THE BREXIT VOTE, PRODUCTIVITY GROWTH AND MACROECONOMIC ADJUSTMENTS IN THE UNITED KINGDOM

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MAIN IDEA OF THIS PAPER

- Examine the adjustments of the UK economy in response to the outcome of the Brexit referendum in June 2016
- Interpret these adjustments economically
  - Can be conceptualized based on rational responses of firms and households to negative news about productivity growth in the tradable sector

CONTRIBUTION OF THIS PAPER

1. Document stylized facts about UK macroeconomic adjustments to referendum
   - Novel quarterly data for tradable and non-tradable sectors → **available online!**
2. Introduce a two-sector small open economy model featuring tradable and non-tradable production, where sectors can grow at different speeds
   - Estimate the model using the newly constructed data
3. Conduct Brexit simulation experiments in estimated model
   - Productivity news mechanism generates key empirical adjustment patterns
4. Discuss how specific consequences of Brexit are drivers of productivity growth in the UK tradable sector

MAIN CHANNEL

- Suppose agents learn that productivity growth in T sector is weaker in the future
- Upon announcement: expansion in T sector and a contraction in N sector
  - $\Rightarrow$ immediate fall in relative price of N goods
  - $\Rightarrow$ opportunity to sell T goods at higher price: temporary "sweet spot"
  - $\Rightarrow$ resources are shifted towards T sector, away from N sector
  - $\Rightarrow$ sectoral investment falls, labor market remains robust
  - $\Rightarrow$ the return on domestic bonds falls sharply
- Once news materialize: T sector productivity growth declines
  - $\Rightarrow$ reversal of resource flow towards the non-tradable sector

INTERPRETING THE REFERENDUM OUTCOME AS "ONE SHOCK"

- Our interpretation: Brexit news $\approx$ productivity growth in $T \downarrow$
- Our simulations show that other types of shocks do not generate the empirically observed adjustment patterns
  - E.g. persistent interest rate drop only generated by shock to growth rate rather level
- Drivers behind tradable productivity map into specific Brexit consequences
  1. Barriers to trade in goods and services
  2. Reduced capital flows
  3. Lower labor mobility

  $\Rightarrow$ "Deglobalization shock" (Gourinchas and Hale, 2017)

RELATED LITERATURE

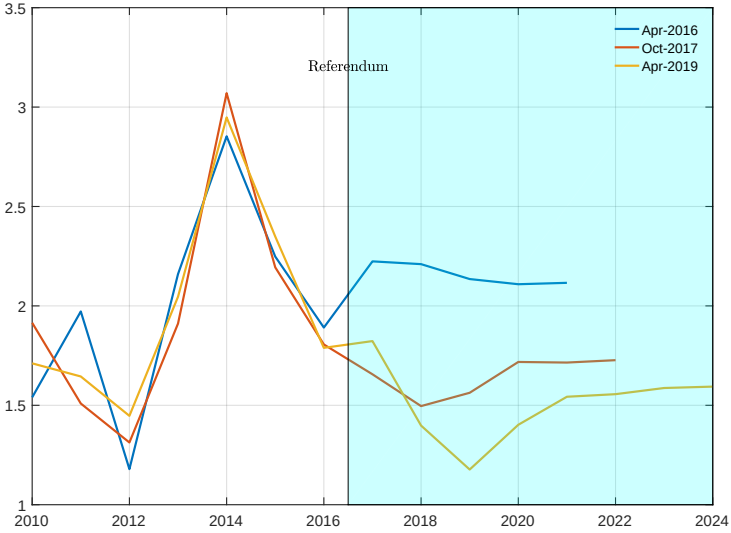
- **Effects of Brexit:**
  - *Synthetic control approach.* Born et al. (2018)
  - *Long-run trade.* Dhingra et al. (2017), Sampson (2017), McGrattan Waddle (2017)
  - *Uncertainty.* Steinberg (2017), Bloom et al. (2018), Faccini and Palombo (2019)
  - *News and asset prices.* Broadbent (2017a, 2017b) and Davis and Studnicka (2018)
- **Calibration of models with T&N sectors:**
  - De Gregorio et al. (1994), Betts and Kehoe (2006), Lombardo and Ravenna (2012)
- **Small open economy models with shocks to growth rate:**
  - Aguiar and Gopinath (2017), Drechsel and Tenreyro (2018)
- **News shocks:**
  - Beaudry and Portier (2006), Jaimovich and Rebelo (2009), several others

PLAN FOR REST OF THE TALK

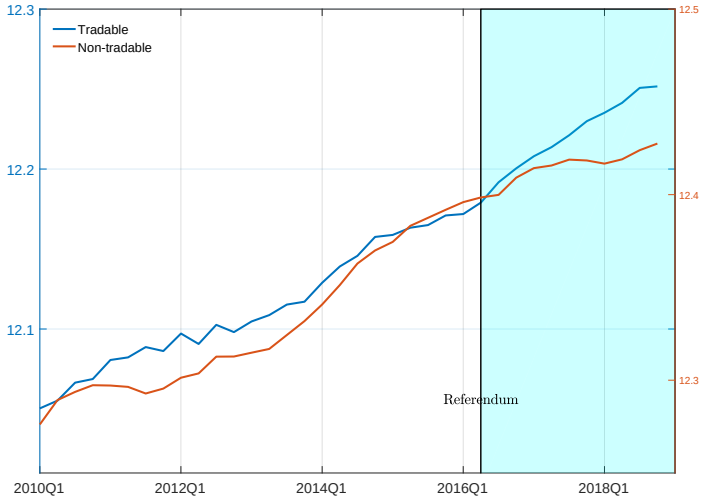
1. Stylized facts
2. Two sector SOE model
3. Data and estimation
4. Main Brexit simulation
5. Robustness exercises and responses to other shocks
6. Discuss drivers of tradable sector productivity growth
7. Conclusion

STYLIZED FACTS

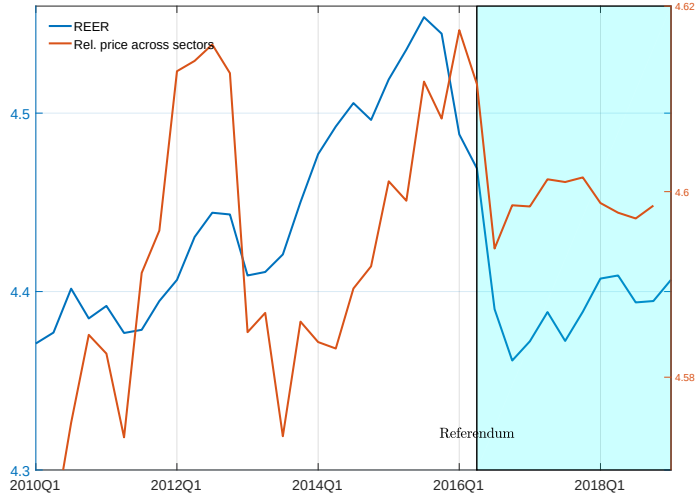
DOWNWARD GROWTH REVISIONS (IMF)



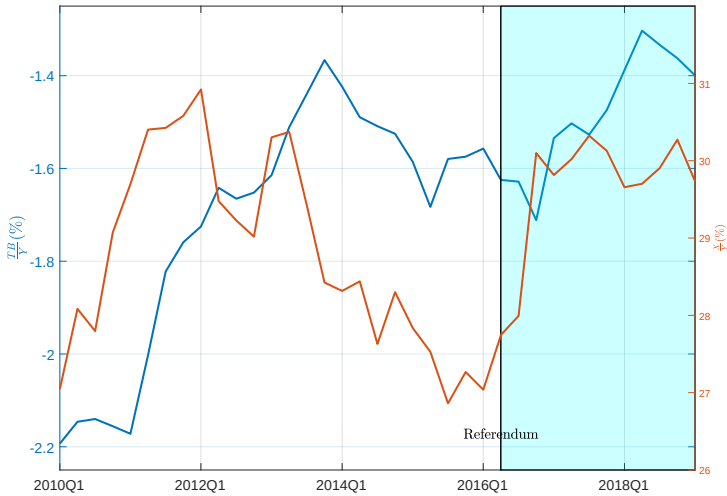
SECTORAL GROSS VALUE ADDED



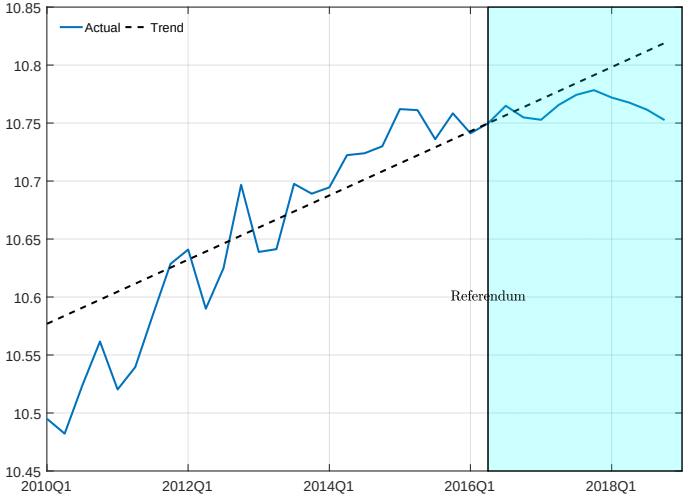
REER AND RELATIVE PRICE ACROSS SECTORS



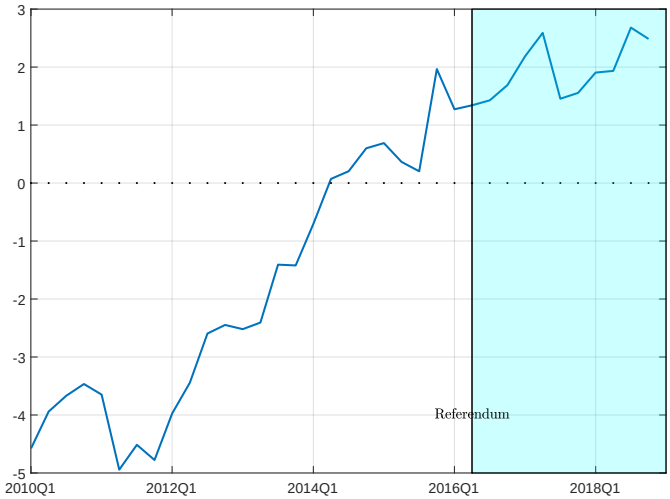
EXPORTS AND TRADE BALANCE



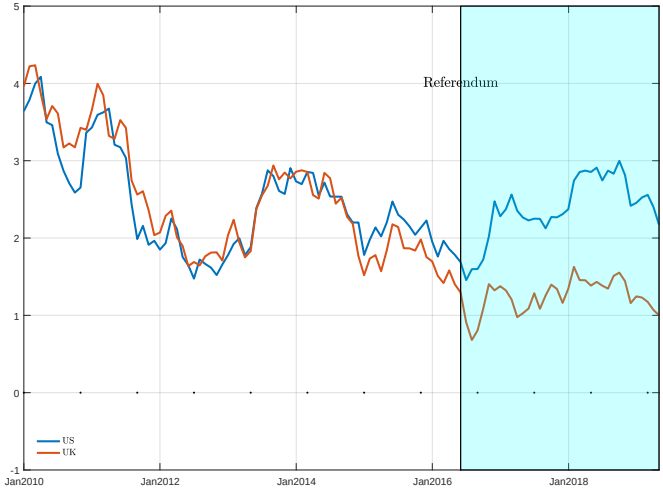
AGGREGATE INVESTMENT



AGGREGATE HOURS



10-year zero-coupon yields



RECAP OF EMPIRICAL FACTS

- UK macroeconomic activity has slowed relative to pre-referendum expectations
- Growth in tradable sector has remained resilient, slowdown non-tradable sector
- The British pound has been subject to a pronounced depreciation
  - With it the relative price of non-tradables
- Exports have been growing robustly
- Weak aggregate investment, little change in aggregate hours
- UK interest rates have declined relative to their world (US) counterpart

THE MODEL

MAIN FEATURES

- Small Open Economy RBC model
- Two sectors: T and N
- Each sector $M = \{T, N\}$ grows at its own rate g_M
- Labour and capital are sector-specific
- Treat tradable price as numeraire

  $\Rightarrow P_{N,t} = P_t \approx$ real exchange rate
- Assets: bond denominated in T units, bond denominated in N units and bond denominated in composite bundle

- The production function in sector M is given by

$$Y_{Mt} = a_{Mt} K_{Mt}^{\alpha_M} (X_{Mt} n_{Mt})^{1-\alpha_M},$$

$$\ln a_{Mt} = \varrho_M^a \ln a_{Mt-1} + \varepsilon_{Mt}^a, \quad \text{with} \quad \varepsilon_{Mt}^a \sim \mathbb{N}(0, \varsigma_M^a)$$

- The growth rate of sectoral productivity is defined as

$$g_{Mt} = \frac{X_{Mt}}{X_{Mt-1}},$$

$$\ln (g_{Mt}/\bar{g}_M) = \varrho_M^g \ln (g_{Mt-1}/\bar{g}_M) + \varepsilon_{Mt}^g, \quad \text{with} \quad \mathbb{N}\left(0, \varsigma_{MT}^g\right)$$

HOUSEHOLDS

- Household's preferences are specified as in GHH

$$\mathcal{U}_t = \left[C_t - X_{Tt-1}\omega^{-1}\left(\theta_T n_{Tt}^{\omega} + \theta_N n_{Nt}^{\omega}\right)\right]^{1-\gamma} / (1-\gamma),$$

where C_t is CES aggregator

$$C_t = \left[\zeta^{1-\sigma} C_{Tt}^{\sigma} + (1-\zeta)^{1-\sigma}\left(\frac{X_{Tt-1}}{X_{Nt-1}} C_{Nt}\right)^{\sigma}\right]^{\frac{1}{\sigma}}$$

- Budget constraint

$$\sum_{M=\{T,N\}} P_{Mt}\left[C_{Mt} + I_{Mt} + \Phi_M(K_{M,t+1}, K_{M,t})\right] + B_t^* + P_t B_t + P_t Y_{Nt}\frac{s}{y} s_t$$
$$= \sum_{M=\{T,N\}}\left[P_{Mt} r_{Mt}^M K_{Mt} + W_{Mt} n_{Mt}\right] + \frac{B_{t+1}^*}{1+r_t^*} + P_t \frac{B_{t+1}}{1+r_t}$$

CLOSING THE ECONOMY

- The interest rate on the T-denominated bond is given by

$$r_t^* = \bar{r}^* + \psi\left(e^{B_{t+1}^*/X_{Tt}-\bar{b}^*} - 1\right) + (e^{\mu_t - 1} - 1)$$

  - Results unaffected by the way we close economy (Schmitt-Grohe and Uribe, 2003)

- Market clearing

$$Y_{Tt} = C_{Tt} + I_{Tt} + \frac{\phi_T}{2}\left(\frac{K_{Tt+1}}{K_{Tt}} - \bar{g}_T\right)^2 + TB_t$$

$$Y_{Nt} = C_{Nt} + I_{Nt} + \frac{s}{y}Y_{Nt}s_t + \frac{\phi_N}{2}\left(\frac{K_{Nt+1}}{K_{Nt}} - \bar{g}_N\right)^2$$

$$TB_t = B_t^* - \frac{B_{t+1}^*}{1 + r_t^*}$$

KEY EQUATIONS

- The detrended bond Euler equations

$$\lambda_t \nu_t = \beta \left(1 + r_t^*\right) g_{Tt}^{-\gamma} \mathbb{E}_t \lambda_{t+1} \nu_{t+1}$$

$$\lambda_t \nu_t p_t = \beta \left(1 + r_t\right) \frac{g_{Tt}^{1-\gamma}}{g_{Nt}} \mathbb{E}_t p_{t+1} \lambda_{t+1} \nu_{t+1}.$$

- The relative price can be written as

$$p_t = \frac{c_{T,t}}{c_{N,t}} \frac{1 - \frac{c_{T,t}}{\mathcal{C}_t}}{\frac{c_{T,t}}{\mathcal{C}_t}}$$

- p_t is related to MRS between sectors and forward-looking Euler equations
- Shocks to $g_{T,t+j}$ will affect p_t today

- Central to our mechanism: movement of relative price and relative returns across the non-tradable and tradable sector
- These movements unfold ...
  - ... across time: Euler equations
  - ... across sectors: substitution across goods
- In the paper, we also present a two-period endowment version of the model, in which we show analytically:

$$\frac{\partial r_N}{\partial g_T'} > 0 \quad \text{and} \quad \frac{\partial p}{\partial g_T'} > 0$$

OUR STRATEGY

- We first estimate the model at business cycle frequencies to pin down starting point of our simulations (parameters and balanced growth path)
- Use novel data on sectoral productivity and the relative price of N output
- Based on estimated parameters, conduct Brexit experiment
  - Feed in news about productivity growth rate in T sector

DATA AND ESTIMATION

DATA AND ESTIMATION

- Construct time-series data for T and N Gross Value Added and labor productivity
  - Classify 2-digit SIC sectors into T and N using supply and use tables for 1997-2016 (Lombardo and Ravenna, 2012) ▸ sut2016
  - Chain-link detailed industry data using the standard ONS methodology and add up sectoral hours
- This is a novel data set for the UK
  - Same data we use for some of the stylized facts
  - **Now available online!**

TABLE: Industries shares in non-tradable and tradable sector (%)

	Non-tradable	**Tradable**
Agriculture	0.07	1.35
Mining and Quarrying	0.00	2.29
Manufacturing	0.89	20.99
Electricity, Gas, Steam Air Conditioning	3.19	0.00
Water Supply, Sewage, Waste Mgmt	1.07	0.91
Construction	10.93	0.00
Services	83.85	74.46

DATA AND ESTIMATION

- The model is estimated with Bayesian techniques
- Use aggregate UK time-series data from 1987Q3 - 2016Q2 (period during which the UK was a full member of the EU)
- This estimation procedure gives us:
  - Values for the structural parameters
  - A balanced growth path from which we can start simulations

OBSERVABLES FOR ESTIMATION

- **New time-series.** Quarterly growth rates of sectoral labor productivity and of the relative price of non-tradable goods ▸ GVA ▸ SecLabProdREER
- **Traditional macro variables: shares.** Consumption, investment and trade balance (as nominal shares of GDP)
  $\Rightarrow$ sample averages of nominal ratios are correctly pinned down
- **Traditional macro variables: other.** Quarterly growth rate of the real effective exchange rate and total hours
- Not all series available over full sample: handle with Kalman filter

STRUCTURAL SHOCKS

- Sectoral productivity shocks to level and growth rates, risk-premium shock, government spending shock, foreign interest rate shock, exchange rate shock
  - No news shock in the estimation
- Introduce measurement errors for each of the constructed observables
- Also look at alternative shocks and explain how they generate different dynamics

CALIBRATED PARAMETERS

Parameter	Source	Period	Value
θ_T	ONS& own calcs	$1994-2016$	$n_T/n = 0.5$
θ_N	ONS & own calcs	$1994-2016$	$n_N/n = 0.5$
$\frac{s}{y}$	ONS & own calcs	$1987-2016$	0.184
$\frac{tb}{y}$	ONS & own calcs	$1987-2016$	-0.015
δ_M	ONS & own calcs	$1987-2016$	$i/y = 0.181$
$\bar{g}_T$	ONS & own calcs	$1987-2016$	1.83%
$\bar{g}_N$	ONS & own calcs	$1987-2016$	1.02%
σ	mid-range estimate		-0.5
β			$r^* = 0.01$
ψ			5×10^{-6}
ϕ_N			4
γ			2

▸ shares

POSTERIOR MEAN ESTIMATES

			90% HPDI	
Parameter	Distribution	Mean	Lower	Upper
Structural parameters				
$c_T/\mathcal{C}$	Gaussian	0.59	0.57	0.61
ω	Gaussian	1.99	1.85	2.13
α_T	Gaussian	0.31	0.30	0.32
α_N	Gaussian	0.25	0.24	0.26
ϕ_T	Gaussian	9.65	8.45	10.85
Selected Shocks				
ς_N^g	Inv. Gamma	0.014	0.012	0.016
ς_T^g	Inv. Gamma	0.014	0.012	0.016
ς_T^a	Inv. Gamma	0.013	0.011	0.015
ς_N^a	Inv. Gamma	0.013	0.011	0.012
ϱ_N^g	Beta	0.25	0.07	0.43
ϱ_T^g	Beta	0.15	0.04	0.25
ϱ_N^a	Beta	0.75	0.58	0.93
ϱ_T^a	Beta	0.97	0.95	0.99

BREXIT SIMULATIONS

THE BREXIT EXPERIMENT

- The economy starts on its balanced growth path in period 0
- In period 1, it is revealed that there will be a persistent reduction in tradable sector TFP growth from period 11
  - Mimics period between EU referendum and (unmet) Brexit deadline of March 2019
- Upon arrival of news, households see full future path of productivity growth in T
  - *No uncertainty* ("MIT shock")
- The economy converges in the long-run to the same balanced growth path

CALIBRATION

- Calibrate scale of shock using studies of the potential Brexit effects

Study	Estimated reduction in trade, %	Estimated reduction in GDP, %
Ebell and Warren (2016)	21–29	2.7–3.7
IMF (2018)		5.2–7.8
Kierzenkowski et al (2016)	10–20	2.7–7.5
UK Government (2018)	13–18	6.3–10.7

- We calibrate our experiment so trade falls by 10% (conservative estimate)
- Our long-impact on GDP is 3% consistent with 0.3 trade elasticities

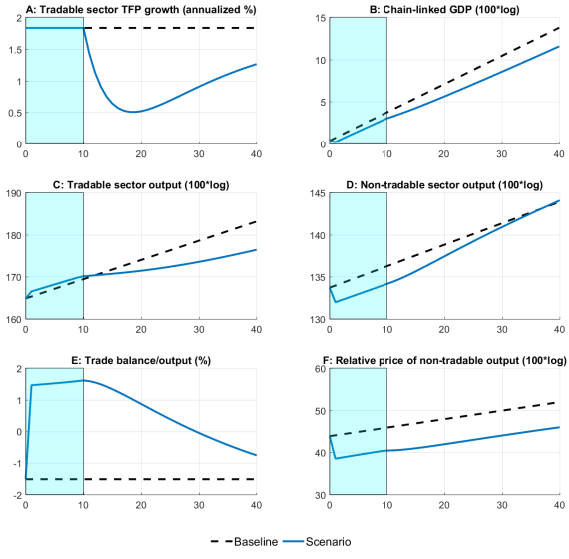
- In our scenario, the growth rate of LAP in T is determined by:

$$\begin{aligned}\ln(g_{Tt}) &= \varrho_T^g \ln(g_{Tt-1}) + \left(1-\varrho_T^g\right)\ln(\widetilde{g}_{Tt}) \\ \ln(\widetilde{g}_{Tt}) &= \widetilde{\varrho}_T^g \ln(\widetilde{g}_{Tt-1}) + \left(1-\widetilde{\varrho}_T^g\right)\ln(\bar{g}_T) + \varepsilon_{Tt}^g,\end{aligned}$$

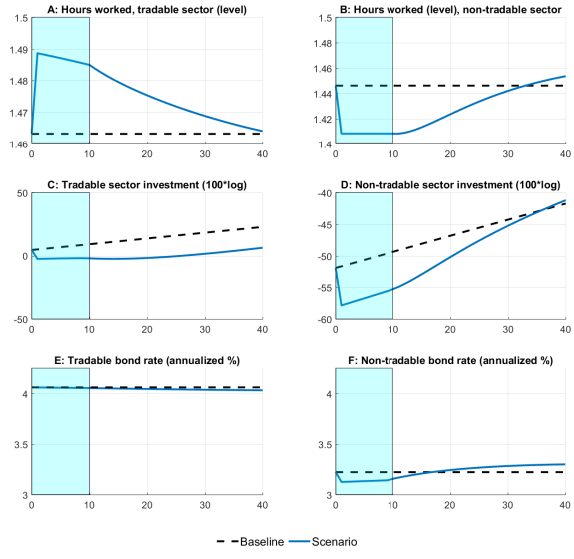
  where $\widetilde{\varrho}_T^g > \varrho_T^g$ so that $\widetilde{g}_{Tt}$ represents the persistent component

- We set $\widetilde{\varrho}_T^g = 0.95$ and $\varrho_T^g = 0.8$
  - Initial fall in T productivity growth is gradual
  - Level of productivity level back on BGP after about 30 years

EFFECT ON AGGREGATES



EFFECT ON INPUT FACTORS AND BOND RATES

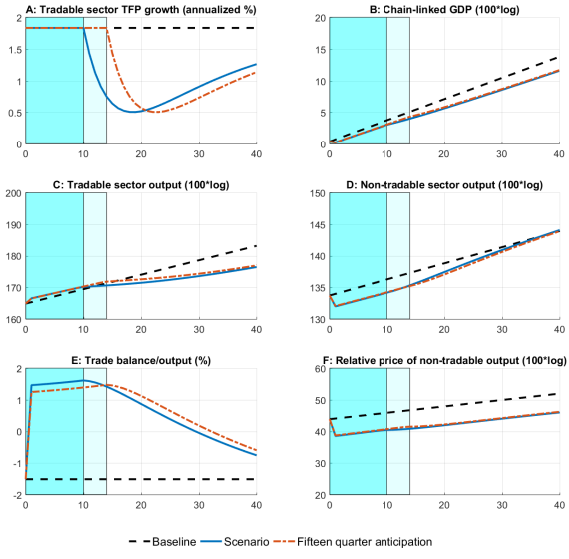


MACRO ADJUSTMENTS IN THE UK

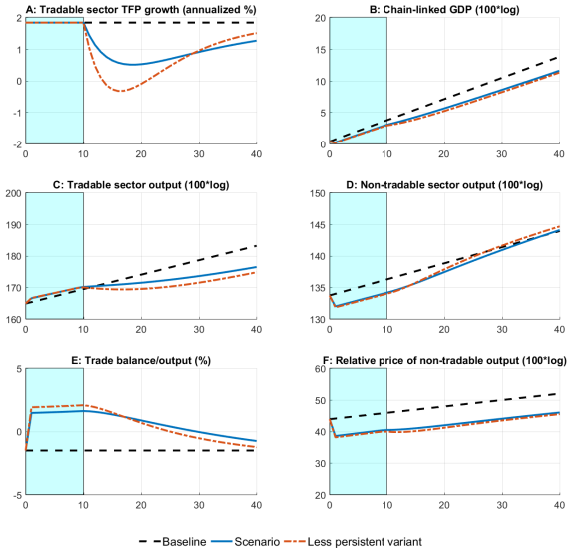
- Model responses in line with the empirical adjustment patterns
  - GDP growth in the UK slows down since the referendum vote
  - The relative price of non-tradables falls permanently
  - Growth rate of the T sector increases relative N sector
  - Exports increase after the referendum, creating a *sweet spot*
  - Bond return denominated in terms of N goods falls on impact
  - Sectoral investment falls and labor market remains resilient

ROBUSTNESS EXERCISES AND COMPARISON WITH OTHER STRUCTURAL SHOCKS

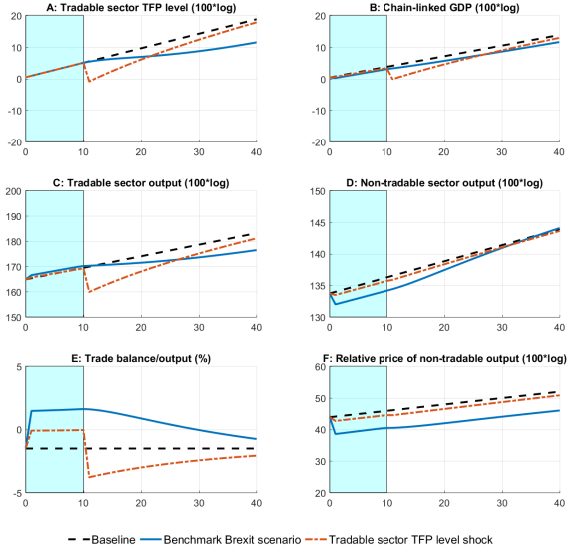
LONGER ANTICIPATION PHASE



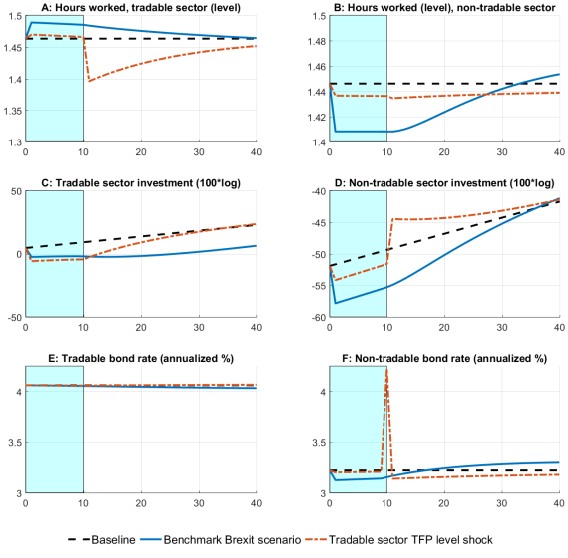
LESS PERSISTENCE IN BREXIT SHOCK



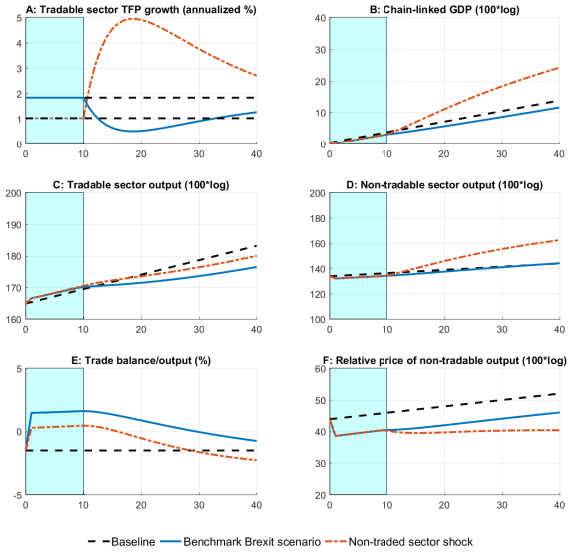
LEVEL RATHER THAN GROWTH RATE SHOCK IN T



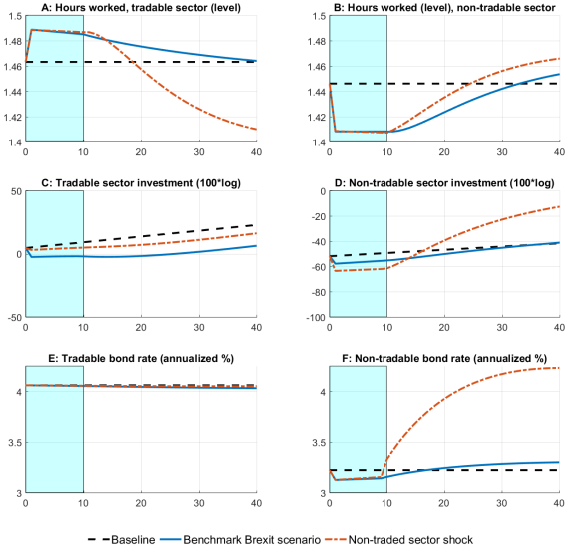
LEVEL RATHER THAN GROWTH RATE SHOCK IN T



RISE IN PRODUCTIVITY GROWTH IN N RATHER THAN FALL IN T



RISE IN PRODUCTIVITY GROWTH IN N RATHER THAN FALL IN T



WHY OTHER SHOCKS DO NOT MATCH THE EMPIRICS

- Level rather than growth rate shock in T
  - Generates a short-lived interest rate differential exactly when the shock materializes
  - Inconsistent with the persistent decoupling of UK from world interest rates in the data immediately after the referendum
- Rise in productivity growth in N rather than fall in T
  - To generate the on-impact reduction in the relative price of non-tradable goods, a (perhaps implausibly) large increase in productivity growth in N-sector is required
  - Shock implies a large long-run expansion in GDP as well as a large increase in domestic rate $\rightarrow$ difficult to find theoretical arguments in support
- A number of other shocks also do not generate the observed adjustment
  - Preference shocks, government spending shocks, risk premium shock, ...

DISCUSSION: DRIVERS OF PRODUCTIVITY GROWTH IN THE TRADABLE SECTOR

DRIVERS OF PRODUCTIVITY GROWTH IN THE TRADABLE SECTOR

- Our interpretation: Brexit news $\approx$ productivity growth in $T \downarrow$
- Simulations show that this shock generates the empirically observed adjustment patterns, other structural shocks do not
- Final part of the paper: show that economic drivers behind tradable productivity map into specific Brexit consequences that commentators have pointed to
  - Trade barriers, capital flows, labor mobility
  - This lends further support to our overall interpretation of the adjustments

DRIVERS OF PRODUCTIVITY GROWTH IN THE TRADABLE SECTOR

1. Barriers to trade in goods and services
   - Classic theories about how trade barriers endogenously determine the rate of growth of an economy, e.g. Grossman and Helpman (1989, 1991)
   - Growth-enhancing resources in the UK's tradable sector may have to be diverted to import substitution after Brexit $\Rightarrow$ future $g_T \downarrow$
2. Reduced capital flows
   - Less FDI, fewer technological spillovers, see e.g. McGrattan and Waddle (2020)
   - May reduce technology capital investments in tradable activities $\Rightarrow$ future $g_T \downarrow$
3. Lower labor mobility
   - Portes and Forte (2017): potential restrictions on movement of workers will likely have a significant negative impact on UK growth and productivity $\Rightarrow$ future $g_T \downarrow$

$\Rightarrow$ "Deglobalization shock" (Gourinchas and Hale, 2017)

CONCLUSION

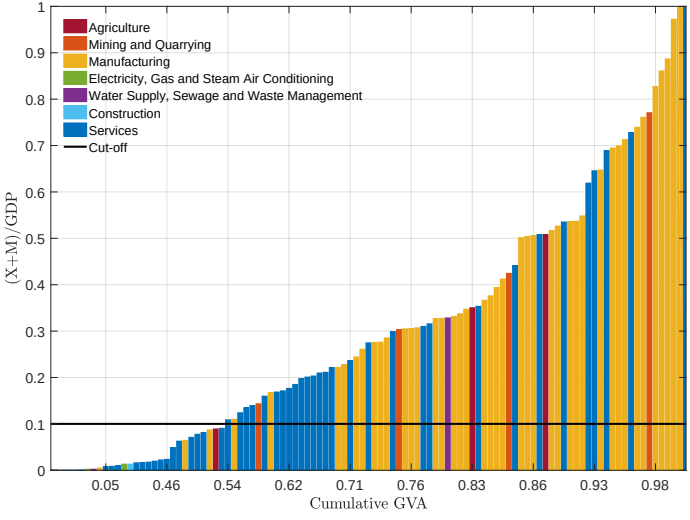
CONCLUSION

- Document the UK's macroeconomic adjustments to the 2016 referendum
- Interpret referendum negative news about the tradable sector
- Observed responses are consistent with this theoretical rationalization
- Central to the mechanism:
  - Immediate permanent drop in relative price of nontradables
  - "Sweet spot" for tradable producers
  - Fall in domestic interest rate
  - Resource reallocation during the anticipation phase
  - Reversal upon the realisation of the shock

APPENDIX SLIDES

INDUSTRY CLASSIFICATION (SUT 2016)

GOBACK



SHARES

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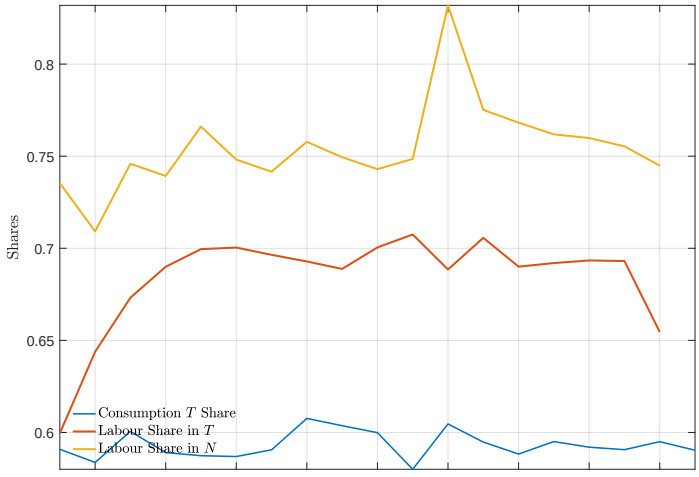

RELATIVE LABOR PRODUCTIVITIES

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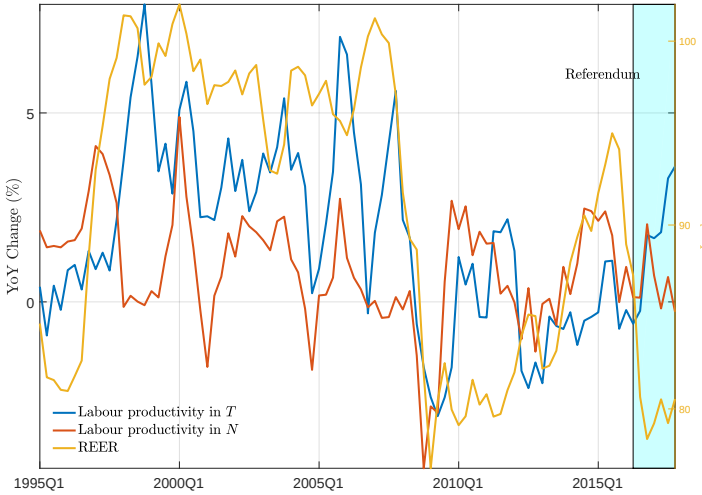
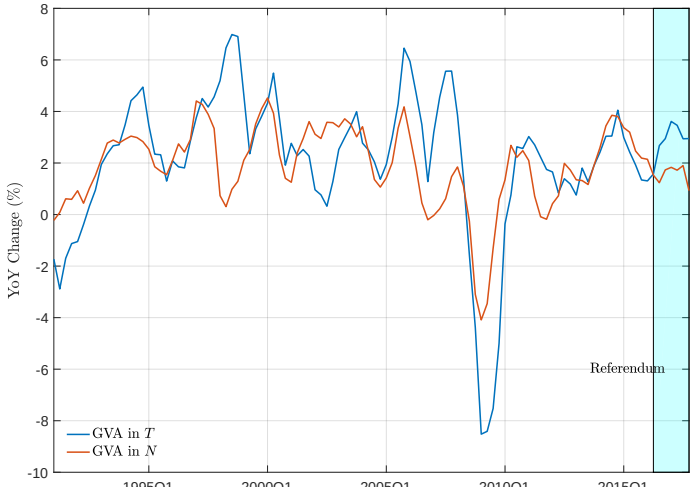


GVA

GOBACK


YoY Change (%)
8
6
4
2
0
-2
-4
-6
-8
-10
1995Q1
2000Q1
2005Q1
2010Q1
2015Q1
Referendum
GVA in T
GVA in N