When Brexit Means Brexit: Recovering Trade Policy Expectations from UK Import Stockpiling*

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Abstract

We use pre-Brexit stockpiling dynamics to recover expectations over the magnitude and timing of post-Brexit trade costs. Our identification hinges on a model of inventory management in the presence of future trade policy risk, disciplined by the high-frequency boom-bust dynamics of UK imports around Brexit deadlines. We find that the expected trade costs of Brexit were perceived to be large but declined with successive deadline revisions. In contrast, the credibility of proposed Brexit deadlines was highest at the final deadline. These anticipatory effects are obscured in low-frequency trade data, biasing estimates of expected trade costs toward zero.

JEL Classifications: F12, F13, F14

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1 Introduction

Trade policy is increasingly implemented on a discretionary basis. Firms must make decisions given limited credible information on the magnitude, likelihood, and timing of future changes in trade costs. In this paper we recover a distribution over anticipated future trade costs when neither the magnitude nor the timing of these cost changes are credibly specified in advance by policymakers. We apply our approach to the pre-Brexit period, in which UK importers faced a trade policy process with minimal explicit structure.

Our core identification logic is straightforward. If trade policy is expected to change in the near future, firms have an incentive to shift the timing of their purchases to minimize the total cost of importing, including trade costs and inventory holding costs. This incentive can give rise to large swings in trade without any current change in policy. These swings can be used to infer the expected change in future policy.

We recover the distribution of Brexit costs on this basis, using an $(\underline{s}, \bar{s})$ model of inventory accumulation with stochastic trade policy. We proceed in three steps. First, stockpiling behavior identifies expected future trade costs. Second, variation across successive proposed deadlines for Brexit identifies the perceived timing of those costs. Third, external discipline from a robust combination of prediction markets and survey data allows us to separate the likelihood of Brexit from the severity of the associated trade-cost increase. Altogether, we are able to infer a distribution over the timing and magnitude of a trade policy change in which neither was explicitly defined. We find significant perceived trade costs of Brexit which declined by over 80 percent following multiple deadline revisions; meanwhile, the likelihood of Brexit was highest by the final (realized) deadline.

Conditional on our mechanism, high-frequency data is essential to accurately identify expectations. Our evidence of sizable anticipated Brexit costs contrasts with previous literature finding that aggregate trade did not respond to Brexit prior to the formal departure date (Dhingra and Sampson, 2022; Freeman et al., 2025). The short-run inventory accumulation incentive rationalizes this discrepancy: aggregated to quarterly frequency or lower, our model predicts no significant observable adjustment in behavior.

Our work extends the approach of Alessandria et al. (2024), who study the high-frequency inventory accumulation dynamics of US importers surrounding the annual renewal of China's MFN status. They consider a possible trade policy change with fixed possible timing and magnitude. Many recent trade policy disputes have lacked such structure. Brexit provides a clean reference point for these cases. The pre-Brexit period featured four commitments to resolve uncertainty by a particular date, and three last-minute revisions of those commitments. The trade costs associated with these deadlines were unclear. The deadlines therefore constitute a repeated trade policy threat, affecting a large and stable share of UK trade, but varying over time in severity and credibility.

We represent our mechanism through an $(\underline{s}, \bar{s})$ model of inventory accumulation (Alessandria et al., 2010) with stochastic trade policy and idiosyncratic shocks to fixed order costs. Here, importing firms use a storage technology that allows them to retain stock over time, subject to holding costs. In the face of a possible future trade-cost increase, inventory accumulation drives import spikes like those we observe prior to Brexit deadlines. Evidence for our mechanism draws from two sources. First, the dynamic model provides a striking fit to high-frequency variation in UK import data around our Brexit deadline shocks. Second, it aligns well with untargeted survey evidence on inventory accumulation among UK manufacturing firms.

Combining import data with external probabilities from prediction market and survey evidence reveals that the perceived trade costs of Brexit declined substantially across deadlines. Meanwhile, the credibility of Brexit deadlines first collapsed before recovering dramatically. By late 2020, Brexit was viewed as nearly certain to occur, but at substantially reduced cost to importers. Our results demonstrate that inventory dynamics put nuanced structure on perceived future trade costs even in settings with minimal credible policy detail. This methodology extends naturally to a range of important episodes of trade policy uncertainty, including the recent dynamics of US trade flows.

1.1 Related Literature

A large literature documents a significant decline in UK imports from the EU following the TCA, albeit with varying magnitudes (Kren and Lawless, 2024; Freeman et al., 2025; Novy et al., 2024). These changes in UK trade were forecast by well-publicized ex-ante studies during the post-referendum period (Dhingra et al., 2017).

Despite consensus that Brexit implied a significant increase in trade costs, evidence for the pre-TCA period is equivocal. Crowley et al. (2019) find the referendum itself had negative cross-sectional impacts on entry and exit decisions among UK firms. Graziano et al. (2021) and Fernandes and Winters (2021) similarly find cross-sectional impacts on the intensive margin. Nonetheless, Dhingra and Sampson (2022) and Freeman et al. (2025) demonstrate an absence of significant aggregate trade adjustments emerging from this cross-sectional variation over the four-year post-referendum period. Related studies reach similar conclusions in general-equilibrium settings. Steinberg (2019) demonstrates the muted effect on trade of an increase in the second moment of policy uncertainty ahead of Brexit. Broadbent et al. (2024), meanwhile, explore anticipatory post-referendum dynamics in a small-open-economy setting and find countervailing forward-looking dynamics working against a simple decline in UK–EU trade, distinct from but complementary to the channel we consider.

An influential literature argues Brexit-related uncertainty had large macroeconomic consequences outside trade. Bloom et al. (2019) and Bloom et al. (2026) show this uncertainty had large effects on UK aggregate investment, while Hassan et al. (2024) extend this methodology to address global uncertainty. We provide a consistent narrative regarding the time variation of Brexit uncertainty, using a distinct identification approach. Furthermore, our evidence of inventory accumulation incentives can explain the coexistence of noticeable domestic macroeconomic effects with no notable trade adjustment: firms keenly anticipated Brexit costs, but for that reason they did not reduce trade prior to the imposition of costs.

Beyond the Brexit context, we contribute to a wider literature on trade policy uncertainty (TPU) that begins with Handley and Limão (2017) and Ruhl (2011). Our results relate most directly to Alessandria et al. (2024), who study U.S. product-level import patterns associated with the annual renewal of China's MFN status. Similar to our setting, they find high-frequency dynamics of inventory accumulation and decumulation surrounding trade policy deadlines. We extend their framework to demonstrate the importance of this mechanism in an episode of repeated deadlines with minimal structure on the timing and magnitude of trade costs. Outside of the China MFN renewal context, Khan and Khederlarian (2021) find the converse property predicted by our model, with U.S. importers running down inventories in anticipation of tariff *reductions* under NAFTA. Békés et al. (2017) find complementary evidence on the role of inventories in precautionary sales management, focusing on demand-side rather than supply-side volatility. Our paper also relates to recent work that uses trade flows and a dynamic exporting model to recover trade policy expectations (Alessandria et al., 2025c; Alessandria et al., 2025b; Hoang and Mix, 2023). Our core mechanism further connects with work considering how inventories can be used to smooth shocks to trade costs (Alessandria et al., 2010; Lafrogne-Joussier et al., 2023).

By providing a mechanism for the lack of a TPU-related decline in trade ahead of Brexit, we contrast with the view that TPU reduces trade in itself (Pierce and Schott, 2016; Handley and Limão, 2017). Our results suggest large time-varying Brexit uncertainty. The lack of an aggregate trade reduction therefore suggests direct negative effects of uncertainty on trade are dominated by dynamic substitution away from future trade costs.

1.2 Outline

The rest of the paper is organized as follows. In section 2, we provide reduced-form analysis of UK import dynamics in the pre–TCA period. In section 3, we introduce a structural model of inventory accumulation to estimate deadline-specific Brexit risk. Section 4 provides external validation of our mechanism using survey evidence on Brexit-related UK inventory accumulation. In section 5, we use evidence from prediction markets and survey data to decompose our Brexit risk measure into a likelihood and a severity component. Section 6 concludes.

2 Pre-Brexit Import Dynamics

We start by describing the dynamics of trade and trade policy in the period leading up to Brexit. Numerous analyses have suggested there was anticipatory stockpiling ahead of Brexit negotiation deadlines in import and export data (Office for National Statistics, 2021). We deploy a formal framework to measure the swings in trade flows around deadlines. We find evidence that UK imports from the EU displayed a significant increase ahead of each proposed deadline, after controlling for UK demand-side fixed effects and good-level seasonalities. We further find both the magnitude and dynamics of anticipatory stockpiling vary by deadline.

2.1 Timeline of Brexit Trade-Policy Uncertainty

We orient our empirical analysis around the negotiation timeline, which we now briefly summarize.

The United Kingdom voted to leave the EU by referendum in June 2016, while the agreement on the resulting TCA was only reached four and a half years later in December 2020. The period between these two events featured four policy commitments to deliver Brexit by specific deadlines, and three revisions to prior commitments. In each case, the validity of the commitment was not clear until several days before the proposed horizon.

In March 2017, the United Kingdom triggered Article 50 of the Treaty of the EU, committing to leave the bloc within two years. In March 2019, eight days prior to the implied deadline, the UK and European Council agreed to rescind this commitment. The Council declared a state-contingent extension: countries would revert to MFN on April 12 without UK parliamentary approval for a Brexit deal.

On April 10, the Council withdrew the second Brexit deadline, extending negotiations to October 31, 2019, despite the lack of a deal in UK parliament.

On September 9, UK parliament passed the Benn Act, mandating the prime minister to obtain parliamentary approval before allowing a no-deal exit. On October 19 2019, discussion of Prime Minister Boris Johnson's proposed withdrawal agreement was delayed by parliament, triggering the Benn Act and requiring Johnson to request a deadline extension. The EU Council approved this extension three days prior to reversion to MFN, on October 28.

Policymakers proceeded to update their deadline commitment to December 31, 2020. Between the third and fourth deadlines, a UK general election delivered a landslide majority to the pro-Brexit government of Boris Johnson, and the United Kingdom signed a formal withdrawal agreement with the EU, containing no indication of the trade agreement to be implemented.

On December 24, 2020, the final TCA deal was agreed, with volatile negotiations having continued up to that date. The associated changes in trade policy began implementation eight days later.

2.2 Stockpiling Evidence

There is overwhelming survey evidence that UK firms responded to Brexit deadline uncertainty through inventory accumulation and stockpiling. The Bank of England's Agents' Survey found stockbuilding was the leading form of preparation undertaken by interviewed firms in preparation for both the March 2019 and December 2020 deadlines. Figure 1 documents the share of firms citing stockbuilding when asked about their preparation for a 'no deal, no transition' Brexit. We contrast this with other preparatory activities reported in the survey, such as supply-chain adjustment, a proxy for the extensive margin; and cash reserves, as a proxy for anticipated financial constraints. Stockpiling dominates at both ends of the pre-Brexit period, but the dominance of 'intensive margin' stockpiling adjustment is notably larger at the beginning than at the end of the process.

Complementing this, the IHS Markit Purchasing Manager's Index, a diffusion index, found that the share of UK manufacturing firms accumulating stocks of intermediate inputs was three times larger in March 2019 than at any previous observation in the survey's twelve-year history. Manufacturers' stocks of finished goods also displayed their largest recorded increase, though by a smaller margin.

The UK Office for National Statistics' Quarterly Stocks Survey, from which the UK National Accounts changes in inventories measure is constructed, similarly report textual analysis of the share of firms citing Brexit in describing their inventory accumulation. While only limited by the quarterly frequency of observations, the survey reports clear spikes at those Brexit deadlines situated at quarter-ends. As documented in Figure A1, the March 2019 and December 2020 deadlines both feature sharp spikes in Brexit references.

Firms' potential need to smooth Brexit-related disturbances is supported by anecdotal evidence of widespread shutdowns in UK manufacturing, concentrated in the automotive sector. The UK's Society of Motor Manufacturers and Traders reported a 44.5 percent decline in production in April 2019 following factory closures intended to mitigate potential disruption around the March deadline. Similar closures occurred at a smaller scale at the October deadline, with plant closures by JLR, BMW, and Toyota. Reports of such closures had largely subsided by the December 2020 deadline, however.

2.3 UK Import Data

We now turn to the manifestation of this stockpiling behavior in the UK import data.

2.3.1 Aggregate Data

We start with a high-level overview of trade dynamics using aggregate monthly UK data from HMRC Overseas Trade Statistics. Throughout, we restrict our focus to the intensive margin of UK imports, including only goods traded at least once per year in our sample.

We emphasize there appear to be noticeable differences in imports by source in periods around Brexit deadlines. Figure 2 presents aggregate UK imports from the EU and the rest of the world, relative to October 2018. The four Brexit deadlines are indicated with dashed vertical lines. Prior to the first deadline in March 2019, we see that UK imports from the EU and the RoW track each other closely. Only in February 2019 do these series move apart. A particularly sharp increase in EU imports relative to RoW imports is visible ahead of the first deadline, with UK imports from the EU outstripping those from the rest of the world for two periods. In April 2019, EU and RoW imports are quite similar. The third and final deadlines each show a pattern similar to the first, but of considerably smaller magnitude.

Following the implementation of the TCA in January 2021, the two series diverge. Imports from the rest of the world display sustained growth, while imports from the EU remain largely stable.

2.3.2 Reduced-Form Specification

To improve our understanding of the suggestive patterns visible in the aggregate data, we shift to a reduced-form analysis of the underlying trade flows. This approach allows us to exclude any compositional changes around the Brexit deadline to isolate the role of perceived policy changes. Specifically, we aggregate trade flows to the HS6 level, defining each HS6 category as a good with generic index g. We aggregate exporting regions r to simply EU and RoW. Periods are indexed by year t and calendar month m. To abstract from extensive-margin adjustments, we restrict our analysis to the subset of goods imported from both regions at least once per year in our sample.

To extract the differential growth in each period of UK imports from the EU relative to the RoW, we estimate the following model:

$$\log V_{g,r,t,m} = \sum_{t'=2015}^{2020} \sum_{m'=1}^{12} \beta_{t,m} \mathbf{1}\{t' = t \wedge m' = m \wedge r = EU\} + \gamma_{g,r,m} + \gamma_{g,t,m} + \epsilon_{g,r,t,m}. \quad (1)$$

On the left-hand side, $V_{g,r,t,m}$ denotes the value of UK imports indexed by good, region, year, and month. On the right, $\gamma_{g,r,m}$ controls for seasonal effects at the country-good level, while $\gamma_{g,t,m}$ controls for UK demand shocks at the good level. The resulting coefficients, $\beta_{t,m}$, extract the average EU-specific change in trade across goods in a month of our sample after controlling for seasonality.

In estimating equation 1, we take 2015 as the reference year, as subsequent years are liable to be affected by the 2016 referendum. Figure 3 plots the import coefficients in our period of interest. Vertical lines indicate months including a proposed Brexit deadline, and shaded regions indicate 95 percent confidence intervals. Our subsequent analysis abstracts from bilateral volatility during the first half of 2020 on account of the COVID-19 pandemic, as marked in Figure 3 by a vertically shaded component.[1]

There are three notable features of the resulting import dynamics. First, all deadlines except April 2019 exhibit a significant increase in imports above zero. This pattern provides reduced-form evidence of anticipatory stockpiling behavior. Second, the pre-deadline import increases are heterogeneous in magnitude, with the first deadline's peak increase in imports considerably exceeding those of the latter two. Third, the dynamics of adjustment differ across deadlines, with the first and final deadlines displaying multiple periods of increased imports.

These fluctuations imply UK importers responded in advance of future policy commitments regarding Brexit deadlines. This pattern contrasts with a common view in the literature that observable Brexit implications are largely absent from the pre-TCA period (Dhingra and Sampson, 2022). The discrepancy arises because of the dimension of disaggregation: whereas previous work has emphasized sectoral or firm-level heterogeneity, the variation of interest here emerges in the distribution over time.

EU MFN tariffs do not correlate systematically with pre-deadline import increases. Fur-

[1]The finding that bilateral COVID-era United Kingdom–EU import disturbances are manifest after adjusting for the relevant fixed effects is also found by Freeman et al. (2025) using firm-level data.

thermore, controlling for MFN rates does not significantly alter the aggregate fixed effects. Appendix A.3 documents these findings. This confirms that expected Brexit trade costs did not simply correspond to tariff risk. Instead, Brexit risk appears to reflect a common exposure to trade disruption which lacked explicit structure.

2.3.3 Sensitivity

We consider alternative specifications and find the boom and bust around Brexit deadlines to be robust. We extract comparable trade increases using a PPML estimator, as well as by dropping seasonal fixed effects, as depicted in Figure A2. Figure A4 provides EU fixed-effect estimates for our full sample, including the year of the referendum and the first year after the imposition of the TCA. Figure A3 shows the region fixed effects of interest are robust to controlling for EU MFN tariffs.

Further details on these sensitivities are given in Appendix A.

3 Structural Model

We now relate the import dynamics around Brexit deadlines in the data to a process for trade policy risk using a partial-equilibrium $(\underline{s}, \bar{s})$ model of inventory dynamics. We extend the inventory model developed in Alessandria et al. (2010) to include an additional shock to fixed import costs to match the multi-period stockpiling dynamics of our empirical fixed effects. Rationalizing the data requires a framework in which firms respond to the prospect of future trade policy changes by adjusting the timing of their imports. In this model, firms faced with a proposed deadline carrying a positive probability of an increase in future trade costs have an incentive to front-load imports and hold larger inventories, thereby endogenously generating the large expansions and sharp contractions in imports observed in the data.

In this section, we first outline the structural model we use to parse the data. We then introduce trade policy risk incorporating uncertainty in the timing and magnitude of trade policy changes. By taking external structural parameters from the literature, we proceed to identify time-varying expectations of the likelihood of Brexit consistent with the evidence from the previous section.

3.1 Firm's Problem

There exists a continuum of importers, each selling a differentiated good. Time is discrete. At the beginning of period t, a firm i enters with an inventory stock $s_{i,t} \in S \subset \mathbb{R}_+$ of the good it imports and sells.

The firm faces two sources of shocks. It draws an i.i.d. normally-distributed demand shock, $z_{i,t} \sim N(0, \zeta)$. It also draws a fixed cost shock, facing fixed cost of importing $f_{i,t} \in \{\bar{f}, \infty\}$ with probability weights $\{1-\mu, \mu\}$ respectively. The high fixed cost rules out importing in that period in equilibrium.

The firm chooses a price $p_{i,t}$ given a demand curve

$$\tilde{q}_{i,t} = e^{z_{i,t}} p_{i,t}^{-\sigma}, \tag{2}$$

where σ denotes the demand elasticity. Actual sales are constrained by available inventories $s_{i,t}$, a magnitude inherited from the previous period. Realized sales are therefore

$$q_{i,t} = \min\{s_{i,t}, \tilde{q}_{i,t}\}. \tag{3}$$

The firm's sales either meet market demand or hit the stockout threshold.

With probability $1-\mu$, the firm draws the finite fixed cost $\bar{f}$ and may choose to restock in equilibrium. A restocking firm selects an import quantity $m_{i,t} \in \mathbb{R}_+$, incurring the fixed cost $\bar{f}$ and a variable cost of imports ξ_t. Imports arrive in the subsequent period. The law of motion for inventories in this case is

$$s_{i,t+1} = (1-\delta)(s_{i,t} + m_{i,t} - q_{i,t}), \tag{4}$$

where a common depreciation rate δ applies to inventories held and goods in transit.

Firms maximize the expected present discounted value of profits under risk neutrality, using a constant discount factor $\frac{1}{1+r}$. It is instructive to first consider the case of a constant import cost, $\{\xi_t\}_{t=0}^{\infty} = \bar{\xi}$. Under this restriction, optimal pricing and import decisions admit a stationary recursive characterization.

A firm's state is defined by its inventory s_i, demand shock z_i, and fixed cost draw f_i. Let

$\iota_i \in \{0,1\}$ denote the discrete decision to restock, such that $\iota_i = 0$ imposes $m_i = 0$. The firm's dynamic programming problem is

$$\begin{aligned} V(s_i, z_i, f_i) &= \max_{p_i, m_i, \iota_i} \left\{ p_i q(p_i, s_i, z_i) - \iota_i (f_i + \bar{\xi} m_i) + \frac{1}{1+r} \mathbb{E}\big[V(s_i', z_i', f_i')\big] \right\} \\ \text{s.t.} \quad & s_i' = (1-\delta)\big[s_i - q(p_i, s_i, z_i) + \iota_i m_i\big], \end{aligned} \tag{5}$$

where future states follow the exogenous distributions of z_i' and f_i'.

In this Markovian setting, conditional on choosing to restock ($\iota_i = 1$), the firm optimally adjusts inventories to a constant target level $\bar{s}$. This target is implicitly defined by

$$\bar{\xi} = \left(\frac{1-\delta}{1+r}\right) \mathbb{E}\left[\frac{\partial V}{\partial s}(\bar{s}, z_i', f_i')\right], \tag{6}$$

where independence of future z_i and f_i draws from current values implies $\bar{s}$ is independent of the current state. Conditional on drawing a finite fixed cost, the discrete decision to import is more likely when demand is high or inventories are low.

3.2 Trade Cost Shocks

The pre-Brexit period was characterized by time-varying risks of future trade costs. To incorporate this, we generalize the static constant-ξ environment to include shocks to ξ at Brexit deadlines. The variable cost begins at ξ_0 and is unchanged between deadlines. Let $\mathcal{T}$ denote the set of months in the event-study window depicted in Figure 3, from November 2018 to December 2020. Define $\mathcal{D} \subset \mathcal{T}$ as the set of months containing deadlines, containing four elements $\mathcal{D} = \{d_1, d_2, d_3, d_4\}$.

In this environment, the importer dynamics discussed in section 3.1 are shaped by a sequence of continuation values $\{V_t\}_{t \in \mathcal{T}}$, where $V_t : S \times \mathbb{R} \times \{\bar{f}, \infty\} \to \mathbb{R}_+$. Continuation values following deadlines are uncertain as trade costs may change at deadlines. We model Brexit outcomes as permanent changes in variable trade costs. The associated continuation value of a particular realized Brexit policy is therefore characterized by a fixed point satisfying (5). We express these fixed points as a mapping from trade-cost deviations. Denote by $V(\Delta\xi)$ the stationary value function under variable cost $\xi_0 + \Delta\xi$.

We impose a parsimonious three-point distribution for trade cost changes at each Brexit deadline $d \in \mathcal{D}$. Continuation values are distributed over $\{V(0), V(\Delta\xi_d), V_\gamma\}$ corresponding respectively to 'soft Brexit,' 'hard Brexit,' and a state of continued uncertainty reflecting deadline extension. A soft Brexit corresponds to the limiting case of no increase in trade costs. A hard Brexit is defined by an increase in variable trade costs $\Delta\xi_d$. Continued uncertainty V_γ is the stationary value function corresponding to no immediate change in trade costs but a repeated risk of moving to the hard-Brexit outcome in subsequent periods.

This distribution provides the minimal basis required to represent uncertainty in both the magnitude and the timing of Brexit costs. Uncertainty over the magnitude of costs is given by the likelihood of a hard Brexit conditional on Brexit; uncertainty over their timing is given by the likelihood of continued uncertainty as against uncertainty resolution.

The impact of the trade policy process on imports is summarized by the expected post-deadline continuation values. The continuation value at a deadline $d \in \mathcal{D}$ is summarized by the parameter tuple $\{\eta_d, \gamma_d, \Delta\xi_d\}$:

$$\mathbb{E}_d[V_{d+1}] = (1-\gamma_d)\eta_d V(\Delta\xi_d) + (1-\gamma_d)(1-\eta_d)V(0) + \gamma_d V_\gamma. \tag{7}$$

Here γ_d gives the likelihood of a deadline extension, while η_d gives the likelihood of hard Brexit conditional on Brexit occurring at the deadline.

The inter-deadline value functions defining between-deadline trade flows are inferred by backward induction from the next upcoming deadline. For a firm i with state $\{s_i, z_i, f_i\}$ at time $t \in \mathcal{T}\backslash\mathcal{D}$ the continuation value respects

$$\begin{aligned} V_t(s_i, z_i, f_i) = \max_{p_i, m_i, \iota_i} &\left\{ p_i q(p_i, s_i, z_i) - \iota(f_i + \xi_0 m_i) + \frac{1}{1+r}\mathbb{E}[V_{t+1}(s_i', z_i', f_i')] \right\} \\ \text{s.t.} \quad & s_i' = (1-\delta)[s_i - q(p_i, s_i, z_i) + \iota_i m_i], \end{aligned} \tag{8}$$

noting that, with constant pre-Brexit variable import cost ξ_0, a period's value function is fully determined by the subsequent period's continuation value.

The resulting sequence of value functions can be mapped to aggregate import quantities by solving forward for the distribution over inventories. The sequence of value functions implies a sequence of re-stock policies $\{s_t'\}_{t\in\mathcal{T}}$, which in turn induce import policies $\{m_t\}_{t\in\mathcal{T}}$.

Given a distribution over inventories at t denoted λ_t, we have

$$\lambda_{t+1}(s) = \int_S \int_{\mathbb{R}} [(1-\mu)\mathbf{1}\{s'(u,z,\bar{f}) = s\} + \mu\mathbf{1}\{s'(u,z,\infty) = s\}] d\Phi(z)\, d\lambda_t(u) \tag{9}$$

for all $s \in S$, where Φ is the demand-shock distribution. Beginning from the cost-ξ_0 stationary distribution λ_{SS}, this recursion yields a sequence of inventory distributions $\{\lambda_t\}_{t\in\mathcal{T}}$. Imports at each date follow from the orders of firms with finite fixed order costs:

$$M_t = (1-\mu)\int_S \int_{\mathbb{R}} m(s,z,\bar{f}) d\Phi(z)\, d\lambda_t(s). \tag{10}$$

Conditional on structural parameters, this system defines a mapping from a trade policy process $\{\eta_d, \gamma_d, \Delta\xi_d\}_{d\in\mathcal{D}}$ to an aggregate import sequence $\{M_t\}_{t\in\mathcal{T}}$ comparable to the data.

3.3 Estimation

The event-study fixed effects of section 2.3.2 provide a sequence of empirical moments $\{\hat{\beta}_t\}_{t\in\mathcal{T}}$. These estimates can be used to discipline a distribution over trade costs. In this section we identify probability weights $\{\eta_d, \gamma_d\}_{d\in\mathcal{D}}$.[2] We also internally estimate μ, the probability of a firm being unable to import in a period.

Our policy process allows for deadline-specific Brexit costs $\Delta\xi_d$. In this section, we impose constant costs across deadlines $\Delta\xi$. This is justified by a powerful quantitative simplification implied by our structural model: the first moment of Brexit risk, $\eta_d\Delta\xi_d$, is a quantitative sufficient statistic for import decisions given Brexit probability γ_d. We first work with the product, the key measure of Brexit risk, and delay its decomposition to section 5.

To proceed with estimation, we require externally set values for structural parameters $\{\sigma, \delta, r, \zeta, \bar{f}, \xi_0, \Delta\xi\}$. Parameter choices are summarized in Table 1. We choose r to match an annual discount rate of 3 percent, and normalize ξ_0 to deliver unit demand in steady state. Following Alessandria et al. (2010), we set $\delta = 5$ percent and $\bar{f} = 0.1$; following Khan and Khederlarian (2021), we set $\sigma = 2.7$ to be consistent with short-run trade elasticities from tariff changes. We estimate $\Delta\xi$ by minimizing the mean-squared deviation of the model from the 2021 post-TCA fixed effects from the data.

[2] Given the extreme deviations in imports in April–May 2020, we omit these moments in our estimation procedure.

Given these externally set structural parameters, a tuple $\theta := \{\{\eta_d, \gamma_d\}_{d\in\mathcal{D}}, \mu\}$ gives rise to a sequence of aggregate imports $\{M_t(\theta)\}_{t\in\mathcal{T}}$ and steady state $M_{SS}(\theta)$ implying import deviations

$$\tilde{\beta}_t(\theta) = \log \frac{M_t(\theta)}{M_{SS}(\theta)} \tag{11}$$

for all $t \in \mathcal{T}$. Here, the $\tilde{\beta}_t(\theta)$ values provide a direct analogue in the model to the EU fixed effects estimated from the data in equation 1.

We then obtain our estimate $\hat{\theta}$ by simulated method of moments using the objective

$$\hat{\theta} = \arg\min_{\theta} \left\{ \left(\hat{\beta} - \tilde{\beta}(\theta)\right)' W \left(\hat{\beta} - \tilde{\beta}(\theta)\right) \right\}, \tag{12}$$

where the weighting terms are simply the inverse of the variances of event-study fixed effects, $W = \text{diag}(\frac{1}{\mathbb{V}(\beta)})$.

3.4 Identification

Our estimator allows for a distinct credibility parameter, γ_d, for each deadline, while imposing a constant Brexit cost, $\Delta\xi$. Separate identification of the credibility parameters γ_d requires that alternative timings for the resolution of Brexit uncertainty generate distinct aggregate trade dynamics. Meanwhile, the assumption of a constant Brexit cost is innocuous only if alternative decompositions of Brexit risk into hazard η_d and severity $\Delta\xi_d$ generate the same aggregate trade dynamics. We now explain why these conditions hold.

3.4.1 Deadline Timing

Risk $\eta_d\Delta\xi$ and credibility γ_d are separately identified by the aggregate trade data. This is not immediate. Both incentivize precautionary stockpiling and increase imports at deadlines. Our identification uses the multi-period anticipatory stockpiling of our data for additional discipline. Here, we lay out a highly stylized formal example which captures the intuition of this identification strategy. We then illustrate the effect in a numerical example using our calibrated structural model.

Consider a three-period problem, $t \in \{0, 1, 2\}$. An importer may purchase one indivisible unit of a good, total, in one of the three periods. Each time the importer carries the good between periods, they accrue a holding cost δ. After time 0, time 1 occurs with certainty.

At time 1, the problem terminates with probability $1-\gamma$ and period 2 never occurs. With probability γ, the deadline is extended and the problem terminates after period 2.

If the importer is holding the good when the problem terminates, it receives some exogenous payoff $V > \delta^2$. The price of the good is normalized to zero.

In period 1, with some probability μ, the importer is unable to import the good in that period. This corresponds to the stochastic fixed cost of our full model.

Consider two policies, $\{\sigma_0, \sigma_1\}$, where σ_t is the policy of first attempting to purchase the good in period t. The value of σ_0 is

$$W(\sigma_0) = V - (1+\gamma)\delta. \tag{13}$$

The importer is guaranteed to obtain the payoff, but will accrue one or two periods of holding costs.

The σ_1 policy has value

$$W(\sigma_1) = (1-\mu)(V - \gamma\delta) + \mu\gamma V. \tag{14}$$

With probability $1-\mu$, the importer obtains the payoff, and faces strictly lower holding costs. With probability μ, the importer is prevented from importing in period 1. If period 2 occurs, which happens with probability γ, the importer purchases in period 2 and obtains the payoff. With probability $\mu(1-\gamma)$, this policy obtains no payoff.

Multi-period anticipatory stockpiling corresponds to a high $W(\sigma_0)$ relative to $W(\sigma_1)$. Consider the case with $\mu \to 0$. Then

$$W(\sigma_1) - W(\sigma_0) = \delta > 0. \tag{15}$$

Front-loading imports is strictly dominated, regardless of γ.

Take $\mu \in (0,1)$. Differentiating the difference in payoffs, we have

$$W_\gamma(\sigma_1) - W_\gamma(\sigma_0) = \mu\left(V + \delta\right) > 0. \tag{16}$$

A higher probability of delay strictly worsens the relative payoff of pre-deadline importing. When the importer potentially has multiple shots at importing across multiple periods, due to a diffuse deadline with $\gamma > 0$, import risk μ is mitigated and multiple periods of anticipatory stockpiling become less likely. Taking $\gamma \to 0$ implies risk is concentrated at a single date, and import risk becomes large. Multi-period stockpiling then becomes more likely.

This simple mechanism is maintained in our infinite-horizon structural model. Figure 4 illustrates a numerical application. We fix two γ values, one with $\gamma = 0.0$ (full credibility) and one with $\gamma = 0.9$ (low credibility). Both scenarios have the same μ value, and both have an η value adjusted to deliver the same deadline peak.

Two periods ahead of the deadline, the credible deadline import increase is twice as large as in the low-credibility case. This allows heterogeneity in pre-deadline imports to provide the identifying variation in our estimation of γ.

3.4.2 Approximate Linearity

Brexit deadlines introduce a draw over future variable trade costs in our environment. We claim that the expected trade cost, $\eta_d \Delta\xi_d$, is sufficient to quantify aggregate trade dynamics. Separate identification of the hazard η_d and severity $\Delta\xi_d$ is therefore unnecessary for identification of their product, the first moment of Brexit risk.

Consider a case in which deadlines are strictly credible, $\gamma_d = 0$ at each deadline. The expected post-deadline continuation value at a deadline $d \in \mathcal{D}$ can be described as an η_d-weighted combination of functions of changes in import cost at each outcome,

$$\mathbb{E}_d[V_{d+1}] = \eta_d V(\Delta\xi_d) + (1 - \eta_d)V(0). \tag{17}$$

The decomposition between η and $\Delta\xi_d$ is relevant to the extent that the value function V is nonlinear in the trade cost. With approximate linearity we instead have

$$\eta_d V(\Delta\xi_d) + (1 - \eta_d)V(0) \approx V(\eta_d \Delta\xi_d). \tag{18}$$

Under approximate linearity, Brexit-induced stockpiling is characterized by the first moment of Brexit risk.

We test this assumption for the range of parameters relevant to our empirical fixed effects. Strikingly, deviations from equation 18 are on the order of numerical noise. Figure A6 provides a numerical illustration of this near-perfect approximation applied to our estimated model. Our identifying assumption of a constant change in trade costs therefore does not bias our estimates beyond the ratio of the hazard η_d and severity $\Delta\xi_d$ itself. We revisit the decomposition of the product term in section 5.

3.5 Results

The first column of Table 2 summarizes the distribution we recover. The risk of a hard Brexit was highest at the first deadline, with a 12.4% chance. This pattern aligns with an interpretation in which the initial deadline delay revealed policymakers' underlying aversion to a 'disorderly' hard Brexit, permanently reducing the probability of large trade costs.

Brexit credibility, given by $1-\gamma$, peaks at the final deadline and is lowest at the October 2019 deadline. These deadlines feature similar peak stockpiling. But the final deadline is driven by a near-degenerate loading of trade-policy risk on the deadline date, while the October 2019 deadline signals a diffuse increase in risk distributed over many periods.

A striking feature of our results is the lack of correlation between Brexit risk and Brexit credibility. The return to credibility under the final deadline did not restore the same magnitude of risk, exemplifying the identifiable distinction between expected trade costs and their dynamic structure.

The similar η values attached to the second and final deadlines underscore the importance of a feasible structural model: while the April 2019 import deviation is near zero in the data, without positive Brexit risk at this date, stock accumulated in the March import surge would imply a large negative value. By keeping track of a sequence of inventory distributions, λ in our notation, we can measure the persistent risk driving the anomalous absence of a post-deadline crater in the data.

Figure 5 plots the simulated import deviations associated with our estimated parameters against the targeted moments from the data. The model provides a compelling fit to the core dynamics around deadlines. This fit further reinforces the view that forward-looking stockpiling behavior provides a parsimonious explanation for the fluctuations in aggregate UK trade in this period.

3.5.1 External Assessment

The Brexit cost process we estimate receives narrative corroboration from contemporary policy developments. Our results imply imminent risk declined and the probability of an extension increased between the March and October 2019 deadlines. Between these deadlines the UK parliament passed the Benn Act. This act legally mandated the UK prime minister to request an extension from the EU in the absence of a formal Brexit agreement. This imposed a significant institutional limit on the possibility of a no-deal Brexit due to UK political dysfunction. This moves weight from η to γ in our notation.

Our results further imply a substantial increase in deadline credibility in 2020. The United Kingdom approved the Withdrawal Agreement on January 23 2020. The Withdrawal Agreement specified an explicit process for the final deadline, plausibly eliminating the scope for further ad hoc deadline extensions.

External evidence of extension probabilities from other sources is mixed. The Bank of England's Decision Maker Panel (DMP), a survey of UK firms, provides qualitative supporting evidence for the relative credibility of the October 2019 and December 2020 deadlines. Surveyed UK firms assigned a substantially larger probability of Brexit in 2020 when asked in December of that year than they did to a 2019 exit asked in the month of the October 2019 deadline.

This qualitative finding is supported by a contract hosted by the UK prediction market PredictIt, which implied a high probability of deadline extension for the October 2019 deadline. However, we emphasize a considerable discrepancy in magnitudes between the prediction market implied probability and the DMP survey probability. These differing probabilities may indicate heterogeneous information sets or limited prediction market liquidity. These limitations underline the importance of isolating the measure of deadline credibility relevant to importers, as represented by the import data.

The December 2020 deadline was anomalous among deadlines in generating no prediction markets around Brexit extension, consistent with a near-degenerate distribution.

One discrepancy between our estimated credibility measure and contemporaneous UK betting market probabilities occurs in the March 2019 deadline. Here, a PredictIt market implies a substantially higher probability of deadline extension than our model. The large magnitude of import stockpiling belies the view that Brexit was seen as near-certain to face an extension, a view which is reinforced by the much smaller import magnitudes of the October deadline.

We compile a monthly series of recovered probabilities in Figure A7. Appendix Table 5 provides further details on sources.

3.6 The Dynamic Structure of Brexit Risk

Our framework emphasizes Brexit risk which (i) varied over time ($\eta_d \neq \eta_s$); (ii) featured uncertainty in its resolution timing ($\gamma_d > 0$); and (iii) induced non-trivial multi-period dynamics of precautionary stockpiling ($\mu > 0$). We now summarize how each of these extensions of the standard framework is motivated by the data.

3.6.1 Brexit Risk Varied Over Time

We illustrate the role of time-varying Brexit risk by comparison with a model featuring static Brexit risk. As before, we initialize our model at its pre-Brexit stationary distribution λ_{SS}. In the first month of our sample period $\mathcal{T}$ we introduce a constant probability ν that Brexit will occur that period with cost $\tilde{\xi}$. We select ν by the same SMM procedure described in section 3.3.

Constant Brexit risk induces an initial spike in imports on impact followed by a constant but small increase in imports. This occurs because firms face some risk of higher trade costs in subsequent periods, value inventories slightly more, hold higher stocks in steady state, and import slightly more to maintain these stocks. Figure 6 depicts the simulated imports for our fitted ν value. The constant increase in imports is sufficiently small to be statistically identical to our empirical fixed effects in normal times. Our model can therefore replicate the common finding that aggregate intensive-margin trade did not respond to Brexit in the pre-TCA period at low frequencies: the predicted secular change in imports is not different from zero.

The constant-risk model is rejected by the data when Brexit deadlines occur. In these instances, the empirical fixed effects become positive and the model fixed effects deviate from the data at 95 percent confidence. Deadline-specific Brexit risk is therefore essential to match the data, and time-invariant Brexit risk counterfactually characterizes anticipatory behavior as insignificant.

3.6.2 Brexit's Resolution Date was Uncertain

Fitting parameters $\{\gamma_d\}_{d\in\mathcal{D}}$ allows for uncertainty in the date of Brexit resolution, separate from the trade costs of Brexit resolution. We estimate a 'Credible Deadlines' version of the model with $\gamma_d = 0$ to evaluate the contribution of this channel. Our procedure is identical to that of section 3.3 besides this parameter restriction. We report the results in the second column of Table 2.

The model continues to hit the peaks and troughs of Brexit stockpiling well. However, it cannot capture heterogeneity in the pre-Brexit stockpiling dynamics of different deadlines. The simulated imports deviate from the data in the build-up to the October 2019 deadline as timing uncertainty γ is projected onto Brexit risk η. This increases mean-squared error by more than 25 percent. The fit of the restricted model to the data is documented in Appendix Figure A5(a).

3.6.3 Brexit Induced Dynamic Stockpiling

We address the multiple significant pre-deadline fixed effects in our data by allowing for stochastic fixed costs of importing, $\mu > 0$. This proxies for a range of possible import timing frictions.

To assess the contribution of this channel we estimate a version of the model with the restriction $\mu = 0$. This neutralizes the discipline identifying the γ_d terms, so we normalize them to zero.

This deterministic fixed-cost model provides a weaker fit, increasing the mean-squared error by over 50 percent relative to the baseline case. As expected, the model-implied import series deviates from the data at 95 percent confidence in periods directly prior to the deadline periods. Multiple periods of pre-deadline import risk are therefore central to explaining Brexit stockpiling.

3.6.4 Uncertainty Effects were Small

Brexit deadlines imposed both an expected increase in trade costs $\eta_d \Delta\xi_d$, and uncertainty over the path of trade costs. Almost all trade dynamics in our model are driven by the expected increase in trade costs alone.

We decompose the simulated import dynamics surrounding Brexit deadlines into a certainty-equivalent component, in which firms face cost increase $\eta_d \Delta\xi_d$ with certainty; and an uncertainty component, defined as the difference between the baseline model's simulated imports and the certainty-equivalent series.

Consistent with the literature, we find that pre-deadline stockpiling is dampened by uncertainty. However, this dampening effect reduces deadline-month import booms by less than 10 percent of the first-moment import boom at all deadlines.[3] The dampening effect is largest at the March 2019 deadline, at just over 8 percent. For subsequent deadlines, it is on the order of 3 percent. The time-series decomposition and deadline shares are documented in Figure A6 and Table 4.

Pre-Brexit stockpiling can therefore plausibly be accounted for without reference to uncertainty. This is in stark contrast with the findings of the macroeconomic literature on the pre-Brexit period, where uncertainty has been identified as a central driver of economic outcomes (Bloom et al., 2019; Bloom et al., 2026).

4 Inventory Mechanism Validation

Our model of inventory accumulation provides a strong fit to the import data. We further validate this mechanism using direct survey evidence on inventory accumulation. Our model's implied inventory dynamics provide a good fit to this survey evidence, which is untargeted in our estimation procedure.

We use data from the IHS Markit[4] Purchasing Managers' Index (PMI). The PMI construction featured a monthly diffusion index in which UK manufacturing firms were asked whether their stocks of purchases increased relative to the preceding month. IHS Markit

[3]The contribution of uncertainty is even smaller here than Alessandria et al. (2024) find for the U.S.'s annual renewal of China's MFN status. Whereas that case involved a small probability of large tariffs, the trade policy risk in Brexit was smaller, but more likely to occur. The smaller change in potential trade costs results in a reduced contribution of nonlinearity.

[4]IHS Markit is now a subsidiary of S&P Global.

reported the fraction of UK manufacturing firms attributing such an increase in inventories specifically due to Brexit over our sample period.[5] This attribution by firms provides indicative evidence which credibly removes confounding incentives behind inventory accumulation in the period.

The survey evidence reports the share of firms which increased inventories in a month and cited Brexit as a cause for having done so. We replicate this series in our structural model. We first simulate a large sample of N firms. For a firm $i \in \{1, ..., N\}$, we draw an initial level of inventories from the model's stationary distribution, $s_{i,0} \sim \lambda_{SS}$. We then simulate a draw of fixed costs and demand shocks across the sample period, $\{f_{i,t}, z_{i,t}\}_{t\in\mathcal{T}}$, using the distribution of our estimated model.

The policy functions implied by our model are common across firms. This sequence of policies $\{s'_t\}_{t\in\mathcal{T}}$ together with the shocks facing firm i implies a time series of firm i's inventories by the recursion

$$s_{i,t+1} = s'_t \left(s_{i,t}, f_{i,t}, z_{i,t}\right). \tag{19}$$

As our data pertains to firms increasing inventories specifically on account of Brexit, we then simulate a counterfactual sequence with the same idiosyncratic shock process but an aggregate environment with no Brexit risk. The latter yields a static counterfactual policy $\hat{s}'$. Beginning with the same $s_{i,0}$ we simulate a counterfactual series of inventories

$$\hat{s}_{i,t+1} = \hat{s}' \left(\hat{s}_{i,t}, f_{i,t}, z_{i,t}\right). \tag{20}$$

We describe a firm i as increasing inventories in a period t on account of Brexit when

$$\frac{s_{i,t+1} - s_{i,t}}{s_{i,t}} > \frac{\hat{s}_{i,t+1} - \hat{s}_{i,t}}{\hat{s}_{i,t}}. \tag{21}$$

The analogue of the survey evidence follows from aggregating across the simulated sample of firms:

$$\chi_t = \frac{1}{N}\sum_{i=1}^{N} \mathbf{1}\left\{\frac{s_{i,t+1} - s_{i,t}}{s_{i,t}} > \frac{\hat{s}_{i,t+1} - \hat{s}_{i,t}}{\hat{s}_{i,t}}\right\}. \tag{22}$$

Here χ_t denotes the share of simulated firms who increased inventories in a period t by more

[5] The public monthly series is reported here.

than they would have in the absence of Brexit. This is comparable to the sequence of survey moments, which we denote $\{\tilde{\chi}_t\}_{t\in\mathcal{T}}$.

The survey samples UK manufacturing firms, while our model develops a hypothetical importing sector. The absolute value of the share of firms increasing inventories due to Brexit is not directly determined as the overall manufacturing sector contains other firms, for instance firms which do not import from the EU. The resulting sequence of shares $\{\chi_t\}_{t\in\mathcal{T}}$ is comparable only in relative terms. We therefore normalize each moment of the model and data series by the terminal observation χ_T, corresponding to the final Brexit deadline of December 2020.

The model-implied index tracks the timing and relative ranking of the major inventory movements around the deadlines. Figure 7 plots the two series. The exact match at the terminal deadline follows from normalization. Validation follows from the rest of the series. Both series generate three local maxima at the March 2019, October 2019, and December 2020 deadlines. Both attain a global maximum in March 2019. The relative magnitudes of the April 2019, October 2019, and December 2020 deadlines match almost exactly. The qualitative shape of the inter-deadline periods are also replicated, with an M-shaped pattern between the early and late 2019 deadlines and an abrupt increase from near zero before the March 2019 and December 2020 deadlines.

There are two meaningful deviations. The March 2019 deadline, while forming the peak in both the model and the data, is quantitatively smaller in the model. This difference occurs in spite of the model generating an increase in imports in March 2019 which is quantitatively large. This increase in trade loads excessively on the intensive margin of imports, and undershoots the extensive margin evidence discussed here.

Second, the dynamics of the model series feature longer lags than the survey evidence. This may be attributed to the model capturing equilibrium inventory accumulation which is only indirectly due to Brexit, while firms' self-reporting may omit indirect effects.

The close similarity between the model- and data-implied inventory accumulation processes nonetheless provides powerful validation of the model mechanism.

5 Decomposing Brexit Risk

Our previous results isolate the first moment of Brexit risk by holding $\Delta\xi$ constant across deadlines. We now relax this assumption to estimate time-varying severity of the trade costs of Brexit. Separate identification of the 'hazard' η_d and 'severity' $\Delta\xi_d$ components of Brexit risk requires discipline additional to the trade data (see section 3.4.2). We incorporate external probability measures using a robust combination of prediction market data and survey evidence.

5.1 Estimation

For simplicity, in this section we project all Brexit risk onto the deadline periods. This corresponds to the Credible Deadlines specification of section 3.6.2 defined by the restriction $\gamma_d = 0$ for all $d \in \mathcal{D}$. At a deadline d, uncertainty resolves in a hard Brexit with cost increase $\Delta\xi_d$ with probability η_d; it otherwise resolves in a soft Brexit with no cost increase. Our aim is to recover the evolution of the potential cost of Brexit across deadlines. For deadlines $d, s \in \mathcal{D}$, our object of interest is the ratio

$$\rho_{d,s} := \frac{\Delta\xi_d}{\Delta\xi_s}. \tag{23}$$

To estimate $\rho_{d,s}$, we first recover the ratio of first-moment Brexit risk $\frac{\eta_d \Delta\xi_d}{\eta_s \Delta\xi_s}$. This ratio can be estimated using our import fixed effects following the SMM procedure of section 3.3.

The decomposition between hazard η and severity $\Delta\xi$ remains underdetermined by the trade data. We therefore complete the identification with additional empirical moments measuring the ratio η_d/η_s, and estimate $\rho_{d,s}$ by

$$\hat{\rho}_{d,s} = \frac{\widehat{\left(\frac{\eta_d \Delta\xi_d}{\eta_s \Delta\xi_s}\right)}}{\widehat{\eta_d/\eta_s}}. \tag{24}$$

5.1.1 Data

We proxy the likelihood of a hard Brexit using observable measures of the probability of a no-deal Brexit. We introduce two measures of this probability. During the October 2019 and

December 2020 deadlines, the Bank of England's Decision Maker Panel (DMP) surveyed firms monthly on the probability they assigned to a no-deal Brexit. As complementary evidence, UK prediction markets Betfair and Smarkets hosted markets on the likelihood of a no-deal Brexit over the March 2019, October 2019, and December 2020 deadlines. These markets can be used to infer implied probabilities of no-deal. Further details on these external probability measures are given in Appendix Table 5.

The implied probability of a no-deal Brexit in the deadline months aligns closely for all periods where both sources are available. Figure 8 documents the two series. The coherence of these distinct sources corroborates the validity of the measure.

5.2 Results

Table 3 summarizes our estimated cost ratios and their components. Results are expressed relative to the March 2019 deadline. Figure 9 plots the implied time series costs against the monthly probability of no-deal Brexit.

The potential cost of Brexit facing UK firms declined substantially over time. Costs decreased by more than half in the transition from March 2019 to October 2019, and again from October 2019 to December 2020.

This decline is partly driven by the first moment of Brexit risk. This risk was substantially larger at the March 2019 deadline, and similar across October 2019 and December 2020.

Under these external probability measures, most of the decline results from the changing probability of Brexit costs. A hard Brexit was only slightly less likely in March 2019 than in October 2019. This only mildly amplifies the first-moment risk to trade costs. The probability of a hard Brexit was considerably larger at the December 2020 deadline, however. This implies a far larger discrepancy in costs: the import spike of March 2019 was larger than in December 2020 despite a far lower probability of Brexit costs being imposed.

The implied cost of an identical change in trade policy declined by almost 80 percent across iterated deadline events. The key variation across these deadlines comes from firms' period of adjustment to Brexit risk. With the long-run cost unchanged, it follows that transitory costs significantly dominate in scale. The capacity of firms to smooth this transitory component of a trade shock is integral to its impact. As is well documented by survey evidence (see section 2.2), stockpiling was the dominant margin by which firms responded to the transitory exposure of the first deadline. The operation of this smoothing technology emerges as essential to characterizing the impact of trade shocks. Omitting a rigorous treatment of firms' capacity to smooth shocks through inventories risks excluding a major component of the present value of a change in trade costs such as Brexit.

6 Final Thoughts

We recover a distribution over perceived future trade costs in the case of Brexit, where both the timing and magnitude of these costs was uncertain. We do so using import data and a structural mechanism which is both intuitive and validated by the data. Our analysis shows that high-frequency import data separately identify the magnitude and dynamics of Brexit risk. It further reveals the bias induced by aggregating trade-cost risk over time. In contrast, we show that the distinct 'hazard' and 'severity' components of this risk are underdetermined by the trade data alone. We therefore complete the identification using external evidence on probabilities.

Our approach illustrates an intuitive but powerful methodology for recovering trade policy expectations in episodes with a dearth of explicit structure. Such episodes are increasingly widespread, with a salient recent example being US trade flow dynamics, which have been characterized by substantial anticipatory imports and exports (Alessandria et al., 2025a).

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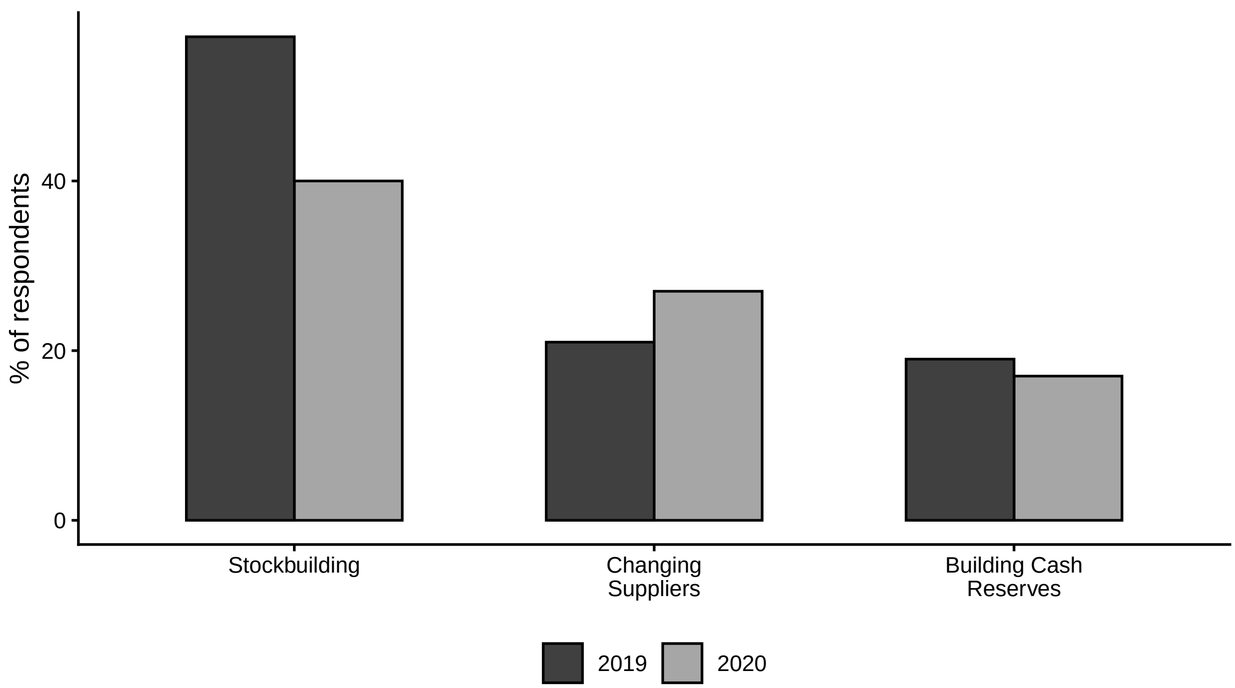


Figure 1: Firms' Brexit Preparations by Activity

Notes: Data reflect share of surveyed firms claiming to undertake each activity in preparation for a 'no deal, no transition' Brexit. 2019 refers to firms surveyed ahead of March 2019 deadline. 2020 refers to firms asked at the start of 2020 explicitly about plans for the December 2020 deadline.
Source: Bank of England Agents' Survey.

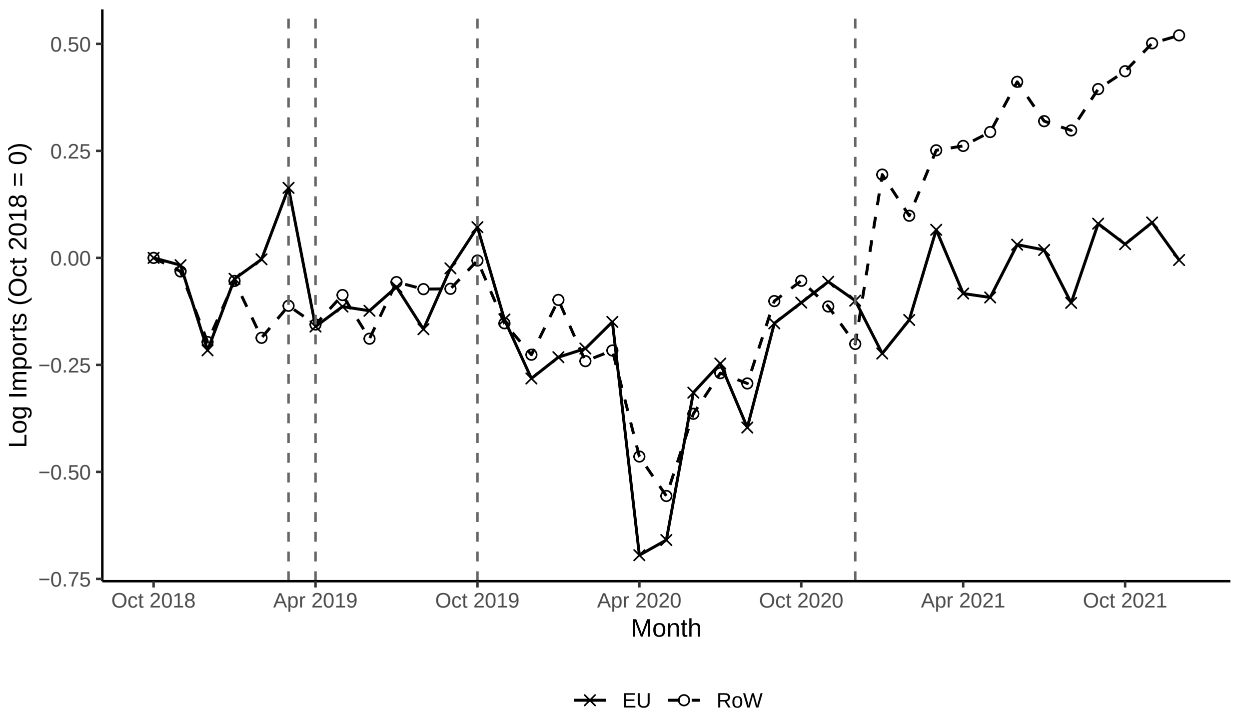


Figure 2: United Kingdom Imports from EU and RoW

Notes: Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from our structural estimation exercise. Source: HMRC Overseas Trade Statistics.

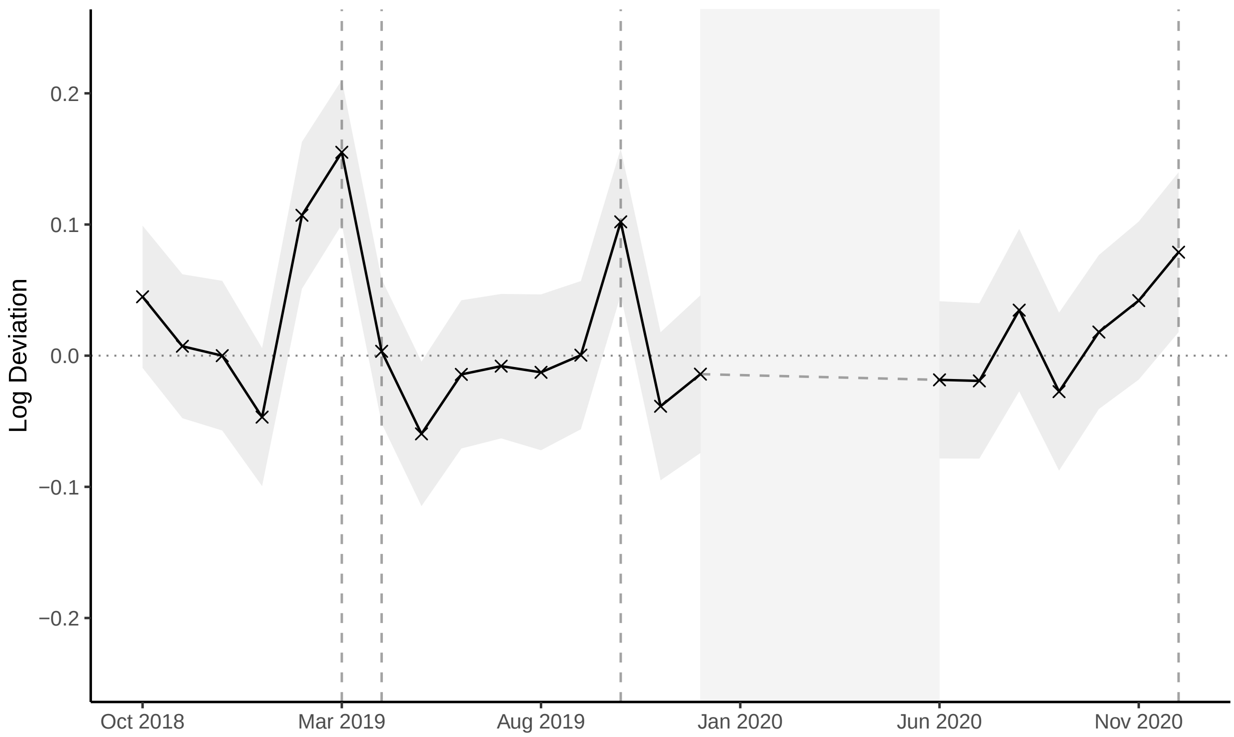


Figure 3: United Kingdom Excess Imports from the EU

Notes: Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from our structural estimation exercise.

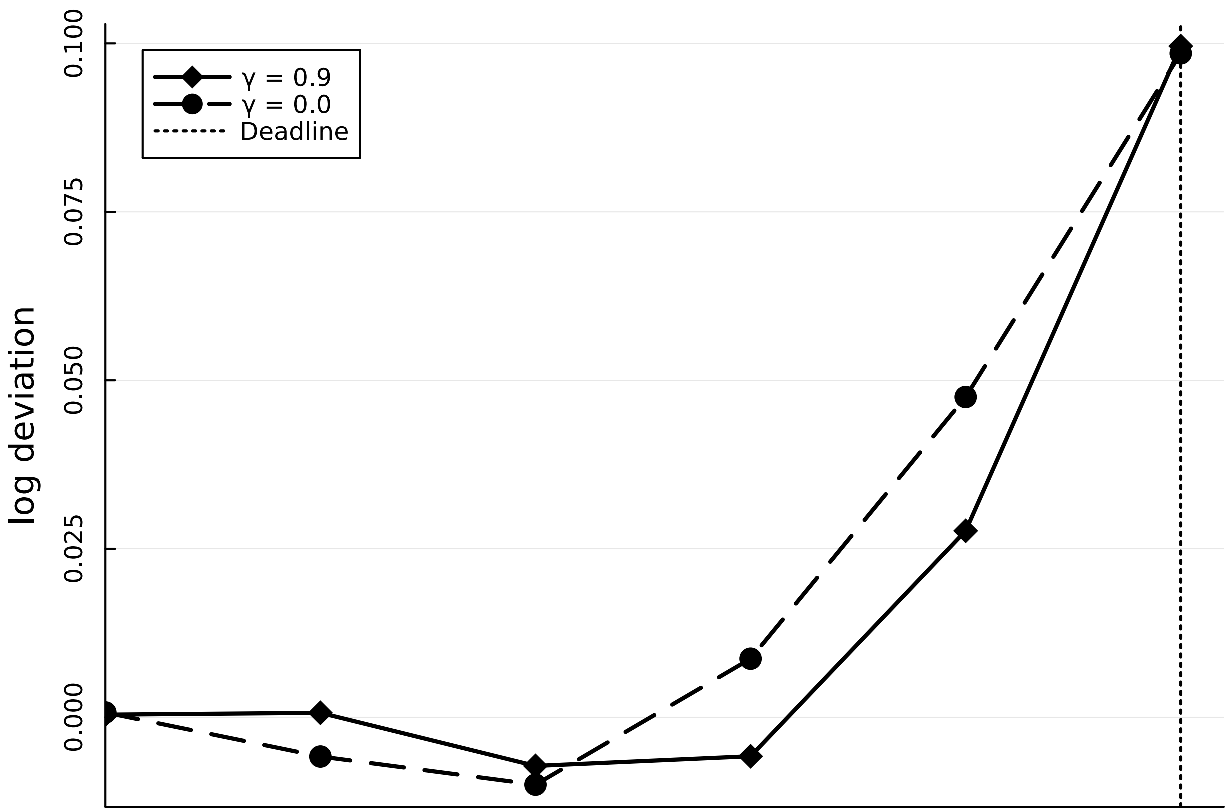


Figure 4: γ Identification Numerical Example

Notes: η value calibrated in each model to obtain identical increase at the deadline period.

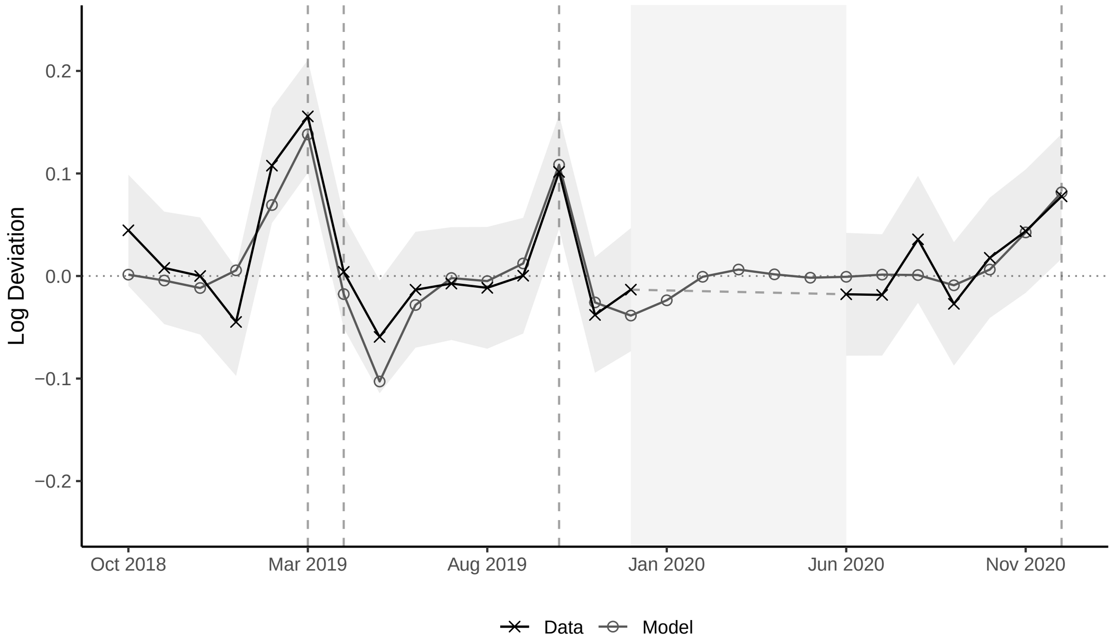


Figure 5: Baseline Model Fit

Notes: Model-generated imports follow the estimation procedure in section 3.3. Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from estimation.

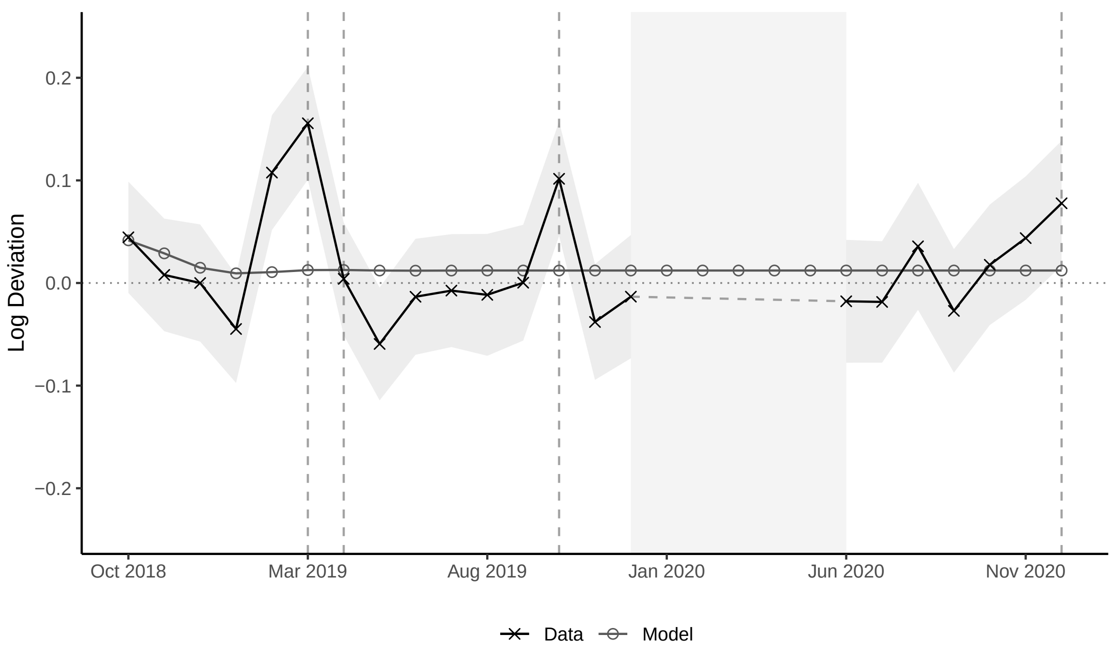


Figure 6: Constant-Risk Specification

Notes: Model-generated imports follow the estimation procedure in section 3.6.1. Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from estimation.

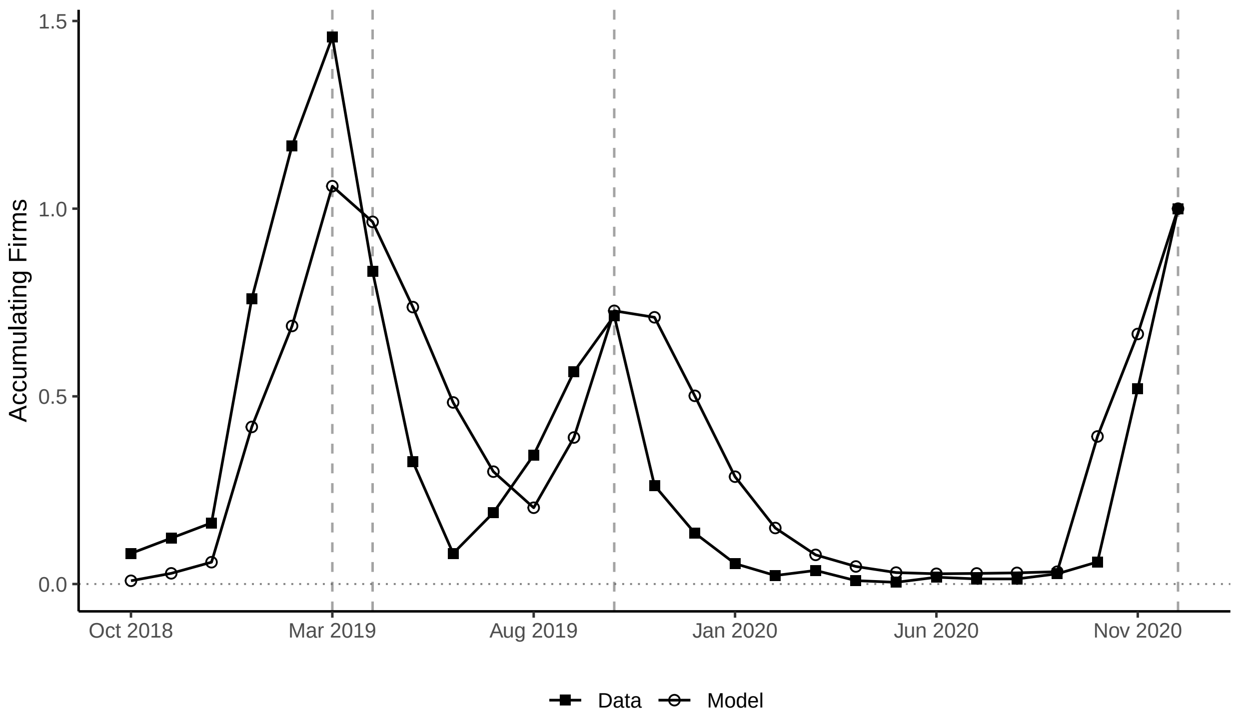


Figure 7: Firms Increasing Inventories due to Brexit

Notes: Data refers to the IHS Markit survey evidence described in section 4. Model-generated shares follow the methodology described in the same section. Periods containing deadlines are marked with vertical dashed lines. Terminal values are normalized to unity in both series.

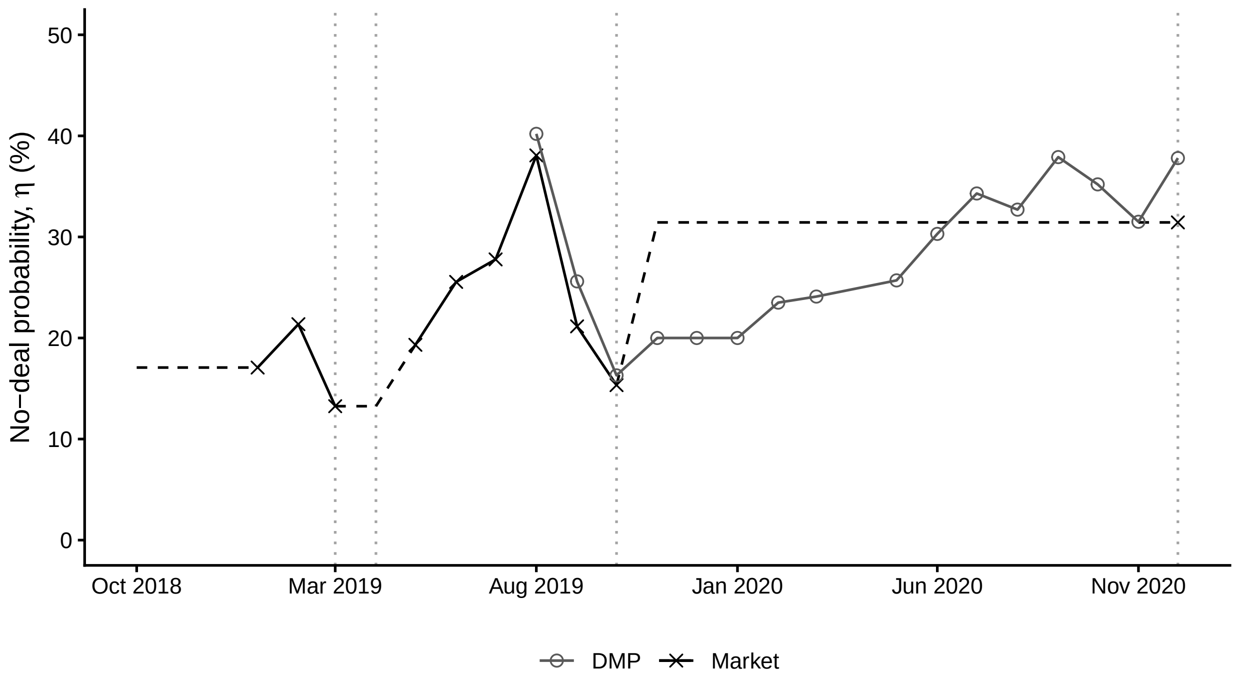


Figure 8: No-Deal Brexit External Probabilities

Notes: DMP refers to Decision-Maker Panel survey probability of a no-deal Brexit. Market refers to implied probabilities from prediction markets Betfair and Smarkets. See Appendix Table 5. Dashed lines indicate interpolated values. Vertical lines indicate Brexit deadlines.

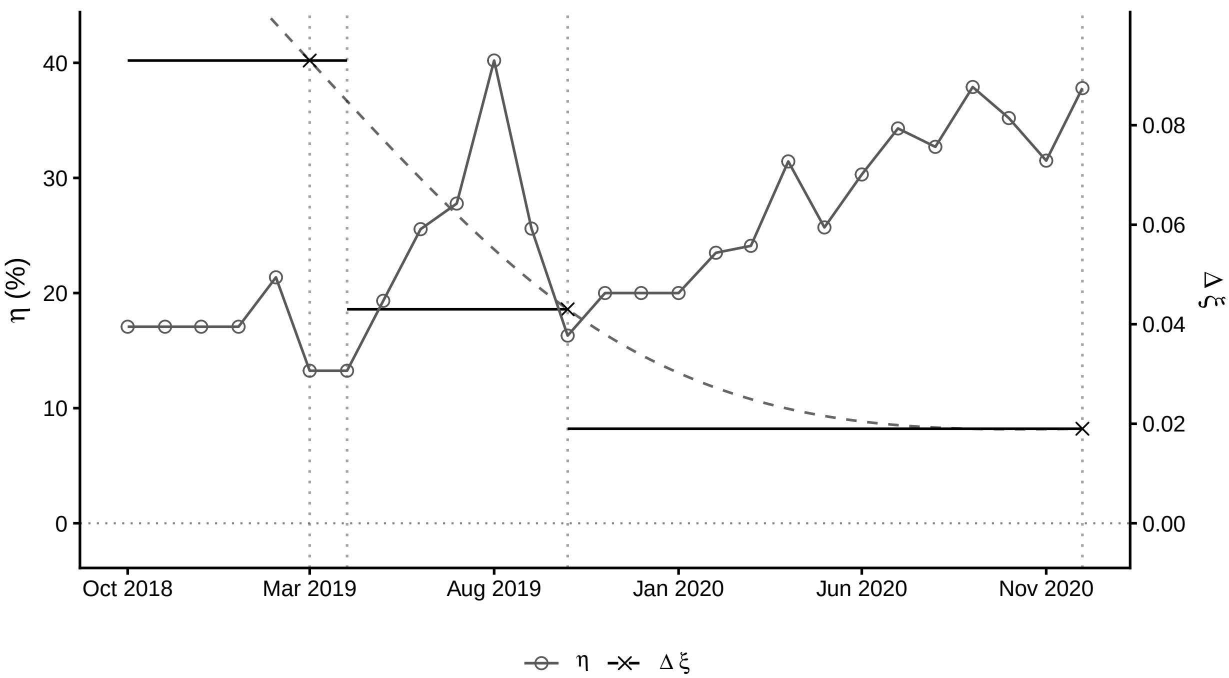


Figure 9: Cost and Likelihood of No-Deal Brexit

Notes: η series gives monthly probabilities of no-deal taken from the Decision Maker Panel survey and Betfair prediction markets. $\Delta\xi$ series gives deadline-specific cost changes conditional on a hard Brexit, detailed in section 5. Vertical lines indicate Brexit deadlines.

Table 1: Externally Set Parameters

Parameter	Description	Source	Value
σ	Demand elasticity	Khan and Khederlarian (2021)	2.7
δ	Inventory depreciation rate	Alessandria et al. (2010)	0.05
$\bar{f}$	Fixed cost of importing	Alessandria et al. (2010)	0.1
r	Interest rate	Standard time preference	0.03
ζ	Standard deviation of demand	Alessandria et al. (2024)	1.0
ξ_0	Pre–TCA import cost	Normalized	$\frac{\sigma}{\sigma-1}$
$\Delta\xi$	Post–TCA import cost increase	Post–TCA import reduction	$0.09 \times \xi_0$

Table 2: Estimated Parameters by Model Specification

Parameter	Deadline	Baseline	Credible Deadlines	Constant f
η	Mar 2019	0.124	0.137	0.065
	Apr 2019	0.076	0.067	0.056
	Oct 2019	0.032	0.079	0.033
	Dec 2020	0.072	0.079	0.033
γ	Mar 2019	0.063	0.000*	0.000*
	Apr 2019	0.000*	0.000*	0.000*
	Oct 2019	0.939	0.000*	0.000*
	Dec 2020	0.015	0.000*	0.000*
μ	–	0.340	0.401	0.000*
MSE $\times 10^{-3}$		0.974	1.240	1.516

Notes: η denotes deadline risk conditional on Brexit. γ denotes deadline credibility. * indicates an externally set value. Mean-squared error is calculated using the distance between model-implied changes in trade and the reduced-form fixed effects used in estimation.

Table 3: Relative Magnitudes of Brexit Trade Costs

	First-Moment Ratio	η-Ratio	$\Delta\xi$-Ratio
Oct. 2019 / Mar. 2019	0.573	1.230	0.466
Dec. 2020 / Mar. 2019	0.575	2.853	0.202

Notes: The first-moment ratio reports the relative Brexit risk measure estimated by the SMM procedure of section 3.3. The η-ratio reports the external probability measures described in section 5. The $\Delta\xi$ ratio reports the relative Brexit costs described in section 5. Values are expressed relative to the March 2019 deadline.

A Robustness

We consider the following variations on the benchmark estimates of section 2.3.2.

A.1 No Seasonal Controls

Our core estimates include month fixed effects $\gamma_{g,r,m}$ to remove the contribution of seasonal variation in shaping pre-TCA trade flows. To ensure our estimates are not driven by base-year sensitivity, we run the same model with these fixed effects removed. As can be seen in panel a of Figure A2, the first and final deadlines continue to show large significant increases in the preceding periods. The October 2019 deadline appears more muted, although it remains significant at 90 percent.

A.2 PPML

To address the presence of zeros in our trade data, we re-estimate the model using a Poisson pseudo-maximum-likelihood estimator. We estimate the following:

$$V_{g,r,t,m} = \exp\left(\sum_{t'=2015}^{2020}\sum_{m'=1}^{12}\beta_{t,m}\mathbf{1}\{t' = t \wedge m' = m \wedge r = EU\} + \gamma_{g,t,m} + \gamma_{g,r,m}\right) + \epsilon_{g,r,t,m}. \tag{25}$$

The resulting region fixed effects are shown in panel b of Figure A2. While this gives noisier estimates, we still obtain a significant increase in trade at each deadline.

A.3 MFN Controls

To understand whether Brexit stockpiling was motivated by a risk of aggregate trade disruption, or specifically by the threat of tariff risk for certain goods, we re-run our estimates controlling for EU MFN rates aggregated to the HS6 level. Letting τ_g denote the measure of tariff exposure, we estimate:

$$\log V_{g,r,t,m} = \sum_{t'=2015}^{2020}\sum_{m'=1}^{12}\left(\beta_{t,m} + \delta_{t,m}\log(1+\tau_g)\right)\mathbf{1}\{t' = t \wedge m' = m \wedge r = EU\} + \gamma_{g,t,m} + \gamma_{g,r,m} + \epsilon_{g,r,t,m}. \tag{26}$$

Estimates of $\beta_{t,m}$ and $\delta_{t,m}$ are plotted in Figure A3. The tariff elasticity estimates do not imply any systematic relationship between tariff risk and pre-Brexit stockpiling, while the region fixed effects are largely unchanged in magnitude. This pattern implies MFN risk was not a significant component of the perceived Brexit risk facing UK firms. This result is unchanged when using the UK Global Tariff, which was ultimately adopted as the UK's post-TCA MFN schedule.

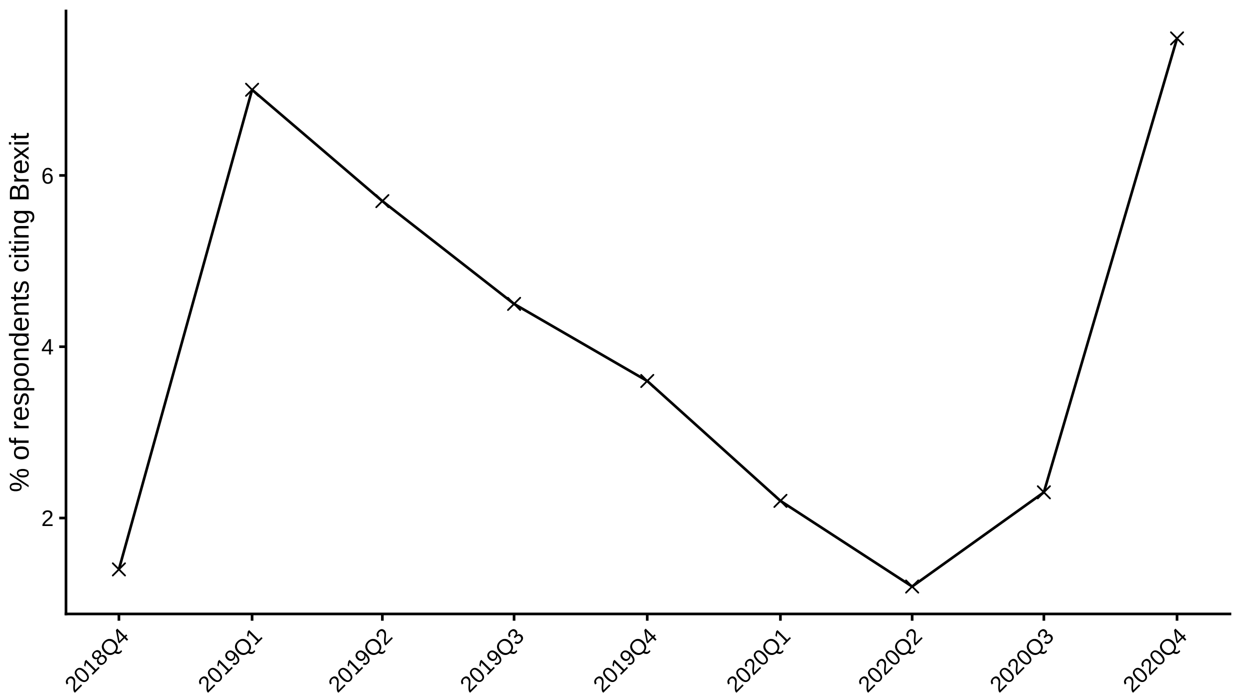
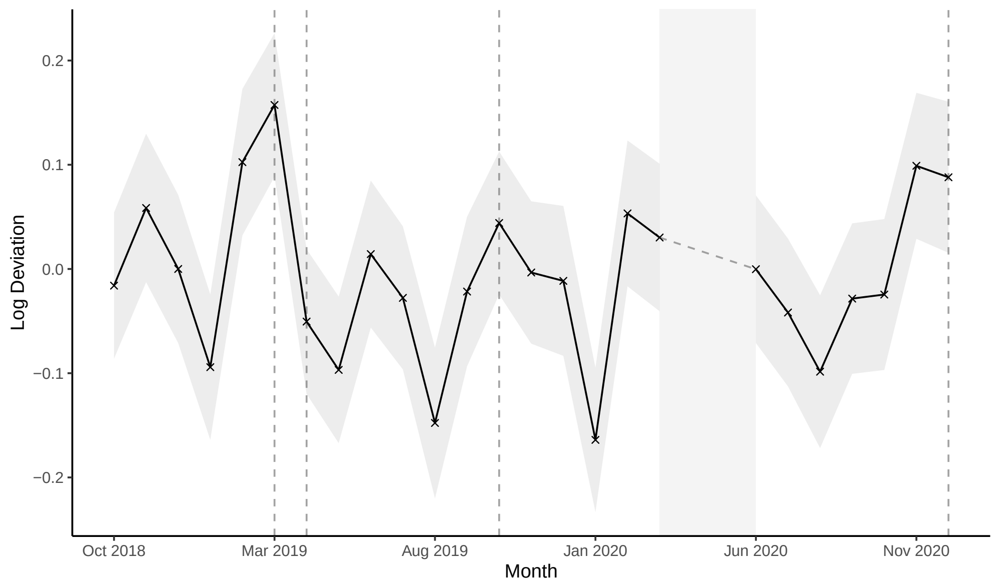
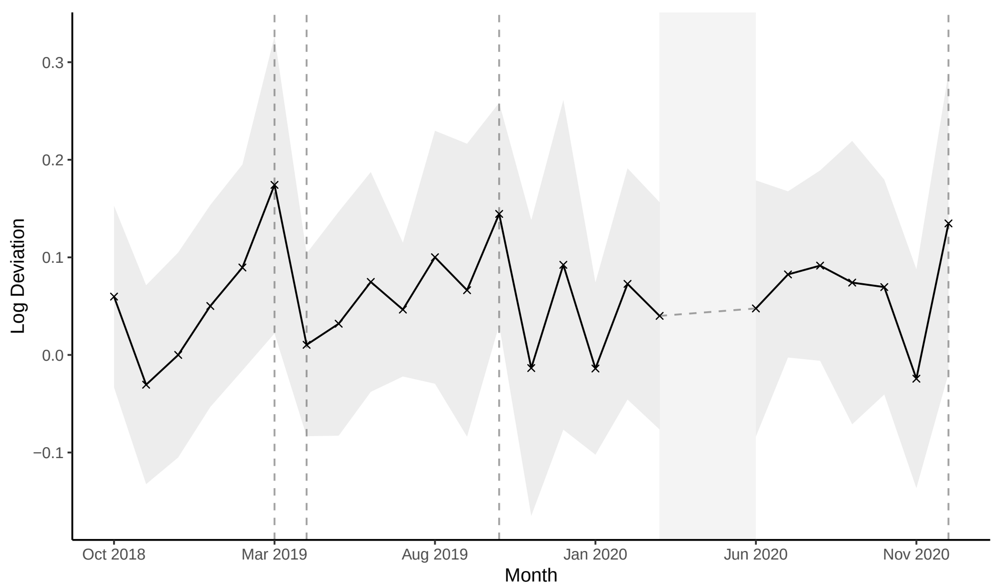


Figure A1: Quarterly Stocks Survey Respondents Citing Brexit

Notes: Values indicate the share of surveyed firms who mentioned Brexit when responding to the QSS. Source: ONS Quarterly Stock Survey



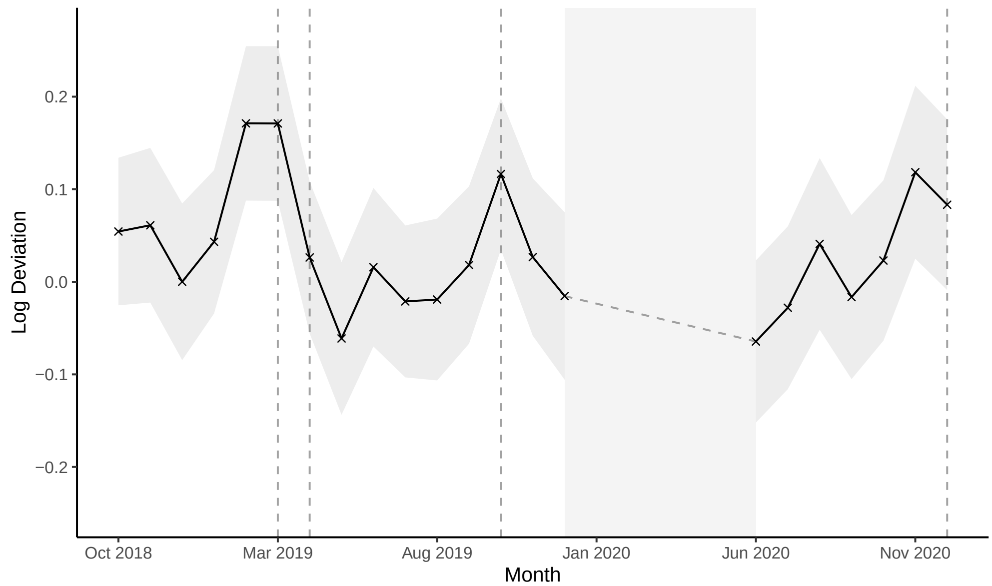
(a) No Seasonal Control



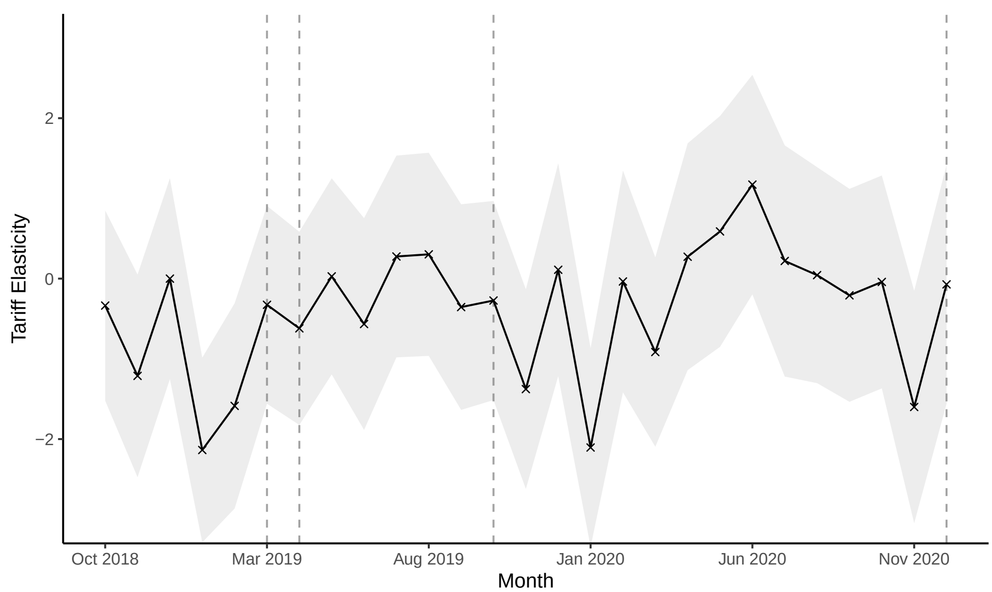
(b) PPML Regression

Figure A2: Excess Import Fixed Effects — Sensitivities

Notes: Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from our structural estimation exercise. Details of estimation are given in Appendix A.



(a) EU Fixed Effect



(b) Tariff Elasticity

Figure A3: MFN Controls

Notes: Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from our structural estimation exercise. Details of estimation are given in Appendix A.

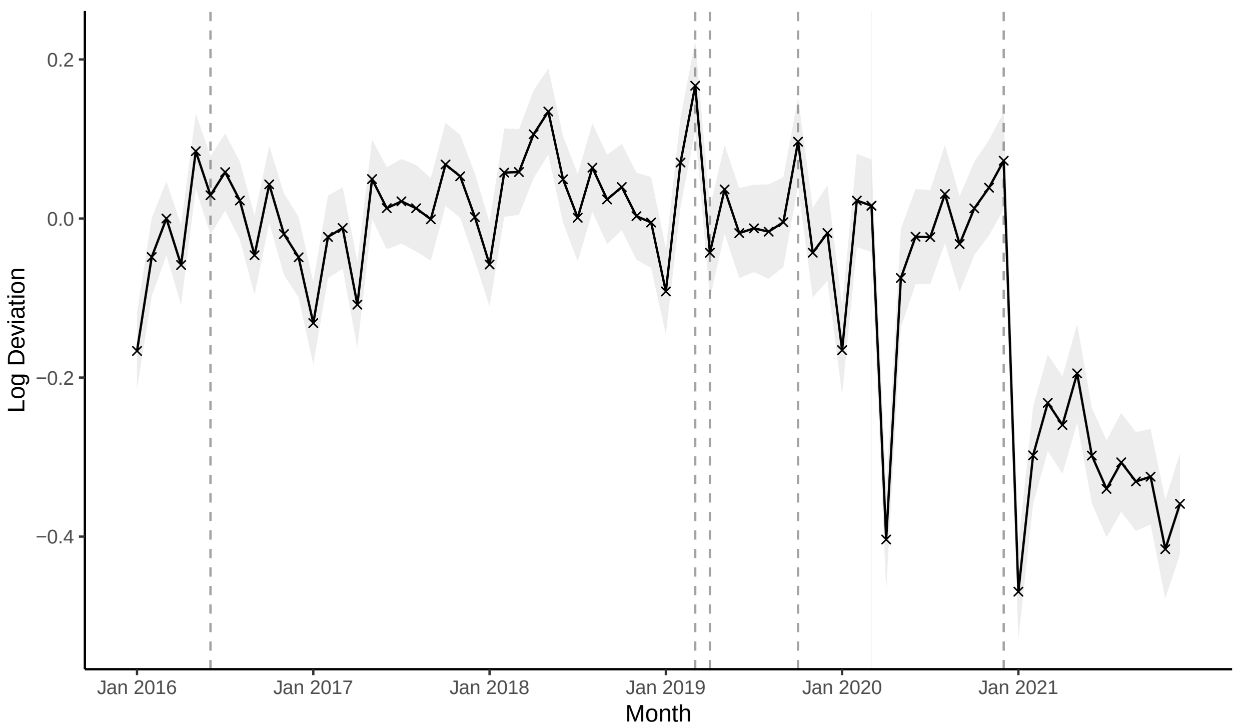
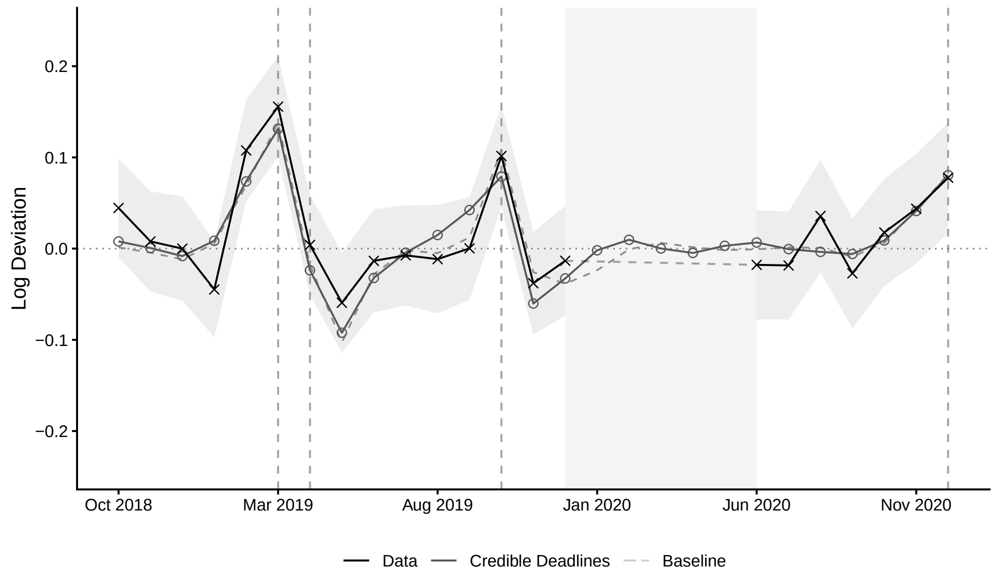
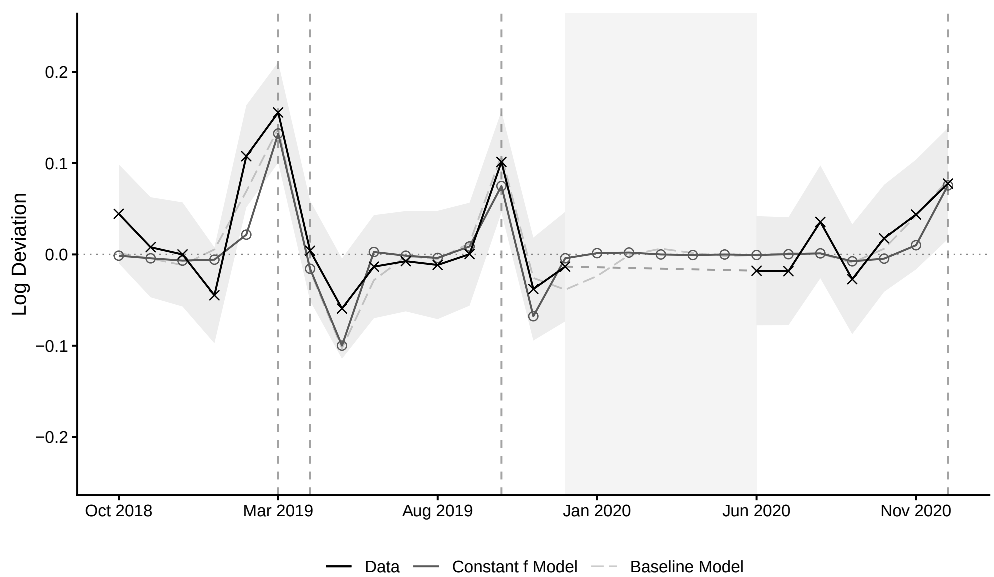


Figure A4: Excess Import Fixed Effects — Full Sample

Notes: Periods containing deadlines and the Brexit referendum are marked with dashed vertical lines. Shaded regions are 95 percent confidence intervals.



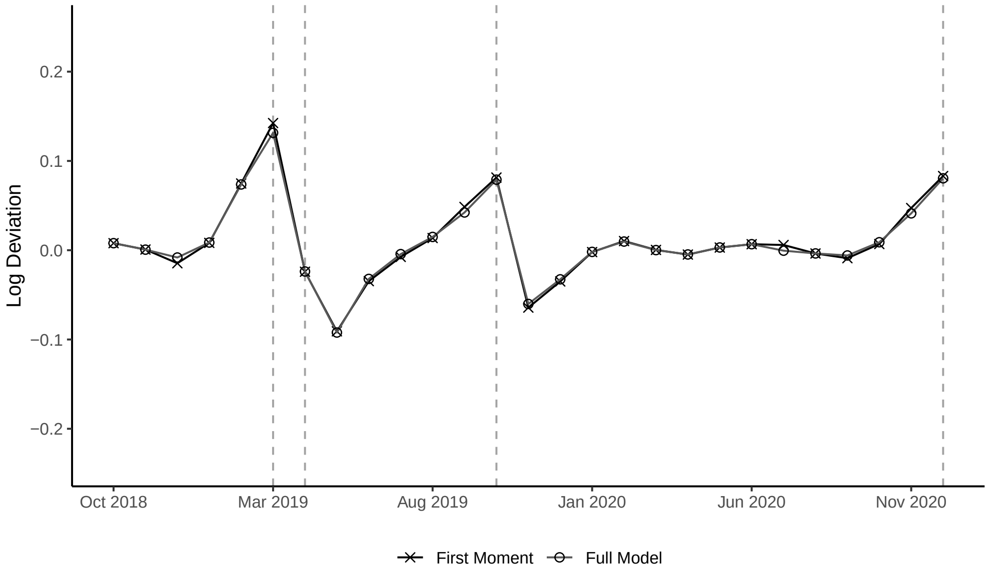
(a) Credible Deadlines



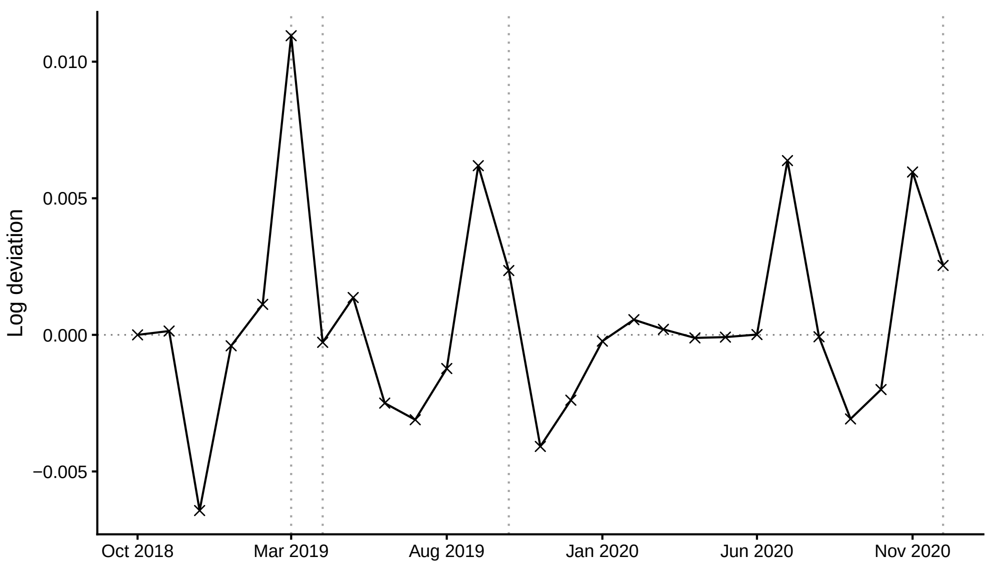
(b) Constant f

Figure A5: Alternative Model Specifications

Notes: Model-generated imports follow estimation of restricted models described in 3.3. Periods containing deadlines are marked with vertical dashed lines. Shaded regions are 95 percent confidence intervals. Block-shaded region indicates periods excluded from estimation.



(a) Levels



(b) Difference

Figure A6: Model Decomposition into First-Moment and Uncertainty

Notes: Full-model fixed effects follow the estimation procedure of section 3.3. First-moment fixed effects follow the procedure of section 3.4.2. Periods containing deadlines are marked with vertical dashed lines.

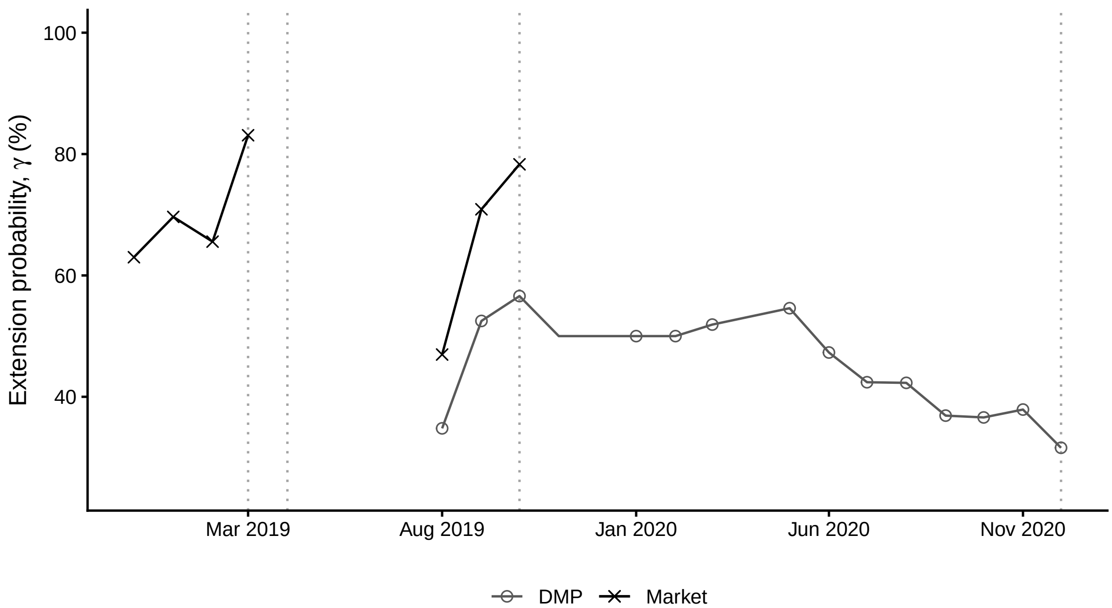


Figure A7: Brexit Extension External Probabilities

Notes: DMP refers to Decision-Maker Panel survey probability of Brexit extension. Market refers to implied probabilities from prediction market PredictIt. See Appendix Table 5. Vertical lines indicate Brexit deadlines.

Table 4: Uncertainty Contribution to Deadline Stockpiling

Deadline	Uncertainty Share (%)
March 2019	8.328
October 2019	2.979
December 2020	3.154

Notes: Shares give the ratio of the certainty-equivalent deadline import peak minus the full model import peak as a share of the full model import peak.

Table 5: External Probability Measures

Source	**Wording**	**Response Recorded**	**Outcome**	**Type**	**Probability**
March 2019					
Betfair Exchange	No-deal Brexit in 2019?	March 2019 (average)	No-deal	Prediction Market	0.20
PredictIt	Will the United Kingdom officially exit the European Union by March 29?	March 2019 (average)	Extension	Prediction Market	0.80
October 2019					
Betfair Exchange	No-deal Brexit in 2019?	October 2019 (average)	No-deal	Prediction Market	0.15
Decision Maker Panel	What do you think is the percentage likelihood (probability) of the UK leaving the EU in 2019 with no deal?	October 2019	No-deal	Survey	0.17
PredictIt	Will the UK officially exit the European Union by Nov. 1?	October 2019 (average)	Extension	Prediction Market	0.80
December 2020					
Decision Maker Panel	[Likelihood] of the transition period for the UK leaving the EU ending in 2020 with no trade deal agreed?	December 2020	No-deal	Survey	0.38
Smarkets	UK–EU Trade Deal by end of 2020? ["No" response]	December 2020 (average)	No-deal	Prediction Market	0.35
Decision Maker Panel	[Likelihood] of the transition period for the UK leaving the EU ending in each of the following years? [2021/2022/2023 or later]	December 2020	Extension	Survey	0.30