Relationship stickiness, international trade, and economic uncertainty*

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Abstract

We study how stickiness in business relationships influences the trade impact of aggregate uncertainty. To begin, we construct a product-level index of relationship stickiness using firm-to-firm relationship duration data. We then demonstrate how relationship stickiness shapes trade dynamics in response to uncertainty shocks. We find that episodes of uncertainty lead to a decline in the overall establishment of new business relationships, with the impact varying depending on the level of stickiness. In markets characterized by high stickiness, uncertainty shocks primarily impede investments in new firm-to-firm relationships. In contrast, for non-sticky products, the adjustment to uncertainty shocks mainly manifests as the disruption of existing relationships.

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1 Introduction

How do firm-to-firm relationships influence the response of international trade to uncertainty? One distinguishing characteristic of trade relationships is the level of stickiness they exhibit. In certain product categories, particularly intermediate inputs, the presence of search and customizing costs leads to the formation of long-lasting firm-to-firm relationships and the establishment of rigid trade networks (Antràs and Chor, 2013). While extensive research has been conducted on the implications of these rigidities for trade organization, our knowledge regarding their influence on the transmission of uncertainty shocks to trade flows remains limited.

In this paper, we present evidence that products characterized by stickiness exhibit greater persistence in their firm-to-firm networks when faced with uncertainty shocks. Our study makes two primary contributions. Firstly, we introduce a new metric to quantify relationship stickiness across approximately 5,000 product categories, derived from a comprehensive dataset of firm-to-firm trade information. Secondly, we investigate the dynamics of trade adjustment in response to uncertainty shocks, exploring how the magnitude and mechanism of this adjustment differ based on the level of product stickiness.

Our measure of relationship stickiness is based on the idea that the *duration* of firm-to-firm trade relationships provides valuable insights into the degree of specificity associated with products. This measure is developed within a theoretical framework of firm-to-firm input trade. In this model, firms receive offers randomly and decide to switch to a new input supplier only if the offered price is significantly lower than the price charged by their existing partner, allowing to cover the cost associated with establishing a new relationship. Within this model, higher switching costs and search frictions contribute to lengthening existing firm-to-firm relationships, conditional on the quality of a match. Therefore, the duration of relationships is a relevant empirical moment that can be used to derive a product-level measure of stickiness.

To estimate our model, we use firm-to-firm export data from France. This dataset provides a valuable panel dimension, allowing us to track importers over time and calculate the duration of their relationships with French firms. We take advantage of the unique level of disaggregation in the data to account for individual characteristics that influence the quality of a match and contribute to variations in relationship durations within specific product categories. We then leverage the variability in average durations *across* different products to derive a measure of relationship stickiness (RS) for over 5,000 HS6 products. We present a substantial body of evidence supporting the notion that our recovered measure of relationship stickiness effectively captures relational specificity at the product level. The measure correlates with existing proxies for relationship specificity found in the literature and also exhibits additional variation within industries. Furthermore, we delve into the micro-foundations of our relationship stickiness measure. Our results suggest that stickiness is influenced by a combination of technological determinants and characteristics of the market structure.

Equipped with this measure, we delve into the impact of relationship stickiness on the adjustment of trade flows in response to uncertainty shocks. In our stylized model, uncertainty shocks diminish the buyer's propensity to switch to a new match, conditional on the level of stickiness.[1] The effect is particularly pronounced in markets characterized by higher stickiness, where the switching cost is larger. To empirically test the model's prediction, we combine micro-level data on firm-to-firm relationships with macro-level data on uncertainty. Specifically, we leverage quarterly data on country-level uncertainty

[1]In the model, uncertainty episodes are linked to the presence of downside risk. Consequently, the uncertainty shock leads to a reduction in expected future profits, impacting firms' propensity to switch before the risk materializes. We demonstrate that the qualitative findings remain consistent even when subjected to mean-preserving uncertainty shocks, when firm managers exhibit risk-averse behavior.

obtained from Ahir et al. (2019), which we merge with product-level information on the number of new and disrupted relationships involving French firms and their European partners. By integrating measures of aggregate uncertainty shocks and product-level stickiness, we gain insights into the heterogeneity of trade responses at the product level when faced with aggregate uncertainty shocks.

During periods of high uncertainty, there is a consistent decrease in the number of new trade relationships.[2] The quantitative impact exhibits some variation across different specifications, with an estimated contemporaneous effect of approximately -5%. The influence of uncertainty is particularly pronounced in product markets characterized by a high degree of stickiness. As we move from the first to the third quartile of the relationship stickiness distribution (RS), the magnitude of the effect ranges from -1.5% to -10%. Additionally, we provide evidence that separation rates increase during periods of heightened uncertainty, with the impact diminishing as we move along the stickiness distribution and becoming statistically insignificant for the most sticky products. To ensure the robustness of our findings, we conduct an extensive analysis that includes various robustness checks. These tests involve using alternative proxies for relationship stickiness and examining different sub-samples. Our results remain consistent across these robustness analyses.

Lastly, we examine the implications of these findings for trade growth. Consistent with prior research, we estimate a substantial -12 percentage point response of product-level trade growth to episodes of uncertainty. The majority of this effect stems from a decrease in the net creation of firm-to-firm relationships, a trend that is particularly pronounced in sticky markets. Conversely, adjustments at the intensive margin are relatively minor. Interestingly, we can contrast these results with the effects associated

[2] To isolate the role of uncertainty, our regression controls for the state of the economy, as measured by GDP growth, and its interaction with stickiness.

with a shock to the level of growth in the destination market. In instances of low growth, we observe a significant reduction in product-level trade as well. However, approximately 50% of this effect is driven by adjustments at the intensive margin, particularly in sticky-product markets.

Related literature. This paper contributes primarily to two areas of research: the literature on relationship-specific investments in trade and the literature on the transmission of uncertainty shocks into international trade flows. We highlight the significance of stickiness in international contexts, a factor that has been consistently emphasized in models involving relationship-specific investments or search costs in the supplier market, along with market incompleteness (Grossman and Helpman, 2003; Antràs, 2003; Antras and Helpman, 2004; Grossman and Helpman, 2005; Feenstra and Hanson, 2005).[3]

In the existing literature, relationship specificity is typically measured using proxies developed by Rauch (1999) or Nunn (2007).[4] Our contribution to this literature is the development of a novel measure of product relationship specificity, which operates at a detailed level by leveraging information on the duration of firm-to-firm trade relation-

[3]The interaction between relationship specificity and the legal environment plays a crucial role in shaping countries' specialization patterns (Levchenko, 2007; Nunn, 2007), and the resulting welfare gains (Chor and Ma, 2020). The degree of relationship specificity also influences the decision to integrate suppliers domestically or internationally (Acemoglu et al., 2009; Antràs and Chor, 2013). Furthermore, the trade impact, purpose, and optimal design of trade policy are contingent upon the stickiness of business relationships (Antràs and Staiger, 2012; Grossman and Helpman, 2021).

[4]Alternative measures have also been proposed, such as the Herfindahl index of intermediate input use (Levchenko, 2007), the share of wholesalers importing a product (Bernard et al., 2010a), suppliers' R&D expenses and the number of patents they issued (Barrot and Sauvagnat, 2016), or the distance to final demand (Antràs et al., 2012). Chor and Ma (2020) introduce a measure of contractibility inspired by Nunn (2007)'s framework.

ships. In contrast to other measures, our indicator is calculated at a more granular level, and alllows us to capture the influence of a broader range of product-market characteristics that affect churning in product markets. By doing so, our measure provides additional insights and complements the information contained in alternative measures of stickiness.

In doing so, we contribute to the existing literature that explores the relationship between trade frictions and the duration of trade relationships (Besedes and Prusa, 2006; Monarch, 2014; Macchiavello and Morjaria, 2015; Schmidt-Eisenlohr and Monarch, 2015; Heise, 2016).[5] The closest paper to ours is Monarch (2014), who structurally estimates the switching costs across Chinese suppliers for US importers. We employ a less computationally demanding procedure that enables us to obtain a measure of stickiness for a broader range of products.

Additionally, our paper makes a contribution to the literature on the transmission of uncertainty to international trade flows. The literature has established a connection between uncertainty and the volatility of international trade, as demonstrated by Novy and Taylor (2019). Moreover, there is a body of research examining the trade effects of reducing policy uncertainty, such as Portugal's accession to the European Community (Handley and Limao, 2015) and China's entry into the WTO (Handley and Limao, 2017; Pierce and Schott, 2016). The impact of Brexit-induced uncertainty on trade has also

[5]Notably, Schmidt-Eisenlohr and Monarch (2015) and Heise (2016) use similar firm-to-firm data but focus on the heterogeneity in the duration of relationships across firms. Schmidt-Eisenlohr and Monarch (2015) demonstrates that the survival probability of seller-buyer relationships increases with their size and age, using matched US importer-exporter data. Heise (2016) investigates the systematic relationship between exchange-rate pass-through and the duration of firm-to-firm relationships. In contrast, our approach leverages the duration of seller-buyer relationships in international markets to derive a product-level measure of relationship stickiness while controlling for individual characteristics.

been extensively studied, with significant findings of both extensive and intensive trade responses (Graziano et al., 2018; Ahmad et al., 2020; Exton and Rigo, 2020). In comparison to this existing literature, our study provides further evidence that uncertainty affects trade at the extensive margin, specifically at the firm-to-firm level, and that this effect is more pronounced in stickier product markets. These findings align with the work of Carballo (2015) and Carballo et al. (2018), who also highlight the importance of extensive margin adjustments in response to uncertainty.[6]

The remainder of the paper is organized as follows. Section 2 provides a detailed description of the firm-to-firm data that forms the basis of our analysis. In Section 3, we develop a theoretical framework based on a search model to derive our measure of relationship stickiness and discuss its potential impact on the transmission of uncertainty to trade. Section 4 explains the estimation procedure and presents the results of the estimation. Section 5 investigates the transmission of uncertainty shocks into international trade. Finally, Section 6 concludes.

2 Data

This section provides an overview of our dataset and explains the process of constructing the duration of firm-to-firm relationships, which serves as our primary variable of interest. Further details and additional facts about the dataset can be found in the Online

[6]The interaction between uncertainty and the degree of stickiness is also discussed in Heise et al. (2017). They primarily examine the level of trade policy uncertainty and its impact on the stickiness of trade through firms' procurement practices. In contrast, our empirical analysis focuses on temporary uncertainty episodes and their effects on trade dynamics, given the degree of stickiness. Given the temporary nature of uncertainty episodes, we believe that the potential endogeneity of stickiness to uncertainty is not a severe concern in our specific context.

Appendix.

Data sources. Our analysis relies on a panel of firm-to-firm trade data obtained from the French Customs and detailed in Bergounhon et al. (2018). This dataset provides comprehensive information on export transactions between French firms and their individual partners within the European Union. Notably, the data allow us to track and identify both the exporting French firms and their clients over time, using unique tax identifiers. Each transaction in the dataset is associated with a specific product category (at the 8-digit level of the European combined nomenclature), a precise date (month and year), and the corresponding shipment value in euros.

For our baseline analysis, we focus on French exports to the eleven historical members of the European Union during the period of 1996-2010. Our objective is to measure relationship stickiness at the product level. It is important to note that the French customs data do not include information on the specific nature of the product for transactions below a certain value threshold. As a result, our sample may not fully represent the smallest transactions. We further control for changes in the product nomenclature using the harmonization algorithm outlined in Behrens et al. (2018). Details regarding the construction of our sample can be found in the Online Appendix.

Facts on trade relationships. We estimate relationship stickiness using a sample that spans from 1996 to 2006. Within this period, our estimation sample consists of more than 100 million firm-to-firm transactions. These transactions involve 110,000 distinct French exporters and 1.6 million foreign importers. For the purpose of our analysis, we define a relationship as a collection of transactions between a specific pair of firms engaged in trade within a particular product category. Overall, our dataset comprises 19.4 million firm-to-firm relationships, with an average of five transactions per relationship.

The distribution of transactions by buyers exhibits a high degree of skewness. A mere 8% of importers are observed engaging in more than 20 transactions with French firms, yet they contribute to over 85% of total trade. Conversely, 44% of buyers are involved in just one transaction with a French seller throughout the ten-year period. These one-time buyers are associated with remarkably small transactions, accounting for only 1.5% of the total trade value. It is likely that a significant portion of these transactions represents non-market activities, such as exporters sending samples to potential clients. Consequently, we made the decision to exclude these one-shot buyers from our baseline estimation of relationship stickiness. We demonstrate in the online appendix that this choice does not undermine the robustness of our relationship stickiness estimates.

Duration of trade relationships. A crucial component of our measure of relationship stickiness, as discussed in Section 3, is the duration of firm-to-firm relationships. To calculate these durations, we examine the time series of interactions between buyers and French firms. In our baseline estimation, we define the duration as the number of months between the first and last transactions within a continuous relationship involving a specific pair of firms for a given product. A relationship is considered continuous if it comprises a sequence of transactions that is not interrupted by a transaction involving the same importer but a different seller.

The many-to-one matching structure of the firm-to-firm data, where multiple buyers often purchase a particular product from a single French seller, facilitates the definition of continuous relationships. At any given time, over 90% of European buyers purchase a specific product from a single French seller, while French sellers frequently interact with multiple European buyers.[7] This observation allows us to track importers over time in

[7] A similar many-to-one structure has been observed in various contexts. For instance, Monarch (2014) examined U.S. imports from China and found similar patterns, with U.S. importers often sourcing from a single Chinese supplier for a specific product. Additionally, Muûls (2015) documented a similar

their sequential interactions with French firms and define a continuous relationship as a series of consecutive transactions involving the same importer and a specific French firm. However, there are several challenges in operationalizing this measure: i) Some importers interact with multiple exporters within a month for a given product, ii) Durations may be overestimated if the buyer switches to a non-French seller before returning to the previous partner, iii) Transaction frequencies may vary across firms and products, iv) Some relationships are censored, meaning they do not have complete information on the start or end date. We discuss each of these challenges in detail in the Online Appendix and demonstrate the robustness of our relationship stickiness measure when employing alternative duration measures.

In the Online Appendix, we also provide additional insights into the durations of trade relationships. Firstly, we find a substantial heterogeneity in the durations of these relationships. Approximately 40% of the firm-to-firm relationships last only one month, while around 30% persist for over a year. This variation highlights the diverse nature of trade relationships and the differing lengths of time over which buyers and sellers interact. Furthermore, we observe a positive correlation between the duration of trade relationships and the average size of transactions. This correlation holds both across buyers within a specific product and within a buyer across different suppliers encountered throughout their interactions with French firms. These findings suggest that the duration of trade relationships is influenced by the quality of the match between buyers and suppliers. We take into account this aspect of relationship quality in our theoretical model and empirical estimations, recognizing that the nature of the buyer-seller match can impact the duration of trade relationships.

phenomenon among Belgian importers, who also tend to import from a single country for a given product.

3 Theoretical framework

In Section 2, we discussed the panel structure of the firm-to-firm data, which allows us to examine the duration of relationships. Building on this, we now present a stylized theoretical framework that serves two main purposes. First, the theory aims to establish a relationship between the expected duration of relationships and relationship stickiness. This mapping will provide us with a theoretical foundation for our empirical analysis. Second, the theory will shed light on the differential impact of uncertainty shocks across products with varying degrees of stickiness. By incorporating the notion of stickiness into our theoretical framework, we can gain insights into the heterogeneous effects of uncertainty on trade.

3.1 Relationship duration and stickiness in a search model

Our analysis is based on a simple search model that captures the interaction between sellers and buyers of a particular product. Within this model, we recognize that different products exhibit varying levels of relationship stickiness due to heterogeneous search frictions or costs associated with switching between suppliers. To simplify the notation, we omit explicit product-specific subscripts, but it should be noted that all parameters we introduce in the following discussion may vary across products. This is true in particular of the parameters at the root of stickiness which we will define now, namely λ and γ.

Let's consider a buyer who purchases a product from a supplier at a quality-adjusted price of p. The buyer's objective is to maximize the net present value of the stream of future profits, denoted as $V(p)$. We assume that $V(p)$ is decreasing in p, indicating that higher prices reduce the buyer's profitability ($V' < 0$). In each period, the buyer has a probability λ of receiving an offer $\tilde{p}$ from a new input supplier. This offer represents the quality-adjusted price at which the new supplier is willing to sell the product. The specific value of $\tilde{p}$ is determined by a random variable P that follows a cumulative distribution function $H_P(p) = \mathbb{P}(P \leq p)$. Stronger search frictions, characterized by a lower value of λ, result in longer firm-to-firm relationships while offering the current supplier a monopoly position until a better offer is received.

The decision to switch is based on comparing the net present value of future profits under the new offer $V(\tilde{p})$ with the net present value under the current price $V(p)$, taking into account the sunk switching cost $C(\gamma; p)$.[8] The switching cost is assumed to be increasing in a structural parameter $\gamma \geq 1$ ($\frac{\partial C}{\partial \gamma} > 0$). The switching cost may also vary across firms, in which case $\frac{\partial C}{\partial p} \neq 0$. In the case where $\gamma = 1$, indicating no switching costs ($C(1; p) = 0$), the buyer switches suppliers as soon as it receives an offer below the current price. However, when $\gamma > 1$, there is a positive switching cost, and the buyer's reservation price $p^*(\gamma; p)$ is implicitly defined by $V(p^*(\gamma; p)) - V(p) = C(\gamma; p)$. The reservation price $p^*(\gamma; p)$ represents the threshold below which the buyer is willing to switch suppliers. The value function $V(\cdot)$ is defined recursively through a Bellman equation, and its specific form is explained in Appendix A.1. The model captures the decision-making process of the buyer in terms of switching suppliers, considering the trade-off between the potential gains from switching and the associated sunk switching cost.

Under the conditions described, the duration $\mathcal{T}$ of a buyer-seller relationship, conditional on its price, follows a geometric distribution with mean:

$$\mathbb{E}[\mathcal{T}|p] = \sum_{j=1}^{+\infty} j(1 - \lambda H_P(p^*(\gamma; p))^{j-1} \lambda H_P(p^*(\gamma; p)) = \frac{1}{\lambda H_P(p^*(\gamma; p))}. \quad (1)$$

[8] We assume that the price p is determined prior to the arrival of a new offer, and there is no renegotiation between the firm and its supplier when a better offer arrives. Note that relationship duration does not depend per se on buyer-seller surplus division surplus, see, e.g., renegotiations "on-the-match" in Fontaine et al. (2022).

The model can be extended in continuous time, where offers follow a Poisson process. The duration $\mathcal{T}$ of a relationship at price p then follows an exponential distribution $\mathcal{E}$ with parameter $\lambda H_P(p^*(\gamma; p))$.

In this model, the expected duration of a relationship is the reciprocal of the switching probability. It depends on the firm's current deal p, the frequency of offers λ, and the product-specific cost of establishing a new relationship represented by $C(\gamma, p)$, which affects the reservation price $p^*(\gamma; p)$. Holding other factors constant, a firm that encounters a more competitive supplier is more likely to maintain a long-lasting relationship with that supplier. However, conditional on the quality of the match between the supplier and the buyer, higher search frictions and switching costs shift the distribution of durations towards longer and "stickier" relationships. These product characteristics are precisely what our measure of relationship stickiness captures.

Parametrization To prepare for our empirical analysis, we will now concentrate on a specific case that encompasses three parametric assumptions. First, we introduce a parametrization for the switching cost function, which results in a reservation price of $p^*(\gamma; p) = p/\gamma$. This parameter γ now represents the constant price wedge between the current price and the reservation price. Second, we assume that the distribution of quality-adjusted prices follows an inverse-Pareto distribution with a shape parameter of k. Third, we assume an iso-elastic demand curve for the importer, with a price elasticity of demand denoted as $\sigma > 1$.[9] Under the specified assumptions, we can express the distribution of durations conditional on the size r of the transaction, instead of relying

[9]The combination of the second and third assumptions leads to the implication that the distribution of observed transactions between buyers and sellers closely resembles a Pareto distribution for large transaction sizes. This finding is in line with the canonical model of firm heterogeneity under monopolistic competition, as exemplified by Melitz and Redding (2014). Relatedly, assuming a multiplicative friction is also a standard assumption of the trade literature.

on the unobserved price offered by the supplier:

$$\mathcal{T}|\{R=r\} \sim \mathcal{E}\left[\frac{1}{\eta}\left(\frac{r}{r_{min}}\right)^{-\frac{k}{\sigma-1}}\right], \tag{2}$$

where r_{min} is the lower bound of the distribution of transactions and $\eta \equiv \frac{\gamma^k}{\lambda}$. The parameter η acts as an indicator of relationship stickiness specific to each product. It captures various factors that contribute to longer durations in firm-to-firm relationships after a match has been made. These factors include infrequent offers exchanged between the buyer and seller, indicated by a low value of λ, high switching costs faced by the buyer, represented by a high value of γ, or a limited dispersion in the distribution of price offers, reflected in a high value of k. Once we have estimated the value of η, we will delve into analyzing the relative contribution of these different structural forces.

It is worth noting that while equation (2) is derived based on specific parametric assumptions, the underlying insights of the model hold more generally. We discuss this in greater detail in the Online Appendix, where we explore the model's predictions under alternative assumptions such as a fixed switching cost ($C(\gamma; p) = \gamma - 1$) and the use of alternative price distributions. We show that the ranking of products, based on our measure of stickiness, remains consistent even when considering alternative functional forms and assumptions.

3.2 Relationship stickiness and macroeconomic uncertainty

In order to account for macroeconomic uncertainty, we extend the baseline model by introducing a macroeconomic variable, denoted as I, which represents the level of aggregate demand faced by all firms in the market. This variable affects the net present value of a relationship by influencing instantaneous profits. We assume that instantaneous profits are an increasing function of I. The aggregate demand evolves randomly over time according to an autoregressive process of order 1. The law of motion for aggregate demand, denoted as G, is defined by the conditional probability density function $g(I_{t+1}|I_t) = \phi(I_{t+1} - \alpha I_t)$, where ϕ represents the p.d.f of a truncated normal distribution $\mathcal{N}(\mu, \sigma^2)$. We assume the income process to be bounded from above, which means that a shock to the variance σ^2 does not necessarily result in a mean-preserving change. We then simulate the model using increasing values for σ, starting from a high income level. This setup allows us to associate the shock with downside risk, which aligns with the measure of uncertainty used in the subsequent empirical analysis. The chosen measure of uncertainty, taken from Ahir et al. (2019), is also not mean-preserving.[10]

In the extended model, the decision of each buyer to switch is still determined by their reservation price, denoted as $p^*(\{\gamma, G\}; p, I)$, but now it is conditional on the current level of demand I. In Appendix A.1, we derive the value function of a buyer in the presence of economic uncertainty $V(p, I)$. Here, we will outline how uncertainty impacts buyer-seller relationship durations and consequently the definition of relationship stickiness derived in Section 3.1 when there is no uncertainty. Additionally, we will describe how episodes of uncertainty influence buyer-seller trade across the distribution of relationship stickiness.

Ranking buyer-seller relationship durations under uncertainty: In the previous section, we discussed the relationship between product-level stickiness and buyer-seller relationship durations in an economic environment without uncertainty. We demonstrated that a higher degree of stickiness (represented by a higher η value) results in longer buyer-seller relationships, assuming a constant match quality. However, since durations are expected to be influenced by uncertainty, we need to verify that different

[10] In Section O.3.4 of the Online Appendix, we further extend the model to incorporate risk-averse firm managers and mean-preserving uncertainty. We demonstrate that the results discussed in this section remain consistent even under these additional considerations.

Table 1: ***Expected duration of relationships at various points of the price distribution***

	Percentile of price				
	10th	25th	50th	75th	90th
No uncertainty					
No stickiness	35	14	7	5	4
Medium stickiness	40	22	12	10	9
High stickiness	43	25	15	12	11
Low uncertainty					
No stickiness	35	14	7	5	4
Medium stickiness	90	35	17	10	8
High stickiness	256	95	40	21	15
High uncertainty					
No stickiness	35	14	7	5	4
Medium stickiness	121	45	20	11	9
High stickiness	1,315	520	199	73	15

Notes: The table presented displays the simulation results of the model under different levels of uncertainty and product stickiness. The numbers provided represent the expected duration of relationships across the price distribution, measured in months. Specifically, the scenarios include: i) “No stickiness”: This scenario corresponds to a value of $\gamma = 1$, indicating no stickiness effect, ii) “Medium stickiness” and “High stickiness”: These scenarios use stickiness values chosen in the model without uncertainty to match the durations at the median of the price distribution, for the mean product and the product at the third quartile of the distribution in our data (durations of 12 and 15 months, respectively), iii) “No uncertainty”: In this scenario, the aggregate demand is constant, iv) “Low uncertainty” and “High uncertainty”: These scenarios introduce AR(1) aggregate demand shocks with low or high variance, respectively. These simulations allow us to observe the effects of different levels of uncertainty and product stickiness on the expected relationship durations.

levels of uncertainty (σ) do not alter the ranking of products based on the duration of their relationships. To accomplish this, we simulate expected durations for various degrees of stickiness (γ) under different levels of uncertainty (σ).

The results, presented in Table 1, confirm that relationship stickiness can be reliably regarded as an ordinal measure. Product-level buyer-seller relationship durations continue to provide meaningful information about product-level stickiness, even in the presence of uncertainty. Specifically, when we elevate the level of switching costs, the distribution of expected durations is consistently shifted upwards. This observation holds true irrespective of the presence of uncertainty.

Uncertainty shocks and relationship stickiness We use the model to gain insights into how trade adjusts to uncertainty shocks. The simulation involves a population of firms that interact with suppliers drawn from the inverse-Pareto distribution described earlier. These firms make decisions on whether to switch suppliers based on the model dynamics. Initially, the macroeconomic environment exhibits high demand and low uncertainty, with a small variance in the AR(1) process. After reaching a steady state, we introduce an uncertainty shock by increasing the variance of the AR(1) process unexpectedly. Through this simulation, we can observe the adjustment of trade in response to the uncertainty shock. This allows us to understand the dynamics of buyer-seller relationships and switching behavior during periods of increased uncertainty.

Table 2 presents the switching probabilities before and after the uncertainty shock for three different populations of firms operating in markets with varying levels of stickiness for their products. Importantly, the switching probabilities are calculated after the occurrence of the uncertainty shock but before any adjustment in aggregate income, allowing us to capture the pure effect of increased uncertainty about the future. After a shock occurs, the probability of switching trade relationships tends to decrease. The reason is that an increased downward risk reduces the value of all new relationships, thus

Table 2: ***Impact of uncertainty shocks on switching probabilities***

	Stickiness		
	None	Medium	High
Switching probability			
Before	.060	.029	.017
After	.060	.025	.008
Change (%)	-0	-15	-53

Notes: The table shows the switching probability in a population of 2,000 firms before and after an uncertainty shock. The calibration of the model assumes an AR(1) process for aggregate demand shocks that displays a low variance until the economy is hit by an "uncertainty" shock, i.e. an unanticipated shock to the variance of the process. The probability "after" the shock is computed on impact, i.e. when firms realize the variance of the income process has increased but the level of income is still the same as in the "Before" period.

pushing down the reservation price below which firms decide to pay the (sunk) switching cost. The impact of increased uncertainty on switching probabilities is particularly pronounced in markets characterized by higher levels of stickiness. These predictions of the model will be later brought to the data. Specifically, the empirical analysis aims to examine whether the combination of uncertainty and relationship stickiness contributes to the dynamics of establishing new trade relationships.

4 Relationship stickiness: estimation and facts

4.1 Measuring relationship stickiness

In the preceding section, we demonstrated that the ranking of products based on the duration of buyer-seller relationships provides valuable insights into the level of stickiness, irrespective of uncertainty levels. Now, we will explore how we can use the baseline model presented in Section 3.1 to derive an empirical measure of stickiness.

Our dataset consists of a vector of observed durations for all relationships involving a European buyer and a French exporter. To estimate the parameters of equation (2), we leverage the statistical properties of the product-specific empirical distribution of these random variables. Within the model's assumptions, we can express the expected duration of a relationship, given that transactions R fall within the q-th quantile of its product-specific size distribution, as follows:[11]

$$\mathbb{E}\left[\mathcal{T} \mid R \in R_q\right] = \int_{r_{q-1}}^{r_q} \eta \left(\frac{r}{r_{min}}\right)^{\frac{k}{\sigma-1}} H_R'(r)dr = \eta \ \ln\left[\frac{\mathbb{P}(R \geq r_{q-1})}{\mathbb{P}(R \geq r_q)}\right], \tag{3}$$

[11]The first equality follows from the law of iterated expectations, while the second one stems from the properties of the Pareto distribution. If X follows a Pareto distribution with shape parameter κ and locus x_m, then $\frac{q}{Q} = 1 - \left(\frac{X_q}{X_m}\right)^{\kappa}$, where Q represents the number of cut points, and X_q denotes the value for the q-th cut-point. Further details can be found in Appendix A.2.

where R_q denotes the q^{th} quantile of the distribution:

$$R_q := [r_{q-1}, r_q] \equiv \left\{ r \mid \bar{H}_R^{-1}\left(\frac{q-1}{Q}\right) \leq r \leq \bar{H}_R^{-1}\left(\frac{q}{Q}\right) \right\}$$

and $H_R(r) \equiv 1 - \bar{H}_R(r) = \mathbb{P}(R \leq r)$. The log-linear relationship of equation (3) with respect to η allows us to use a fixed effect model to estimate the product-specific index of relationship stickiness, up to a constant term. The implementation details can be found in Appendix A.2, which outlines a straightforward process. The quantity $\left[\frac{\mathbb{P}(R \geq r_{q-1})}{\mathbb{P}(R \geq r_q)}\right]$ measures the mass of transactions within the quantile of interest and is scaled by the position of the quantile in the distribution. The expected duration within a quintile can be calculated directly from the available data.[12]

4.2 Stylized facts on relationship-specific indicators

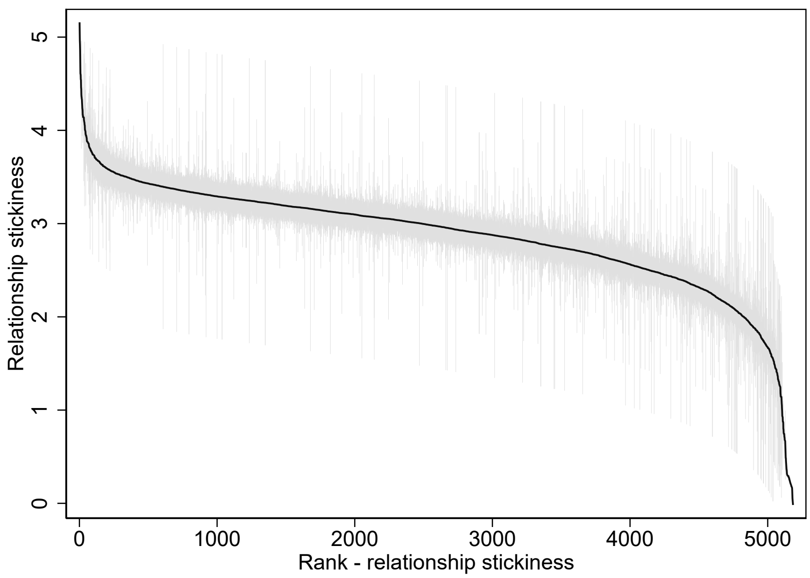
Using the approach described in Section 4.1, we successfully estimate the relative level of stickiness for a total of 5,186 HS6 products.

The analysis reveals substantial variations in the level of relationship stickiness across HS6 products, with a mean at 2.87, a median at 2.97, and an interquartile range of 0.62 (Figure 1). Interpreting the point estimates as the logarithm of the η parameter, an interquartile range of 0.62 suggests that the expected duration of trade flows is approximately 1.8 times longer at the 75th percentile of the product distribution compared to the 25th percentile.[13]

[12] It is worth noting that our objective is not to derive a product×country-specific measure of stickiness. In our model, stickiness is considered a product attribute. Exploring the country dimension of stickiness could be an interesting avenue for future research, although it would require working with a more diverse set of destinations beyond the EU area.

[13] Among the most relationship-specific products are several industrial chemical, pharmaceutical, and mineral products. These findings may appear surprising. Chemicals, for instance, are commonly per-

Figure 1: ***Distribution of RS estimates***



Notes: The figure shows the distribution of estimated relationship stickiness indicators (solid line) and their 10% confidence interval (grey area). The distribution covers 5,186 HS6 products.

It is important to note that the precision of our estimates varies across different products. Empirically, we observe that products with a larger number of firm-to-firm relationships tend to have narrower confidence intervals, with the two variables being correlated at 75%. This pattern is expected since our empirical approach relies on the law of large numbers to smooth the impact of duration heterogeneity within product-specific subsamples. As the number of relationships increases, the approximation improves. Importantly however, the number of observations does not affect the point estimates themselves. To account for estimation errors, our empirical analysis relies on a parametric bootstrap.

Table 3 presents the correlations between our measure of relationship stickiness (RS) and other product-specific attributes commonly used in the literature. The first column shows the pairwise correlation coefficients, while column (2) reports the coefficients from a regression of our RS measure on all other characteristics. Our measure of product stickiness is positively correlated with alternative measures of product specificity such as Rauch (1999) and Nunn (2007). Consistent with Heise et al. (2017), differentiated products tend to exhibit higher levels of relationship stickiness, as shown by the positive correlation with the dummy for differentiated products recovered from Rauch (1999) and the negative correlation with elasticities of substitution estimated in Imbs

ceived as homogeneous products. But the chemical industry comprises both commodity chemicals and specialty chemicals. The latter category involves chemicals that are tailored to the unique requirements of each client, thus contributing to the establishment of enduring relationships. At the other end of the distribution, we find a range of final goods that are typically produced in large quantities and sold in anonymous markets (e.g., men's suits). Additionally, certain non-differentiated primary goods (such as ferro-alloys or raw silk) and various capital goods, including machines used in the textile industry, are also represented. These products are characterized by infrequent purchase patterns and are not subject to the same degree of relationship stickiness.

Table 3: ***Correlation with other measures***

Measure	Corr(η,.) (1)	OLS η (2)
$\mathbf{1}_{differentiated}$ (Rauch)	.07***	.05**
Share of not homogen. products (Nunn)	.04**	$-.04$
Upstreamness (Antras et al.)	.13***	.21***
Elasticity of subs. (Imbs & Mejean)	-.06***	-.16***
Product complexity (Haussman & Hidalgo)	.16***	.09***
Observations		3,876
R^2	-	.07

Notes: This table reports the pairwise correlation coefficients (column (1)) and the multivariate correlations (column (2)) bewteen estimated RS indices and various characteristics of these products. Robust standard errors in (). Significance levels: * 10%, ** 5%, *** 10%.

and Mejean (2015). Similarly, more complex goods, as captured by the measures used in Nunn (2007) and Hausmann and Hidalgo (2014), are also positively correlated with our stickiness measure. The positive correlation between the level of upstreamness and stickiness suggests that products further from final demand involve more buyer-specific investment, elaborate contracts, or customization, in line with the perspective of Antràs and Chor (2013) on global value chains and locked-in effects.[14]

Despite the expected positive correlations, the linear combination of existing indicators can only account for 7% of the heterogeneity observed in our estimation (column (2)). This limited explanatory power arises from the fact that the relationship stickiness (RS) indicator varies within specific industries, while many of the alternative variables are measured at a more aggregated level. For example, while Nunn's index may suggest a high level of input specificity for the car industry, our measure reveals that specific components within the industry exhibit a higher degree of stickiness while the cars are less sticky.

In addition to the main results presented, we provide a comprehensive online appendix that includes a systematic sensitivity analysis. This analysis examines the robustness of our findings with respect to various factors, such as the time period, geographic structure of the data, definition of sales quantiles, empirical model, and measurement of durations. Furthermore, we conducted several external validity checks to evaluate the relevance of our relationship stickiness measure.[15]

[14]There are exceptions to this pattern, with certain products that are upstream in value chains but do not display a high level of stickiness. Examples of such products include ethylene, propene, seeds (colza or sunflower), or salt of rosin.

[15]Namely, we demonstrate the consistency of our measure with three key findings from the literature. First, sectors with higher stickiness levels exhibit a higher share of intrafirm trade, as predicted by Antràs and Chor (2013). Second, the interaction between relational stickiness and institutional quality shapes countries' comparative advantages, aligning with the findings of Levchenko (2007) and Nunn (2007).

4.3 Exploration of the sources of stickiness

In our analysis, relationship stickiness is influenced by both technological determinants and market structure characteristics. In what follows, we perform an exploratory analysis linking different proxies for technological determinants and market structures characteristics to relationship stickiness. We employ two proxies for technological determinants of stickiness. Firstly, we calculate a measure of sunk costs using accounting data and the methodology proposed by Sutton (2007).[16] While sunk costs contribute to the persistence of trade relationships, they do not capture the role of buyer-specific customization costs, which can also drive stickiness. To proxy for this input-specificity, we compute the share of exports in the product category that is intermediated by wholesalers, following the approach outlined in Bernard et al. (2010b). If wholesalers are unable to customize products according to each customer's specific needs, a higher share of wholesalers should indicate lower levels of input-specific investments. Thus, we calculate the value share of exports intermediated by wholesalers and the share of wholesalers among exporters in the product category.

We introduce another set of proxies that capture market structure characteristics. The first set reflects trading partners thickness, which we define as the effective number of French and international sellers (McLaren, 2003): "# of exporting countries", "# of French exporters" and "# of firms worldwide".[17] In line with the literature on customer

Lastly, trade of more relationship-specific products is more sensitive to distance, which is in line with the notion that information and monitoring costs associated with distance are amplified by stickiness, as suggested by Rauch (1999); Head and Ries (2008).

[16] Sunk costs are computed as capital to output ratio at the industry level times the median output of firms in an industry. To obtain a measure that varies at the HS6 level, we compute sunk costs at the industry level and take the median across exporters of a given HS6 product.

[17] The number of firms worldwide is proxied by the ratio of the number of French exporters of a product over French world market share.

Table 4: ***Microfoundations of relationship stickiness***

	coef.	s.e.	R^2	Data source
Proxy for market thickness				
# of exporting countries	-0.061	0.019	0.002	[CEPII-BACI]
# of French exporters	-0.009	0.006	0.000	[French Customs]
# of firms worldwide	-0.017	0.005	0.002	[Estimation]
French HHI	0.234	0.029	0.013	[French Customs]
Proxy for search frictions				
Share salesmen	1.532	0.124	0.029	[Patault and Lenoir (2022)]
Wage bill salesmen	1.183	0.112	0.021	[Patault and Lenoir (2022)]
Price dispersion	0.066	0.011	0.008	[French Customs]
All market. det.			**0.075**	
Proxy for technological specificity				
Sunk costs	0.087	0.007	0.033	[Customs + INSEE-FICUS]
Sh. wholesale (value)	-0.310	0.027	0.026	[Customs + INSEE-FICUS]
Sh. wholesale (count)	-0.061	0.043	0.000	[Customs + INSEE-FICUS]
All techno. det.			**0.070**	

Notes: The Table presents the results of univariate regressions, where each proxy for technological and market-specific parameters is regressed against our baseline measure of relationship stickiness. The first column displays the estimated coefficient, the second column shows the estimated standard deviation, the third column presents the R^2 of the regression, the fourth columns displays the data source. The R^2 values in bold indicate the R^2 of the multivariate regressions for each set of correlates, which include multiple proxies simultaneously.

capital (Gourio and Rudanko, 2014; Patault and Lenoir, 2022), we also consider the average share of salesmen in firms' employment ("Share salesmen") or their wage bill ("Wage bill salesmen"), among exporters of a given HS6 product. These proxies capture the importance of sales personnel in firms' operations and their potential role in building and maintaining customer relationships. Last, drawing inspiration from the empirical literature on search and price dispersion (Kaplan and Menzio, 2015), we compute price dispersion as a proxy for search frictions.[18]

The results presented in Table 4 confirm that all proxies are correlated with our measure of relationship stickiness, with the expected sign. Both sets of proxies contribute similarly to explaining the cross-product dispersion in estimated stickiness ($R^2 = 7\%$), indicating that both technological and market structure factors play a role in determining the level of stickiness observed. However, it is important to note that despite the inclusion of these proxies, a significant portion of the dispersion in stickiness remains unexplained. This suggests that there are other factors or features of firm-to-firm relationships that our measure captures but are not fully captured by the chosen proxies.

5 Trade and the heterogeneous impact of uncertainty shocks

In this final section we test for a systematic relationship between trade adjustments, uncertainty shocks and relationship stickiness. Insights from the model in Section 3 suggest that the sensitivity of new business relationships to uncertainty should vary across products based on their level of relationship stickiness. We study such effects in

[18] We compute the dispersion of prices across partners of the same exporrter. This choice is motivated by the fact that dispersion across sellers may reflect technological sources of heterogeneity (see Fontaine et al., 2020, for a discussion).

this section.

5.1 Data and empirical strategy

To test the prediction of our model, we employ a Poisson empirical model:

$$E(X_{pct}|Uncert_{ct}, RS_p, FE) = exp\left(\alpha Uncert_{ct} + \beta RS_p + \gamma RS_p \times Uncert_{ct} + FE\right), \quad (4)$$

where X_{pct} represents either the count of new seller-buyer relationships or the count of terminated relationships in a specific market (product $\times$ destination) at a given point in time.[19] In our model, the variables measuring the number of new seller-buyer relationships and the number of terminated relationships represent two sides of the same concept. However, due to the geographical censorship of our data, where we only observe sellers located in France, we consider both outcome variables in our analysis. We use as explanatory variable an external measure of macroeconomic uncertainty $Uncert_{ct}$ and its interaction with relationship stickiness RS_p, together with other controls. Importantly, the regression systematically controls for product or product$\times$period fixed effects so that the identification exploits the variability across destinations and/or over time, within a product. This dimension of heterogeneity has not been exploited when estimating relationship stickiness and is thus useful to separately identify the response of trade to uncertainty shocks, conditional on the level of stickiness.

[19]In our analysis, new relationships are defined as the initial transaction between a specific pair of firms, taking into account data from the pre-sample period to account for left-censoring. Disrupted relationships, on the other hand, include all relationships that we observe for the last time over three consecutive months, utilizing data from the post-sample period to address right censoring. The estimation period we consider is from 1996 to 2010, with the years 1996 to 1999 used to control for left-censoring and the years 2007 to 2010 used to control for right-censoring.

We measure uncertainty at the country and quarterly levels using the "World Uncertainty Index" (WUI) developed in Ahir et al. (2019). We define uncertainty episodes based on the WUI series for the 12 countries in our sample. Specifically, we identify periods as uncertainty episodes when the uncertainty index exceeds one standard deviation above its average level.[20] We match the corresponding uncertainty series with our firm-to-firm trade data, which we aggregate to a quarterly frequency to align with the WUI data. In the Online Appendix, we present the time-series of these uncertainty shocks for the countries in our study, alongside their GDP growth. Consistent with previous research by Ahir et al. (2019), we observe that high uncertainty episodes often precede periods of economic growth slowdown. Therefore, we include controls for GDP growth and its interaction with relationship stickiness in our analysis. To obtain market-price GDP growth data, we rely on Eurostat's national accounts indicators. We account for the first-stage error associated with the relationship stickiness (RS) indicator using a parametric bootstrap approach.[21]

5.2 Uncertainty, stickiness, and the extensive margin of trade

The results of the estimation of equation (4) are presented in Table 5 and visually summarized in Figure 2. Columns (1)-(4) of Table 5 examine the impact of uncertainty

[20]We have also conducted sensitivity analyses using a threshold of 1.64 standard deviations above the average, and the results remained virtually unchanged. Additionally, in Table 5, we provide results using the direct level of the index to measure uncertainty.

[21]Specifically, we perform 400 draws of RS for each product from a Gaussian distribution calibrated to the mean and estimated standard deviation of the corresponding RS indicator. Subsequently, we run 400 regressions using the relationship stickiness values generated from these draws. The coefficients and their standard errors reported in the estimation tables are obtained by calculating the mean and standard deviation of these estimates.

and its interaction with relationship stickiness on the number of new seller-buyer relationships, while columns (5)-(8) analyze the effect on the number of disrupted relationships. In the odd-numbered columns, the coefficients are identified across countries within a product×period. In the even-numbered columns, the identification is within a country×period, controlling for product×quarter fixed effects to account for seasonal variations in trade. The presence of country×period fixed effects prevents the identification of the level impact of uncertainty. Finally, we either use uncertainty shocks or the level of the uncertainty index as explanatory variables. It is important to note that all specifications involve an interaction with the RS indicator, which takes positive values across the entire distribution. Therefore, interpreting the point estimates may not be straightforward. To provide a sense of the magnitudes, panels (a) and (b) of Figure 2 illustrate the impact of uncertainty across deciles of relationship stickiness, based on the results from columns (1) and (5) of Table 5.

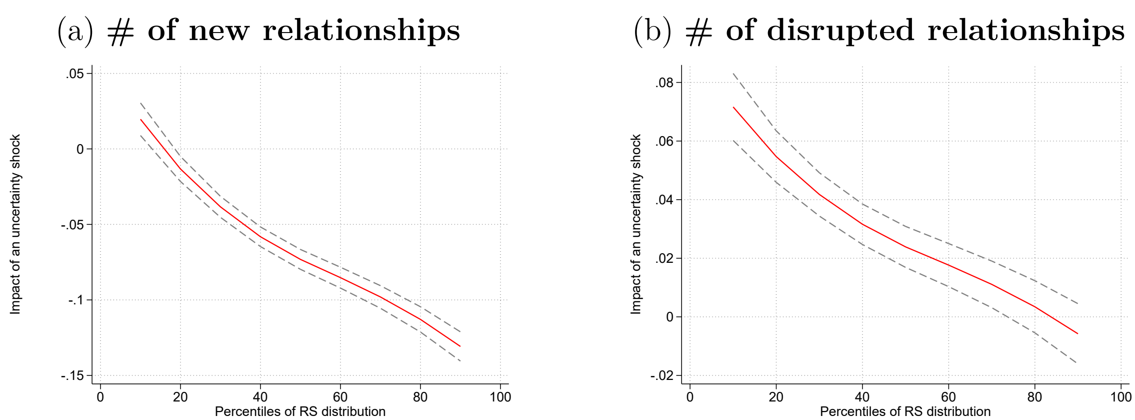
Columns (1) and (3) consistently demonstrate that high uncertainty episodes are associated with a significant reduction in the number of new firm-to-firm relationships, aligning with the intuitive notion that uncertainty discourages firms from engaging in new economic activities. The coefficients in column (1) indicate that an uncertainty shock is linked to a 5.6% (=.35-.14*2.9) decrease in new relationships for the average product in terms of stickiness. These columns also reveal a negative coefficient on the interaction between uncertainty and relationship stickiness, suggesting that the decline in new firm-to-firm relationships during periods of high uncertainty is more pronounced in sticky product categories compared to less sticky ones. The amplified adverse effect of uncertainty on sticky products is further confirmed by columns (2) and (4), which use an alternative set of fixed effects. In quantitative terms, specification (1) implies a decrease of approximately 1.5% in the number of new relationships for products in the first quartile of the RS indicator distribution during high uncertainty periods, as depicted

Table 5: ***Uncertainty and relationship stickiness: Baseline results***

	# new relationships				# disrupted relationships			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Uncertainty	.35***		1.12***		.24***		.99***	
	(.008)		(.024)		(.006)		(.021)	
× RS	-.14***	-.12***	-.46***	-.42***	-.07***	-.05***	-.33***	-.26***
	(.003)	(.003)	(.009)	(.008)	(.002)	(.002)	(.008)	(.007)
Obs	2,869,082				1,938,463			
Uncertainty measure	Shocks		Index		Shocks		Index	
Controls	GDP growth, -×RS				GDP growth, -×RS			
Period	2000-2010				1996-2006			
Fixed effects								
Product time	✓		✓		✓		✓	
Country	✓		✓		✓		✓	
Product quarter		✓		✓		✓		✓
Country time		✓		✓		✓		✓

Notes: The estimations were conducted using a Poisson regression framework with high-dimensional fixed effects. Uncertainty shocks are defined as periods when the uncertainty index in the destination country exceeds the average uncertainty plus one standard deviation. The variable *RS* represents our measure of relationship stickiness, which is not centered (Mean: 2.9, P05: 1.8, P95: 3.5). All regressions include controls for the level of GDP growth in the destination country and its interaction with relationship stickiness. The standard errors reported in parentheses are obtained using a bootstrapping procedure. Significance levels: * 10%, ** 5%, *** 1%.

Figure 2: ***Impact of an uncertainty shock along the distribution of RS***



Notes: This figure illustrates the percentage-point impact of an uncertainty shock on the number of new firm-to-firm relationships (panel a) and the number of disrupted firm-to-firm relationships (panel b). The results are obtained from the estimations in Table 5, specifically column (1) for panel (a) and column (5) for panel (b).

in Figure 2. For more sticky products at the third quartile of the RS distribution, the number of new relationships drops by almost 10% during high uncertainty periods.[22] These findings align with the model's predictions that uncertainty hinders the formation of new business relationships, with a more pronounced effect observed for highly sticky products.

In columns (5)-(8), we examine the impact of uncertainty on separation rates using the number of disrupted relationships as a proxy. We find a higher incidence of separations during periods of high uncertainty, but the negative effect diminishes with stickiness. At the higher end of the RS distribution, the effect becomes statistically insignificant. This pattern holds across different specifications using various sets of fixed effects and alternative uncertainty measures. Quantitatively, the specification in column (5), visualized in panel (b) of Figure 2, suggests that during uncertain periods, the number of disrupted relationships increases by 5% for a product in the first quartile of the RS indicator distribution. For a more sticky product in the third quartile of the RS distribution, the number of disrupted relationships increases by less than 1%, and the effect is not statistically significant. Interpreting the impact of uncertainty on exit is more complex within the framework of the model presented in section 3. The model predicts a reduction in switches during uncertain periods, but disrupted trade relationships encompass both switches to non-French suppliers and true exits. The positive association between uncertainty and trade disruption aligns with empirical findings in Carballo et al. (2018), where they propose a model in which uncertainty lowers the cost cutoff, leading to an increased likelihood of trade disruption. Considering the interaction between uncertainty and relationship stickiness, the results are consistent with the model's

[22] The first quartile is 2.61 and the third quartile is 3.23. Therefore, we compute: $E(X|Uncertainty = 1)/E(X|Uncertainty = 0) - 1 = exp(.35 - 2.61 \times 0.14) - 1$ =-0.015 for the first quartile, and -0.097 for the third quartile using the same formula.

prediction that there is relatively less movement among the most sticky products during uncertain times.

The results presented in this section provide evidence supporting the response of trade to uncertainty shocks, specifically in terms of the creation and disruption of firm-to-firm relationships. Notably, our findings highlight the variation in the magnitude of these responses based on the level of product stickiness. We have conducted a series of robustness checks, which are detailed in the Online Appendix O.7. These checks demonstrate that our results hold when excluding durables from the analysis, excluding intrafirm trade, using the ranking of the RS index instead of its level, and utilizing an alternative stickiness index estimated over a different period. Furthermore, in unreported results, we have confirmed that the impact of uncertainty across the distribution of stickiness remains significant even after controlling for the interaction between uncertainty and each of the product market characteristics outlined in Table 3. These robustness checks provide additional support for the validity of our findings.

5.3 Trade adjustments to uncertainty and GDP shocks

The analysis so far has focused on trade adjustments at the extensive (firm-to-firm) margin in response to uncertainty episodes. The model does not explicitly address the dynamics of trade within existing relationships. Novy and Taylor (2019) however highlight the potential impact of uncertainty on trade at the intensive margin, particularly through adjustments in inventories. Comparing the size of adjustments at the intensive and extensive margins is thus useful to confront various adjustment mechanisms.

By decomposing the growth in product-level trade of French exports, we can examine the contributions of different components to overall trade dynamics. This decomposition approach is inspired by the work of Bernard et al. (2018). Given the overall (year-on-year) growth of product-level bilateral trade g_{cpt}, we have $g_{cpt} = g_{cpt}^{Intensive} + g_{cpt}^{Start} + g_{cpt}^{End}$

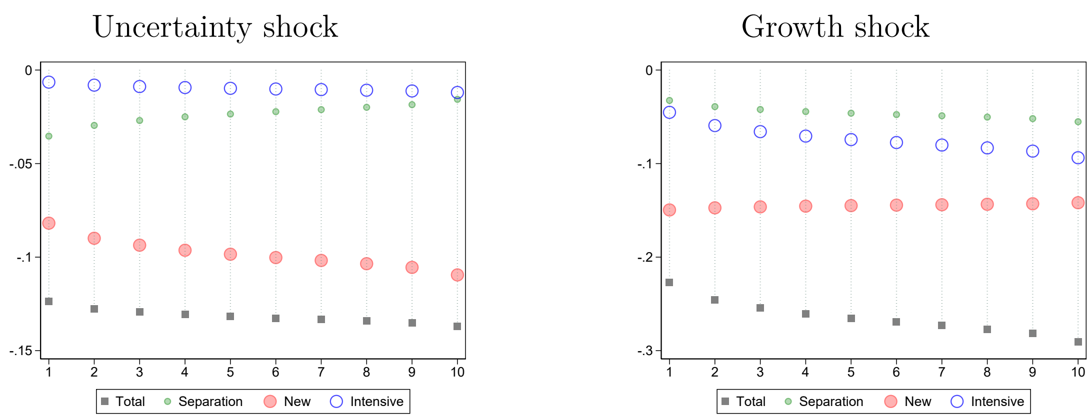
where $g_{cpt}^{Intensive}$ represents the change in the value of trade within existing relationships, whereas g_{cpt}^{Start} and g_{cpt}^{End} stand for the impact of new and disrupted relationships on growth. Growth is measured using mid-point growth rates at the quarterly level. We then regress product-level growth and its components on uncertainty and its interaction with relationship stickiness. Additionally, we control for GDP shocks and their interaction with relationship stickiness. The inclusion of GDP shocks allows us to compare the effects of different types of shocks on trade dynamics. To ensure comparability, we use a binary dummy variable for GDP shocks, indicating when the growth rate in the destination country is one standard deviation below its average over the estimation period. The results remain robust when using the level of GDP growth. The estimated equation reads:

$$Y_{cpt} = \alpha Uncert_{ct} + \gamma RS_p \times Uncert_{ct} + \beta GDP_{ct} + \delta RS_p \times GDP_{ct} + FE + \varepsilon_{pct}$$

where Y_{cpt} is the level of growth or one of its component and the remaining variables are defined as in Section 5.1.

Figure 3 provides a visual representation of the results, and the corresponding point estimates are reported in Table O.11 of the Online Appendix. The left panel focuses on the response of trade growth to an uncertainty shock, while the right panel examines the impact of a growth shock. Several interesting findings emerge from the comparison of these graphs. First, both types of shocks, uncertainty and growth, have a negative effect on trade growth. On average, high uncertainty episodes are associated with a reduction of 0.12 percentage points in trade growth, while a drop in the destination country's growth leads to a larger decrease of 0.25 percentage points. When examining the impact across the distribution of RS indices, we observe that the effect of uncertainty shocks remains relatively constant. In contrast, the impact of a GDP shock is 0.6 percentage points larger at the 10th decile compared to the 1st decile of the RS distribution. Another

Figure 3: ***Impact of shocks on trade growth, along the distribution of RS***



Notes: These figures summarize the response of product-level trade to two different shocks: an uncertainty shock (left panel) and a shock to the destination market's growth (right panel). The results are obtained from the estimation of the following equation:

$$Y_{pct} = \alpha Uncert_{ct} + \gamma RS_p \times Uncert_{ct} + \beta GDP_{ct} + \delta RS_p \times GDP_{ct} + FE + \varepsilon_{pct}$$

In this equation, the left-hand side variable (Y_{pct}) represents the mid-point growth rate or one of its components. The variables $Uncert_{ct}$ and GDP_{ct} correspond to uncertainty and GDP shocks, respectively. The term RS_p represents the relationship stickiness variable, and the coefficients α, γ, β, and δ capture the relationships between these variables. The equation also includes fixed effects (FE) at the product$\times$country level to account for any specific characteristics or heterogeneity across products and countries. The error term ε_{pct} captures any unobserved factors or random variation in the data.

important observation is that the adjustments in trade vary across the different margins. Uncertainty shocks primarily affect the extensive margin, which refers to the net creation of firm-to-firm relationships discussed earlier. This finding is consistent with the results presented in Carballo et al. (2018). The intensive margin, which captures trade within existing relationships, is less elastic to uncertainty shocks. In contrast, the elasticity of trade to GDP shocks primarily arises from the intensive margin. This finding aligns with the evidence presented in Bricongne et al. (2012).

Finally, the intensity of trade adjustments indeed varies along the distribution of stickiness. For uncertainty shocks, the heterogeneity primarily manifests at the extensive margin, consistent with the findings in section 5.2. The results provide strong evidence for subdued extensive adjustments in markets with sticky products, where there are fewer new entries but also fewer separations. On the other hand, when GDP growth shocks occur, the heterogeneity affects adjustments at the intensive margin, while the response of trade at the extensive margin remains relatively constant.[23]

Our findings aligns with the argument presented by Antras (2020), who suggest that severe but temporary shocks, such as the 2008-09 trade collapse or the COVID-19 crisis, do not fundamentally alter firms' sourcing strategies and are often followed by a rapid recovery. The negative effect of such shocks primarily stems from a reduction in the formation of new relationships and, in the case of first-moment shocks, a decline in firm-to-firm trade at the intensive margin. However, negative shocks have little to no impact on the disruption of existing sticky firm-to-firm trade relationships. Moreover, our results indicate that the nature of a country's adjustment to shocks is contingent upon

[23]In order to validate the robustness of our findings, we examine alternative proxies for first and second moment shocks of uncertainty. Specifically, we use the average stock returns and the average volatility of returns as measures provided by Baker et al. (2020). Results are displayed in Table O.12 of the Online Appendix.

the structure of its comparative advantages. The degree to which a country specializes in more or less sticky products is expected to play a role in shaping the various margins of its trade adjustment to macroeconomic uncertainty.[24]

6 Conclusion

This study examines the influence of relationship stickiness on the effects of uncertainty, particularly in international trade. Using detailed firm-to-firm data, we construct a novel measure of relationship stickiness for a wide range of product categories. Our analysis reveals that uncertainty shocks result in a decrease in the creation of business relationships. However, the extent of this impact varies depending on the level of stickiness. Less sticky product categories experience more disruptions in firm-to-firm relationships, while highly sticky categories see a greater slowdown in the formation of new trade relationships. These findings emphasize the significance of considering relationship stickiness when studying the real consequences of uncertainty in trade.

While this paper primarily investigates trade adjustment in response to uncertainty shocks, the concept of relationship stickiness holds relevance for various macroeconomic outcomes, including exchange-rate shocks and trade policy. Additionally, the degree of stickiness in firm-to-firm relationships can influence the international transmission of shocks. We hope that the measure developed in this study will encourage further research exploring these areas and shed light on the broader implications of relationship stickiness in macroeconomics.

[24]It is worth noting that in the case of French exports, the distribution is relatively evenly spread along the RS distribution, implying that averaging the point estimates in Figure 3 provides a reasonable approximation of the response of aggregate exports to uncertainty and GDP growth shocks.

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A Appendix

A.1 A general formulation of the model

Baseline model without uncertainty: We examine the steady-state value function, denoted as $V(p)$, which arises from the intertemporal optimization problem faced by a buyer when importing inputs at price p, considering a given stickiness parameter γ. In the event of a new match, the firm makes a decision to switch suppliers only if the value of the new offer exceeds the value of its current supplier by an amount that sufficiently compensates for the associated switching cost. This condition implicitly defines an optimal switching policy, denoted as $p^*(\gamma; p)$, which satisfies the equation: $V(p^*(\gamma; p)) - V(p) = C(\gamma; p)$ Here, $V(.)$ represents the value of a match. Note that formally V also depends directly on the parameter γ through $C(\gamma; p)$, we omit this dependence to alleviate notations. The value function is determined by the following Bellman equation:[25]

$$V(p) = \pi(p) + \beta \left[\delta \cdot (V_0 - V(p)) + \lambda \int_0^{p^*(\gamma;p)} [V(p') - C(\gamma;p) - V(p)]\, dH_P(p') + V(p) \right] \tag{A.1}$$

Instantaneous profits are represented by $\pi(p)$. The terms enclosed in brackets correspond to the expected future value of the buyer-seller relationship, which is discounted by a factor of β. It is assumed that all firms in all industries face an exogenous probability of relationship termination, denoted as δ.[26] When a relationship comes to an end, the buyer's discounted sum of future expected profits is represented by V_0. To ensure that the model allows for a stationary distribution of equilibrium transaction prices, it is necessary to have a strictly positive exogenous separation rate. By differentiating the Bellman equation with respect to γ, and using that the value function is decreasing in γ by construction, we obtain that $V' < 0$: buyers with lower prices are more profitable.

Introducing uncertainty When uncertainty is introduced, the firm's decision to switch suppliers becomes conditional on its expectations regarding the future value of aggregate demand. In this framework, the optimal switching policy, which we denote $p^*(\{\gamma, G\}, p, I)$, depends on the current level of demand and its stochastic process G. The optimal switching policy is implicitly defined by $V(p^*(\{\gamma, G\}; p, I), I) - V(p, I) = C(\gamma, p)$.

[25] For simplicity, the equation is expressed in continuous time. Note that the relationship between duration and the switching probability in continuous time is identical to that obtained in equation (1).

[26] We abstract from δ in our baseline model as we measure the duration of buyer-seller relationships between switches. However, it should be noted that while δ impacts the duration of these relationships, it does so in a manner that maintains the ranking of products.

Here, $V(.)$ solves the following Bellman equation:

$$\begin{aligned} V(p,I) \quad &= \quad \pi(p,I) + \beta \int_{\underline{I}}^{\bar{I}} \Big[\delta \cdot (V_0 - V(p,I')) \\ &+\lambda \int_0^{p^*(\{\gamma,G\};p,I')} (V(p',I') - C(\gamma,p) - V(p,I'))\, dH_P(p') \\ &+V(p,I') \Big]\, dG(I' \mid I) \end{aligned}$$

where $\underline{I}$ and $\bar{I}$ are the lower and upper bars of the value of aggregate demand.

A.2 Details on the estimation of relationship stickiness

Equation (1) indicates that the duration of a buyer-seller relationship, given match quality, follows a geometric distribution with mean $\frac{1}{\lambda H_P(p^*(\gamma;p))}$. Under our parametric assumptions, P follows an inverse-Pareto distribution with a skewness parameter k, i.e $H_P(p^*) = \left(\frac{p^*}{p_{max}}\right)^k$ where p_{max} represents the upper bound of prices. Substituting the expression for the linear reservation price ($p^* = p/\gamma$) and incorporating the assumption of iso-elastic demand with an elasticity of σ, yields $\left(\frac{p^*}{p_{max}}\right)^{-k} = \gamma^{-k}\left(\frac{r}{r_{min}}\right)^{-\frac{k}{\sigma-1}}$. Finally, by defining $\eta = \gamma^k/\lambda$, we arrive at the expression for the distribution of durations conditional on sales, as provided in equation (2):

$$\mathcal{T}|\{R=r\} \sim \mathcal{E}\left[\frac{1}{\eta}\left(\frac{r}{r_{min}}\right)^{-\frac{k}{\sigma-1}}\right]$$

As described in section 4.1, we can integrate over the range of r values, within a given quantile q to derive a log-linear relationship:

$$\ln \mathbb{E}\left[\mathcal{T} \mid R \in R_q\right] = \ln\left[\int_{r_{q-1}}^{r^q} \mathbb{E}\left[\mathcal{T} \mid R = r\right] dH(r)\right] = \ln \eta + \ln\ln\left[\frac{\mathbb{P}(R \geq r_{q-1})}{\mathbb{P}(R \geq r_q)}\right], \quad \text{(A.2)}$$

The left-hand side of the equation represents the expected duration of a transaction, conditioned on the transaction falling within the qth quantile of the distribution. On the right hand-side the term $\ln\left[\frac{\mathbb{P}(R\geq r_{q-1})}{\mathbb{P}(R\geq r_q)}\right]$ is quantile-specific but does not vary across products and countries, thanks to the joint properties of the Pareto distribution and the Poisson process. In the empirical analysis, we can calculate the logarithm of the mean duration of firm-to-firm relationships within various size quantiles of the product- and country-specific distribution. This quantity is denoted as Dur_{qpc}. It serves as an empirical proxy of conditional expected durations. With this (noisy) measure of conditional expected durations, we can estimate a relative measure of relationship stickiness using a log-linear specification:

$$\log Dur_{qpc} = FE_p + \alpha \ln\ln\left[\frac{\mathbb{P}(R \geq r_{q-1})}{\mathbb{P}(R \geq r_q)}\right] + \epsilon_{qpc}, \tag{A.3}$$

where FE_p is a product fixed effect, and ϵ_{qpc} is the error term.

To compute the mean duration conditional on a size quantile (Dur_{qpc}), the following steps are taken: (i) The size of a relationship is determined as the average value of transactions involving a specific seller-buyer pair, measured in constant euros;[27] (ii) Each trade relationship is then assigned to a size-decile, which is specific to the corresponding product category; and (iii) Within each decile, the average duration of the relationships is calculated. For the purpose of this calculation, each distribution is divided into 10 quantiles. The first quantile represents transactions falling between the 1st and 10th percentile, the second to ninth quantile correspond to the eight deciles spanning from the 10th to the 90th percentile and the tenth quantile represents transactions between the 90th and 99th percentiles.

[27] To account for inflation, nominal values are deflated using the French PPI constructed by INSEE..

O Online Appendix

O.1 Details on the data

The dataset used in the analysis includes information on individual transactions, such as the seller identifier, buyer identifier, product category (at the 8-digit level of the European combined nomenclature), date (month and year), and the value of the shipment in euros. However, it does not provide information on whether the transactions are arm's length or intrafirm.[28] The dataset covers the period from 1993 to 2017, but the analysis focuses on various sub-periods. The main reason for analyzing sub-periods is due to changes in the product category nomenclature over time, which complicates the definition of product markets when estimating stickiness. To address this issue, a harmonization algorithm, described in Behrens et al. (2018), is applied to recover time-invariant product categories. This algorithm minimizes information loss when applied over shorter time horizons. In the baseline specification, the measurement of relationship stickiness uses data from 1996 to 2006. To assess robustness over time, an alternative period of 2011-2017 is also considered. For the analysis of the impact of uncertainty on the dynamics of firm-to-firm relationships, data from 1996 to 2010 is used.

The dataset encompasses all the relationships involving French exporters and European buyers within each product category.[29] The analysis focuses on trade with the eleven historical members of the European Union. The decision to exclude the new mem-

[28]We discuss how intrafirm trade may affect our results in section O.7.

[29]The dataset used in the analysis does not include exports from the smallest French exporters. These exporters are allowed to complete a simplified form that does not specify the product category. As a result, transactions involving these exporters are excluded from the analysis. In 2007, the simplified reporting regime applied to 21,616 exporters out of a total of 66,131, accounting for approximately 2% of transactions and 0.5% of the total value of French exports. Furthermore, there was a significant increase in the declaration threshold for firms to fill in the most detailed customs form in 2011. This

ber states from the analysis is based on two reasons. Firstly, information on individual importers prior to their entry into the EU is not available, limiting the completeness of the dataset. Secondly, the entry of new member states into the European Union lead to significant trade adjustments, potentially resulting in substantial changes in firm-to-firm relationships. The large churning in relationships could introduce biases in the estimates of relationship stickiness, warranting their exclusion from the analysis.

Table O.1 presents comprehensive statistics related to the data used to calculate the baseline measure of relationship stickiness. The observations in the dataset are based on individual transactions, with each transaction representing a unique combination of a seller, a buyer, a product, and a specific month. Columns (1)-(3) of the table provide statistics on the number of transactions and the number of firms involved in these transactions. Columns (4)-(6) offer additional statistics on the dimensionality of the graph when treating multi-product importers and exporters as independent units. This approach considers firms that engage in transactions involving multiple products as distinct entities.

In the cross-section, the dataset exhibits a bipartite graph structure that connects individual seller×product pairs to individual importers. This graph structure predominantly aligns with a many-to-one matching pattern. Specifically, at a given point in time (defined by a particular month in a specific year), we observe most buyers purchasing a specific product from a single seller, while sellers simultaneously serve multiple importers, even within a single country. This observation is visually presented in Figure O.1, which showcases the distribution of the number of sellers interacting with a given importer during a specific month (top panel) and the distribution of the number of partners from the same country with whom a French exporter engages (bottom panel).

change further motivates the selection of the preferred time period for analysis as 1996-2006, prior to the implementation of the threshold increase.

More than 90% of importers have only one French supplier for a given product within a particular month. Even when focusing on importers with more than 50 transactions, this proportion remains high, exceeding 80%. Conversely, 26% of French exporters sell the same product to multiple partners within the same month, and this proportion increases to 55% when considering partners located in different countries.[30] Given this underlying data structure, the model in section 3 assumes a many-to-one matching structure, where importers interact with a single supplier at any given moment. If an importer is observed engaging with two different exporters within a month, we consider those two transactions as occurring simultaneously.

The distribution of the number of transactions by buyers is highly skewed, as illustrated in Figure O.2. Only 8% of importers are observed over more than 20 transactions with French firms, but they account for more than 85% of trade. The dynamics of their relationships with French firms should thus provide insightful information. At the other end of the spectrum, 44% of buyers are engaged in only one transaction with a French seller over the ten-year period. These buyers make surprisingly tiny transactions: they account for only 1.5% of the value of trade. There are good reasons to believe that a substantial share of these transactions correspond to non-market transactions, such

[30]This finding contrats with the results in Bernard et al. (2018) who employ qualitatively similar data and observe many-to-many relationships between exporters and importers. One potential explanation for this discrepancy, apart from the different country coverage, is that their analysis does not condition on a specific product, whereas our approach does. Indeed, our data reveals that buyers often engage with several French exporters within a given month, albeit for different products (refer to Figure O.3 and the comparison with Figure O.1, where the former aggregates partners across products within a firm while the latter counts the number of partners for a specific product). Once we condition the analysis on a particular product, the occurrence of purchasing from multiple French exporters becomes exceedingly rare.

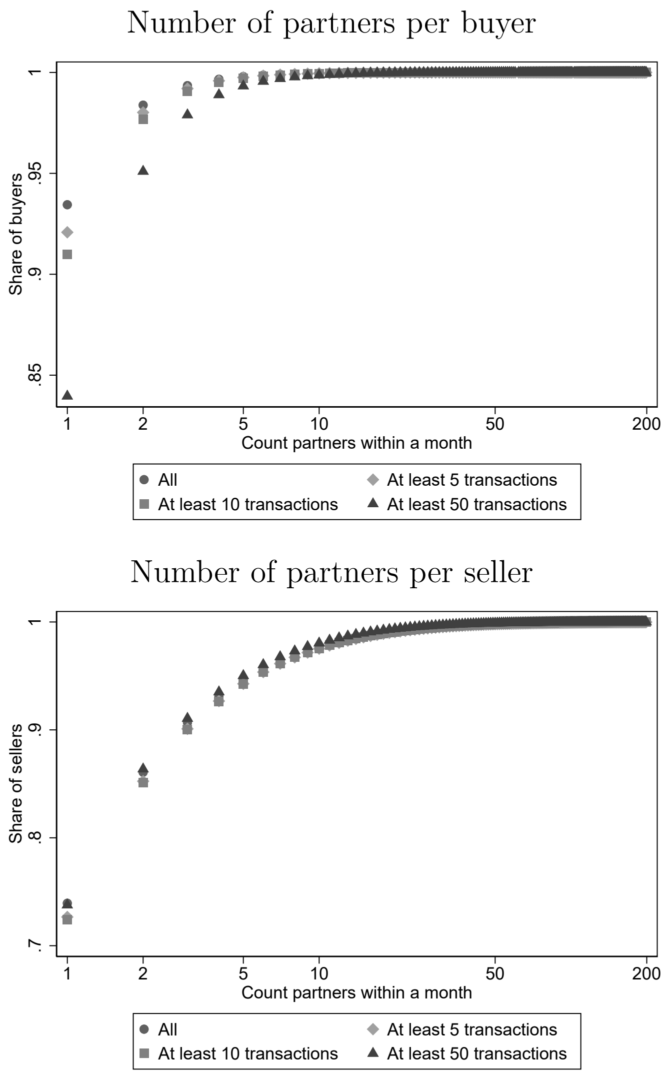
as samples sent by exporters to prospective clients. We thus decided to exclude these one-shot buyers when estimating stickiness.

Figure O.4 illustrates the distribution of the number of French partners with whom individual buyers interact throughout their entire presence in the dataset. Buyers that appear only once in the data are excluded from this analysis. The figure reveals that approximately 67% of buyers have a single partner in France, while less than 7% have three or more partners (as indicated by the circles line). It is important to note that interacting with a single partner in France is more likely for firms engaged in a small number of transactions. To provide further insights, the figure presents three additional distributions depicting the number of partners per buyer for importers involved in at least 5, 10, or 50 transactions. Even within the subset of importers observed in at least 50 transactions, around one-third of buyers consistently interact with the same exporter, indicating a level of loyalty in their firm-to-firm relationships. This observation aligns with the notion that certain firm-to-firm relationships in international markets exhibit a high degree of stickiness. The empirical analysis aims to investigate whether this stickiness is systematically associated with specific products or sectors. It seeks to explore whether relationship stickiness is linked to the uniqueness or specificity of certain products or industries.

O.2 Measuring the duration of a trade relationship

The duration is measured as the number of months between the first and the last uninterrupted transactions involving a French exporter and a foreign importer. However, this definition poses several challenges that we will now discuss. In cases where an importer interacts with multiple exporters within a single month, determining the continuity of the relationship becomes somewhat ambiguous as the sequence of these transactions cannot be precisely defined. To address this, we consider these transactions to occur

Figure O.1: ***Distribution of the number of partners, per buyer/seller and date (month×year)***



Notes: Cumulated distributions are presented in the bottom panel for the number of partners a French exporter engages with in a specific country. In the top panel, the cumulative distribution illustrates the number of partners a foreign buyer (×product) interacts with within a given month. The calculation of partner counts is based on a sub-sample of importers (or exporters) involved in a minimum of two transactions throughout the analysis period. Additionally, separate distributions are provided for importers/exporters with at least 5, 10, and 50 transactions.

Table O.1: ***Summary statistics on the structure of the dataset***

	# transac.	# sellers	# buyers	# sellers ×products	# buyers ×products	# buyer×seller ×products
	(1)	(2)	(3)	(4)	(5)	(6)
EU12	101,379,585	109,522	1,583,220	1,340,346	14,195,710	19,383,546
Belgium	19,872,676	74,924	185,596	637,007	2,488,213	3,596,690
Denmark	1,938,872	23,057	26,962	126,801	249,992	352,214
Germany	19,426,804	61,159	349,803	495,009	2,621,373	3,537,033
Greece	2,003,763	20,238	31,828	139,837	302,191	419,877
Ireland	1,293,531	16,414	15,925	88,334	182,032	270,832
Italy	12,662,419	51,963	280,641	381,644	2,144,174	2,792,808
Luxemburg	3,086,374	31,580	19,028	199,820	402,186	560,297
Netherlands	6,158,922	44,031	90,507	267,196	772,004	1,099,336
Portugal	4,833,183	33,528	67,248	238,463	762,041	1,024,489
Spain	12,581,119	53,471	237,767	419,964	1,928,424	2,490,565
UK	10,487,916	49,325	151,545	360,504	1,321,563	1,923,611

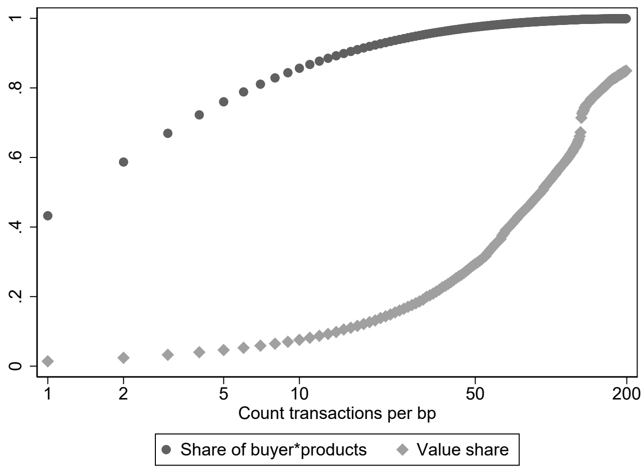
Notes: This table is based on French customs firm-to-firm data covering the period from 1996 to 2006. The first row presents aggregated statistics for all countries, while the subsequent rows provide country-specific statistics. Each column represents a different aspect of the data:

- Column (1): Total Count of Transactions. A transaction is defined as a trade flow occurring within a specific month and year, involving a particular seller-buyer pair and product.
- Column (2): Number of Exporters - This column indicates the count of unique exporters observed throughout the entire period.
- Column (3): Number of Importers.
- Column (4): Count of Distinct Seller-Product Pairs.
- Column (5): Number of Unique Buyer-Product Pairs.
- Column (6): Cumulative Count of Seller-Buyer-Product Triplets.

simultaneously. If the importer had an existing interaction with one of the exporters before, we consider the relationship to continue. Furthermore, if, in the following period, the firm is observed interacting with one or several of these partners again, we include the transaction that took place simultaneously with other transactions. In unreported results, we have verified that our estimates remain virtually unchanged when we exclude importers from the estimation sample who eventually engage with multiple sellers within a month.

The bilateral nature of our data further complicates the concept of a continuous relationship. We lack observations on transactions between foreign importers and their non-French suppliers. However, this censoring does not directly impact our measurement of duration, which relies on the time elapsed between the first and last transactions in-

Figure O.2: ***Distribution of the number of transactions, per buyer×product***

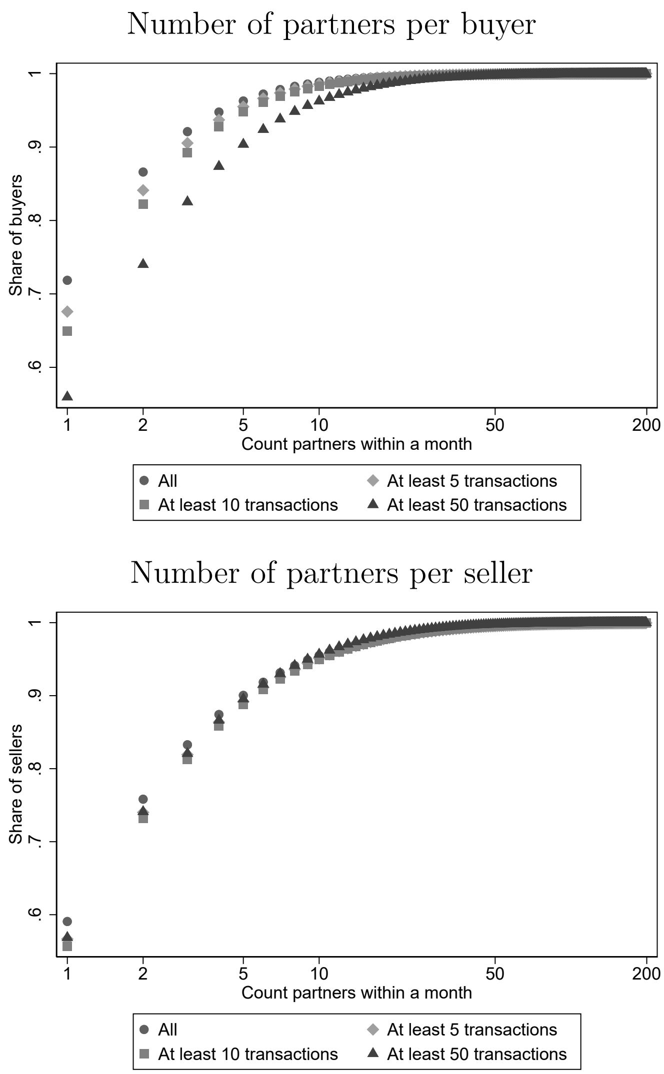


Notes: The graph illustrates the cumulative distribution of the number of transactions per foreign buyer (×product). Each transaction corresponds to the purchase of a specific good, from a particular seller within a given month. The light grey line represents the share of buyers within the population, while the dark line represents the corresponding share in the overall value of exports.

volving two firms, regardless of whether the relationship terminates due to the importer switching to another French supplier, a non-French partner, or ceasing to purchase the product altogether. Nevertheless, it is worth noting that some durations may be overestimated if the buyer switches to a non-French seller before reverting back to their previous partner. In such cases, we observe two consecutive transactions that we assign to a single continuous relationship. To address this concern, we propose an alternative estimation of stickiness. In this approach, duration is computed as the number of transactions within a continuous relationship, rather than the number of months between any two transactions.

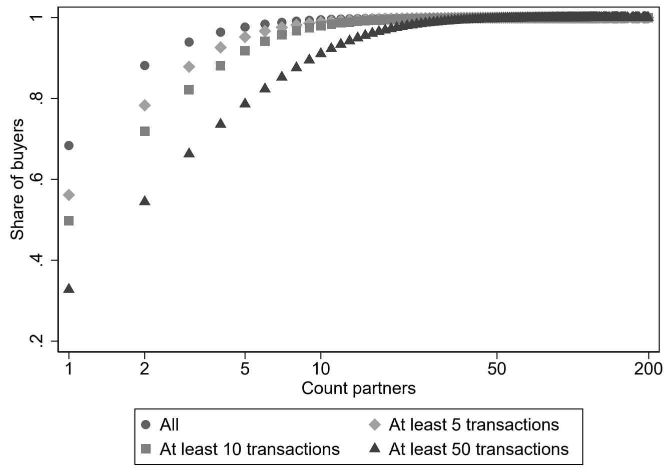
The aforementioned issue is closely tied to the frequency of transactions. While defining continuous relationships would be straightforward with monthly transaction frequencies, utilizing actual transaction data introduces significant heterogeneity in transaction frequencies. On average, there is a 33% probability of a transaction occurring in a given month, corresponding to an average of one transaction every three months. However,

Figure O.3: ***Distribution of the number of partners, per buyer/seller and date (month×year), without conditioning on a particular product***



Notes: The graph displays cumulative distributions for two statistics: the number of partners a French exporter interacts with in a specific country (bottom panel) and the number of partners a foreign buyer interacts with within a particular month (top panel). Both statistics are calculated considering all products within a firm. The number of partners is determined based on a sub-sample of importers (resp. exporters) involved in at least two transactions throughout the analysis period. Additionally, separate distributions are shown for importers (resp. exporters) with at least 5, 10, and 50 transactions.

Figure O.4: ***Distribution of the number of French partners, per buyer×product***



Notes: The graph illustrates the cumulative distribution of the number of partners for each foreign buyer (×product). In this context, a partner refers to a French exporting firm. The calculation of the number of partners is performed using a sub-sample of importers involved in at least two transactions (referred to as "All"), as well as subsets with at least 5, 10, and 50 transactions.

25% of buyers purchase French products more frequently than once every two months, while firms in the first quartile of the distribution make purchases less than once every 10 months (refer to Table O.2 in the appendix). Our baseline approach for measuring durations treats a relationship involving two transactions spaced six months apart in the same manner as a relationship consisting of seven monthly transactions. In section O.5, we address the possibility that the heterogeneous frequencies across products might impact our results. To do so, we replicate the methodology for estimating stickiness using an alternative duration measure that considers the number of transactions within a specific relationship, rather than the elapsed months.

When working with durations, it is common to encounter censoring issues. In our analysis, we address right censoring by excluding transactions that start within two years before the conclusion of our estimation sample. This exclusion ensures that we have sufficient information to accurately measure the duration of relationships. In a robustness check, we additionally estimate relationship stickiness using durations measured in a sample where we exclude left-censored relationships. By doing so, we focus solely on relationships for which we have complete information and avoid any potential biases that may arise from incomplete data on the starting point of these relationships.

In the model, the duration of a relationship is represented as a function of the probability of a switch, which refers to an importer splitting from its current partner to begin interactions with a new one. However, in the actual data, these two concepts do not align perfectly due to the heterogeneity in transaction frequencies. This disparity is highlighted in Table O.2, which compares statistics on (i) the mean duration of a buyer's relationships with French suppliers, (ii) the inverse of the probability of the buyer switching to a new supplier, and (iii) the inverse of the conditional probability of switching given a trade transaction. If buyers consistently purchased French products at regular intervals, such as every month, the three statistics would convey the same information. However, as indicated in the fourth line of Table O.2, transaction frequencies are neither close to 1 nor homogeneous across buyers. On average, the probability of a transaction occurring in a given month is .332, corresponding to a transaction every three months. However, 25% of buyers purchase French products more frequently than once every two months, while firms in the first quartile of the distribution make purchases less than once every 10 months. Due to these heterogeneous frequencies, the three available duration measures are not equivalent. Generally, it can be demonstrated that the mean duration falls between the two switching probabilities. In the data, the three statistics exhibit a correlation of more than 50%, suggesting that the heterogeneity in transaction frequencies does not completely distort the distribution of trade durations across buyers and products.

In our definition of a relationship, we consider two continuous periods with the same firms interacting, interrupted by another relationship involving the same importer but a

Table O.2: ***Descriptive statistics on alternative measures of the duration of firm-to-firm relationships***

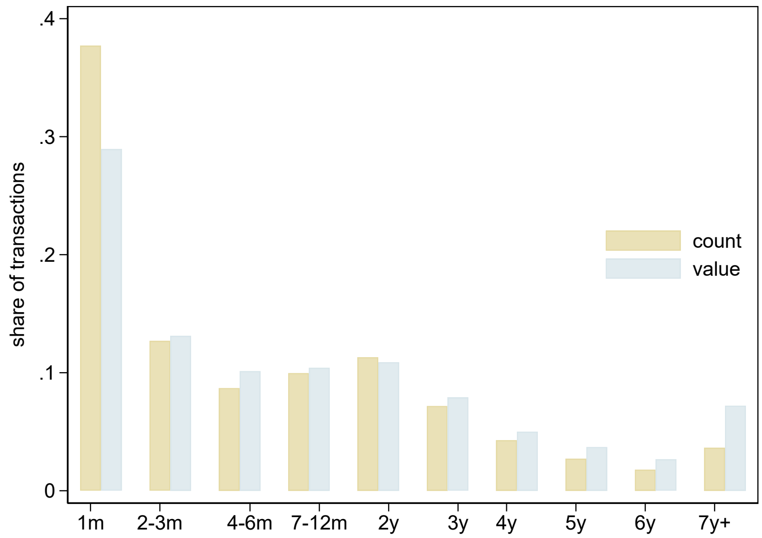
	Mean	Median	P25	P75
Mean duration	18	10	3	25
$1/\mathbb{P}(\text{switch})$	9	20	9	41
$1/\mathbb{P}(\text{switch}\|\text{Trade})$	2	3	2	6
Frequency of transactions	0.332	0.222	0.095	0.500
Proba Recall	0.013	0.000	0.000	0.000

Notes: This table presents statistics on alternative measures of durations. The first line represents our benchmark measure, which is the average number of months between the first and last transactions within a continuous relationship for a specific pair of firms ("Mean duration"). "$1/\mathbb{P}(\text{switch})$" is the reciprocal of the switching probability, calculated as the number of switching episodes divided by the total number of months a buyer appears in the data. "$1/\mathbb{P}(\text{switch}|\text{Trade})$" is the reciprocal of the conditional switching probability given a transaction, computed as the number of switching episodes divided by the total number of transactions. The "Frequency of transactions" is obtained by dividing the total number of transactions by the overall duration of the importer's presence in the data. This measure represents the monthly probability of a transaction. Lastly, "Proba Recall" quantifies the probability that, during a switching episode, the buyer starts interacting with an exporter with whom they had a previous relationship. These statistics are calculated for each individual importer and then averaged across buyers, using the dataset covering the period from 1996 to 2006.

different French exporter, as two separate relationships. This means that we do not retain the complete history of the importer's partners. By abstracting from the entire history of the buyer's interactions with French sellers, we simplify the analysis significantly. Furthermore, in the data, the probability of a "recall," which refers to a buyer switching back to a supplier they have interacted with before, is very small. This is evident from the last line in Table O.2. Given the limited occurrence of such recalls, we can safely ignore them for the purposes of our analysis.

We now turn to two stylized facts on the duration of firm-to-firm relationships. Figure O.5 displays the distribution of durations in the sample used for analysis. The mode of the distribution is at one month which corresponds to an importer that interacts with a French firm over a single month, before eventually switching to another French or non-French supplier. These very short relationships represent less than 40% of the population, whereas roughly 30% of firm-to-firm relationships last more than a year. Part of this heterogeneity is the consequence of heterogeneous match qualities, an importer

Figure O.5: ***Distribution of the durations in firm-to-firm relationships***



Notes: The distribution of durations is presented in terms of two measures: as a share of the total number of relationships ("count") and as a share of the aggregate export value ("value"). These statistics are derived from the analysis of the 19.5 million firm-to-firm relationships identified during the period of 1996-2006.

being more likely to switch if her current match is not satisfactory. This may explain that the distribution is shifted to the right when we weight relationships by their value (blue bars in Figure O.5).

Table O.3 provides evidence of a positive correlation between the duration of trade relationships and the mean size of transactions, which we use as proxy for the quality of the match. This correlation is observed across buyers within a particular product category and within a buyer, across different suppliers encountered throughout their interactions with French firms. The empirical framework includes controls for the correlation between relationship duration and transaction size. By controlling for this correlation, the framework aims to isolate the product-specific attributes that contribute to different degrees of stickiness.

Table O.3: ***Duration and the size of trade flows***

	(1)	(2)	(3)
	Log of duration		
Log of mean exports	.041***	.070***	.237***
	(.000)	(.000)	(.001)
Observations	6,904,758	6,904,585	3,331,224
R^2	0.003	0.151	0.242
Within R^2	0.003	0.007	0.057
Fixed effects		Product	Product× buyer

Notes: This table presents the correlation between the duration of a relationship and a measure of the average size of transactions occurring within that relationship. The statistics are computed using the dataset that covers the period from 1996 to 2006. The standard errors are indicated in parentheses. Significance levels: $*$ 10%, $**$ 5%, $***$ 1%.

O.3 Theoretical appendix

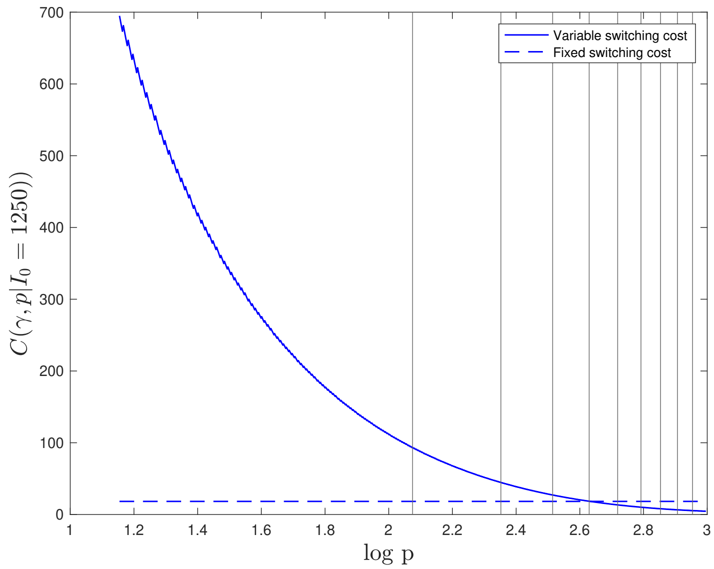
In this section, we provide a detailed description of the model solution used in our baseline estimation, as well as its extension to incorporate uncertainty. The simulation parameters used in our analysis are listed in Table O.4 at the end of this section.

O.3.1 Solution under a multiplicative switching cost

To solve the model, a functional form for the switching cost, denoted as $C(\gamma; p)$, needs to be specified. In the benchmark empirical model, the firm's reservation price, denoted as $p^*(\gamma; p)$, is assumed to be proportional to the price of its current supplier:

$$p^*(\gamma; p) = \frac{p}{\gamma}$$

Figure O.6: ***Switching cost as a function of prices***



Notes: The figure provides a comparison of the distributions of switching costs in the multiplicative and fixed cost models. The vertical lines represent the first to ninth deciles of the price distribution. The calibration of the model is conducted to ensure that the median duration of relationships in our data is matched.

Figure O.6 illustrates the functional form for the corresponding switching cost $C(\gamma; p)$.[31] Under the calibration, the switching cost is decreasing in p, which comes from $V()$ being sufficiently convex.

O.3.2 Solution under a fixed switching cost

To examine the impact of the parametric assumption regarding the form of the switching cost on the qualitative results, we compare the predictions of the baseline model to an alternative framework where the switching cost remains invariant to the buyer's reservation price. In this alternative framework, the switching cost is defined as $C(\gamma, p) = \gamma - 1$, and the optimal switching strategy is no longer multiplicative in p. Consequently, the

[31] The calibration in this figure is performed to match the median duration of firm-to-firm relationships at the median of the simulated price distribution. Detailed information on the calibrated parameters can be found in Table O.4.

relationship between durations and prices is no longer log-linear.

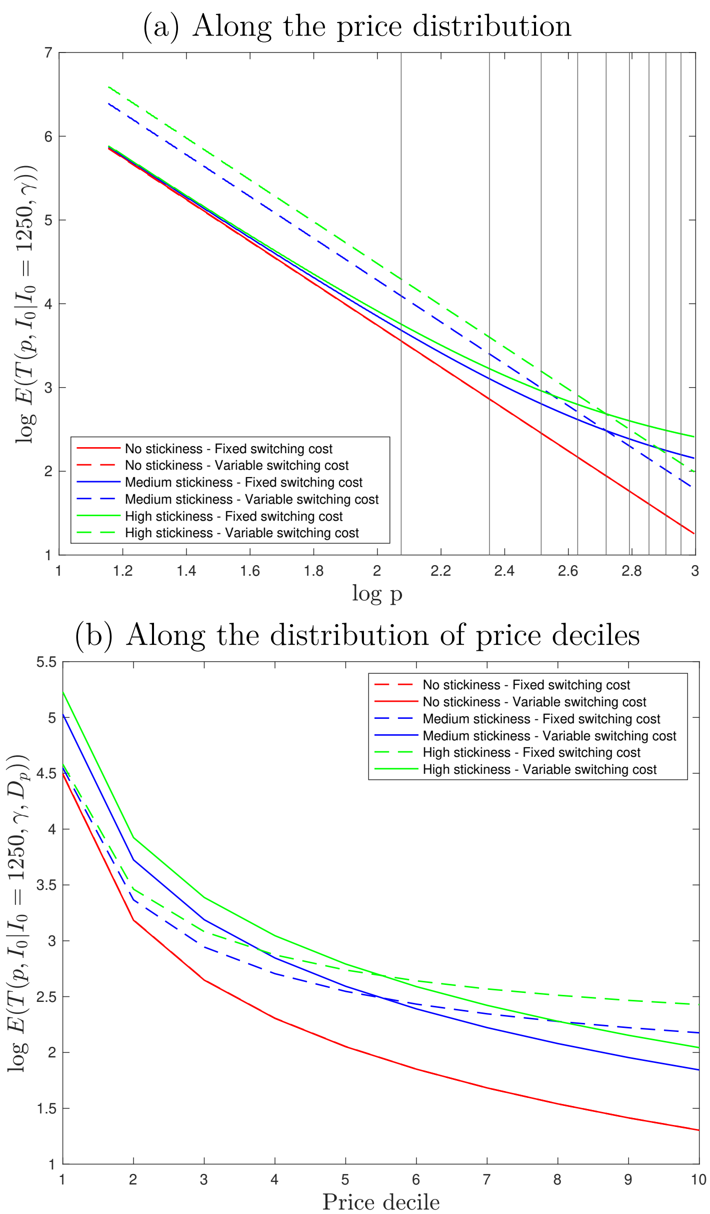
Figure O.7 illustrates the solutions of both models under different degrees of stickiness. The model with a fixed switching cost exhibits more convexity compared to the baseline log-linear case. However, the qualitative impact of increasing stickiness (i.e., increasing γ) remains the same as in the baseline case, resulting in a shift of the distribution of expected durations. It is important to note that the measure of stickiness employed in the empirical analysis relies on the ranking of expected durations across the distribution of price deciles. Despite the differences in the parametric assumptions, the information obtained from the empirical strategy remains valuable, as it captures the relative stickiness of different products and sectors.

O.3.3 Log-normal price distribution

We also conducted simulations using an alternative log-normal distribution for prices. This alternative distribution was calibrated based on the findings of Head et al. (2014), who estimated shape parameters for both Pareto and log-normal distributions using French export data. They determined that a log-normal distribution with a shape parameter of 0.8 provided a good fit to the data. In our simulations, we adjusted the location parameter of the log-normal distribution to match the expected duration at the median of the price distribution observed in our data, which was 12. This adjustment ensured consistency with the observed durations while allowing us to examine the model's performance under an alternative pricing distribution.

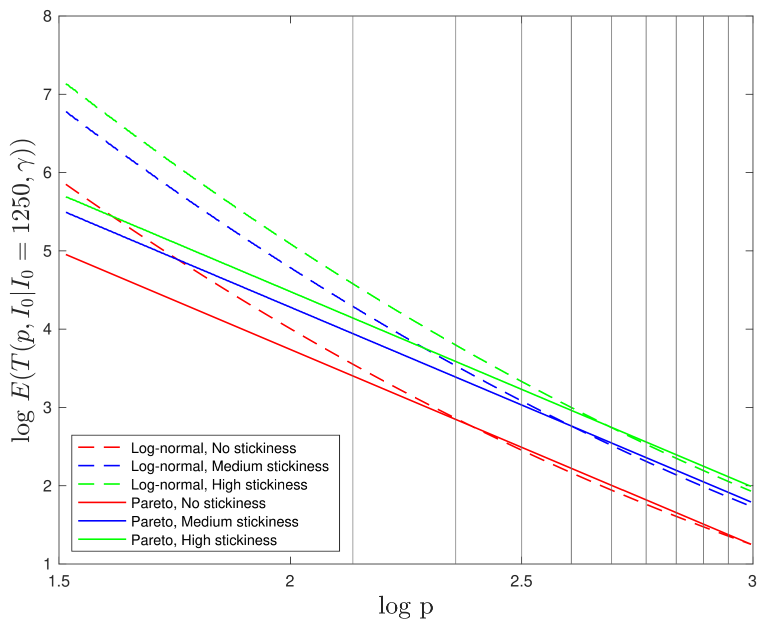
Figure O.8 compares the results obtained under the Pareto and log-normal distributions. The log-linear relationship between durations and prices is lost when moving away from the Pareto case, as expected. However, even under the log-normal distribution, the convexity is relatively moderate, indicating that fitting a linear relationship to the actual distribution generated by the log-normal assumption does not introduce a

Figure O.7: ***Expected durations in the baseline model and in a model with a fixed switching cost***



Notes: In the figure, we can observe a comparison of the model solutions under two different assumptions for the switching cost: the baseline variable switching cost (solid lines) and the fixed switching cost (dotted lines). The blue lines represent the baseline calibration that matches the median duration of relationships in the data. The top panel of the figure displays prices on the x-axis, while the bottom panel shows price deciles. The red lines represent a scenario with no switching cost ($\gamma = 1$), where the relationship between durations and prices is flat. This implies that the duration of relationships remains constant regardless of the price of the current supplier. The green lines depict a "sticky" scenario where the duration at the median is set to 18 months, which corresponds to the 75th percentile of the product-level distribution of median durations.

Figure O.8: ***Robustness to the distribution assumption: Pareto versus log-normal***



Notes: The figure compares the solutions of the model under two different assumptions for the distribution of prices: the Pareto distribution (solid lines) and the log-normal distribution (dashed lines). The various colors in the figure represent different calibrations for three levels of stickiness. The vertical lines in the figure represent the first to ninth deciles of the price distribution.

significant error. The intercept of the linear relationship remains informative about the level of stickiness determined by the model's parameters.

O.3.4 A risk-averse manager under mean-preserving uncertainty

In Section 3.2, we extended the model to incorporate uncertainty shocks. More specifically, we introduced a non-mean-preserving uncertainty shock leading to downside risk. We now test for the robustness of our predictions using an alternative assumption, in which the shock is mean-preserving. In solving the model under the assumption of a mean-preserving uncertainty shock, we incorporate risk aversion. We assume that the utility of profits, denoted as $u(\pi(p, I))$, is concave in the level of profits, represented as $\pi(p, I)$. Specifically, we use the functional form $u(\pi(p, I)) = \pi(p, I)^{1-\rho}$, where ρ represents the degree of relative risk aversion. In our case, we set ρ to a value of 0.9. By introducing risk aversion into the utility function, we capture the firm's aversion to uncertainty and its willingness to trade off expected profits with reduced risk. This allows us to examine the impact of risk aversion on optimal switching decisions and the dynamics of the model. The remaining parameters of the model are kept unchanged, except for the switching costs, which are adjusted to match the observed durations at the median of the price distribution.

In Figure O.9, the bottom panel presents the results of simulations conducted under different levels of uncertainty, while the top panel represents the same comparative statics in the baseline model with downside risk. These results allow us to compare the effects of uncertainty in both models. Similar to the baseline model, we find that higher levels of uncertainty are associated with longer durations on average, particularly in sticky product markets. This confirms that the impact of uncertainty discussed in Section 5 is not limited to shocks affecting only the first moment of the profit function. The presence of risk aversion in the model allows us to capture the real effects of uncertainty on firms' optimal switching decisions and relationship durations.

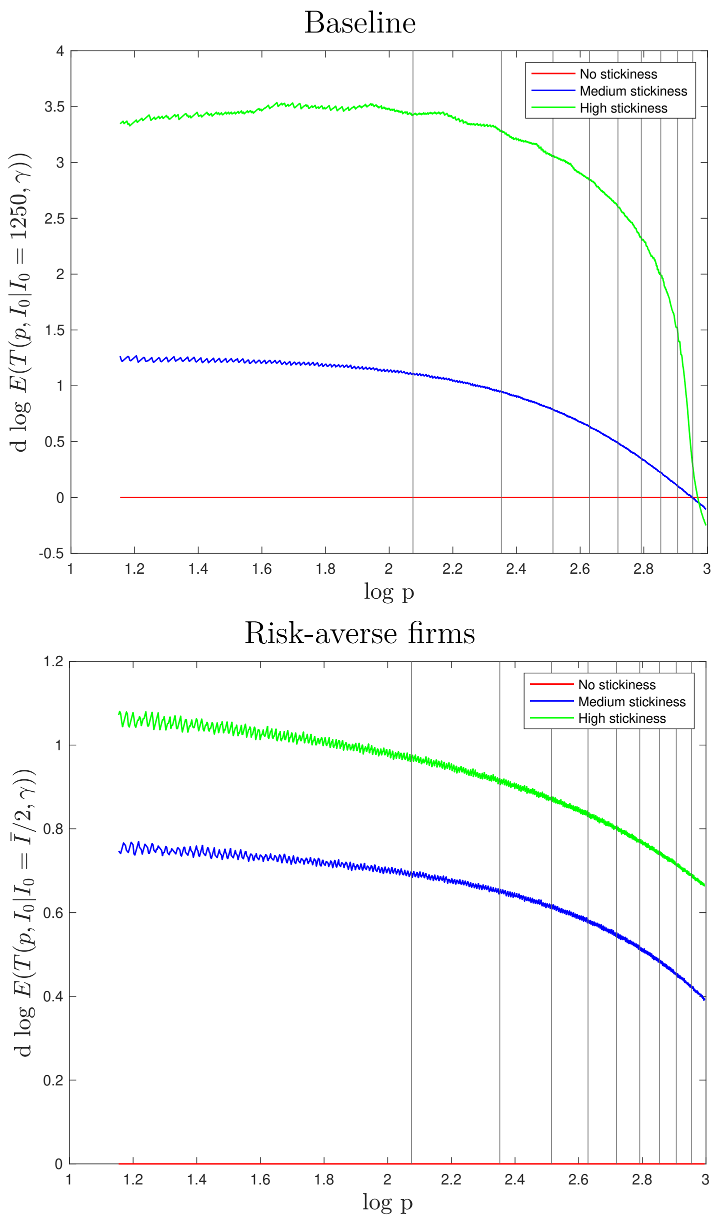
O.4 Further results on relationship stickiness

This section present additional results on relationship stickiness.

- Figure O.10 displays the estimates of relationship stickiness obtained from two sample periods: 1996-2006 and 2011-2017. The correlation coefficient between the two measures is 0.55.

- Figure O.11 depicts the dispersion in relationship stickiness across different Broad Economic Categories (BEC). The graph highlights that passenger cars exhibit the lowest level of stickiness, indicating a higher likelihood of switching suppliers com-

Figure O.9: ***Impact of more uncertainty on expected durations under various degrees of stickiness***



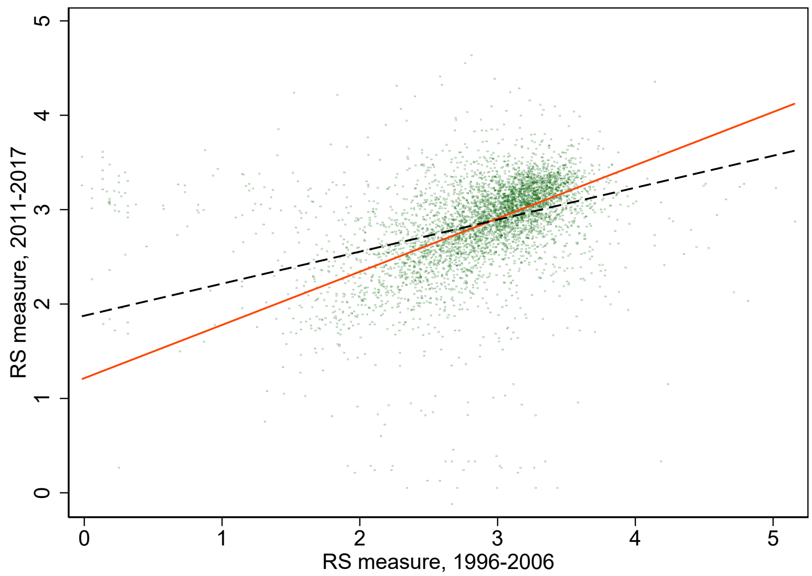
Notes: The figure depicts the percentage change in the expected duration of relationships, contrasting the states of no uncertainty and high uncertainty, across product markets with varying degrees of stickiness. The red line corresponds to a market with no stickiness, the blue line represents a moderate level of stickiness, and the green line represents a high degree of stickiness. In the top panel, which reflects the baseline calibration, the uncertainty shock affects an economy characterized by a high demand level, leading to the emergence of downside risk. Conversely, the bottom panel explores a scenario of a mean-preserving shock, assuming that firm managers exhibit risk aversion.

Table O.4: ***Parameter values for the simulations***

Value function	
Outside option V_0	10
Discount rate β	0.953
Meeting probability λ	0.286
Separation rate δ	0.05
Median duration - No stickiness	7
$\rightarrow \gamma$ (Fixed switching cost)	1.001
$\rightarrow \gamma$ (Variable switching cost)	1.001
Median duration - Medium stickiness	12
$\rightarrow \gamma$ (Fixed switching cost)	19.28
$\rightarrow \gamma$ (Variable switching cost)	1.242
Median duration - High stickiness	15
$\rightarrow \gamma$ (Fixed switching cost)	31
$\rightarrow \gamma$ (Variable switching cost)	1.345
AR(1) process	
Auto-correlation α	0.9
Drift ψ	0
μ	50
Volatility σ - No uncertainty	0
Volatility σ - Low volatility	10
Volatility σ - High volatility	150
Lower bar $\underline{I}$	100
Upper bar $\bar{I}$	1250
Initial Income State I_0	1250

pared to other BEC categories. On the other hand, parts and materials demonstrate the highest stickiness, suggesting a greater tendency for firms to maintain long-term relationships in this category. It is worth noting that there is significant variation in stickiness within each BEC category. This indicates that even within a specific industry or product category, there are firms that exhibit different levels of stickiness in their relationships with suppliers.

Figure O.10: ***Comparison of estimated stickiness indicators, across periods***

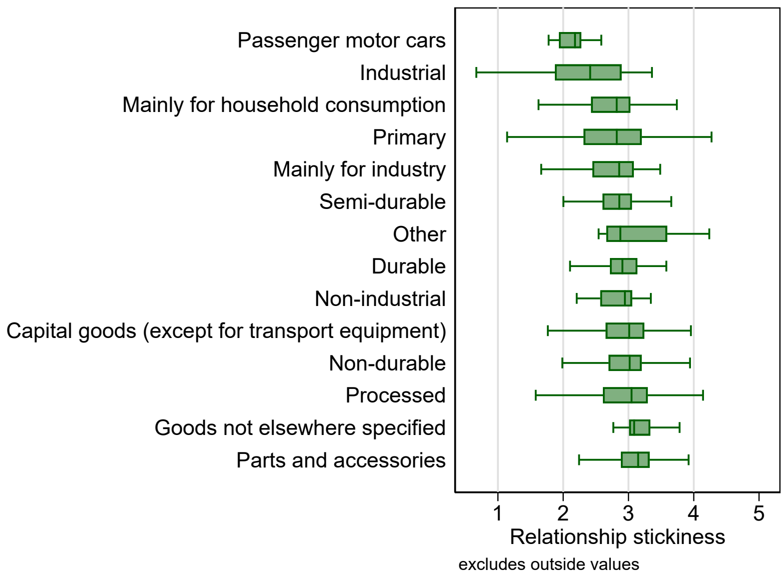


Notes: The figure represents a scatter plot of the baseline RS indicator recovered from the 1996-2006 period (x-axis) against the measure estimated from 2011-2017 (y-axis). The red and dotted lines correspond to the fitted lines, recovered from an unweighted linear fit (dotted line) or a linear regression in which products are weighted by the inverse of the estimated standard error recovered in the baseline case (red line).

O.5 Alternative measures of relationship stickiness

Table O.5 presents a set of robustness exercises that aim to assess the stability of the estimated Relationship Stickiness (RS) indicators. These exercises involve alternative definitions of sales quantiles in equation (3). The table summarizes the results obtained from using quintiles instead of deciles, country-specific quantiles, or a subset of the top quantiles of the distribution of transaction sizes. When using country-specific quintiles, the support and shape of the distribution of productivities are not constrained to be homogeneous across destinations within a product. Focusing on the top percentiles restricts the analysis to the right tail of the distribution of firms' sizes, which aligns better with the model's Pareto assumption as discussed in Head et al. (2014). The table reports that, in all three cases, the distribution of RS indices obtained from these alternative

Figure O.11: ***Relationship stickiness across Broad Economic Categories***



Notes: The figure represents a boxplot of relationship stickiness across Broad Economic Categories (BEC).

definitions is highly correlated with the baseline estimate, with correlations exceeding 80%. Additionally, the inter-quartile ranges of the RS indices remain comparable to those obtained in the baseline estimation. These findings suggest that the estimated RS indicators are robust and not heavily influenced by the specific choice of sales quantiles used in the analysis.

In an attempt to align the semi-elasticity of the duration with respect to the size of the quintile to unity, as suggested by the theoretical model, we conducted a robustness exercise by imposing a coefficient of one.[32] The results remained virtually unchanged. This suggests that this component of the estimated equation does not capture a substantial portion of the heterogeneity present in the data. We also conducted an additional

[32]The structural model implies that the semi-elasticity of the duration with respect to the mass of firms in the corresponding quantile of the distribution should be equal to 1 (as shown in equation (3)). However, in our baseline estimation, we found a semi-elasticity of 0.15, significantly lower than unity.

robustness exercise by controlling for country fixed effects. Again, the results remained largely unchanged, with the estimated RS indicators highly correlated with the baseline estimates. Furthermore, we examined the importance of controlling for the size of the transaction by running a specification without size control. In this case, the estimates were also highly correlated with the baseline estimates, indicating that the size variable contributes little explanatory power to the relationship stickiness measures. The R^2 value decreased only slightly from 0.21 to 0.20, further supporting the robustness of the baseline estimates.

Another potential concern regarding the measurement of durations relates to the infrequent occurrence of transactions. It is possible that products that are purchased less frequently may artificially exhibit longer durations, thereby inflating the measured stickiness. To address this concern, we conducted a robustness check that takes an extreme approach. Instead of measuring durations based on the timespan between the first and last transactions, we measured "durations" using the number of transactions observed within a continuous relationship. Remarkably, the correlation between the stickiness indicator obtained from this alternative measure and the baseline estimate is 75%, indicating a substantial level of agreement. Furthermore, the inter-quartile range of the stickiness distribution remains comparable between the two measures (see Table O.5). This suggests that the potential mis-measurement of durations resulting from the heterogeneous frequency of purchases is not a significant concern in our analysis.[33] To further

[33]It is important to note that this robustness check primarily addresses concerns about systematic differences in the frequency of purchases across products. However, another potential concern arises from within-product heterogeneity across firms. While a significant portion of this variability is smoothed out when averaging durations within quantiles, there may still be concerns if the measurement error associated with infrequent transactions is correlated with the transaction size. This correlation could arise if there are fixed costs per shipment, as argued by studies such as Hornok and Koren (2015) and

reinforce this point, we conducted additional checks. First, we computed the duration of a relationship regardless of potential interruptions, which yielded a correlation of 0.78 with our baseline measure. Second, we calculated the duration of a relationship at the 4-digit level of the HS nomenclature and found a correlation of 0.69 with the baseline measure. These additional analyses provide further support for the robustness of our findings.

In addition to the various measures of stickiness, we also computed a simple measure of average durations. The correlation between this average duration measure and our baseline measure of stickiness is high, at 0.8. However, we made an interesting observation regarding the sources of dispersion in average durations. We found that approximately one fifth of the across-product dispersion in average durations can be explained by the dispersion of sales within a specific product category. This indicates that there is variation in average durations even within the same product category, likely reflecting differences in match qualities between firms. In contrast, the dispersion in sales explains only a small fraction (1/20th) of the empirical variance in our measure of stickiness. This comparison highlights the effectiveness of our empirical strategy in controlling for within-product dispersion, which we argue captures the heterogeneity in match qualities. Considering these results, we believe that the model-driven measure of stickiness used in our paper offers several advantages over a model-free measure such as the average duration of trade relationships. Our approach explicitly accounts for the within-product dispersion and provides a more nuanced understanding of the underlying mechanisms driving stickiness in international trade relationships.

To assess the stability of our relationship stickiness (RS) estimates, we conducted several tests using different estimation samples. Our hypothesis is that our estimation

Blum et al. (2019). Despite these potential concerns, the stability of our results across various definitions of durations and quantiles suggests that they are not significant in practice.

strategy captures the ex-post impact of product-specific attributes, implying that the RS estimates should be consistent regardless of the time period or country sample used. First, we estimated country-specific distributions of RS indicators using the same empirical strategy but focusing on important destination countries for French exports, including Belgium, Germany, Italy, Spain, and the UK. The correlation between the baseline distribution obtained from the pooled sample and the country-specific estimates is high, averaging around 60%. This suggests that the estimated RS indicators exhibit substantial consistency across countries. We also examined the stability of our estimates over time by estimating relationship stickiness using the 2011-2017 period. Despite potential data limitations in the more recent years due to increased censoring, the correlation between the RS estimates from this period and the baseline distribution is significant at 0.60. It is worth noting that our baseline distribution of RS indices is based on the 1996-2006 period, which benefits from better-quality customs data. Furthermore, we extended our estimation strategy to a completely different dataset, specifically the panel of firm-to-firm trade flows from Colombian exports. Although we could not estimate RS for the exact same set of products due to data limitations, we estimated equation (3) for 383 HS4 products with more than 100 transactions, pooling all destination countries together. The correlation between the recovered estimates and the mean RS per HS4 product in our baseline estimates is significant and positive, at 0.4. This suggests a consistent pattern of relationship stickiness across different datasets, even when considering a different exporting country. Overall, our stability analysis reveals high levels of correlation among RS estimates obtained from various datasets, including those from a different country. These positive correlations provide empirical support for our interpretation of RS as capturing the consequences of structural factors that lead to significantly different mean durations in relationships across various product categories.

Table O.5: ***Alternative estimates of stickiness***

	(1) corr. w/ baseline	(2) IQR	(3) # of products
Baseline	100%	0.62	5,186
Robustness to the definition of size quintiles:			
Quintiles	96.2%	0.61	5,016
HS6-iso2 specific quantiles	96.93%	0.61	5,016
Top quantiles	89.1%	0.63	4,895
Imposing alpha==1	98.9%	0.59	5,024
Without size control	99.9%	0.60	5,024
Robustness to the specification:			
Average duration	83.33%	0.72	5025
Adding country fixed effects	99.9%	0.60	5,024
# of transactions rather than months	82.3%	0.59	4,974
Dealing with left censoring	90.2%	0.61	4,976
Duration (including interruption)	78.2%	0.53	5,014
Relationship at the 4-digit level	69.1%	0.61	5,214
Stability over space and over time:			
Focus on Belgium	60.1%	0.85	5,191
Focus on Germany	73.4%	0.71	5,084
Focus on Italy	53.3%	0.94	5,160
Focus on Spain	58.0%	0.92	5,161
Focus on UK	54.6%	0.98	5,135
Sample 2011-2017	54.7%	0.55	4,921
Using Colombian data (HS4 level)	44.2%	0.56	382

Notes: The table presents a comparison of the baseline set of relationship stickiness (RS) estimates with several robustness exercises discussed in the text. The table includes three columns: (1) correlation coefficient with the baseline, (2) inter-quartile range, and (3) number of estimated coefficients.

O.6 External validity checks

Relationship stickiness and intrafirm trade. In their study, Antràs and Chor (2013) propose a property-rights model where relationship-specific investments create a "locked-in" effect, that pushes firms to integrate their suppliers. Specifically, downstream firms have an incentive to integrate suppliers due to contractual frictions in procuring customized components that are later integrated into production. According to this framework, the prevalence of vertical integration is expected to be higher in product markets with stronger locked-in effects.

Table O.6 investigates whether the extent of intrafirm trade in US product-level trade data varies systematically across different relationship stickiness indicators. The analysis focuses on the correlation between the relationship-specific indicator and the share of intrafirm trade in US exports (columns (1)-(2)) and US imports (columns (3)-(4)). To account for other product-level characteristics that are known to be correlated with relationship stickiness (as discussed in Section 4.2), columns (2) and (4) include additional controls. The share of intrafirm trade is derived from data provided by the Bureau of Economic Analysis for the year 2002. Intrafirm trade is identified based on 6-digit NAICS categories, which are merged with the HS6 nomenclature (version 2002) using the correspondence established by Pierce and Schott (2012).

The results indicate a positive and statistically significant correlation between a product's level of relationship stickiness and its share of intrafirm trade. Moreover, relationship stickiness accounts for approximately 10% of the variation observed in the share of intrafirm trade across different product categories. These findings suggest that relationship stickiness plays a meaningful role in explaining the prevalence of intrafirm trade.

Relationship stickiness and comparative advantages: In their studies, Nunn (2007) and Levchenko (2007) argue that goods requiring high relationship-specific investments are more likely to thrive in countries with strong institutions, including effective contract enforcement, secure property rights, and shareholder protection. These institutions, in turn, shape the geography of trade, similar to other sources of comparative advantage. To test the validity of our relationship stickiness measure, we replicate an exercise similar to Nunn (2007) using more disaggregated data obtained from the UN-COMTRADE database at the 6-digit level of the Harmonized System (HS) nomenclature, which we merge with our own measure of relationship stickiness.

Table O.7 presents the results of these regressions. In each regression, we control for the measure of relationship specificity developed by Nunn (2007). In the first three columns, we follow Nunn's approach and explain the value of a country's exports at the product level using an interaction term between the quality of the country's institutions (measured by Kaufmann et al. (2010)) and the degree of relationship stickiness of the product. In columns (4) and (5), we depart from Nunn's specifications and consider measures of specialization that account for product-country pairs with zero trade flows, such as the Balassa index and a dummy variable identifying Balassa indices above 1.[34]

The findings confirm the results of Nunn (2007) that countries with strong contract enforcement tend to specialize in the production of more relationship-specific goods. In columns (3) and (5), we show that both Nunn's measure and our measure of product stickiness have explanatory power in this regression. However, when we use the Balassa index as a measure of comparative advantage, the interaction term with Nunn's measure becomes statistically insignificant, while our relationship stickiness indicator remains positively associated with greater trade from countries with robust enforcement laws.

Overall, these results provide support for the validity of our relationship stickiness measure and its ability to capture the role of institutions in shaping trade patterns, consistent with the findings of Nunn (2007) and Levchenko (2007).

Relationship stickiness and the distance effect: To assess how relationship stickiness interacts with standard determinants of international trade and shapes the geography of trade, we employ the gravity equation framework. We interact the distance variable with our relationship stickiness measure, and the results are presented in Table O.8. Bilateral trade data at the HS6 level are obtained from the BACI database for the

[34]The Balassa index is computed using BACI multilateral data and represents the value of product-level exports originating from a particular source country over the value of worldwide exports in the same product category.

year 2005 (Gaulier and Zignago, 2010), while distance is measured as the weighted distance between countries' main cities based on Mayer and Zignago (2011). Additionally, we control for product upstreamness in value chains and its interaction with distance.

The consistent findings across specifications indicate that the effect of distance on trade is amplified in product markets characterized by higher relationship stickiness. This result holds regardless of the fixed effects structure, including in the most demanding specification in column (4). The elasticity of trade with respect to distance also appears to increase for more upstream goods, although the effect is sensitive to the choice of fixed effects. Interpreting the magnified impact of distance for high-relationship stickiness products within this reduced-form framework is challenging. One possible interpretation is that information frictions are more significant in these markets, leading to higher switching costs and concentration of trade in closer geographic locations (Rauch, 1999). Another explanation could be that stickier relationships are associated with higher monitoring costs, which tend to increase with distance (Head and Ries, 2008).

These sanity checks consistently support our main findings. Our relationship stickiness measure captures meaningful variability across disaggregated product markets, and its correlation with external indicators aligns with our interpretation. It provides further evidence that relationship stickiness plays a role in shaping trade patterns.

O.7 Robustness on relationship stickiness and uncertainty

Table O.9 and Table O.10 present an extensive robustness analysis of the results discussed in Section 5.2. Both tables follow a similar structure. Table O.9 focuses on testing the robustness of the results concerning the effect of uncertainty on entry behavior, while Table O.10 examines the robustness of exit patterns.

Non-durable goods. In columns (1)-(2), we examine the robustness of the baseline regression by excluding durable products from the sample. This exclusion is motivated

Table O.6: ***Share of intrafirm trade and relationship stickiness***

	(1)	(2)	(3)	(4)
	Share of intrafirm			
	exports		*imports*	
RS (η)	0.185***	0.108**	0.123***	0.084***
	(0.030)	(0.043)	(0.022)	(0.032)
Nunn' measure		0.406***		0.198***
		(0.066)		(0.049)
Upstreamness		0.065***		0.019
		(0.016)		(0.012)
Elasticity (σ)		-0.002		-0.008**
		(0.006)		(0.003)
Observations	437	378	437	378
R-squared	0.085	0.134	0.072	0.083

Robust standard errors are in parentheses with *, **, *** denoting significance at the 10, 5, and 1% levels.

Table O.7: ***Institutional comparative advantage***

	(1)	(2)	(3)	(4)	(5)
		log(exports)		Balassa Index	$\mathbf{1}_{Balassa>1}$
Rule of law					
$\times$ *RS*	0.200***		0.228***	0.105**	0.011***
	(0.035)		(0.030)	(0.048)	(0.004)
$\times$ Nunn specif.		0.812***	1.067***	0.366	0.041**
		(0.100)	(0.144)	(0.302)	(0.020)
$\times$ Upstreamness			0.076*	0.041	0.007
			(0.045)	(0.072)	(0.005)
Fixed effects	$country(122)$ *and* $sector(4,326)$				
Observations	296,185	296,185	292,957	527,406	527,406
R-squared	0.604	0.606	0.609	0.012	0.139

Clustered (country) standard errors are in parentheses with *, **, *** denoting significance at the 10, 5, and 1% levels.

Figure O.12: ***Uncertainty episodes and GDP growth***

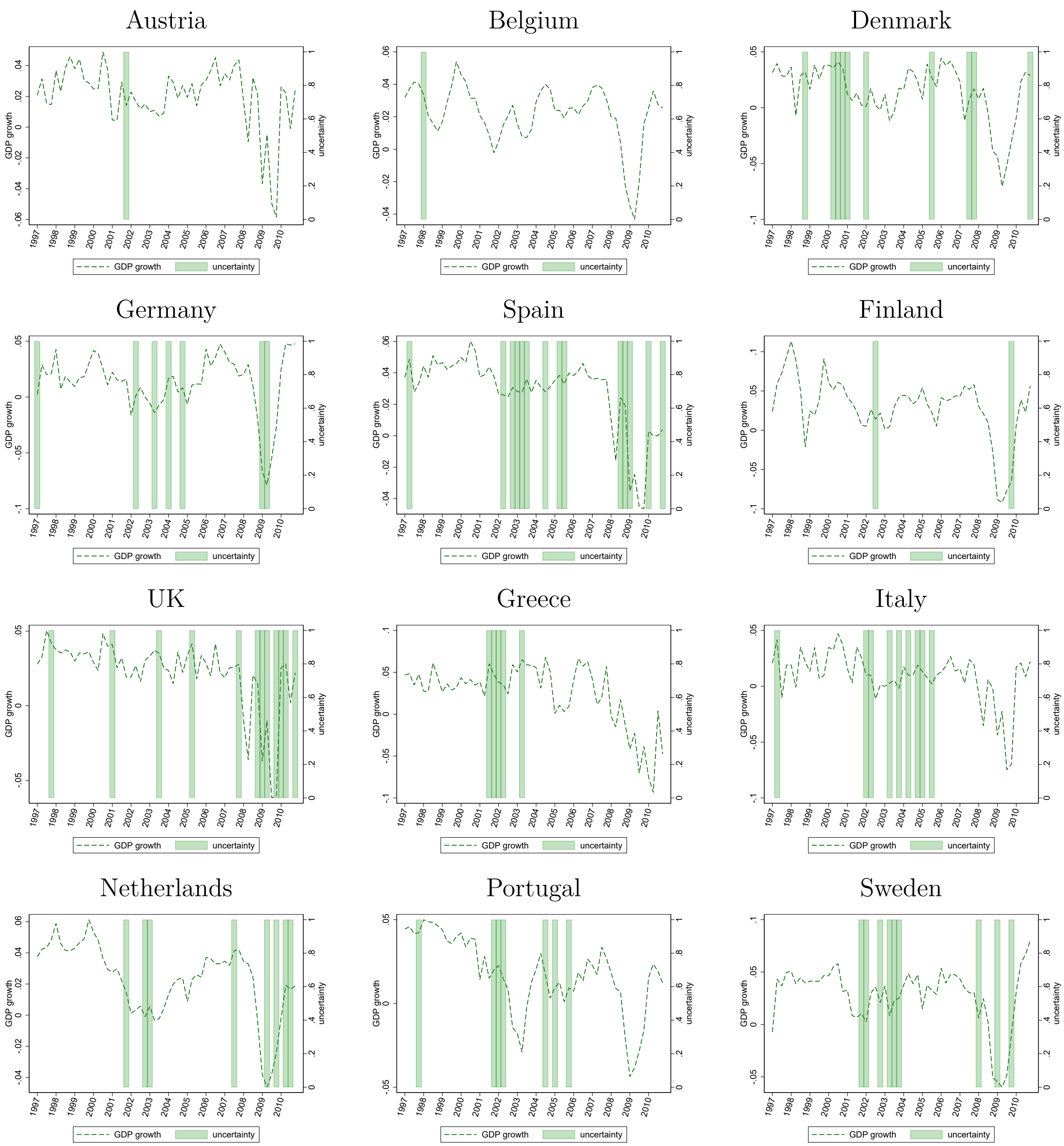


Table O.8: ***Gravity for trade in goods with sticky relationship***

	(1)	(2)	(3)	(4)
Distance (log)	-0.553***	-0.370***	-0.521***	-0.893***
	(0.015)	(0.019)	(0.020)	(0.025)
- × RS		-0.064***	-0.056***	-0.028***
		(0.006)	(0.006)	(0.006)
- × Upstreamness		0.002	0.012**	-0.021***
		(0.005)	(0.005)	(0.007)
RS	-0.198***	0.322***		
	(0.007)	(0.051)		
Upstreamness	0.044***	0.026		
	(0.005)	(0.040)		
Fixed effects				
Exporter	✓	✓	✓	
Importer	✓	✓	✓	
Product			✓	
Exporter×Product				✓
Importer×Product				✓
Observations		5,704,026		5,473,532
R-squared	0.164	0.164	0.285	0.578

Clustered (country) standard errors are in parentheses with *, **, *** denoting significance at the 10, 5, and 1% levels.

by the findings of Novy and Taylor (2019), who highlight that durable goods exhibit the highest sensitivity to uncertainty shocks. In their model, firms can postpone orders of durable products during periods of high uncertainty by relying on their existing inventories. The effect of such behavior on our results is not entirely clear, as it primarily affects adjustments at the intensive margin. However, it is possible that firms may still delay the search for new trading partners even if they have inventories to rely on.

Despite these potential complexities, we find that our results remain robust when excluding durable products from the analysis. However, it is worth noting that focusing on non-durable products shifts the elasticities of separations in response to uncertainty episodes towards more positive values. This suggests that uncertainty has a stronger impact on separations in the absence of durable goods.

Excluding intrafirm trade. In columns (3)-(4), we address concerns about the potential impact of intrafirm trade on our estimates. Due to data limitations, we are unable to distinguish between arm's length transactions and intrafirm transactions in our dataset. However, it is possible that the response of both types of trade flows to uncertainty episodes could drive the observed heterogeneity that we attribute to relationship stickiness in Section 5.2.

To control for this potential confounding effect, we construct a sub-sample using external data from the INSEE-LiFi survey. This survey allows us to identify French exporters that are part of multinational firms. We then exclude from our analysis all their exports to countries where they have multinational linkages, either through having an affiliate or because their headquarters are located in those countries. By doing so, we remove all intrafirm trade flows from the estimation sample. However, it is important to note that this procedure may also remove transactions that are not intrafirm, as exporters with affiliates in a country may still export to non-affiliated partners.

Interestingly, the results in columns (3)-(4) are qualitatively and quantitatively unchanged in terms of the response of entries to uncertainty episodes. This suggests that the observed relationship between uncertainty and entry is not solely driven by intrafirm trade flows. However, it is worth noting that the elasticities at the exit margin are slightly shifted towards more positive values when intrafirm transactions are neglected. This is likely due to the over-representation of less sticky products in the estimation sample, as stickiness is correlated with the prevalence of intrafirm trade (as shown in Table O.6).

Relationship stickiness: level vs. rank. In columns (5)-(6), we introduce a different approach to address concerns about the potential contamination of the level of relationship stickiness (RS) by uncertainty. Instead of using the level of RS, we focus on the ranking of products within the distribution of stickiness indicators displayed in Figure 2. The rationale behind this approach is that while the level of RS may be influenced by uncertainty, the ranking of products should be immune to this source of endogeneity, as long as uncertainty is common across products.

The results obtained from this alternative measure of stickiness are robust and actually indicate a stronger heterogeneity in adjustments to uncertainty compared to the baseline specifications.

Relationship stickiness: 2011-2017. In columns (7)-(8), we use the level of stickiness estimated over the period 2011-2017. This measure of relationship stickiness is based on a different sample compared to the one used to assess the role of uncertainty on the creation and destruction of trade relationships. The results obtained from this alternative measure of stickiness are consistent with the baseline specifications. In fact, these results indicate an even stronger heterogeneity in adjustments to uncertainty compared to the baseline specifications.

In summary, the results presented in this section confirm and reinforce the findings discussed in Section 5.2. These results provide further evidence regarding the sensitivity of trade to uncertainty episodes, the role of adjustments at the extensive margin, and the magnified impact of uncertainty in more sticky product markets.

Table O.9: ***Uncertainty and the creation of new trade relationships: Robustness***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var:	*# new trade relationships*							
Uncertainty episode	0.380***		0.106***		-0.010*		0.051**	
	(0.022)		(0.020)		(0.006)		(0.021)	
- × RS index	-0.153***	-0.138***	-0.050***	-0.039***				
	(0.008)	(0.008)	(0.007)	(0.007)				
- × RS Percentile					-0.001***	-0.001***		
					(0.000)	(0.000)		
- × RS11-17							-0.033***	-0.030***
							(0.007)	(0.008)
Specification	wo durables		wo MNEs		RS Pctiles		2011-2017	
Obs.	2,070,483	2,322,807	2,503,927	2,803,631	2,529,448	2,815,907	2,312,256	2,577,849
Fixed Effects								
Product × quarter		✓		✓		✓		✓
Product × period	✓		✓		✓		✓	
Country	✓		✓		✓		✓	
Country × period		✓		✓		✓		✓
Effect of uncertainty for products at P25 and P75 of the RS distributions								

Notes: The table presents Poisson estimations with high-dimensional fixed effects to examine the impact of uncertainty on new trade relationships. The main explanatory variable is an indicator for uncertainty episodes, which is equal to 1 during periods when uncertainty in the destination country exceeds the average uncertainty plus one standard deviation. The measure of relationship stickiness, denoted as *RS*, is included as a key independent variable. The first two columns (1)-(2) exclude observations related to bilateral exports of firms that have an affiliate or their headquarters in the destination country. Columns (3)-(4) focus on a sub-sample that excludes durable goods. In columns (5)-(6), the measure of relationship stickiness is replaced by the percentile ranking of products within the distribution of stickiness indicators (as shown in Figure 2). Columns (7)-(8) employ relationship stickiness estimated on a different sample period, specifically from 2011 to 2017. To facilitate comparison, the table also reports the estimated impact of an uncertainty shock for products at the 25th percentile (P25) and 75th percentile (P75) of the relationship stickiness distribution. All estimations control for GDP growth and its interaction with the relationship stickiness measure as additional covariates. Robust standard errors are in parentheses. Significance levels: * 10%, ** 5%, *** 1%.

Table O.10: ***Uncertainty and the disruption of new trade relationships: Robustness***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var:	*# disrupted trade relationships*							
Uncertainty episode	0.276***		0.159***		0.165***		0.078***	
	(0.022)		(0.021)		(0.023)		(0.006)	
- × RS index	-0.085***		-0.067***		-0.043***		-0.037***	
	(0.008)		(0.008)		(0.008)		(0.008)	
- × RS 11-17					-0.044***	-0.036***		
					(0.008)	(0.008)		
- × RS Percentile							-0.001***	-0.001***
							(0.000)	(0.000)
Specification	wo durables		wo MNEs		2011-2017		RS Pctiles	
Obs.	1,479,936	1,541,383	1,796,915	1,868,636	1,670,535	1,734,716	1,831,898	1,901,523
Fixed Effects								
Product × quarter		✓		✓		✓		✓
Product × period	✓		✓		✓		✓	
Country	✓		✓		✓		✓	
Country × period		✓		✓		✓		✓
Effect of uncertainty for products at P25 and P75 of the RS distributions								

Notes: The table presents Poisson estimations with high-dimensional fixed effects to examine the impact of uncertainty on disrupted trade relationships. The main explanatory variable is an indicator for uncertainty episodes, which is equal to 1 during periods when uncertainty in the destination country exceeds the average uncertainty plus one standard deviation. The measure of relationship stickiness, denoted as *RS*, is included as a key independent variable. The first two columns (1)-(2) exclude observations related to bilateral exports of firms that have an affiliate or their headquarters in the destination country. Columns (3)-(4) focus on a sub-sample that excludes durable goods. In columns (5)-(6), the measure of relationship stickiness is replaced by the percentile ranking of products within the distribution of stickiness indicators (as shown in Figure 2). Columns (7)-(8) employ relationship stickiness estimated on a different sample period, specifically from 2011 to 2017. To facilitate comparison, the table also reports the estimated impact of an uncertainty shock for products at the 25th percentile (P25) and 75th percentile (P75) of the relationship stickiness distribution. All estimations control for GDP growth and its interaction with the relationship stickiness measure as additional covariates. Robust standard errors are in parentheses. Significance levels: * 10%, ** 5%, *** 1%.

Table O.11: ***Uncertainty and trade growth: margin decomposition***

	(1)	(2)	(3)	(4)
Dep. var:	Growth	=Start	+ End	+ Intensive
RS index	-0.07***	-0.21***	0.13***	0.01***
	(0.002)	(0.002)	(0.001)	(0.001)
Uncertainty shock	-0.11***	-0.05***	-0.06***	0.001
	(0.004)	(0.002)	(0.002)	(0.001)
- × RS index	-0.01***	-0.02***	0.01***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.0004)
GDP shock	-0.14***	-0.16***	-0.002	0.02
	(0.007)	(0.004)	(0.003)	(0.003)
- × RS index	-0.04***	0.01***	-0.01***	-0.03***
	(0.002)	(0.001)	(0.001)	(0.001)
Observations	3,538,965	3,538,965	3,538,965	3,538,965
Period		1996-2010		

Notes: OLS results are reported with bootstrapped standard errors shown in parentheses. The dependent variable, growth, represents the year-on-year growth rate of product-level French exports to the destination under consideration. The overall growth is decomposed into three different growth margins: Start refers to the number of new seller-buyer relationships, End represents the number of disrupted relationships, Intensive reflects the evolution of seller-buyer sales within existing trade relationships. The uncertainty shocks variable is a dummy equal to 1 during periods when uncertainty in the destination country exceeds the average uncertainty plus one standard deviation. The GDP shock variable is a dummy equal to 1 during periods when GDP growth is below the average GDP growth minus one standard deviation. *RS* is our measure of relationship stickiness, which is not centered (Mean: 2.9, P05: 1.8, P95: 3.5). Significance levels: $*$ 10%, $**$ 5%, $***$ 1%.

Table O.12: ***Uncertainty and trade growth: margin decomposition with an alternative measure of uncertainty***

	(1)	(2)	(3)	(4)
Dep. var:	Growth	=Start	+ End	+ Intensive
RS index	-0.02	-0.31***	0.27***	0.01
	(0.017)	(0.012)	(0.008)	(0.006)
Vol. of returns	-0.18***	-0.09***	-0.08***	-0.01***
	(0.006)	(0.004)	(0.003)	(0.002)
- × RS index	0.01***	-0.01***	0.02***	-0.00
	(0.002)	(0.001)	(0.001)	(0.001)
Level of returns	-0.01**	0.01***	-0.02***	-0.01***
	(0.005)	(0.003)	(0.002)	(0.002)
- × RS index	0.01***	-0.01***	0.01***	0.01***
	(0.002)	(0.001)	(0.001)	(0.001)
Observations	3,538,965	3,538,965	3,538,965	3,538,965

Notes: OLS results are reported with bootstrapped standard errors shown in parentheses. The dependent variable, growth, represents the year-on-year growth rate of product-level French exports to the destination under consideration. The overall growth is decomposed into three different growth margins: Start refers to the number of new seller-buyer relationships, End represents the number of disrupted relationships, Intensive reflects the evolution of seller-buyer sales within existing trade relationships. The level and volatility of stock returns are from (Baker et al., 2020). RS index is our measure of relationship stickiness, which is not centered (Mean: 2.9, P05: 1.8, P95: 3.5). Significance levels: $*$ 10%, $**$ 5%, $***$ 1%.