ECONOMIC STATISTICS CENTRE OF EXCELLENCE

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ESCoE Research Seminar

Inflation Dynamics and Price Flexibility in the UK

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Inflation Dynamics and Price Flexibility in the UK

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Motivation

- 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
- Focus on the connection between time variation in the distribution of consumer-price changes and aggregate price flexibility
- 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 Ss 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
  $\Longrightarrow$ 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

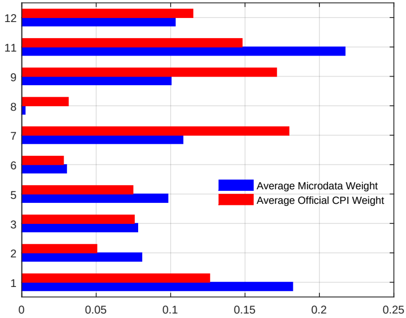
1. On the importance of examining the distribution of price changes:
   - Time variation in price flexibility: Berger and Vavra (2017)
   - Connection with structural modeling: Midrigan (2011), Vavra (2014), and Alvarez et al. (2016), among others
   - Distinction between the intensive and the extensive 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)

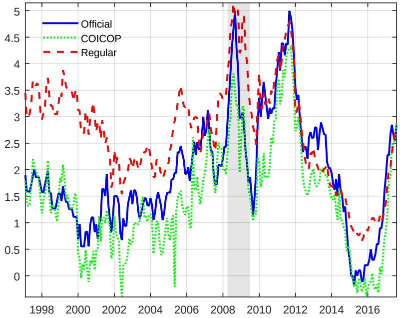
Microdata on consumer prices

- 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

Microdata on consumer prices

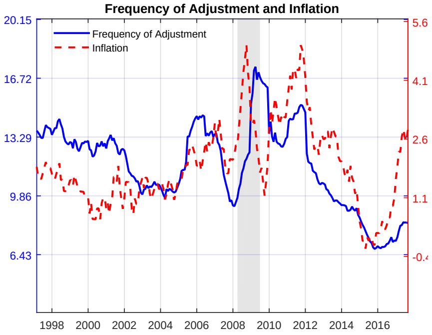
Representativeness

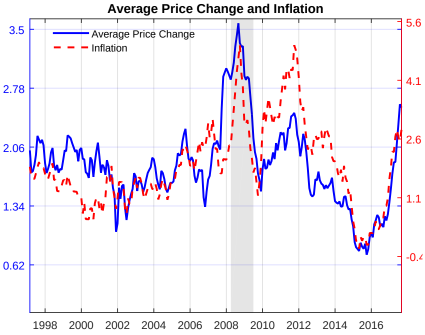




Frequency and average price changes

Data facts #1

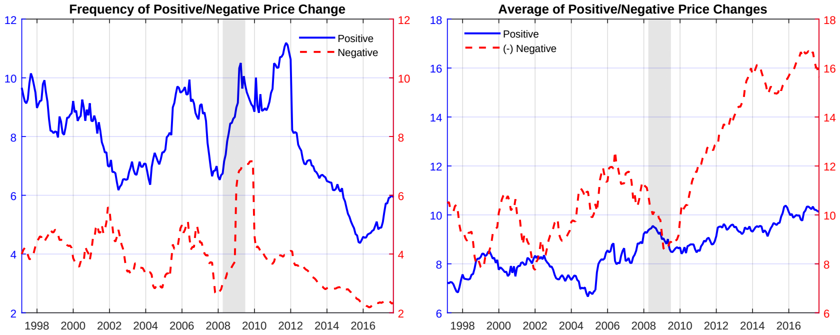




The frequency of adjustment displays time variation (comoving with inflation), in particular in the second part of the sample

Asymmetries

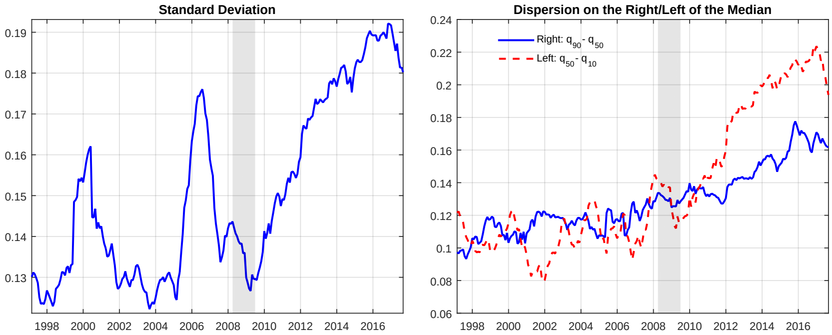
Data facts #2



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

Cyclicality 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

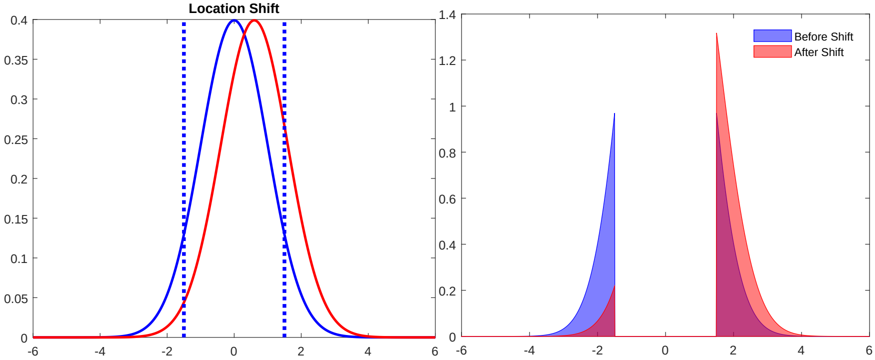
Analytical framework

Barro (1972) and Dixit (1991)

- Firms face a dynamic control problem where x—the deviation of the current price from the optimal price—is the state variable
- A wedge between the state variable and zero entails an out-of-equilibrium cost αx^2. Moreover, firms bear a fixed cost λ to adjust x
- When not adjusting, x follows a Brownian motion $dx = \phi dW$, where W is the increment to the Wiener process.
- The resulting optimal policy is:
  - 'Do not adjust' when $|x| < \sigma$
  - 'Adjust to zero' when $|x| \geq \sigma$
- It can be proved that $\sigma = \left(6\lambda\phi^2/\alpha\right)^{1/4}$ and $fr = \left(\alpha/6\lambda\right)^{1/4}\phi$

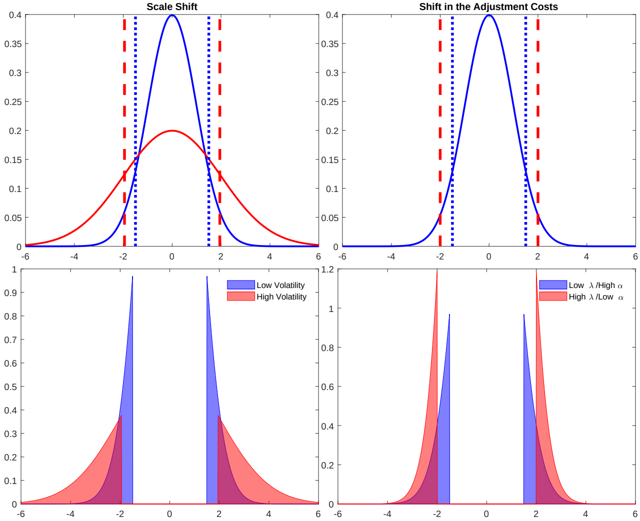
Analytical framework

First moment 'shocks'



Analytical framework

Second moment 'shocks' & 'cost shifts'



What can explain the stylized facts?

Summary

We show (using a stylized Ss model) that

1. The stylezed facts we uncover from the microdata 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 Ss 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

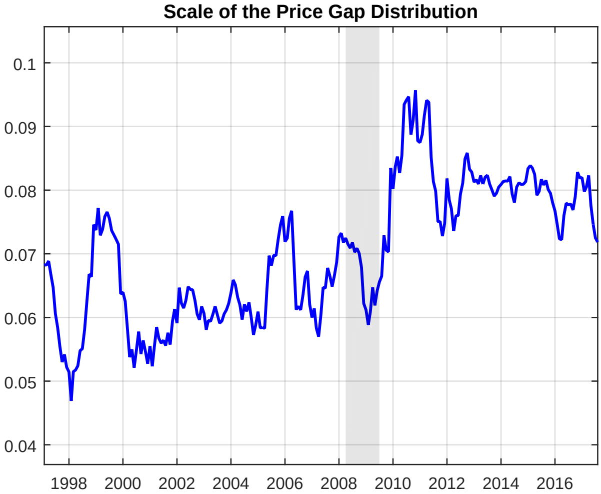
$$\pi_t = -\int x\Lambda_t(x)\, f_t(x)\, dx.$$

A generalized Ss model

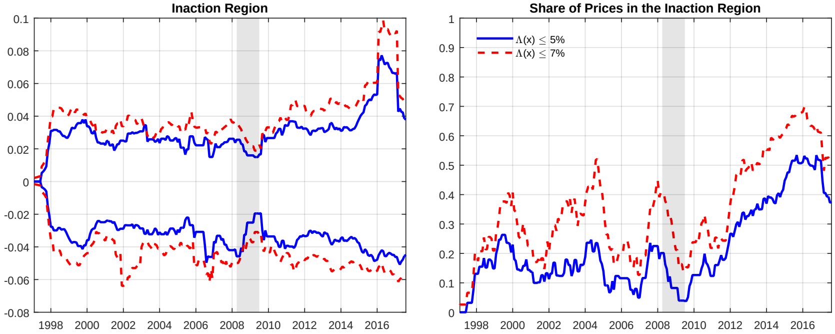
Taking the model to the data

- We assume parametric forms for
  1. Distribution of price gaps ⇒ Asymmetric Power Distribution (4 parameters: location, scale, tail decay, asymmetry)
  2. Hazard function ⇒ 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

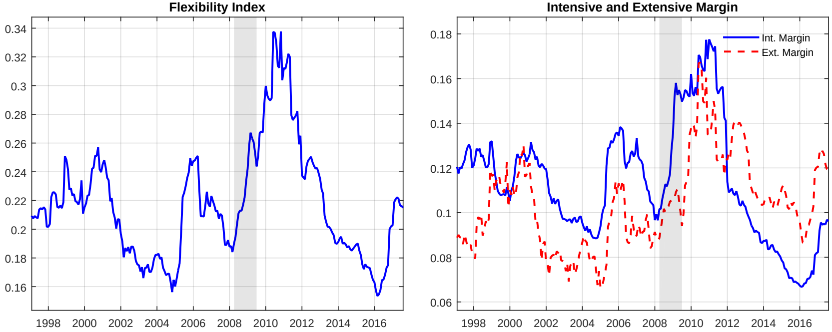


An index of aggregate price flexibility

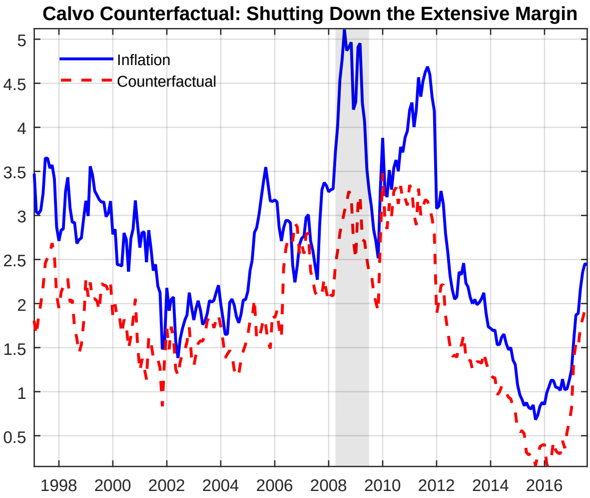
- Important changes in the distribution of price gaps and the hazard function for shock propagation
  $\Longrightarrow$ Must bear some implications for the pass-through of nominal shocks onto inflation
- Following Caballero and Engel (2007) one can derive a measure of Aggregate Price Flexibility:

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

Implications for price flexibility

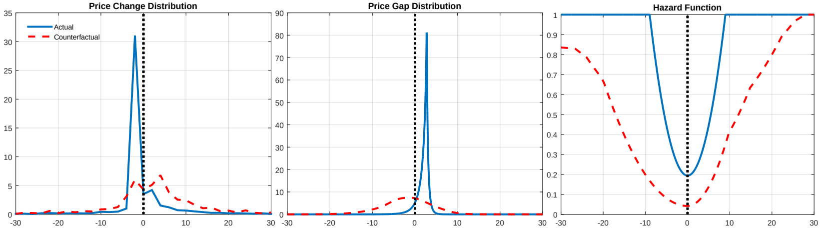


On the importance of the extensive margin

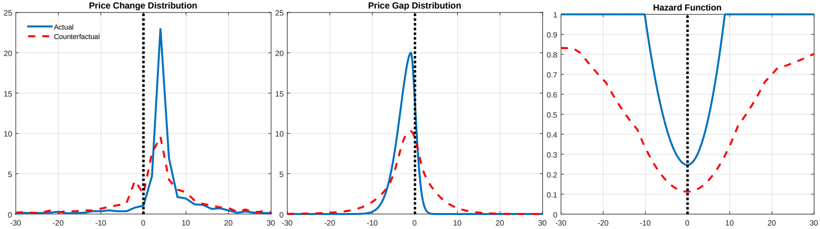


On the importance of state-dependent pricing

VAT event study



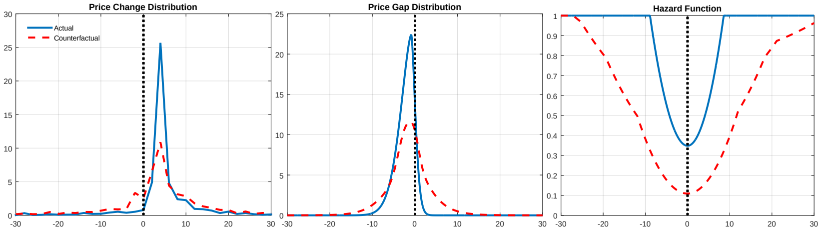
(a) VAT Decrease: Dec. 2008



(b) VAT Increase: Jan. 2010

On the importance of state-dependent pricing

VAT event study



(c) VAT Increase: Jan. 2011

On the importance of state-dependent pricing

VAT event study

	VAT 1							
	π	$\mathcal{F}$	Int	Ext	Int^+	Int^-	Ext^+	Ext^-
Actual	-5.941	0.346	0.235	0.111	0.211	0.023	0.105	0.006
Scenario 1	-1.604	0.101	0.060	0.041	0.055	0.005	0.040	0.001
Scenario 2	1.863	0.200	0.096	0.104	0.038	0.058	0.048	0.056
	VAT 2							
	π	$\mathcal{F}$	Int	Ext	Int^+	Int^-	Ext^+	Ext^-
Actual	11.631	0.471	0.322	0.149	0.019	0.304	0.003	0.146
Scenario 1	4.580	0.181	0.135	0.045	0.008	0.127	0.001	0.045
Scenario 2	4.111	0.218	0.148	0.070	0.043	0.105	0.016	0.054
	VAT 3							
	π	$\mathcal{F}$	Int	Ext	Int^+	Int^-	Ext^+	Ext^-
Actual	14.487	0.573	0.428	0.145	0.019	0.409	0.002	0.143
Scenario 1	4.708	0.190	0.136	0.053	0.006	0.130	0.001	0.053
Scenario 2	4.258	0.239	0.154	0.086	0.041	0.113	0.020	0.066

Price flexibility and inflation dynamics

A STARMA (p,q) model

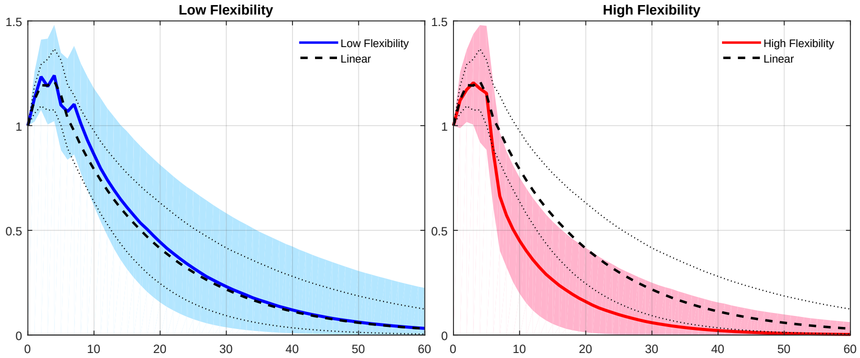
We allow for state dependence in price flexibility using a smooth transition ARMA [$STARMA(p,q)$] model:

$$\begin{aligned}\pi_t &= G\left(\widetilde{\mathcal{F}}_{t-1},\gamma\right)\left(\phi_0^H+\sum_{j=1}^{p}\phi_i^H\pi_{t-j}+\varepsilon_t^H+\sum_{i=1}^{q}\theta_i^H\varepsilon_{t-i}^H\right)\\ &\quad+\left[1-G\left(\widetilde{\mathcal{F}}_{t-1},\gamma\right)\right]\left(\phi_0^L+\sum_{j=1}^{p}\phi_i^L\pi_{t-j}+\varepsilon_t^L+\sum_{i=1}^{q}\theta_i^L\varepsilon_{t-i}^L\right),\end{aligned}$$

with $\varepsilon_t^i \sim N\left(0,\sigma_i^2\right)$ for $i=\{L,H\}$.
$G\left(\widetilde{\mathcal{F}},\gamma\right)=(1+e^{-\gamma\widetilde{\mathcal{F}}})^{-1}$, where $\widetilde{\mathcal{F}}$ denotes the normalized flexibility index and γ 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:

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

Horizon	Slope at $G = 0.3$		Slope at $G = 0.5$		Slope at $G = 0.9$		F-$stat$	$\tilde{R}^2$
(a) BoE MPC RPIX/CPI (Absolute) Forecast Errors								
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