

# INFLATION DYNAMICS AND PRICE FLEXIBILITY IN THE UK

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# Motivation

- Focus on the connection between time variation in the distribution of consumer-price changes and aggregate price flexibility
- A number of papers have focused on measuring the pass-through of nominal shocks onto prices and quantities
- Much less on time variation in price flexibility and how this affects inflation dynamics
- State dependence in price flexibility at the core of modeling price-setting frictions

# What we do in this paper

- 1 Track the evolution of the UK distribution of consumer price changes over the last two decades
- 2 Rationalize the most distinctive patterns of time variation in the density of price changes within a stylized menu cost model
- 3 Examine the evolution of aggregate price flexibility using a generalized  $S_s$  setting and its relevance for understanding inflation dynamics
- 4 We also highlight that the time variation in aggregate price flexibility does not seem to be fully accounted for by the BoE and market participants when forming inflation expectations

# Preview of the key findings

- In the period after the Great Recession the **dispersion of price changes** has displayed a sustained upward trend, while the **frequency of adjustment** has dropped  
⇒ We show how a persistent increase in the inaction to nominal shocks may be compatible with these trends
- A large part of inflation volatility over the last decade is associated with **increased importance of the Extensive Margin**
- Both the Bank of England and professional forecasters tend to overestimate inflation persistence in periods of relatively high price flexibility, especially at medium-term forecast horizons

# Related literature

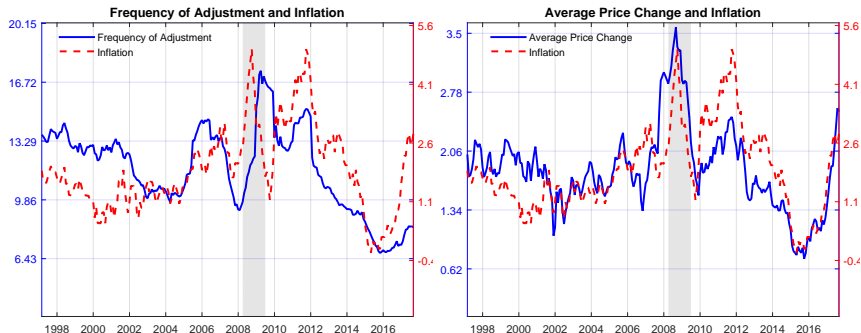
- 1 On the importance of examining the distribution of price changes:
  - Time variation in price flexibility: Berger and Vavra (2017)
  - Connection with structural modeling: Midrigan (2011), Vavra (2014), and Alvarez et al. (2016), among others
  - Distinction between the intensive and the extensive margin of price adjustment: Gagnon et al. (2013)
- 2 Analysis of UK data:
  - Frequency of price adjustment and hazard functions: Bunn and Ellis (2012)
  - Impact of the Great Recession on price setting: Dixon et al. (2014)
  - On the importance of the extensive margin: Carvalho and Kryvtsov (2017)

# Microdata on consumer prices

- ONS microdata that underpin the UK CPI (1997:2-2017:8)
- Prices are collected on a monthly basis (one month publication lag), for more than 1,100 categories of goods and services (about 27.5 mln observations)
- We only use ‘Classification Of Individual COnsumption by Purpose’ (COICOP) approved price quotes (about 60% of those included in the CPI) and exclude sales
- In order to identify a price trajectory, we link price quotes looking at the base prices for a given good. We break a trajectory in the presence of product substitutions
- Prices are appropriately weighted following the CPI aggregation

# Frequency and average price changes

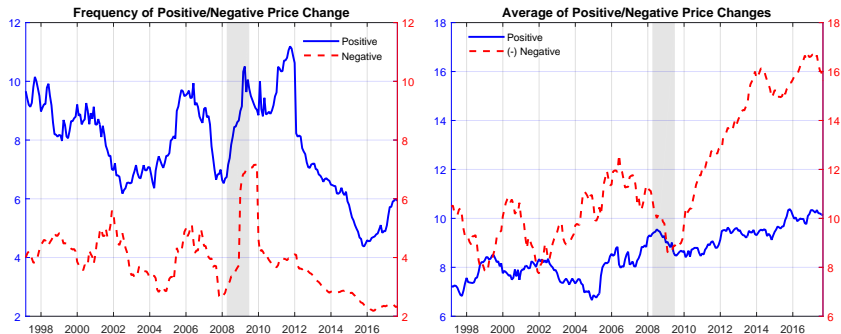
## Data facts #1



The frequency of adjustment displays time variation (comoving with inflation), in particular in the second part of the sample

# Asymmetries

## Data facts #2

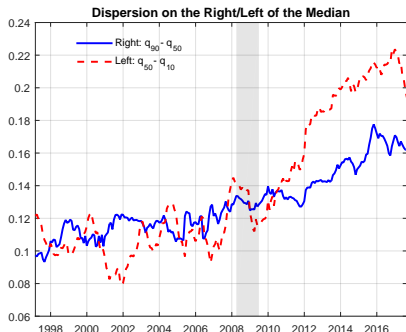
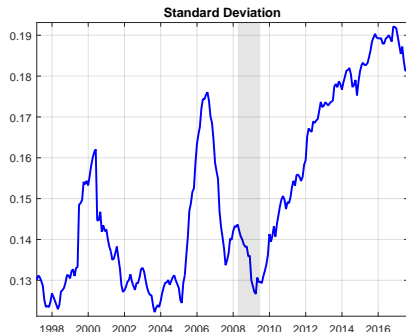


The frequency of adjustment trends down in the post recession period. The latter period is associated with few, yet large price cuts



# Cross-sectional dispersion of price changes

## Data facts #3



Dispersion increases, in particular the dispersion on the left side of the price change distribution

# More data facts

## Cyclicity of frequency and dispersion

- After the Great Recession, the **frequency of adjustment** has displayed a pronounced **countercyclicality**, while **dispersion** has been markedly **procyclical** throughout the entire sample, with both comovements appearing more marked in the case of negative price changes
- The pairwise correlation between these statistics has turned deeply negative after the Great Recession
- This stands in contrast with U.S. microdata examined by Vavra (2014), who reports that the cross-sectional standard deviation of price changes is strongly countercyclical and comoves with the frequency of adjustment

# What can explain these facts?

In the paper we show (using a stylized  $Ss$  model) that

- 1 These facts are consistent with large movements in the ‘cost of changing prices’
- 2 The latter magnifies the importance of the Extensive Margin of adjustment in the last decade

# A generalized $S_s$ model

Setting (Caballero and Engel, 2007)

- Assume that, due to price rigidities, firm  $i$ 's (log of) the actual price may deviate from the (log of) the target or reset price, which is denoted by  $p_{it}^*$ . **Price gap:**  $x_{it} \equiv p_{it-1} - p_{it}^*$
- Adjustment reflects the cumulated (aggregate and idiosyncratic) shocks since the past price adjustment
- Assuming *iid* shocks to the adjustment cost and integrating over all their possible realizations we obtain an **adjustment hazard**,  $\Lambda_t(x)$
- Denoting with  $f_t(x)$  the cross-sectional **distribution of price gaps** immediately before an adjustment takes place at time  $t$ , aggregate inflation can be recovered as

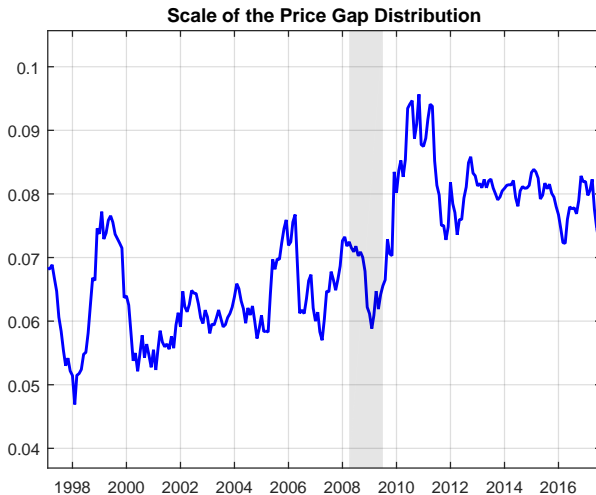
$$\pi_t = - \int x \Lambda_t(x) f_t(x) dx.$$

# A generalized $S_s$ model

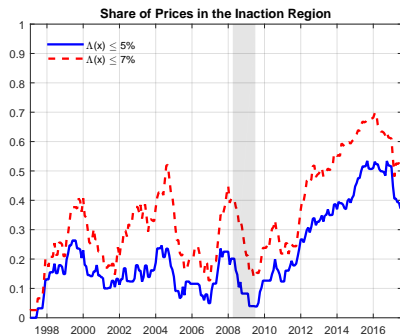
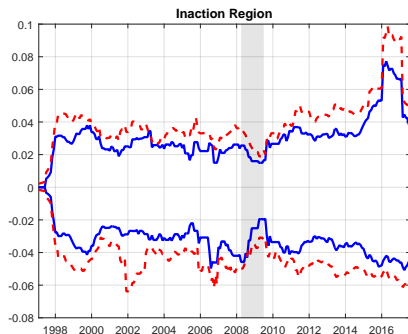
## Taking the model to the data

- We assume parametric forms for
  - ① Distribution of price gaps  $\Rightarrow$  **Asymmetric Power Distribution**  
(4 parameters: location, scale, tail decay, asymmetry)
  - ② Hazard function  $\Rightarrow$  **asymmetric quadratic function**
- We estimate the parameters of the model by SMM, matching a number of cross sectional moments in each period
  - Moments of the price change distribution
  - We also match the frequency and the average size of prices movements (distinguishing between positive and negative price changes)
  - We match the aggregate rate of inflation

# Increased dispersion in the price gap distribution...



# ...widening of the inaction region



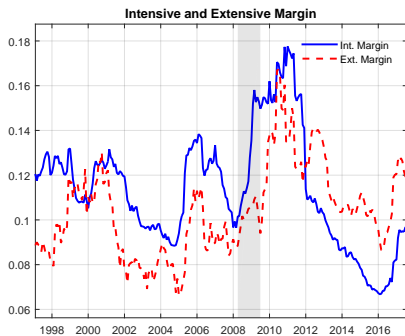
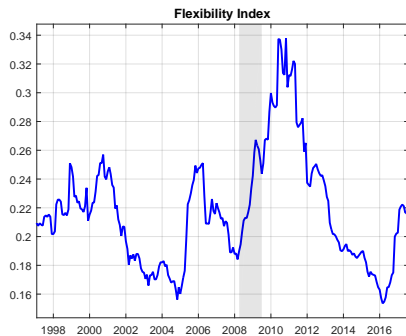
# An index of aggregate price flexibility

- Important changes in the distribution of price gaps and the hazard function for shock propagation  
 $\implies$  Must bear some implications for the pass-through of nominal shocks onto inflation
- Following Caballero and Engel (2007) one can derive a measure of Aggregate Price Flexibility:

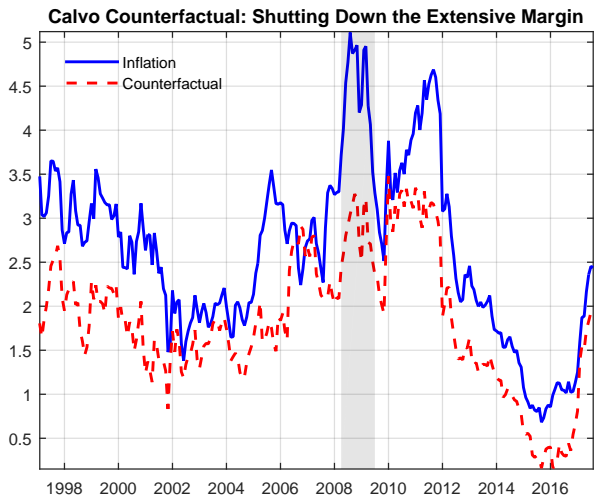
$$\mathcal{F}_t = \lim_{\mu_t \rightarrow 0} \frac{\partial \pi_t}{\partial \mu_t} = \underbrace{\int \Lambda_t(x) f_t(x) dx}_{\text{Intensive Margin}} + \underbrace{\int x \Lambda'_t(x) f_t(x) dx}_{\text{Extensive Margin}}$$



# Implications for price flexibility

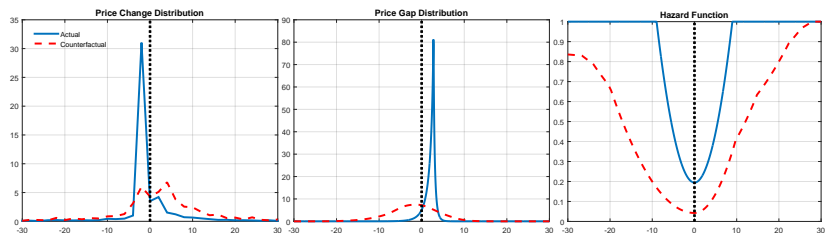


# On the importance of the extensive margin

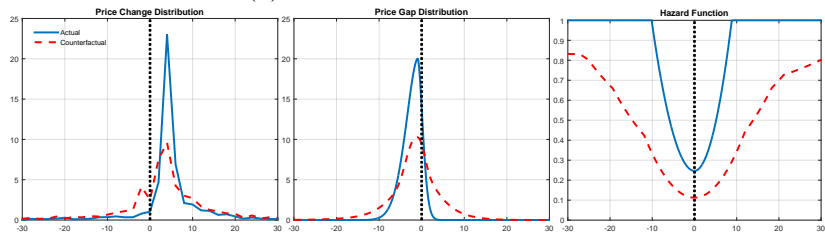


# Price adjustment over the extensive margin

## VAT event study



(a) VAT Decrease: Dec. 2008



(b) VAT Increase: Jan. 2010

# Price flexibility and inflation dynamics

## A STARMA (p,q) model

We allow for **state dependence in price flexibility** using a smooth transition ARMA [*STARMA*(*p*, *q*)] model:

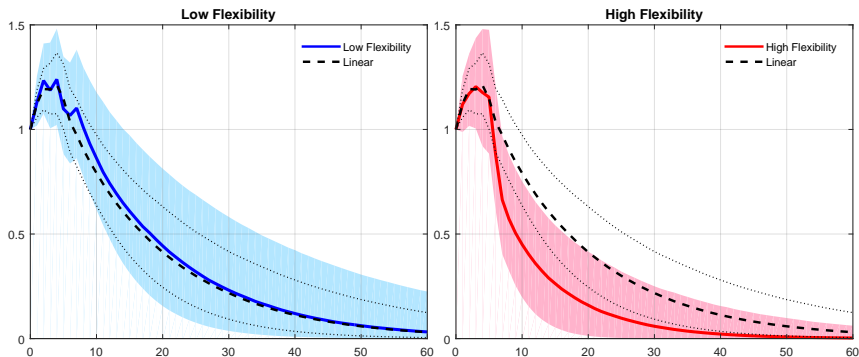
$$\pi_t = G\left(\tilde{\mathcal{F}}_{t-1}, \gamma\right) \left( \phi_0^H + \sum_{j=1}^p \phi_j^H \pi_{t-j} + \varepsilon_t^H + \sum_{i=1}^q \theta_i^H \varepsilon_{t-i}^H \right) + \left[ 1 - G\left(\tilde{\mathcal{F}}_{t-1}, \gamma\right) \right] \left( \phi_0^L + \sum_{j=1}^p \phi_j^L \pi_{t-j} + \varepsilon_t^L + \sum_{i=1}^q \theta_i^L \varepsilon_{t-i}^L \right),$$

with  $\varepsilon_t^i \sim N(0, \sigma_i^2)$  for  $i = \{L, H\}$ .

$G(\tilde{\mathcal{F}}, \gamma) = (1 + e^{-\gamma \tilde{\mathcal{F}}})^{-1}$ , where  $\tilde{\mathcal{F}}$  denotes the normalized flexibility index and  $\gamma$  is the speed of transition across regimes

# Inflation dynamics

## Persistence in periods of low & high price flexibility



- The half-life of the inflation response is twice as big in periods of relatively low flexibility, along with appearing remarkably close to the one obtained in the linear setting
- **Are these features appropriately accounted for when forming inflation expectations?**

# Rationality of inflation forecasts

Let  $e_{T+h|T}$  denote the  $h$ -steps ahead forecast errors and  $G_t$  the regime probability associated to different level of flexibility:

$$|e_{T+h|T}| = a_0 + a_1 G_t + a_2 G_t^2 + a_3 G_t^2 I_{\{G_t > 0.5\}}$$

(a) BoE MPC RPIX/CPI (Absolute) Forecast Errors

Horizon	Slope at $G = 0.3$	Slope at $G = 0.5$	Slope at $G = 0.9$	F-stat	$\tilde{R}^2$
1	0.093 [0.628]	-0.578 [0.232]	0.840 [0.092]	0.229	1.69
2	-0.330 [0.279]	-1.342 [0.060]	2.319 [0.011]	0.045	6.41
3	-0.484 [0.145]	-2.433 [0.027]	4.117 [0.010]	0.003	13.82
4	-0.344 [0.437]	-3.798 [0.007]	6.161 [0.003]	0.000	26.45
5	-0.144 [0.811]	-3.277 [0.024]	5.945 [0.011]	0.000	20.10
6	0.309 [0.603]	-2.542 [0.118]	4.858 [0.032]	0.003	13.70
7	0.634 [0.236]	-2.749 [0.116]	4.402 [0.021]	0.006	12.32
8	0.691 [0.182]	-1.758 [0.302]	3.029 [0.055]	0.063	5.93

(b) Market Participants' (Absolute) Forecast Errors

Horizon	Slope at $G = 0.3$	Slope at $G = 0.5$	Slope at $G = 0.9$	F-stat	$\tilde{R}^2$
1	0.265 [0.361]	-1.107 [0.066]	0.826 [0.122]	0.278	1.11
2	-0.383 [0.264]	-1.658 [0.043]	2.448 [0.010]	0.053	6.12
3	-0.561 [0.150]	-2.883 [0.017]	4.293 [0.008]	0.004	13.10
4	-0.382 [0.418]	-4.522 [0.002]	6.398 [0.002]	0.000	25.60
5	-0.103 [0.862]	-4.086 [0.010]	6.042 [0.009]	0.000	18.74
6	0.453 [0.412]	-3.207 [0.101]	4.516 [0.049]	0.013	10.48
7	0.903 [0.052]	-3.380 [0.095]	3.631 [0.052]	0.019	9.47
8	0.883 [0.099]	-2.385 [0.189]	1.935 [0.221]	0.211	2.19

## Concluding remarks

- Over the last decade the capacity of nominal stimulus to generate inflation has decreased substantially
- We emphasize the importance of time variation in higher moments of the distribution of price changes and their connection with price flexibility
- State-dependent price setting has a prominent role in order to understand inflation dynamics
- Despite the marked non-linearity in the price response to inflationary shocks neither the Bank of England nor professional forecasters appear to account for this type of state dependence