single business partner a firm obtains in a foreign market. While the former types of data exist, the detailed nature of the latter type are not yet readily available and we leave their empirical verification for future work.

Result 3 provides the second set of results and pertains to spells of trade. Since spells of trade are some form of aggregation of the fundamental business relations our model is based on, data required to examine them are generally more easily available. This result provides a theoretical underpinning for well established results in the duration of trade literature and we briefly examine it below.

The third set of insights is summarized by Result 4. It pertains to the effect of trade liberalization on incumbent and newly started trade spells. This result is the primary focus of our empirical analysis. To investigate it we must combine trade flow data with data on economic integration agreements. In order to cast as wide a net as possible, we conduct our empirical investigation using a data set with the richest coverage of products, countries, and economic integration agreements.

We combine data from two sources. First, trade flow data are obtained from UN's Comtrade Database. We use the longest possible panel available with trade recorded annually from 1962 until 2011 using the 5-digit SITC revision 1 classification.[5] As

[5] At the 5-digit level, there are 944 product categories.

Comtrade provides data on both imports and exports, we use data as reported by importers given their widely perceived greater accuracy. Since we use imports of all countries available through Comtrade, our analysis can be equivalently thought of as an analysis of imports or of exports. However, we shall simply use the term trade to avoid any confusion.

Second, data on economic integration agreements are from Baier and Bergstrand (2007). Their Database on Economic Integration Agreements collects information on various agreements as entered into by 195 countries on an annual basis between 1950 and 2005.[6] Our sample observations are defined by the temporal intersection of our two sources, from 1962 to 2005.

One advantage of using trade data at the SITC revision 1 level, reaching back to 1962, is the relative paucity of economic integration agreements at the beginning of the sample period. Thus, for the vast majority of agreements that have been in existence in the post-World War II period, we observe their effect from the start of the agreement itself. Note from Figure 1 that in 1962, when our sample begins, only 1.1% of country pairs have an agreement in place. Thus, not taking into account the exact starting point of this small number of agreements likely generates only a small bias. By 1989 the fraction of country pairs with an agreement increases by an order of magnitude to 14.8%. By the end of our sample, around 21% of country pairs share an agreement.

Since we are interested in the effect of economic integration agreements on trade relationships we define as a unit of observation a continuous trade spell involving two countries and a specific product. By this we mean consecutive years when a trade relationship is active, beginning with a clearly observed starting point. Consistent with our model, we differentiate between a trade relationship which denotes an exporter-importer-product triplet and a trade spell which indicates the consecutive

[6] Available at `http://www3.nd.edu/~jbergstr/`.

years during which a relationship is active.

There are a total of 29,671,095 observations on (positive) trade flows between 1962 and 2005. Of these we have no information on economic integration agreements for 2,021,121 observations (about 7% of trade flow observations), which account for 1.7% of total observed trade in our sample. Most often this pertains to instances of trade with very small economies, or countries which disappeared during the observed period as the database does not offer a historical perspective on agreements.[7]

Type of agreement	Number of observations	Number of observations used in estimation
None	16,990,281	15,237,989
Shallow Agreements	7,664,962	7,082,501
Deep Agreements	2,993,446	2,189,535
Total	27,649,671	24,510,480

Table 1: **Number of Observations by Agreement Type**

Of the remaining 27,649,671 observations, as documented in Table 1, some 61% involve pairs of countries which have no economic integration agreement. These observations account for 41.5% of all observed trade. The remaining observations account for 56.7% of all observed trade and belong to shallow (NR-PTA, PTA, and FTA) or deep (CU, CM, and EU) agreements. Shallow agreements are more common accounting for 22.7% of observations, with deep agreements accounting for 10.8% of observations.

We are primarily interested in the effects of economic integration agreements in a multicountry context. It follows from our model that we need to include standard variables capturing country characteristics.[8] We use the CEPII gravity data as the source for both the exporter's and the importer's GDP, distance, and existence of a

[7]One could interpret these observations as no agreement existing, but that would be incorrect as one would have to make sure no agreement in fact was in place.

[8]In our model we use Melitz (2003) to characterize individual firm behavior. It has been shown in Chaney (2008) that Melitz translates into a distorted gravity equation, so we need to account for those variables as well.

common border and a common language.[9]

The second column of Table 1 shows the number of observations on each type of agreement in the dataset used in estimation. Our estimation sample is smaller by 3,139,494 observations, or some 10%, due to two factors. The majority of these observations, 2,843,686 to be precise, are omitted since they belong to spells of trade that are left censored. For all spells which are active in the first year in which an importing country reports data, the actual start of the spell is not observed. For example, the first year in which the U.S. reports imports in our data set is 1962. Consequently, all spells involving the U.S. in 1962 are left censored, and we omit all such observations from our analysis. The remaining omitted observations, almost 300,000, have missing gravity data and are not used.

Our model accounts for the fact that, in the 44 years in our data set, relationships frequently display multiple spells of service. There are a total of 3,109,559 trade relationships in our data with 7,191,964 observed active spells, or 2.3 per relationship. Some 45% of all trade relationships have only one active spell, with 22% having two active spells, and less than 7% having six or more active spells. Table 2 shows that the vast majority of observed spells of trade are of very short duration, with slightly more than 55% of all spells observed for just a single year and 90% observed for seven or fewer years.

4 Empirical Approach and Results

We discuss our empirical results in the same order as they were derived in Section 2. We focus our empirical investigation on Result 4 which examines the effect of economic integration agreements on disaggregated trade patterns and are new to the literature. Result 3 is by now a stylized fact explored in multiple papers.[10] We

[9] Available at `http://www.cepii.fr/anglaisgraph/bdd/gravity.htm`.

[10] See Besedeš and Prusa (2006b), Nitsch (2009), and Carrère and Strauss-Khan (2017) among others.

Spell length	Number of spells	Fraction of spells
1	4,009,321	55.7%
2	1,109,540	15.4%
3	507,534	7.1%
4	294,258	4.1%
5	213,270	3.0%
6	174,633	2.4%
7	115,726	1.6%
8	99,488	1.4%
9	80,455	1.1%
10	80,313	1.1%
11-20	327,288	4.6%
21-30	82,061	1.1%
31-43	98,077	1.4%
Total	7,191,964	100.0%

Table 2: **Distribution of Spell Lengths**

reproduce it here briefly to show our model can rationalize it. Our data are not sufficiently detailed to examine Results 1 and 2, the investigation of which we leave to future work.

To investigate both Results 3 and 4 we estimate the hazard of a spell of trade ceasing, h^i_{kodt}. The hazard is the probability of exports of product i from country o to country d in spell k ceasing at time $t+n$ conditional on it having survived until time t (or in our model notation, age, $s(t)$), $P\left(T^i_{kod} \leq t+n | T^i_{kod} \geq t\right)$, where T^i_{kod} is a random variable measuring the survived duration of spell kod. As the hazard reflects the conditional likelihood of a spell ceasing, the lower the hazard, the longer the duration of a spell. We estimate the hazard of exports ceasing at time n by estimating a discrete hazard using a random effects probit specification to take into account unobserved heterogeneity:

$$\begin{aligned} h^i_{kodt} &= P\left(T^i_{kod} \leq t+n | T^i_{kod} \geq t\right) \\ &= \Phi\Big(\mathbf{EIA}_{odt}\beta + \mathbf{X}_{od}\omega + \kappa \ln(s(t)_{kodt}) + \lambda \ln(y_{(t-1)kodt}) + \\ &\quad + \rho \ln \mathrm{GDP}_o + \tau \ln \mathrm{GDP}_d + \eta_k + \nu^i_{kod}\Big) \end{aligned} \tag{8}$$

where $\mathbf{EIA}_{odt}$ is the vector of variables describing an agreement between origin o and destination d in year t, $\mathbf{X}_{od}$ is a vector of bilateral time-invariant gravity variables (distance, common border, and common language), $\ln(s(t)_{kodt})$ is the log of the age of spell k in year t, $\ln(y_{(t-1)kodt})$ is the size of trade in the previous year of the spell, $\ln \text{GDP}_o$ and $\ln \text{GDP}_d$ are the log of origin's and destination's GDP, and η_k are spell fixed effects. Relationship-specific random effects are captured by ν^i_{kod}. We assume the hazard depends on the duration of a spell as the logarithm of the current length of the spell (age) at every point in time (measured in years).

Our model allows for trade liberalization via both shallow (by reducing per-unit trade costs) and deep (by reducing fixed costs of trading) agreements. In order to fully characterize how agreements affect spells of trade we begin with Figure 2. There are three types of spells in relation to an economic integration agreement: (i) those that occurred in their entirety before the agreement and are unaffected, (ii) those that started before the agreement and were active when the agreement began, and (iii) those that started after the agreement. Spell A occurs in entirety before a shallow agreement, spell B begins before the agreement and ends after and as such is affected by the agreement, while spell C starts after the agreement. As long as a deep agreement is a brand new agreement (not preceded by a shallow agreement), then spell C is unaffected by it, spell D is an incumbent spell that was active when the agreement started, and spell E is a new spell started after the agreement. In that case, spells such as A and C are identical vis-á-vis an agreement (both occurring before the agreement), as are B and D (both active when the agreement starts), and so are C and E (both starting after the agreement). We do need to be more careful in the few instances when a shallow agreement preceded a deep agreement. As illustrated in Figure 1 this happens fairly rarely.[11] The first such occurrence in our data is in 1966. By 2005 only 2.4% of country pairs had a deep agreement that

[11] There are no instances of agreements being downgraded from deep to shallow in our sample.

was preceded by a shallow agreement. In 2005 those country pairs account for 13.3% of our observations and 12.7% of all observed value of trade.[12] In such a case we can then have an additional type of spell, spell F in Figure 2, which started before a shallow agreement and survived into the period of the upgrade to the deep agreement. For such agreements we can then identify six different kinds of spells.

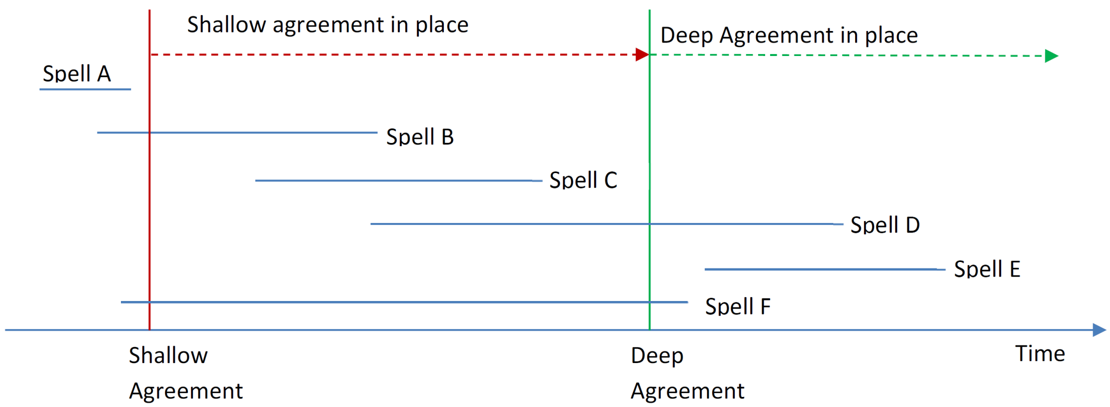

Figure 2: **Trade Spells and Shallow and Deep Agreements**

Given we have two kinds of agreements we need to identify the effects of and the possibility of the nature of the agreement changing from shallow to deep, we will identify their effect by using five dummy variables. The effect of a shallow agreement will be identified by using a dummy variable indicating the agreement is in place (Post Shallow) and a dummy identifying that a spell has started after the agreement (Start After Shallow). Thus, the effect on incumbent spells that are active when the agreement starts will be identified by the first dummy variable, while the effect on spells started after the agreement will be identified by both of those dummies. For country pairs that share a deep agreement we will use two similar dummy variables, identifying that the agreement is in place (Post Deep) and another one identifying spells that have started after the agreement (Start after Deep). Finally, we add a fifth dummy variable to identify all instances of shallow agreements that are updated

[12]It is notable that both of those values were some 5-6 percentage points lower in the few preceding years.

to deep agreements. Thus, the $\mathbf{EIA}_{odt}$ vector of agreement variables contains these five dummies.

4.1 Duration without agreement-related variables

Result 3 states that the probability of a trade relationship ceasing is decreasing in its size and age (or duration). A natural way to examine this result is to estimate a hazard model using the specification given by equation (8), without economic integration variables. We also include the standard gravity variables, GDP of both the importer and the exporter, distance between the two, as well as a dummy indicating the existence of a common border and a common language.

Duration (ln)	-0.433***
	(0.001)
Size (ln)	-0.126***
	(0.000)
Importer GDP (ln)	-0.013***
	(0.000)
Exporter GDP (ln)	-0.086***
	(0.000)
Distance (ln)	0.123***
	(0.001)
Contiguity	-0.110***
	(0.002)
Common language	0.000
	(0.001)
Constant	1.328***
	(0.006)
Observations	24,510,480
Relationships	3,109,593
ρ	0.168***

Estimated using random effects probit. Robust standard errors in parentheses, with *, **, *** denoting significance at 10%, 5%, and 1%.

Table 3: **Basic Hazard Regression**

Results collected in Table 3 are consistent with predictions of our model and are in line with the literature. The hazard rate decreases with duration, indicating that longer lived spells are less likely to cease. It is also decreasing in size, indicating that larger spells are less likely to cease. As is commonly found, distance increases hazard while contiguity decreases hazard. Relationships between larger importers and exporters are less likely to cease, also a common finding. In our application common language has no meaningful effect on hazard.

4.2 The effect of shallow and deep agreement

The focus of our paper is the effect of shallow and deep agreements on duration of trade as reflected by estimating the hazard of trade ceasing using the specification given by equation 8. We collect our estimates in Table 4. Results indicate that, as predicted by our model, both shallow and deep agreements reduce the hazard of already active or incumbent spells, with shallow agreements having a larger effect. Spells which start after the agreement is already in place have a higher hazard and, as a result, shorter duration. Deep agreements that were preceded by a shallow agreement further decrease the hazard.

To properly evaluate whether a variable has a significant effect on the hazard as well as the magnitude of the effect we cannot rely on the estimated coefficients and their standard errors alone. Rather, we need to calculate the predicted hazard evaluated at means of every variable and then change the value of variables of interest. Such an approach to examining the effect of a covariate is necessary as the effect and the precision with which it is estimated depend on the standard errors of all estimated coefficients, all pairwise covariances, and the distributional specification of the probit model.[13] We follow this approach in two steps. We first evaluate the "pure" effects of agreement-specific covariates to understand the effect of each, isolated from the effect of other covariates. We then examine what we will refer as a simulated effect

[13] See Sueyoshi (1995) for a longer discussion of how to evaluate whether the effect of a variable is significant when using a probit approach to estimate the hazard and Besedeš and Prusa (2017) for an application in international trade.

Duration (ln)	-0.411***
	(0.001)
Size (ln)	-0.123***
	(0.000)
Importer GDP (ln)	-0.017***
	(0.000)
Exporter GDP (ln)	-0.079***
	(0.000)
Distance (ln)	0.096***
	(0.001)
Contiguity	-0.115***
	(0.002)
Common language	0.016***
	(0.001)
Post shallow	-0.655***
	(0.002)
Start after shallow	0.795**
	(0.002)
Post deep	-0.206***
	(0.004)
Start after deep	0.195***
	(0.004)
Shallow upgraded to deep	-0.011***
	(0.003)
Constant	1.328***
	(0.006)
Observations	24,510,480
Relationships	3,109,593
ρ	0.155***

Estimated using random effects probit. Robust standard errors in parentheses, with *, **, *** denoting significance at 10%, 5%, and 1%.

Table 4: **The Effect of Shallow and Deep Agreements on the Hazard of Trade Ceasing**

of an agreement. In our simulations we assume that both kinds of agreements take place in year four of an active spell. For the case of a deep agreement preceded by a shallow one, we assume that the shallow agreement started in year 4 of the spell and was upgraded to a deep one in year 8 of the spell. All other variables are kept at their sample means. Our baseline is the predicted hazard of spells in the absence of an economic integration agreement. In addition to the predicted hazard, we plot the

99^{th} percentile confidence interval.[14] As long as confidence intervals of two predicted hazards do not overlap, the two hazards are statistically different and the relevant variable(s) has a statistically significant effect.

4.2.1 Pure effects

We begin our investigation of the pure effect of each of the five agreement-related variables with Figure 3. In it we plot the fitted hazard with all variables at their means and each of the five variables of interest fixed at 0 (no effect) or 1 (identifying an effect). Figure 3 contains four plots, one each for post shallow, start after shallow, post deep, and start after deep variables. We chose not to plot the effect of the variable identifying deep agreements that were preceded by a shallow agreement as it has a very small, almost imperceptible effect. This is best observed in Table 5 where we summarize numerically the magnitude of the effect of each of these variables. We do so in two ways, nominally and relatively, because the relative magnitude is a function of the declining hazard. As a result, simply observing nominal differences is potentially misleading. The nominal effect decreases with spell length, but, since the hazard itself decreases, the relative effect actually increases with spell length. The is uniformly observed for every single variable.

Figure 3 illustrates the effect of agreement related variables and differences in magnitudes, which are tabulated in Table 5. Both shallow and deep agreements reduce the hazard of already active spells as predicted by our model, though the magnitude of the effect is very different. On average, across all possible 44 years of a spell, a shallow agreement reduces the hazard by almost 80%, while a deep agreement does so by slightly less than half that magnitude, 37.6%. Both effects are smallest in relative sense (and largest in nominal sense) in early stages of a spell. The average

[14] The corresponding confidence interval is always represented with a dotted line and of the same color as the curve depicting the predicted hazard. In most instances the confidence interval is imperceptible given the high precision of our estimated coefficients.

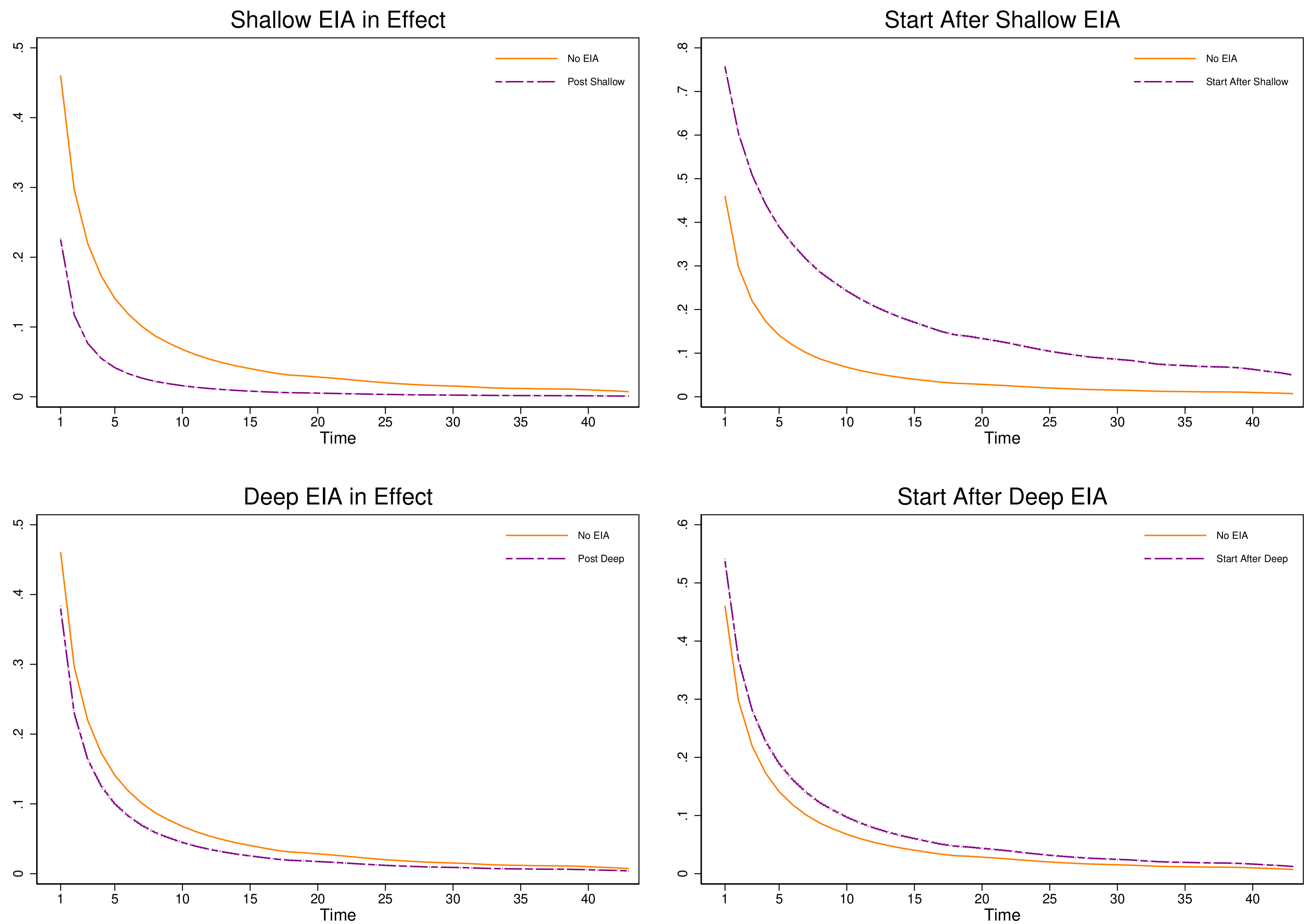

Figure 3: **Pure Effects of Agreements**

	Nominal effects				
	Shallow		Deep		Shallow upgrade
Years	Post	Start after	Post	Start after	to deep
1-3	-0.19	0.30	-0.07	0.07	0.00
4-6	-0.10	0.25	-0.04	0.05	0.00
7-10	-0.06	0.19	-0.03	0.03	0.00
11-20	-0.03	0.13	-0.01	0.02	0.00
21-30	-0.02	0.08	-0.01	0.01	0.00
31-44	-0.01	0.06	0.00	0.01	0.00
average	-0.04	0.12	-0.02	0.02	0.00

	Relative effects				
	Shallow		Deep		Shallow upgrade
Years	Post	Start after	Post	Start after	to deep
1-3	-58.9%	99.7%	-21.8%	22.9%	-1.3%
4-6	-70.2%	175.4%	-29.0%	34.0%	-1.8%
7-10	-75.1%	235.7%	-32.8%	41.0%	-2.1%
11-20	-79.8%	326.6%	-37.0%	49.9%	-2.4%
21-30	-83.1%	422.2%	-40.4%	57.7%	-2.7%
31-44	-85.3%	514.2%	-42.9%	64.3%	-2.9%
average	-79.7%	370.7%	-37.6%	52.2%	-2.5%

Table 5: **Nominal and Relative Pure Effects**

reduction in the hazard due to a shallow agreement is almost 59% for the first three years, increasing to 70.2% in the next three years, and steadily increasing to 85.3% reduction over the last 15 years. Deep agreements reduce the hazard of active spells by 21.8% in the first three years, growing to 29% for the next three years and rising to almost a 43% reduction in the hazard over the last 15 years. While our estimates are very precise, the estimated effects over the first six years or so are of most relevance. This is because, as Table 2 shows, the vast majority of spells are short-lived. While 87.7% of observed spells are six or fewer years in length, only 1.4% are observed to last more than 31 years.

Spells which start after an agreement, either shallow or deep, experience an increase in hazard relative to spells between countries that do not share an agreement. However, the difference in the magnitude of this effect is staggering. The average increase in hazard for spells started after a shallow agreement is 370.7%, while that for spells started after a deep agreement is only 52.5%. In the early stages of a spell, shallow agreements increase the hazard of newly started spells ceasing by 99.7%, doubling the hazard, in the first three years, followed by another 175.5% over the next three years. Deep agreements increase the hazard by, comparatively low, 22.9% for the first three years and 34% for the next three years.

An agreement that started as a shallow one and was upgraded to a deep one offers few additional advantages. The average reduction in hazard is just 2.5%, while the nominal effect is essentially zero. In order to save space we chose not to present a figure illustrating this effect, though we do so for simulated hazard in the next section.

4.2.2 Simulated effects

In order to fully understand the effect shallow and deep agreements have on spells of trade we simulate their effects. While pure effects investigated in the previous section are informative about the general effect of agreements, the specific effect is often a combination of two or more agreement-specific variables. The effect of a shallow agreement on spells that start after the agreement is in place is a combination of the post-shallow and start-after-shallow variables. We do so with the following profile of spells in mind. We simulate the effect of either a shallow or a deep agreement on already active spells by assuming that an agreement started in the fourth year of a spell, at which point we set the post-shallow or post-deep variable to one. For the case of agreements that started as shallow and became deep, we assume that the shallow agreement started in year four of the spell and was changed to a deep agreement in year eight of the spell.[15]

We collect our results in Figure 4 and Table 6. The former contains three panels, one each for simulated effects of shallow, deep, and shallow that became deep agreements, while the latter tabulates nominal and relative effects. Simulated effects

[15]Our choice of these years is rather arbitrary and only serves the purpose to illustrate the magnitude of the effects of agreements on active spells.

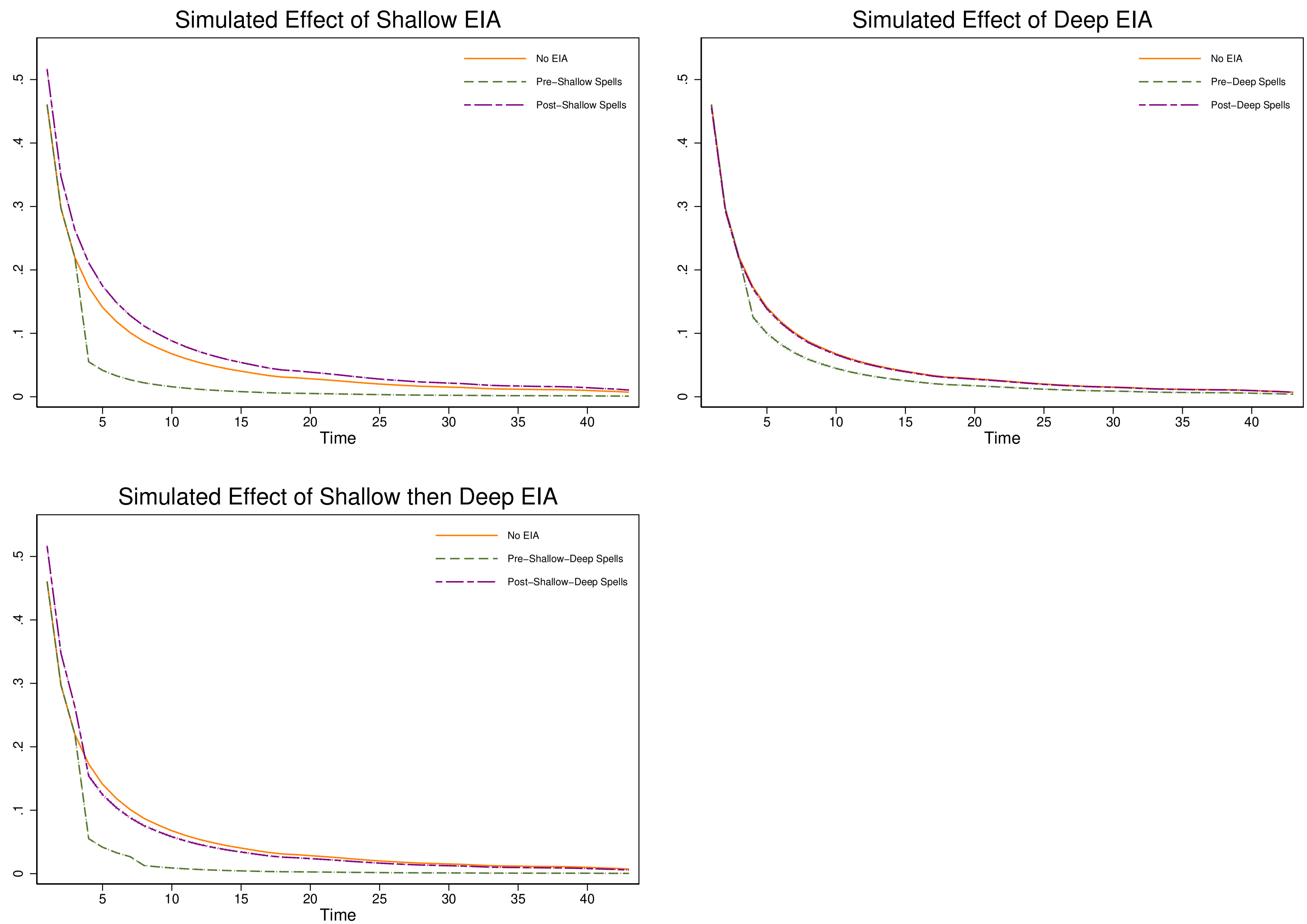

Figure 4: **Simulated Effects of Agreements**

	Nominal effects					
	Shallow		Deep		Shallow then deep	
Years	In year 4	Start after	In year 4	Start after	In year 4	Start after
1-3		0.05		0.00		0.05
4-6	-0.10	0.03	-0.04	0.00	-0.10	-0.02
7-10	-0.06	0.02	-0.03	0.00	-0.07	-0.01
11-20	-0.03	0.01	-0.01	0.00	-0.04	-0.01
21-30	-0.02	0.01	-0.01	0.00	-0.02	0.00
31-44	-0.01	0.00	0.00	0.00	-0.01	0.00
average	-0.03	0.01	-0.01	0.00	-0.03	0.00

	Relative effects					
	Shallow		Deep		Shallow then deep	
Years	In year 4	Start after	In year 4	Start after	In year 4	Start after
1-3		16.3%		-1.2%		16.3%
4-6	-70.2%	23.8%	-29.0%	-1.7%	-70.2%	-11.6%
7-10	-75.1%	28.5%	-32.8%	-2.0%	-82.9%	-13.4%
11-20	-79.8%	34.2%	-37.0%	-2.3%	-89.1%	-15.5%
21-30	-83.1%	39.3%	-40.4%	-2.6%	-91.4%	-17.2%
31-44	-85.3%	43.4%	-42.9%	-2.8%	-92.9%	-18.5%
average	-81.2%	35.7%	-38.7%	-2.4%	-88.9%	-14.1%

Table 6: **Nominal and Relative Simulated Effects**

clearly illustrate the differences in magnitudes of effects on incumbent spells. Shallow agreements reduce the hazard relative to spells between partners that have no agreements much more than do deep agreements. As a result, the additional reduction accorded by deep agreements that were preceded by shallow agreements (bottom left-hand panel) are small. The most notable differences between the effects of shallow and deep agreements are on spells that start after agreements. The hazard of new spells started after a shallow agreement is higher than the hazard of spells in the absence of any agreement. It is also clearly higher than the hazard of spells that were active when the agreement started. Unlike those under shallow agreements, new spells started under deep agreements face a *lower* hazard. While the pure effect on new spells that start after a deep agreement is positive (see Figure 3 and Table 5), the simulated effect is a combination of post-deep and start-after-deep variables as both of those are equal to one for new spells that start after the agreement. The hazard-reducing effect of post-deep is stronger than the hazard-increasing effect of started-after-deep. In the case of shallow agreements, it is the opposite with post-shallow effect being weaker than the started-after-shallow effect resulting in a higher hazard for spells that start after the agreement. This is best seen in the bottom-left plot of Figure 4 and in the last column of Table 6. In the case of new spells that started under a shallow agreement that became a deep agreement, we assumed the change happened in year four of the spell. Over the first three years such a spell has a 16.3% higher hazard. As the agreement is upgraded to a deep one for the remainder of the spell, the hazard is actually smaller than it would be for a spell in the absence of an agreement, by an average of 14.1%.

5 Conclusions

In this paper we characterize the dynamic behavior of trade focusing on duration or hazard of trade ceasing. We start by building a theoretical model which characterizes the behavior of a trade relationship observed at the product level by starting from firm decisions. We characterize the decision of the firm using Melitz (2003) and aggregate to the trade relationship using Klepper and Thompson (2006). In our model, firms acquire new business relations and by accumulating new business relations, an exporter can grow its presence in the market. If an exporter loses all business relations the trade relationship will go dormant until a new business relation is acquired by an exporter firm, or seller.

Our model creates predictions about the duration of active spells of trade, an active instance of a trade relationship. Duration increases in size and age of a spell (and its converse, the hazard, is decreasing in both). This prediction is borne by our data. Moreover, our model is able to generate both exit of a once active trade relationship as well as its regeneration. This feature matches a fact present in international trade data that a number of trade relationships are present in multiple distinct instances.

The focus of our paper is the effect shallow and deep economic integration agreements have on the duration of trade at a disaggregated level. We model shallow agreements as a reduction in per-unit trade costs (tariffs) and deep agreements as reductions in fixed costs of trade. We took advantage of two data sources giving us the longest available disaggegated panel data on trade and economic integration agreements: the UN Comtrade database and the Database on Economic Integration Agreements put together by Baier and Bergstrant (2007). The former allows us to use 5-digit revision 1 SITC data from 1962 to 2005, while the latter provides us with information on economic integration agreements over the same period. We classify non-reciprocal preferential trade agreements, preferential trade agreements, and free trade agreements as shallow agreements, while common markets, currency unions, and economic unions are classified as deep agreements. Armed with these data we estimate the hazard of trade ceasing.

Our model predicts that an economic integration agreement will reduce the likelihood of trade ceasing. However, the effect will be reversed for spells started after the agreement, which start with somewhat smaller values, and are more likely to cease and grow less. We find that both shallow and deep agreements reduce the hazard of spells that are active when the agreement starts, with the effect much larger for shallow agreements. The effect on spells that begin after an agreement is different. Shallow agreements increase the hazard of trade ceasing, while deep agreements slightly reduce the hazard of trade ceasing for spells that are started after the agreement. In the case of shallow agreements that become deep agreements, the conversion results in a small reduction of the hazard.

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A Theoretical Appendix

As we mentioned in the paper, most proofs follow directly from the results in Klepper and Thompson (2006). We present them here for completeness.

Preliminary results: We start by characterizing the process that generates buyers in the destination country, d. Suppose $N(t)$ buyers have been generated by time t. New buyers disappear after some length of period distributed exponentially. So the probability of the i^{th} buyer still being active at time t is $1 - H(t - t_i)$. Because the arrival of new buyers is distributed according to a Poisson process, the probability that the i^{th} buyer is still alive at time t is given by

$$\text{Pr(buyer } i \text{ is active at } t) = \frac{\int_0^t 1 - H(v)dv}{t} \tag{A.1}$$

It follows that, conditional on there being $N(t)$ buyers, the number of buyers alive at time t, apart from the first,[16] $n^*(t)$, is binomial:

$$Pr(n^*(t) = k|N(t)) = \binom{N(t)}{k} \left[\frac{1}{t}\int_0^t (1 - H(v))dv\right]^k \left[\frac{1}{t}\int_0^t H(v)dv\right]^{N(t)-k} \tag{A.2}$$

Next, recall that $N(t)$ is distributed Poisson with parameter λt so the CDF is given by

$$CDF = \sum_{N=k}^{\infty} \frac{(\lambda t)^N e^{-\lambda t}}{N!} \tag{A.3}$$

[16] JUAN: 'First' here refers to the first buyer, not the firct unit of time, correct?

Then the unconditional distribution is

$$\text{(A.4)} \qquad p_k(t) = \sum_{N=k}^{\infty} \frac{(\lambda t)^N e^{-\lambda t}}{N!} \binom{N}{k} \left[\frac{1}{t}\int_0^t (1-H(v))dv\right]^k \left[\frac{1}{t}\int_0^t H(v)dv\right]^{N-k}$$
$$= \sum_{N=k}^{\infty} \frac{(\lambda t)^N e^{-\lambda t}}{N!} \frac{N!}{k!(N-k)!} \left[\frac{1}{t}\int_0^t H(v)dv\right]^{N-k}$$
$$= \frac{\lambda^k e^{-\lambda t}}{k!} \left[\int_0^t (1-H(v))dv\right]^k \sum_{N=k}^{\infty} \frac{\lambda^{N-k}}{(N-k)!} \left[\int_0^t H(v)dv\right]^{N-k}$$

We can change variables, $z = N - k$, to obtain

$$\text{(A.5)} \qquad p_k(t) = \frac{\lambda^k e^{-\lambda t}}{k!} \left[\int_0^t (1-H(v))dv\right]^k \sum_{z=0}^{\infty} \frac{\lambda^z}{z!} \left[\int_0^t H(v)dv\right]^z$$

and using the series expansion $e^x = \sum_{z=0}^{\infty} x^z/z!$ we can rewrite the expression above as

$$\text{(A.6)} \qquad p_k(t) = \frac{\lambda^k e^{-\lambda t}}{k!} \left[\int_0^t (1-H(v))dv\right]^k e^{\lambda \int_0^t H(v)dv}$$
$$= \frac{1}{k!} \left[\lambda \int_0^t (1-H(v))dv\right]^k e^{-\lambda \int_0^t (1-H(v))dv}$$
$$= \frac{\rho(t)^k}{k!} e^{-\rho(t)}$$

where $\rho(t) = \lambda\mu\left(1 - e^{-t/\mu}\right)$. Finally the probability of the first buyer still being alive is $1 - H(t)$. With these results in hand, we can write the probability of exactly k buyers being active at time t as

$$\text{(A.7)} \qquad \Pi_k(t) = \begin{cases} H(t)p_k(\rho(t)) & k = 0 \\ (1-H(t))p_{k-1}(\rho(t)) + H(t)p_k(\rho(t)) & k = 1, 2, 3, \dots \end{cases}$$

where we have shown $p_k(\rho(t))$ is the probability of exactly k events from a Poisson distribution with mean $\rho(t) = \lambda \int_0^t (1 - H(v))dv$. Because we have assumed $H(z)$ is exponential with mean μ we find $\rho(t) = \lambda\mu\left(1 - e^{-t/\mu}\right)$. As t approaches infinity, the first market vanishes with probability 1, and the stationary distribution is Poisson with mean $\lambda\mu$.

The number of business relations in a trade spell, excluding the first buyer, is the sum of n Bernoulli trials with probability of success θ where n is distributed Poisson with mean $\rho(t)$. The distribution of this random sum is

$$p_k(t) = \sum_{n=k}^{\infty} \binom{n}{k} \frac{e^{-\rho(t)}\rho(t)^n}{n!}\theta^k(1-\theta)^{n-k} \tag{A.8}$$

which following the same steps as above we can write as

$$p_k(t) = \frac{e^{-\theta\rho(t)}(\theta\rho(t))^n}{n!} \tag{A.9}$$

Adding to this the probability $\theta(1 - H(t))$ that the business relation with the first buyer is still active at time t, we find

(A.10)

$$v_k(t) = \begin{cases} (\theta H(t) + (1-\theta))p_k(\theta\rho(t)) & k = 0 \\ \theta(1-H(t))p_{k-1}(\theta\rho(t)) + (\theta H(t) + (1-\theta))p_k(\theta\rho(t)) & k = 1, 2, 3, \dots \end{cases}$$

As $t \to \infty$ the first buyer dies and the stationary distribution is Poisson with parameter $\theta\rho(t)$.

Because we defined the duration of a trade spell as the time that has elapsed since the trade spell became active again, and because buyers die independently of new arrivals, the duration of a trade relation is also independent of new arrivals. Then, the distribution for $w(s(t), t)$, is the same as $v_k(t)$ replacing t by s and ignoring the first buyer.

We are now ready to prove **Result 1**. To do so, recall the size of a trade spell is given by $y(t) = \sum_0^{n(t)} r$, where $n(t)$ is a random number following the distribution $w(s(t), t)$ and r is a random draw from the distribution $F(r)$. We can use the result that the characteristic function of a sum of random variables is equivalent to the multiplication of their characteristic functions. The characteristic function for the unconditional distribution of trade spell sizes is obtained by taking the expectation over all n

$$\begin{aligned}
\phi_y(u;s) &= E_n[\phi_r(u)^n|s] \\
&= \sum_{k=0}^{\infty} w(s(t),t)\phi_r(u)^k \\
&= \sum_{k=0}^{\infty} \frac{e^{-\theta\rho(s)}(\theta\rho(s))^n}{n!}\phi_r(u)^k \\
&= e^{\theta\rho(s)(\phi_r(u)-1)}
\end{aligned} \tag{A.11}$$

To find the expected value we calculate

$$E[y] = \frac{\partial\phi_y(u;s)}{\partial u}|_{u=0} = \theta\rho(s)\frac{\partial\phi_r(u)}{\partial u}|_{u=0} = E[r]\theta\rho(s) \tag{A.12}$$

and to find the variance we calculate

$$\begin{aligned}
E[y^2] &= \frac{\partial^2\phi_y(u;s)}{\partial u^2}|_{u=0} \\
&= \theta\rho(s)\frac{\partial^2\phi_r(u)}{\partial u^2}|_{u=0} + \left[\theta\rho(s)\frac{\partial\phi_r(u)}{\partial u}|_{u=0}\right]^2 \\
&= \theta\rho(s)\frac{\partial^2\phi_r(u)}{\partial u^2}|_{u=0} + E[y]^2
\end{aligned} \tag{A.13}$$

From here we find

$$\text{var}[y] = \theta\rho(s)E[r^2] \tag{A.14}$$

Result 1 follows directly from these outcomes.

To show **Result 2**, we first need a definition and a result. Let $G_n(\tau|z_1, z_2, \ldots, z_n)$

denote the distribution of the first passage time, τ, to a state of zero active business relations for a trade spell with n business relations of ages z_i. Now add one business relation of age z_{n+1}. By construction, the first passage distribution is given by

$$\begin{aligned} G_{n+1}(\tau|z_1, z_2, \ldots, z_n, z_{n+1}) &= \frac{H(z_{n+1}+\tau) - H(z_{n+1})}{1 - H(z_{n+1})} G_n(\tau|z_1, z_2, \ldots, z_n) \\ &< G_n(\tau|z_1, z_2, \ldots, z_n) \end{aligned}$$

Then, for **Result 3**, we recognize that $n(t)$ is positively related to duration, $s(t)$, according to Result 1. Since the size of a trade spell equals the product of $n(t)$ and the average size of business relations in each trade spell, it is also positively related to $n(t)$. Duration and size are related to $n(t)$ in different ways, and thus both will be positively related to $n(t)$ even conditional on the other. A more direct proof is provided by Klepper and Thompson (2006).