Brexit and the Macroeconomic Impact of Trade Policy Uncertainty

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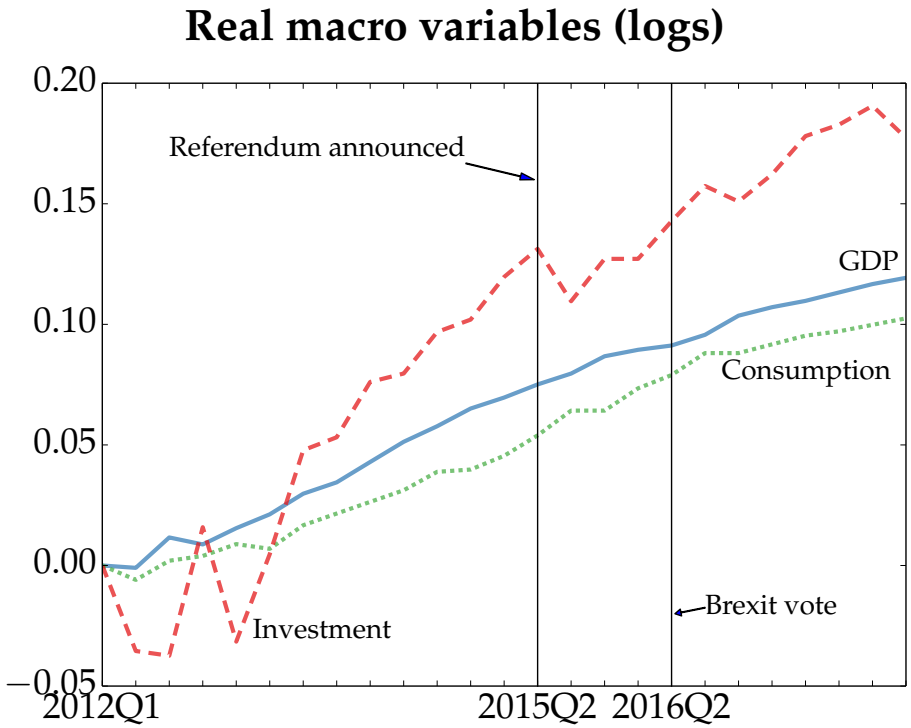
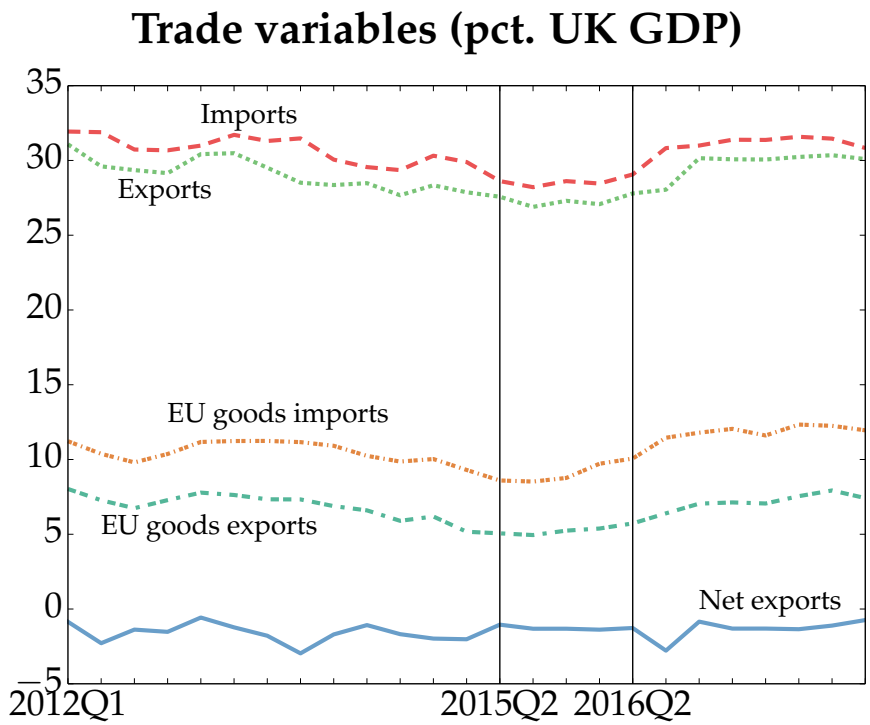
Widespread predictions of harm from Brexit uncertainty

Evidence for harm in recent UK data?





No clear effect of Brexit anticipation on macro or trade variables

If there were, would not be evidence of effect of Brexit uncertainty

What would agents do if they had perfect foresight about Brexit?

Historical evidence: China, 1980–2001

Obtained temporary MFN status with US in 1980 but had to be annually renewed by Congress

- Chinese exporters faced uncertainty about whether tariffs would revert to pre-1980 levels
- WTO accession in 2001 eliminated uncertainty

Pierce and Schott (2016): accession increased US imports from China even though trade costs did not change

Handley and Limaõ (2017): US welfare gains from accession equivalent to 13% tariff reduction

Proposed mechanism: forward-looking firms postponed export participation decisions until uncertainty resolved

What I do

Quantitative analysis of

- Overall macroeconomic impact of Brexit
- Impact of uncertainty about post-Brexit trade policies

Build dynamic GE model of UK, EU, and rest of world

- Firms make forward-looking export participation decisions
- Trade policy uncertainty: will Brexit be hard or soft?
- Post-Brexit trade costs based on LSE studies (Dhingra et al., 2016)
- Calibrate to IO table, facts about export participation dynamics

Compare equilibrium with Brexit uncertainty to counterfactuals

- Overall impact: compare with no-Brexit counterfactual
- Impact of uncertainty: compare with perfect-foresight counterfactuals in which agents learn Brexit outcome immediately

What I find

Result	Soft Brexit	Hard Brexit
(a) Overall impact		
Drop in imports from EU (pct.)	11	45
Cons. equiv. welfare cost (pct.)	0.44	1.18
P.V. of welfare cost (£ per person)	7,000	19,000
(b) Welfare cost of uncertainty		
Percent overall cost	0.18	0.25
Cons. equiv. (basis points)	0.07	0.28
P.V. (£ per person)	12.6	47.5

Model

Overview

Three countries indexed by $i \in I = \{uk, eu, rw\}$

Households

- Work, invest, save, consume

Distributors

- Produce aggregate nontradable good used for consumption, investment, intermediate inputs
- Bundle of domestic and imported differentiated goods

Unit measures of heterogeneous firms

- Monopolistic competitors
- Choose whether to export to each foreign destination
- Advertise to build foreign customer bases

Stochastic trade costs

Uncertainty and trade costs

Each period economy experiences aggregate shock $Z_t \in \mathcal{Z}_t$

- $Z^t = (Z_0, Z_1, \ldots, Z_t)$ denotes history of shocks
- $\Pi(Z^t)$ denotes probability
- Non-stationary process $\Rightarrow$ histories matter!

Two kinds of trade costs

- Tariffs: $\tau_{i,j}(Z^t)$
- Iceberg transportation costs: $\xi_{i,j}(Z^t)$

Households

Choose consumption, investment, bonds to maximize

$$\sum_{t=0}^{\infty} \sum_{Z^t} \beta^t \Pi(Z^t) U(C_i(Z^t))$$

subject to

$$P_i(Z^t)(C_i(Z^t) + X_i(Z^t)) + Q(Z^t)B_i(Z^t) = W_i(Z^t)\bar{L}_i + R_i(Z^t)K_i(Z^{t-1}) + B_i(Z^{t-1}) + T_i(Z^t) + D_i(Z^t),$$

$$K_i(Z^t) = H\left(K_i(Z^{t-1}), X_i(Z^t)\right) + (1-\delta)K_i(Z^{t-1})$$

International financial markets exogenously incomplete

Capital adjustment costs discourage large (dis)investments

- Eaton et al. (2011), Lucas and Prescott (1971)
- Ravikumar et al. (2017): adjustment costs matter for dynamic gains from trade policy changes

Distributors

Produce nontradable CES aggregate of domestic and foreign goods

Top level of aggregation: combine domestic and imported bundles:

$$Y_i(Z^t) = \left[\sum_{j \in I} \mu_{i,j} Y_{i,j}(Z^t)^{\frac{\zeta - 1}{\zeta}} \right]^{\frac{\zeta}{\zeta - 1}}$$

- $Y_{i,j}(Z^t)$: bundle of goods from country j
- ζ: Armington elasticity (not trade elasticity!)

Bottom level: $Y_{i,j}(Z^t)$ produced by combining differentiated varieties from country j

- $P_{i,j}(Z^t)$: price index
- θ: elasticity of substitition between same-country varieties

Firms: overview

Theory of export participation dynamics draws from two sources:

- Arkolakis (2010) model of market penetration
- Sunk-cost models of export participation dynamics (Das et al., 2007; Alessandria and Choi, 2007; Ruhl and Willis, 2017)

Two margins of export participation:

- Extensive: which firms export?
- Intensive: how many foreign customers does each exporter serve?

Life-cycle dynamics:

- Marginal cost of reaching additional foreign customers decreasing in current customer base
- Exporters penetrate foreign markets gradually over time

Consistent with wide variety of facts about cross-sectional distribution and life-cycle dynamics of exporters (Steinberg, 2018)

Firms: production

Unit measure of firms in each country i

Heterogeneous in productitivity a

- Exogenous, constant over firm's life
- Drawn at birth from distribution $F_i(a)$

CRS production technology uses capital, labor, intermediates:

$$f(a,k,\ell,m) = a \min\left\{\frac{k^{\alpha}\ell^{1-\alpha}}{\eta_i}, \frac{m}{1-\eta_i}\right\}$$

- α: share of capital in value added
- η_i: share of value added in gross output

Firms: market penetration and demand

Firms are also heterogeneous in market penetration $n \in [0,1]$ in each export destination $d \in D_i = I \setminus \{i\}$

Conditional on purchasing firm's product, distributor in destination $d \in D_i$ has standard demand function:

$$q_{d,i}(Z^t, p) = \left[(1 + \tau_{d,i}(Z^t))^{-\theta} P_{d,i}(Z^t)^{\theta} Y_{d,i}(Z^t)\right] p^{-\theta}$$

Total demand for firm's product in destination d depends on how many distributors firm sells to:

$$y_{d,i}(Z^t, n, p) = n q_{d,i}(Z^t, p)$$

All firms sell to all domestic distributors:

$$y_{i,i}(Z^t, p) \equiv y_{i,i}(Z^t, 1, p) = q_{i,i}(Z^t, p), \quad \tau_{i,i}(Z^t) = 0$$

Firms: pricing and profits

Conditional on market penetration, firm chooses inputs and price to maximize profits independently for each destination $d \in D_i$:

$$\pi_{d,i}(Z^t, a, n) = \max_{p,k,\ell,m} \left\{ p y_{d,i}(Z^t, n, p) - W_i(Z^t)\ell - R_i(Z^t)k - P_i(Z^t)m \right\}$$

$$\text{subject to} \quad y_{d,i}(Z^t, n, p)(1 + \xi_{d,i}(Z^t)) = af(k, \ell, m)$$

Similar problem for domestic market with $n = 1$ and $\xi_{i,i}(Z^t) = 0$

Yields standard constant-markup pricing rules

Firms: advertising and market penetration

Firm's market penetration (n) depends on advertising effort (s) and last-period market penetration (n_-)

Fraction of distributors that see advertisements (Arkolakis, 2010):

$$b_{d,i}(s) = 1 - [1 - (1 - \lambda)\psi_{d,i}s]^{\frac{1}{1-\lambda}}$$

- $\psi_{d,i}$: controls cost of marketing to destination d
- λ: controls diminishing returns in advertising

Law of motion for market penetration:

$$n = \underbrace{b_{d,i}(s)(1 - n_-)}_{\substack{\text{new customers} \\ \text{gained via ads}}} + \underbrace{b_{d,i}(s)n_-}_{\substack{\text{old customers} \\ \text{retained via ads}}} + \underbrace{(1 - b_{d,i}(s))(1 - \omega_{d,i})n_-}_{\substack{\text{old customers} \\ \text{retained after depreciation}}}$$

- $\omega_{d,i}$: customer base depreciation rate

All firms born as non-exporters with $n_- = 0$ in all destinations

Firms: advertising and market penetration (contd.)

Advertising cost (in units of labor) to reach n customers given last-period market penetration n_-:

$$\frac{\kappa(n,n_-)}{\psi_{d,i}}, \quad \kappa(n,n_-) = \frac{1}{(1-\lambda)}\left\{1-\left[\frac{1-n}{1-n_-(1-\omega_{d,i})}\right]^{1-\lambda}\right\}$$

Key properties:

- $\kappa_1(0,0) > 0 \Rightarrow$ least productive firms do not export at all
- $\kappa_{11}(n,n_-) > 0 \Rightarrow$ more productive exporters reach more customers
- $\kappa_{12}(n,n_-) < 0$: $\Rightarrow$ market penetration rises gradually over time

Generalizes Arkolakis (2010) theory of market penetration to dynamic setting

Firms: market penetration dynamics

Exporters exit exogenously in two ways:

- Death w/ prob. $1-\phi$ (exit from all markets at once)
- Lose all customers w/ prob. $1-\chi$ (independent across destinations)
- Dying firms replaced by new firms with same productivity and $n_- = 0$ in all export destinations

Dynamic problem:

$$V_{d,i}(Z^t, a, n_-) = \max_{n \in [(1-\omega_{d,i})n_-, 1]} \left\{ \pi_{d,i}(Z^t, a, n) - W_i(Z^t)\kappa_{d,i}(n, n_-) + Q_i(Z^t)\phi \tilde{V}_{d,i}(Z^{t+1}, a, n) \right\}$$

where

$$\tilde{V}_{d,i}(Z^{t+1}, a, n) = \sum_{Z^{t+1}} \Pi(Z^{t+1}|Z^t) \left[\chi V_{d,i}(Z^{t+1}, a, n) + (1-\chi) V_{d,i}(Z^{t+1}, a, 0) \right]$$

Equilibrium and computation

For each country i and history Z^t, following objects that satisfy optimality and market clearing conditions

- aggregate quantities and prices
- firm value and policy functions for each $d \in D_i$
- joint dist. of productivity and market penetration for each $d \in D_i$

Perturbation methods used to solve DSGE models not applicable

- Non-stationary stochastic process, multiple steady states
- Aim to measure welfare and impact of uncertainty

Technical contribution: method to solve for exact equilibrium

- Similar to methods for solving for deterministic transition paths
- Requirement: finite number of histories

Calibration and Brexit scenarios

Calibration: overview

1. Assign common parameters (discount factor, capital share, etc.)
2. Calibrate most other parameters so that steady-state matches data
   - Choose aggregate parameters to target input-output matrix
   - Choose firm-level parameters to target bilateral export participation rates, facts about distribution and dynamics of exporters
   - Interpret calibrated steady state as no-Brexit counterfactual
3. Calibrate Armington elasticity to match long-run trade elasticity
   - Guess elasticity
   - Do steps 1 + 2, then run entire quantitative analysis
   - Compare changes in trade flows to changes in tariffs, update guess

Calibration: assigned parameters

Parameter	Meaning	Value	Source/target
(a) Assigned parameters			
β	Discount factor	0.98	LR interest rate = 2%
γ	Risk aversion	2.00	Standard
δ	Depreciation rate	0.06	Standard
α	Capital share	0.33	Standard
θ	EoS across varieties	5.00	Alessandria et al. (2016)
φ	Capital adj. cost	0.80	Steinberg (2018)
λ	Marketing cost convexity	4.00	Steinberg (2019)
$1-\phi$	Death rate	0.15	Melitz and Constantini (2007)

Marketing cost convexity (λ) does not have much impact on concentration of exports or relative growth rate of new exporters

Use value from new paper; results not sensitive to this choice

Calibration: aggregate parameters

Data: World Input Output Database IO matrix from 2011

- Aggregate all industries to one sector, all non-UK countries into EU and rest of the world
- 2011 data: several years before Brexit entered realm of possibility, sensible no-Brexit counterfactual

Parameter	Meaning	Value	Target
η_i	Value-added shares	$(0.46, 0.42, 0.40)$	
$\bar{L}_i$	Labor endowments	$(66.7, 194, 761)$	
$\mu_{uk,j}$	U.K. Armington shares	$(0.84, 0.07, 0.09)$	WIOD
$\mu_{eu,j}$	E.U. Armington shares	$(0.01, 0.89, 0.10)$	
$\mu_{rw,j}$	R.W. Armington shares	$(0.003, 0.024, 0.97)$	

Calibration: data sources for exporter facts

1. EFIGE
   - Survey of firms in UK and 4 other EU countries
   - Key data: overall and regional (EU vs. RW) export participation rates
2. Exporter Dynamics Database
   - Indicators on distribution and dynamics of exporters constructed from customs-level data in 69 countries (including 6 EU countries)
   - Key data:
     - Overall and bilateral export participation rates (including towards UK)
     - Distribution of exporter sizes
     - Exit rate
     - Growth rates of new entrants' and incumbents' export sales

Combine data from both sources to calculate bilateral export participation rates for 6 bilateral trade relationships in model

Calibration: target moments for firm-level parameters

1. Bilateral export participation rates

Exporting country	Destination	Export participation rate (%)
UK	EU	54.5
UK	RW	41.1
EU	UK	5.7
EU	RW	37.3
RW	UK	4.5
RW	EU	10.7

2. Top-5 share of bilateral exports: 58.4%

3. Bilateral exporter exit rate: 45.9%

4. Growth rate of new exporters relative to incumbents: 13.2%

Calibration: firm-level parameters (plus Armington elasticity)

Parameter	Meaning	Value	Target
σ_i	Productivity dispersion	$(0.44, 0.46, 0.49)$	Top-5 share
$\psi_{d,uk}$	U.K. marketing efficiency	$(0.82, 0.41)$	Bilateral export participation rates
$\psi_{d,eu}$	E.U. marketing efficiency	$(0.02, 0.05)$	
$\psi_{d,rw}$	R.W. marketing efficiency	$(0.01, 0.01)$	
$\omega_{d,uk}$	U.K. customer dep.	$(0.78, 0.78)$	Relative growth rate of new exporters
$\omega_{d,rw}$	E.U. customer dep.	$(0.78, 0.78)$	
$\omega_{d,eu}$	R.W. customer dep.	$(0.79, 0.79)$	
$1-\chi$	Exit rate	0.3	Bilateral exit rate
ζ	Armington elasticity	3.25	LR trade elasticity = 5

UK→EU marketing efficiency high because of high export participation rate; opposite for EU→UK marketing efficiency

Armington elasticity lower than target trade elasticity because of firm-level adjustment margins

Brexit scenarios: trade costs

Two possible scenarios as in Dhingra et al. (2016)

- Soft: no change in tariffs, small increase in non-tariff barriers
- Hard: MFN tariffs, large increase in non-tariff barriers
- No change in trade costs with rest of the world

Tariffs (hard Brexit only)

- Data: EU MFN rates for 6-digit HS industries
- Aggregation: weight by COMTRADE bilateral imports/exports
- Assume no tariffs on services trade

Non-tariff barriers interpreted as iceberg costs

- Data: Francois et al. (2013) estimates of NTBs in EU-USA trade for 2-digit ISIC sectors, including services
- Aggregation: weight by WIOD bilateral imports/exports
- Soft (hard) Brexit: 25% (75%) of these values

Brexit scenarios: timing and probabilities

2011: Start in no-Brexit steady state

2015: Unanticipated event: announcement of Brexit referendum

2016: Brexit vote

- Two possible outcomes: "stay" or "leave"
- Π_{vote}: probability of "stay" vote

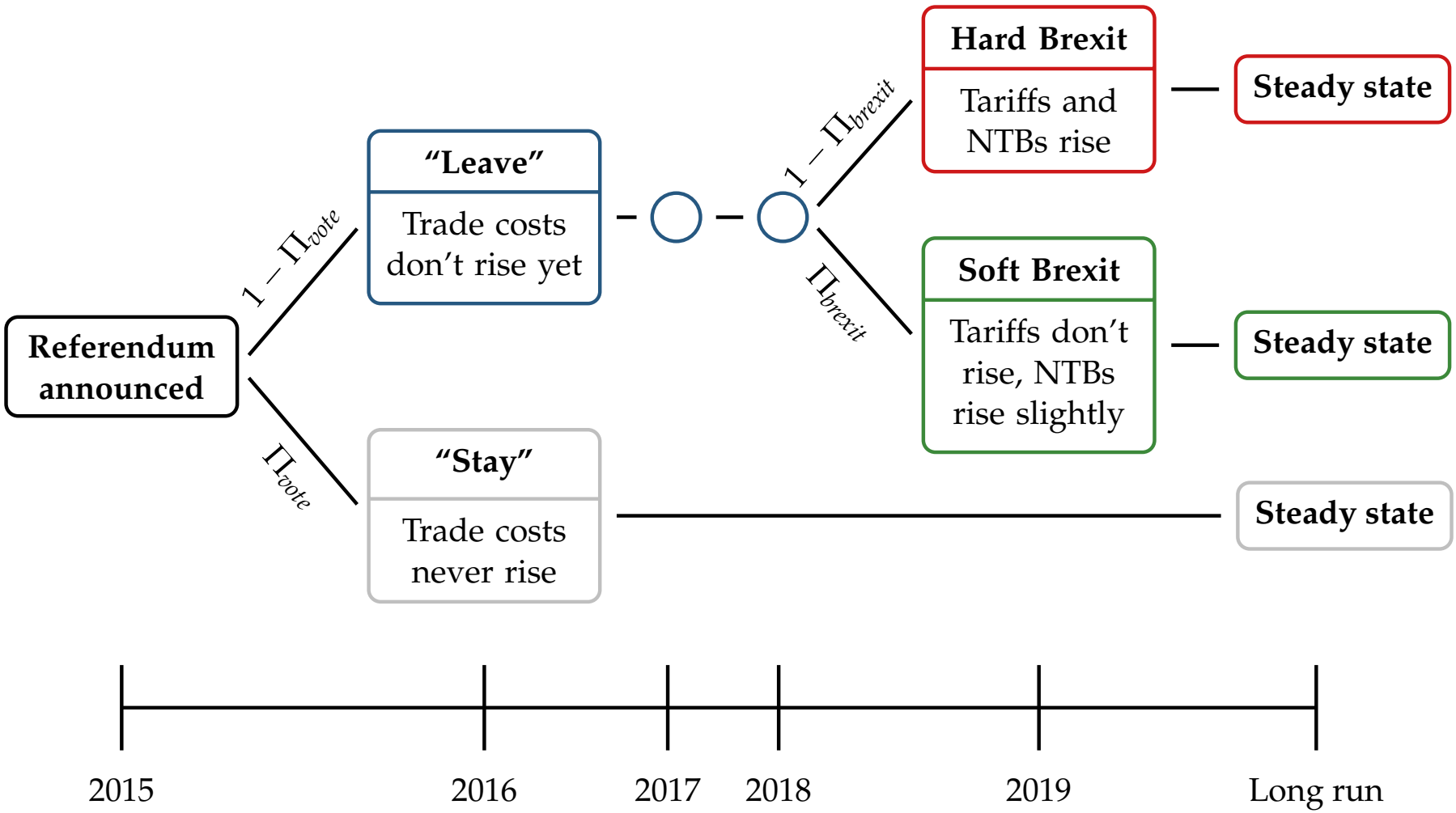
2019: Brexit occurs (conditional on "leave" vote)

- Outcome (hard or soft) not revealed until then
- Π_{brexit}: probability of soft Brexit

Two probabilities to assign

- Π_{vote}: Prediction markets indicated 75% chance of "stay" vote
- Π_{brexit}: No data to go on…set to 50% in baseline model, but has almost no impact

Model uncertainty tree

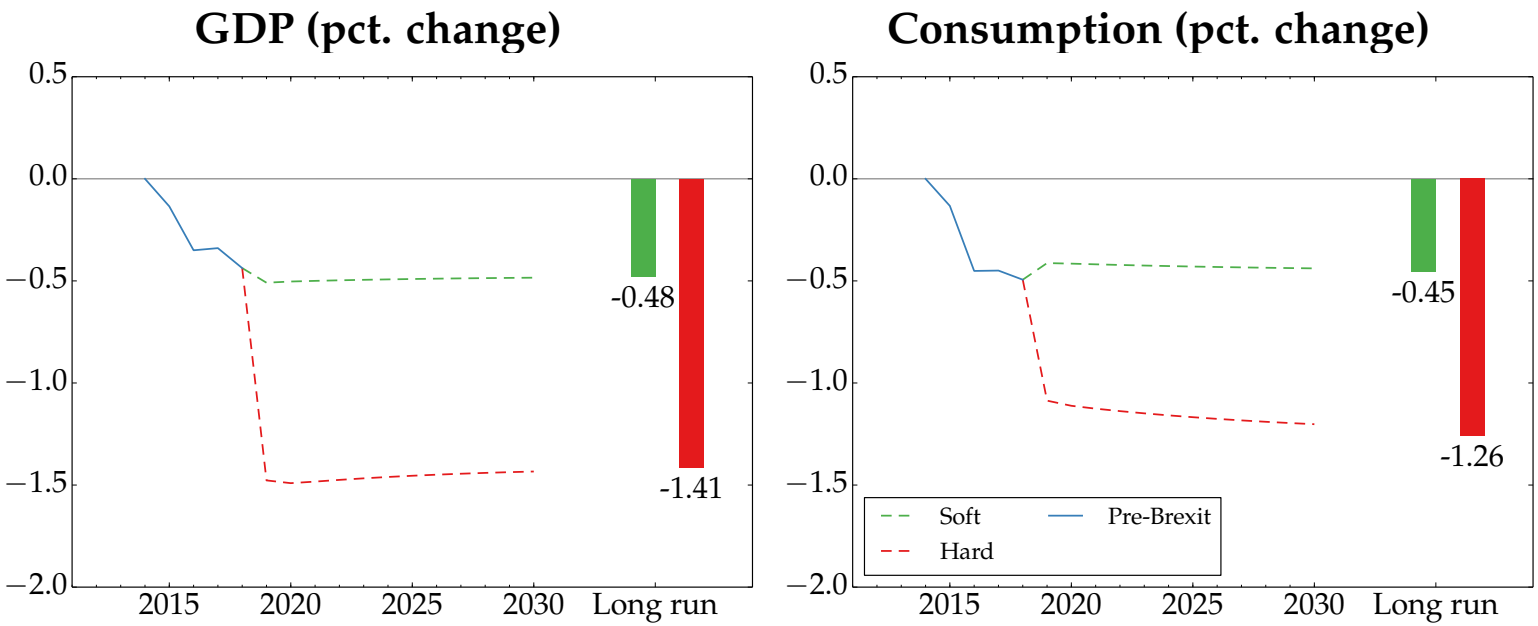


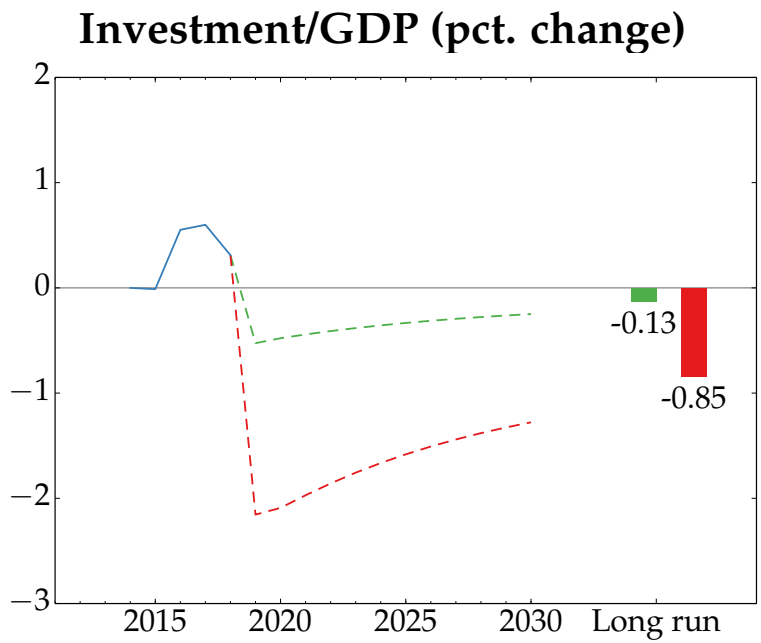
Brexit scenarios: details

Parameter	Meaning	Value	Source
(a) Soft Brexit trade costs			
$\tau_{uk,eu}$	Tariff on U.K. imports from E.U.	0.00%	N/A
$\tau_{eu,uk}$	Tariff on E.U. imports from U.K.	0.00%	N/A
$\xi_{uk,eu}$	NTB on U.K. imports from E.U.	2.18%	Francois et al. (2013)
$\xi_{eu,uk}$	NTB on E.U. imports from U.K.	1.74%	Francois et al. (2013)
(b) Hard Brexit trade costs			
$\tau_{uk,eu}$	Tariff on U.K. imports from E.U.	3.58%	COMTRADE + WTO
$\tau_{eu,uk}$	Tariff on E.U. imports from U.K.	2.12%	COMTRADE + WTO
$\xi_{uk,eu}$	NTB on U.K. imports from E.U.	6.53%	Francois et al. (2013)
$\xi_{eu,uk}$	NTB on E.U. imports from U.K.	5.21%	Francois et al. (2013)
(c) Transition probabilities			
Π_{vote}	Probability of "stay" vote	0.75	Prediction markets
Π_{brexit}	Probability of soft Brexit	0.50	N/A

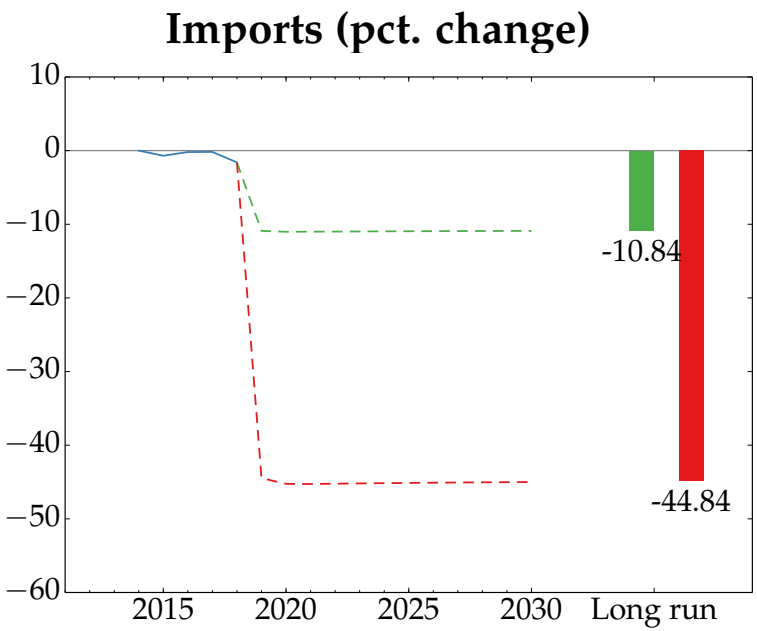
Results

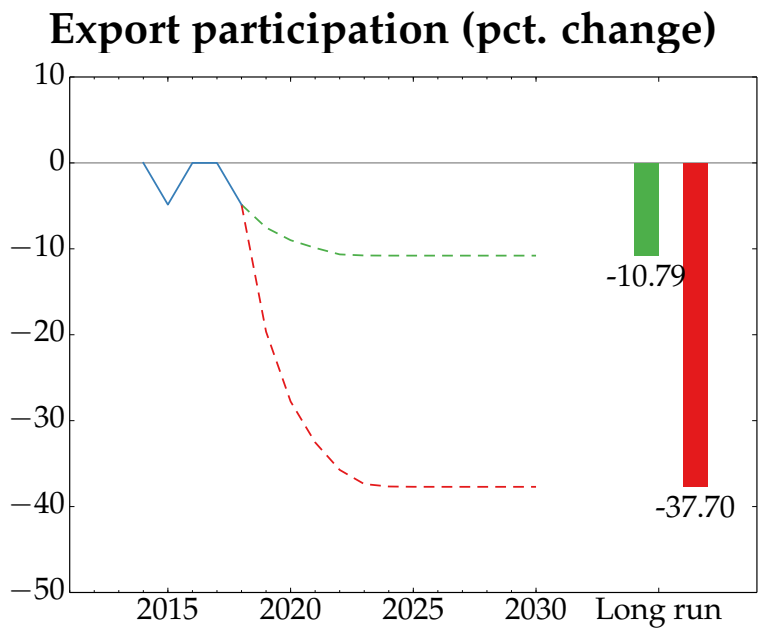
Macroeconomic impact of Brexit

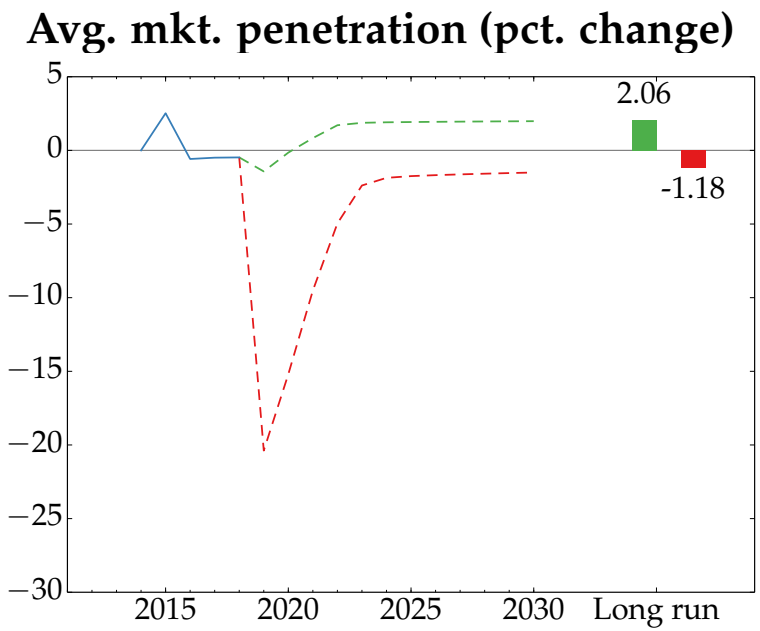




Impact of Brexit on UK imports from EU







Measuring impact of Brexit uncertainty

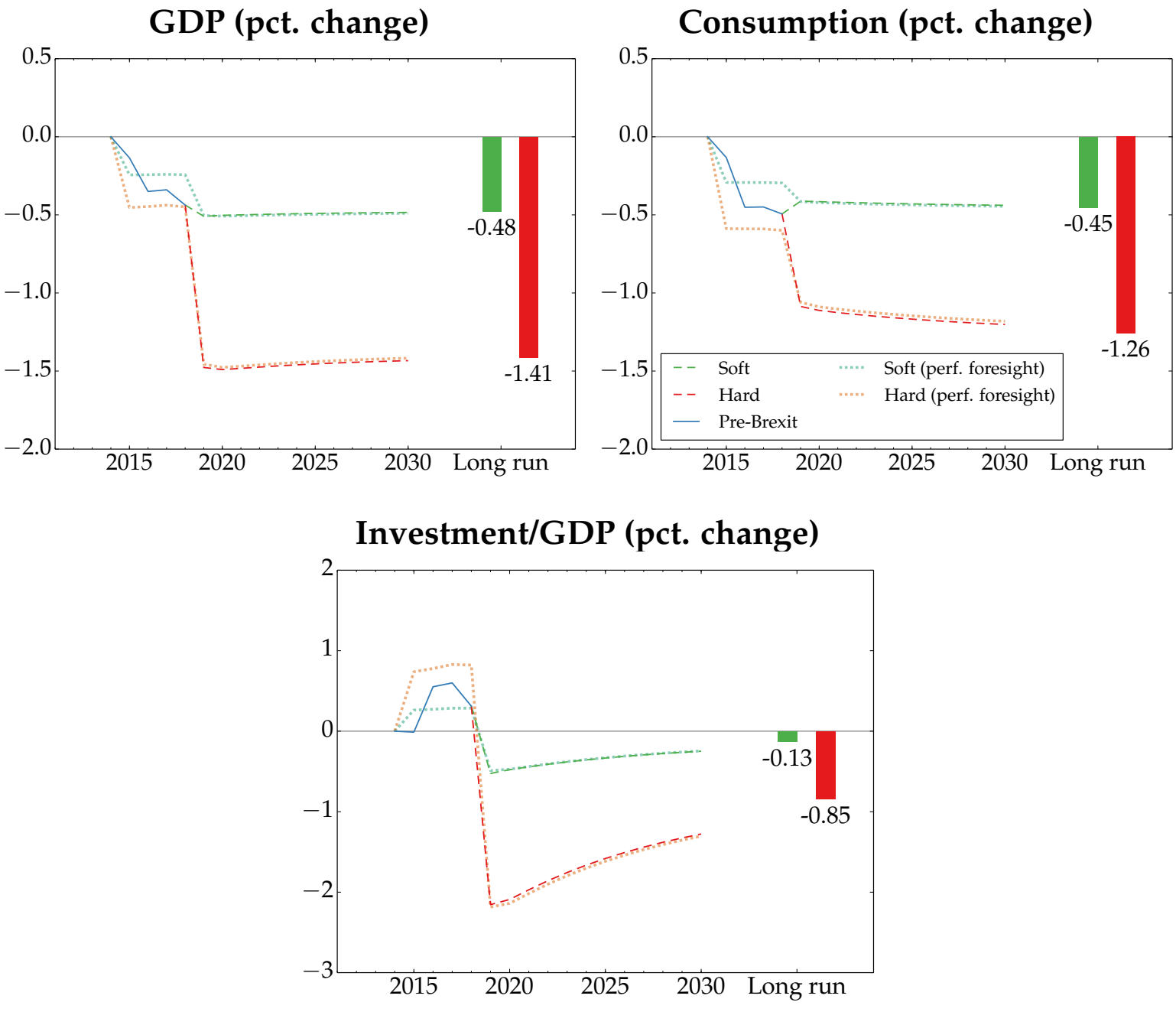
Compare stochastic equilibrium to perfect foresight equilibria

- Households and firms learn outcome of vote and Brexit process (conditional on "leave" vote) immediately in 2015
- One for each branch of uncertainty tree: "stay" vote, soft Brexit, and hard Brexit

Trade costs in perfect-foresight equilibria follow same realized trajectories as in stochastic equilibrium

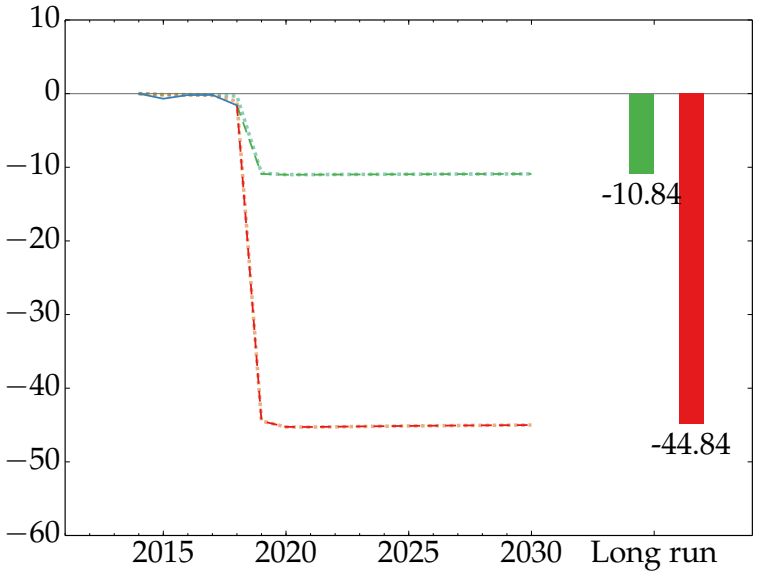
Differences between stochastic and perfect-foresight equilibria are due solely to uncertainty

Macroeconomic impact of Brexit uncertainty

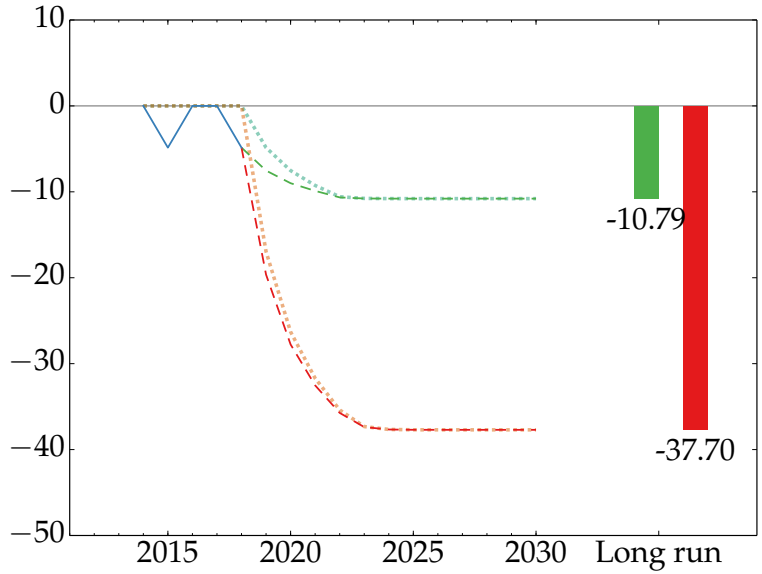


Impact of Brexit uncertainty on UK imports from EU

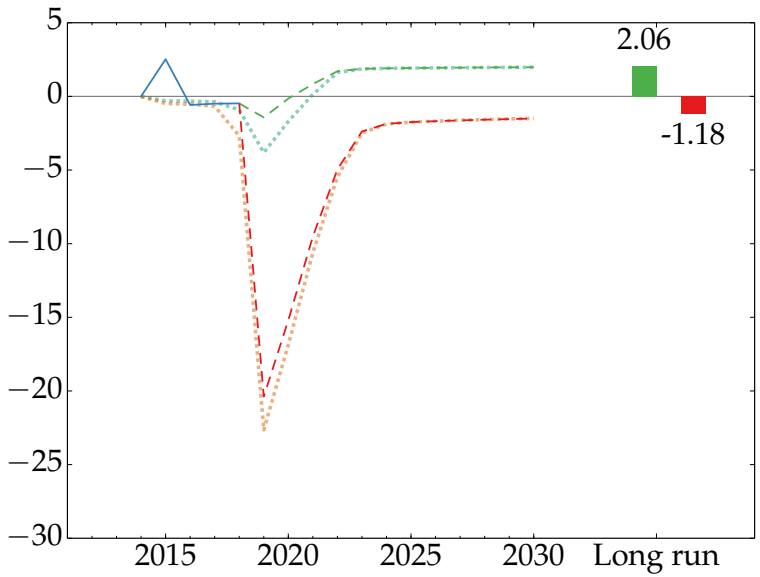
Imports (pct. change)



Export participation (pct. change)



Avg. mkt. penetration (pct. change)



UK welfare losses from Brexit

Total welfare loss: compare with no-Brexit steady state

Cost of uncertainty: compare with perfect-foresight equilibrium

- Similar approach to in Handley and Limaõ (2017)
- How much would households pay to learn whether Brexit will be hard or soft immediately in 2015?

Total (cons. equiv.)		Uncertainty (pct. total)	
Soft	Hard	Soft	Hard
0.44	1.18	0.18	0.24

Present values

- Overall loss: £7,000-19,000 per person
- Loss from uncertainty: less than £50 per person

Alternative scenarios and models

Alternative Brexit scenarios

Baseline analysis assumes:

- Equal chance of soft and hard Brexit
- Non-tariff barriers interpreted as iceberg transportation costs
- Brexit is permanent
- All firms have same increase in trade costs in each outcome

Alternative scenarios:

- Higher probability of soft/hard Brexit
- Interpret non-tariff barriers as marketing costs ($\psi_{d,i}$) instead of iceberg costs
- Additional TPU: reversible Brexit
- Additional TPU: firm-level trade cost uncertainty

UK welfare losses from Brexit in alternative scenarios

	Total (cons. equiv.)		Uncertainty (pct. total)	
Model	Soft	Hard	Soft	Hard
Baseline	0.44	1.18	0.18	0.24
(a) Alternative scenarios				
Lower prob. of hard Brexit	0.44	1.18	0.17	0.24
Higher prob. of hard Brexit	0.44	1.18	0.22	0.24
Increased ad. costs	0.49	1.39	0.25	0.23
Increased ad. costs. and NTBs	0.88	2.07	0.22	0.12
Reversible Brexit (permanent)	0.45	1.18	0.52	0.49
Reversible Brexit (temporary)	0.04	0.11	2.30	0.71
Firm-level trade cost uncertainty	0.45	1.20	0.06	0.10

Alternative models of export participation dynamics

Baseline model nests several common theories of export participation dynamics as special cases:

- $\lambda = 0$: Sunk cost of starting to export (Das et al., 2007)
- $\phi = 0$: Static market penetration decision (Arkolakis, 2010)
- $\lambda, \phi = 0$: Period-by-period fixed cost (Melitz, 2003)
- $\psi_{d,i} \to \infty$: No exporting costs (Armington, 1960)

Also consider Alessandria and Choi (2007) model

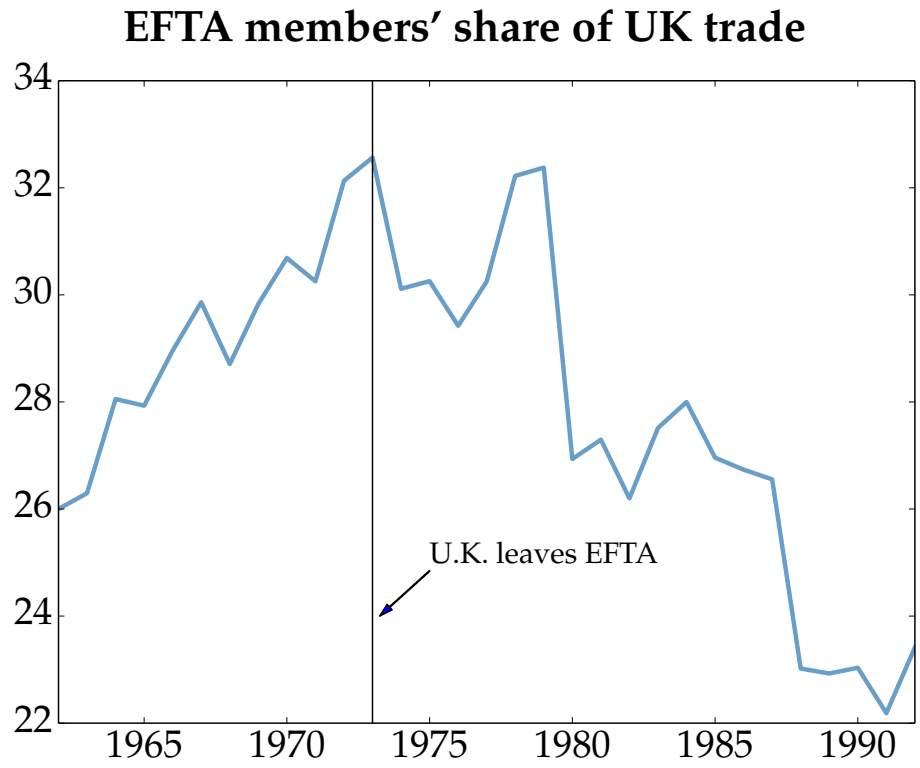
- Idiosyncratic productivity shocks
- Large entry cost, small continuation cost
- Endogenous exit, exporter hysteresis

UK welfare losses from Brexit in alternative models

	Total (cons. equiv.)		Uncertainty (pct. total)	
Model	Soft	Hard	Soft	Hard
Baseline	0.44	1.18	0.18	0.24
(b) Alternative models				
Dynamic sunk cost	0.45	1.19	0.47	0.11
Static mkt. pen.	0.44	1.17	0.17	0.12
Static fixed cost	0.44	1.17	0.12	0.09
No export costs	0.40	1.04	0.14	0.08
Alessandria-Choi	0.48	1.24	0.39	0.09

Conclusion

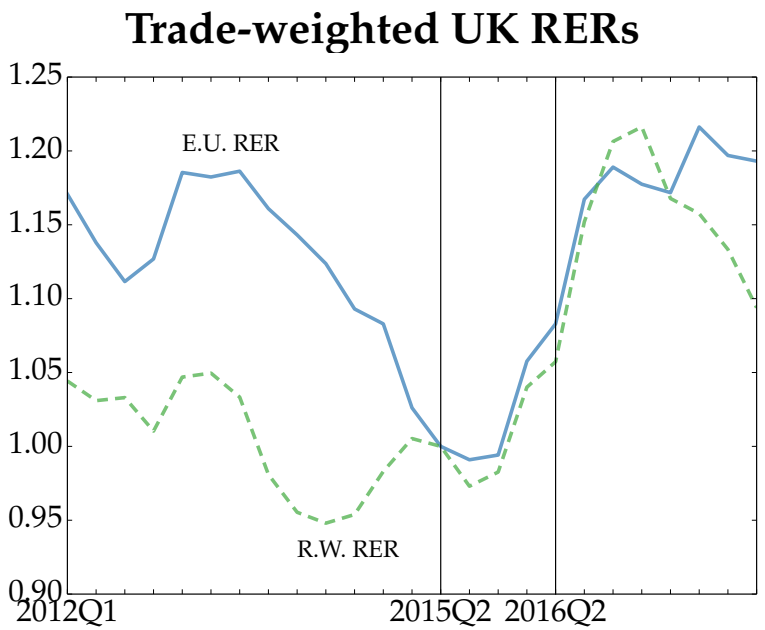
Long-run effects of Brexit vs. EFTA withdrawal

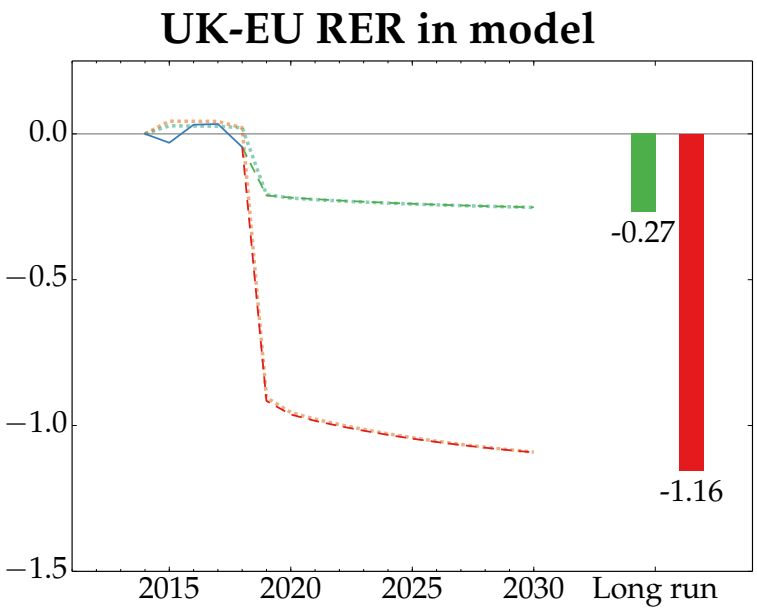


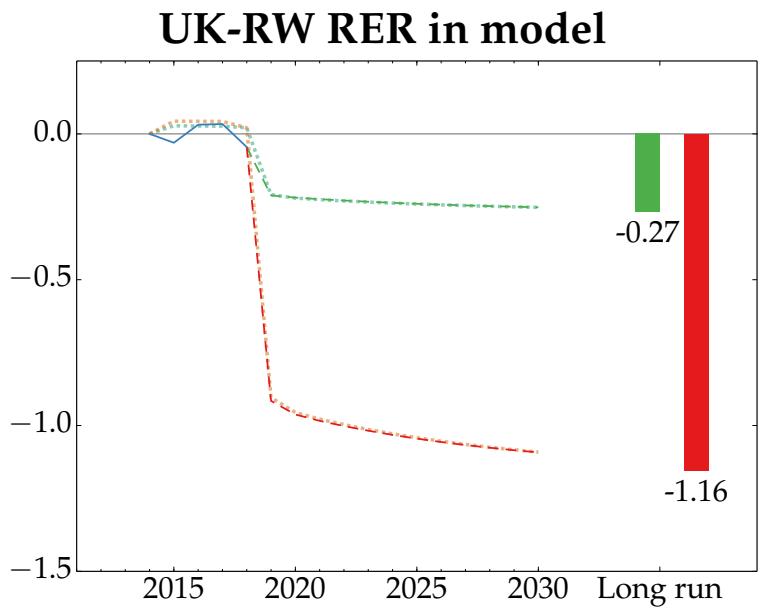
After 1973, EFTA members' share of UK trade fell from 32.6% to 22.2% (drop of 10.4p.p. or 31.9%)

After Brexit, EU share of UK trade falls from 47.1% to 34.6% (drop of 12.5p.p. or 26 .5%)

Pre-Brexit real exchange rate depreciation







Summary

Built dynamic, stochastic GE model to assess impact of Brexit

- Binomial tree process for trade costs with two possible Brexit outcomes: soft and hard
- Heterogeneous firms that make forward-looking, endogenous export participation decisions
- Calibrated no-Brexit steady state to IO table and exporter facts

Main findings:

- Overall cost of Brexit for UK households is large
- Cost of uncertainty about whether Brexit will be hard or soft is small

Results hold under wide range of alternative scenarios and models