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

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The views expressed here are those of the authors and they do not necessarily reflect the official position of the Bank of England
Examine adjustments in the UK economy in response to the *outcome* of the Brexit referendum

Rationalise the outcome of the Brexit vote as a hit to expected supply

⇒ Negative *news* about the productivity growth in tradable sector

⇒ How did household and firms respond to Brexit news?

⇒ Focus on *one channel* but there are others

Formalise this idea by developing and estimating a Small Open Economy (SOE-RBC) model
CONTRIBUTION OF THIS PAPER

1. Document a set of stylized facts about UK macroeconomic developments after the referendum
   ▶ Novel quarterly data for tradable and non-tradable sectors

2. Introduce a two-sector small open economy model featuring tradable and non-tradable production
   ▶ Sectors allowed to grow at different rates

3. Estimate the model using the newly constructed data

4. Conduct Brexit simulation experiments in estimated model
   ▶ Characterize mechanism that generates the key patterns in the UK economy following the referendum
Suppose agents learn that productivity growth in $T$ sector is weaker in the future

Upon announcement: mild expansion in $T$ sector and a contraction in $N$ sector during anticipation phase

- immediate fall in relative price of $N$ goods
- opportunity to sell at higher price: temporary “sweet spot”
- resources are shifted towards $T$ and away from $N$ sector
- sectoral investment falls and performance of labour market remains robust
- the return on domestic bonds falls sharply, while the return on international bonds shows a small decline

Once news materialize: $T$ sector productivity growth declines

- Reversal of resource flow towards the non-tradable sector
RELATED LITERATURE


▶ Macro-adjustments of Brexit/Trade Policy.
  ▶ News and asset prices. Broadbent (2017a, 2017b) and Davis and Studnicka (2018)


GDP GROWTH FORECAST ERRORS

Referendum
DOWNWARD GROWTH REVISIONS (IMF)
SECTORAL GROSS VALUE ADDED

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<thead>
<tr>
<th>Year</th>
<th>Tradable</th>
<th>Non-tradable</th>
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Referendum
RELATIVE PRICE AND REER

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Referendum
SWEET SPOT

Referendum
AGGREGATE INVESTMENT

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<th>Trend</th>
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<td>2016Q1</td>
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<tr>
<td>2018Q1</td>
<td>10.65</td>
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Referendum
10-YEAR ZERO-COUPON YIELDS

Referendum

Jan2010 Jan2012 Jan2014 Jan2016 Jan2018

US

UK
RECAP OF EMPIRICAL FACTS

- UK macroeconomic activity has slowed relative to expectations (pre-referendum) trend
- Growth in tradable sector has remained resilient, marked 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.
MAIN FEATURES

- Small Open Economy RBC model, featuring $T$ and $N$ production

- Each sector $M = \{T, N\}$ grows at its own rate $g_M$

- Tradable good as numeraire

- Labour and capital are sector-specific

- Two bonds: indexed to $T$ prices and indexed in $N$ prices (in zero net supply)
The production function in sector $M$ is given by

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

$$\ln a_{Mt} = \varrho^a \ln a_{Mt-1} + \varepsilon^a_{Mt}, \quad \text{with} \quad \varepsilon^a_{Mt} \sim \mathcal{N}(0, \varsigma^a_M)$$

The growth rate of sectoral labor-augmenting productivity is defined as

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

and follows an autoregressive process of the form:

$$\ln \left(\frac{g_{Mt}}{\bar{g}_M}\right) = \varrho^g \ln \left(\frac{g_{Mt-1}}{\bar{g}_M}\right) + \varepsilon^g_{Mt}, \quad \text{with} \quad \mathcal{N}(0, \varsigma^g_{MT})$$
Household’s preferences are specified as in GHH

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

where \( C_t \) is defined as

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

The budget constraint (\( P_{T,t} = 1 \) and \( P_{N,t} = P_t \))

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

- The interest rate on the foreign (tradable) 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 are unaffected by the way we close the Open Economy model (Schmitt-Grohe and Uribe (2003))

- Market clearing entails

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

\[ Y_{Nt} = C_{Nt} + I_{Nt} + \frac{s}{y} Y_{Nt} s_t + \frac{\phi_N}{2} \left( \frac{K_{Nt+1}}{K_{Nt}} - \bar{g}_N \right)^2 K_{Nt} \]
The detrended Euler equations w.r.t. bonds

\[ \lambda_t \nu_t = \beta (1 + r^*_t) g_{Tt}^{-\gamma} E_t \lambda_{t+1} \nu_{t+1} \]

\[ \lambda_t \nu_t p_t = \beta (1 + r_t) \frac{g_{Tt}^{1-\gamma}}{g_{Nt}} E_t p_{t+1} \lambda_{t+1} \nu_{t+1}. \]

The relative price can also be written as

\[ p_t = \frac{c_{T,t}}{c_{N,t}} \frac{1 - \frac{c_{T,t}}{C_t}}{\frac{c_{T,t}}{C_t}} \]

\( p_t \) is related to marginal rate of substitution between sectors, and to Euler equations

Shocks to \( g_{T,t+j} \) will affect \( p_t \) today
OUR STRATEGY

- We first estimate the model at *business cycle frequencies* to pin down starting point of our simulations.

- To estimate the model, we use new data on *sectoral productivity* and the *relative price of* $N$.

- Following CET (2015), we employ *nominal ratios* as observable variables given that numeraire is the $T$ good.

- Using the estimated parameter values, we conduct a Brexit experiment:
  - Brexit as an (MIT) news shock about the growth rate in LAP in the $T$ sector.
We construct time-series data for $T$ and $N$ Gross Value Added (GVA) and labor productivity.

- We first classify sectors into $T$ and $N$ aggregates using SUT (1997-2016) (Lombardo and Ravenna (2012)).
- Note that financial services listed as $T$.
- We chain-link detailed industry data using the standard ONS methodology and add up sectoral hours.

The model is estimated using Bayesian techniques.

Aggregate UK time-series data from 1987Q3 to 2016Q2.
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 productivity growth from period 11 onwards (a period is a quarter)
- Upon arrival of news, households see the full future path of productivity growth in $T$ (MIT shock), no uncertainty
- This anticipation horizon mimics the length of period between EU referendum and the unmet Brexit deadline of March 2019
- The economy converges in the long-run to the same balanced growth path but shocks have permanent effects
CALIBRATION

- We calibrate the scale of the shock using existing studies of the potential effects of Brexit on trade

- **WTO rules:**
  1. comparative reasons (not the most likely ex-post)

<table>
<thead>
<tr>
<th>Study</th>
<th>Estimated reduction in trade, %</th>
<th>Estimated reduction in GDP, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ebell and Warren (2016)</td>
<td>21–29</td>
<td>2.7–3.7</td>
</tr>
<tr>
<td>IMF (2018)</td>
<td>5.2–7.8</td>
<td></td>
</tr>
</tbody>
</table>

- 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 the following equations:

$$\ln (g_{Tt}) = \varrho^g_T \ln (g_{Tt-1}) + (1 - \varrho^g_T) \ln (\tilde{g}_{Tt}),$$

$$\ln (\tilde{g}_{Tt}) = \tilde{\varrho}^g_T \ln (\tilde{g}_{Tt-1}) + (1 - \tilde{\varrho}^g_T) \ln (\bar{g}_T) + \varepsilon^g_{Tt}.$$ 

where $\tilde{\varrho}^g_T > \varrho^g_T$ so that that $\tilde{g}_{Tt}$ represents the persistent component of tradable sector productivity growth: $g_{Tt}$ converges on $\tilde{g}_{T,t}$

We set $\tilde{\varrho}^g_T = 0.95$ and $\varrho^g_T = 0.8$

$\Rightarrow$ initial fall in $T$ productivity growth is gradual and reduction in the level of tradable sector LAP is more or less complete after about 30 years (120 quarters)
EFFECTS ON AGGREGATES

A: T LAP growth (annualized %)

B: Rel. price across sectors (100*log)

C: T output (100*log)

D: Trade balance/output (%)

E: N output (100*log)

F: Chain-linked GDP (100*log)
EFFECT ON INPUT FACTORS AND BOND RATES

A: Hours worked, T sector (level)

B: Hours worked, N sector (level)

C: T investment (100*log)

D: N investment (100*log)

E: T bond rate (annualized %)

F: N bond rate (annualized %)

Baseline
Scenario
MACRO ADJUSTMENTS IN THE UK

- The model responses are in line with the macroeconomic data
  - GDP growth in the UK slows down since the referendum vote
  - The relative price of non-tradable falls permanently
  - The growth rate of the $T$ sector increases relative to that in the $N$ sector
  - Exports increase after the referendum, creating a *sweet spot*
  - The bond return denominated in terms of $N$ goods falls on impact
  - Sectoral investment falls (in spite of no uncertainty) and labour market remains resilient
WHAT IF NEWS DO NOT MATERIALISE?

A: T LAP growth (annualized %)

B: Relative price (100*log)

C: T output (100*log)

D: Trade balance/output (%)

E: N output (100*log)

F: Chain-linked GDP (100*log)

- Baseline
- Not materialised
- Materialised
WHAT IF NEWS DO NOT MATERIALISE?

- The main macro aggregates fully unwind the news ⇒ most variables adjusting quickly

- Note that economy is not exactly back to baseline

- Could study exercises in which the realisation of the shock differs from what was announced (another MIT shock)
  - If shock is more severe, adjustment likely to be stronger
  - If shock is smaller, the adjustment likely to lie between the main scenario and not materialised news cases
**FINDINGS ON UK BUSINESS CYCLES**

- Large part of the variation of labour productivities in the $T$ and $N$ attributed to permanent shocks
  - Similar to finding by Aguiar and Gopinath (2007) for EMEs ("the trend is the cycle")

- Important variation in the permanent component of labour-augmenting productivity in the post-2000 sample
  - UK productivity puzzle (e.g. Pessoa and Van Reenen, 2014)

HistDecompT
CONCLUSION

▶ We document a number of facts about the UK’s macroeconomic adjustment to the 2016 referendum
▶ Interpret the adjustment as a rational response to negative news about the tradable sector
▶ We find that macroeconomic responses are consistent with this theoretical rationalization
▶ Central to the mechanism:
  ▶ Immediate permanent drop in $P$
  ▶ “Sweet spot” for tradable producers
  ▶ Resource reallocation during the anticipation phase
  ▶ Reversal upon the realisation of the shock
RELATED LITERATURE

▶ **Long-run effects of Brexit.** Dhinga et al. (2017), Sampson (2017), McGrattan and Waddle (2017)

▶ **Macro-adjustments of Brexit/Trade Policy.**
  - **Uncertainty.** Steinberg (2017), Bloom et al. (2018), Faccini and Palombo (2019) and Caldara et al. (2019)
  - **News and asset prices.** Broadbent (2017a, 2017b) and Davis and Studnicka (2018)


▶ **IST.** Greenwood at al. (2000), Justiniano et al. (2011) and Christiano et al. (2015)

▶ **SOE.** Aguiar and Gopinath (2017) and Drechsel and Tenreyro (2018)
Observables. nominal shares of consumption, investment and trade balance to GDP (available from 1987Q3) to avoid contaminating the time-series with noise arising from aggregation

⇒ sample averages of nominal ratios are correctly pinned down

New time-series. the quarterly growth rates of sectoral labor productivity (available from 1994Q1), the quarterly growth rate of the relative price of non-tradable goods (only available from 1997Q1)

Other. the quarterly growth rate of the real effective exchange rate and total hours (demeaned)
Define the real exchange rate as

\[ Q_t = \frac{E_t P_t^c}{P_t^{c,*}} , \]

where \( E_t \) denotes the nominal exchange rate, \( P_t^c \) the nominal price level of the home consumption bundle and \( P_t^{c,*} \) its foreign equivalent.

We assume that the rest of the RW have same preferences.

Under LOOP, it follows that \( P_{Tt}^* / E_t = P_{Tt} \) and that

\[ Q_t = \frac{P_t^c}{P_t^{c,*}} \]

where \( P_t^{c,*} = \xi_t \) follows an AR(1) stochastic process.
INDUSTRY CLASSIFICATION (SUT 2016)

- Agriculture
- Mining and Quarrying
- Manufacturing
- Electricity, Gas and Steam Air Conditioning
- Water Supply, Sewage and Waste Management
- Construction
- Services
- Cut-off
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
<th>Period</th>
<th>Value</th>
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<tbody>
<tr>
<td>$\theta_T$</td>
<td>ONS&amp; own calcs</td>
<td>1994 – 2016</td>
<td>$n_T/n = 0.5$</td>
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<td>$\theta_N$</td>
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<td>1994 – 2016</td>
<td>$n_N/n = 0.5$</td>
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<td>$\frac{s}{y}$</td>
<td>ONS &amp; own calcs</td>
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<td><strong>Structural parameters</strong></td>
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<td>$\varsigma_{s}$</td>
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<tr>
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<td>$r$</td>
<td>43.87</td>
<td>1.22</td>
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LONGER ANTICIPATION PHASE

A: T LAP growth (annualized %)

B: Rel. price across sectors (100*log)

C: T output (100*log)

D: Trade balance/output (%)

E: N output (100*log)

F: Chain-linked GDP (100*log)

- Baseline
- Scenario
- Fifteen quarter anticipation
LESS PERSISTENCE IN BREXIT SHOCK

A: T LAP growth (annualized %)

B: Rel. price across sectors (100*log)

C: T output (100*log)

D: Trade balance/output (%)

E: N output (100*log)

F: Chain-linked GDP (100*log)

- Baseline
- Scenario
- Less persistent variant
LABOUR PRODUCTIVITY IN $T$

d$\ln(Y_T/n_T)$

-2
-1.5
-1
-0.5
0
0.5
1
%

2000Q1 2002Q3 2005Q1 2007Q3 2010Q1 2012Q3 2015Q1

$\beta_{NT}$ $\beta_{TT}$ $s_t$ $\bar{\nu}_t$ $\hat{\mu}_t$ $\hat{\xi}_t$ $\alpha_{NT}$ $\alpha_{TT}$
LABOUR PRODUCTIVITY IN $N$

$d\ln (Y_N/n_N)$

2000Q1  2002Q3  2005Q1  2007Q3  2010Q1  2012Q3  2015Q1

-1  -0.5  0  0.5  1

\%