

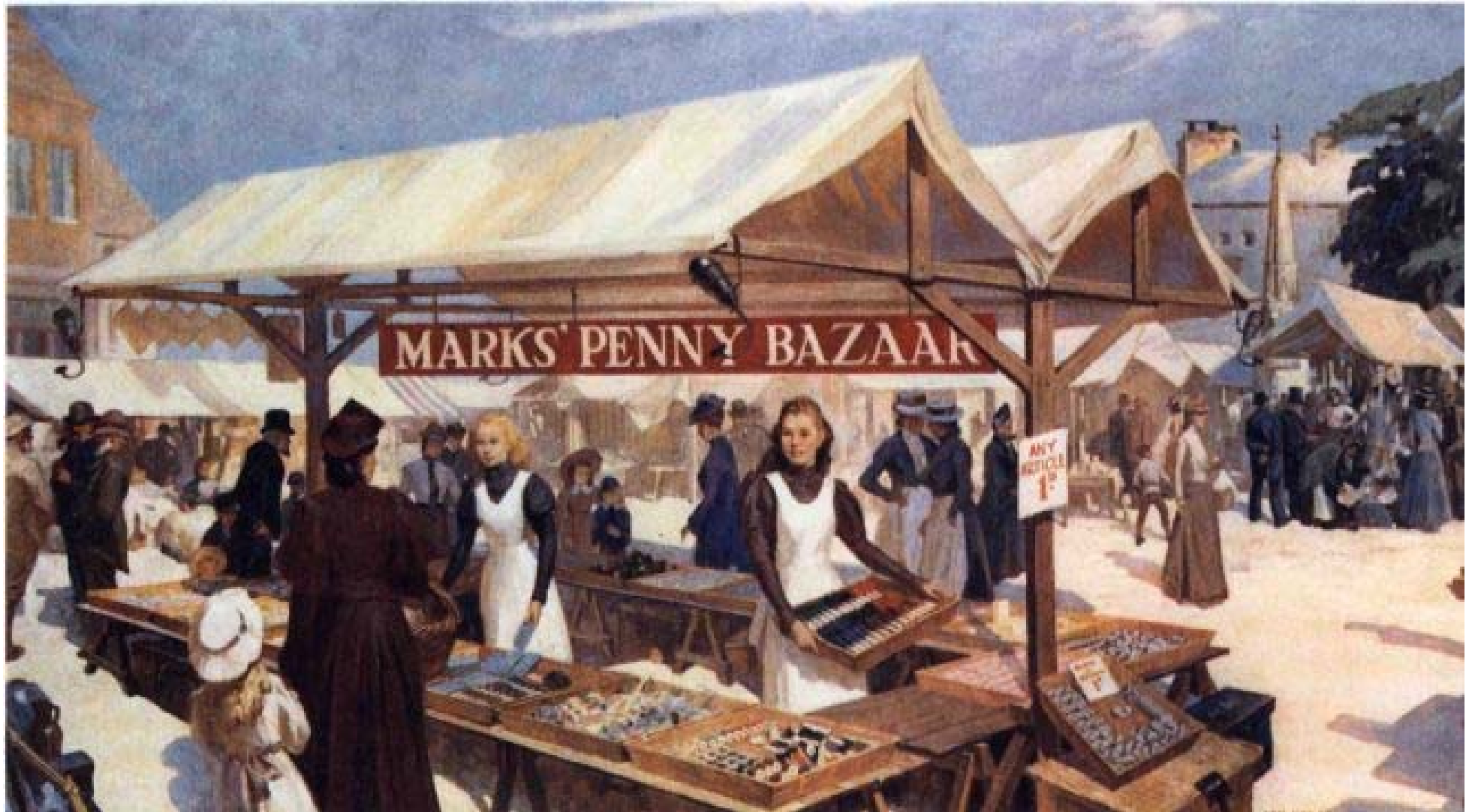
Why nominal rigidity is important in economics and how to measure it.

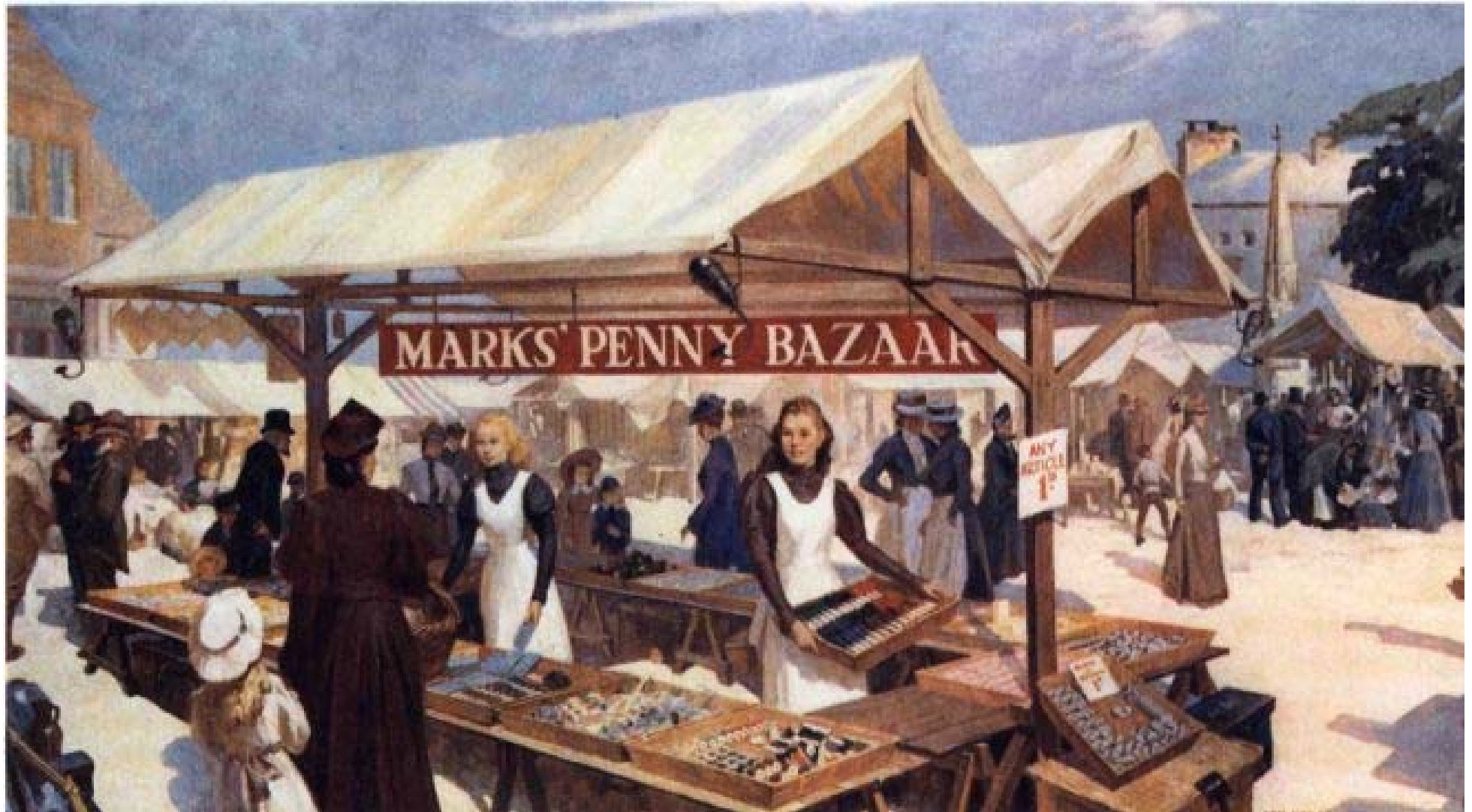
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1 Introduction.

- Two questions.
 1. Why nominal rigidity is important in economics.
 2. How to measure nominal rigidity: theory and application (France and UK).
- Economics and macroeconomics.

2 Why nominal rigidity is important

- In a lot of economics, we look at the real economy and ignore nominal prices
- Relative prices are what matter, use a numeraire. General equilibrium: nominal prices irrelevant.
- This requires prices to be perfectly flexible: always adjust to reflect underlying real (relative) prices. Change every period (can). Classical dichotomy, money as a veil (Hume and beyond).
- But, back in 1930's, some economists realised that prices were not perfectly flexible:

- Gardiner Means: *administered prices* (1935). He looked at BLS data on wholesale prices for 374 items from 1926-33. Found that: 50% changes less than once every four months; 25% less than once every ten months; 13% less than 5 times in eight years.
- Rufus Tucker (1938). Looked at US historical data. Found that this had been the same in the 19th C. Also, it had been well known and commented on - Tucker looked back to Adam Smith and his notion of the "normal price".
- Stigler and Kindahl (1970): list vs transaction prices. Lawrence Weiss 1977: Means vindicated.
- Some prices are flexible: others are not. *Nominal rigidity matters, because it can affect relative prices (even if only in short run).*

3 Nominal rigidity is infectious.

- If some nominal prices are rigid, can influence the whole economy.
- Example (Dixon 1992, 1994). Aggregate price index depends on three prices: $P(f, w, z)$ is *HOD1*. Unionised wage w is a markup over disutility of labour: competitive wage likewise. Markup (elasticity) is *HOD0*

$$\frac{w}{P(w, f, z)} = \frac{\varepsilon(w, f, z)}{\varepsilon(w, f, z) - 1} \theta$$

$$\frac{z}{P(w, f, z)} = \theta$$

- Complete nominal rigidity. Let the share of rigid sectors be $\alpha > 0$. Then all prices are rigid and "pegged" to fixed prices f . Let us take the

competitive sector (no unions). With Cobb-Douglas preferences

$$\begin{aligned}\frac{z}{z^{1-\alpha} f^\alpha} &= \theta \\ \frac{z^\alpha}{f^\alpha} &= \theta \\ z &= f \cdot \theta^{\frac{1}{\alpha}}\end{aligned}$$

- The flexible prices z get "pegged" to the fixed nominal prices f , no matter how small the fix-price sector is (α) is. This is a special case (constant Marginal utility of labour θ), however to some extent it will hold under more general assumptions. For example, an upward sloping labour supply curve, so that $\theta(N) = N$:

$$\begin{aligned}\frac{z}{z^{1-\alpha} f^\alpha} &= \theta(N) = N \\ z &= f N^{\frac{1}{\alpha}}\end{aligned}$$

Combine with a downward sloping demand curve:

$$N = \frac{M}{z}$$

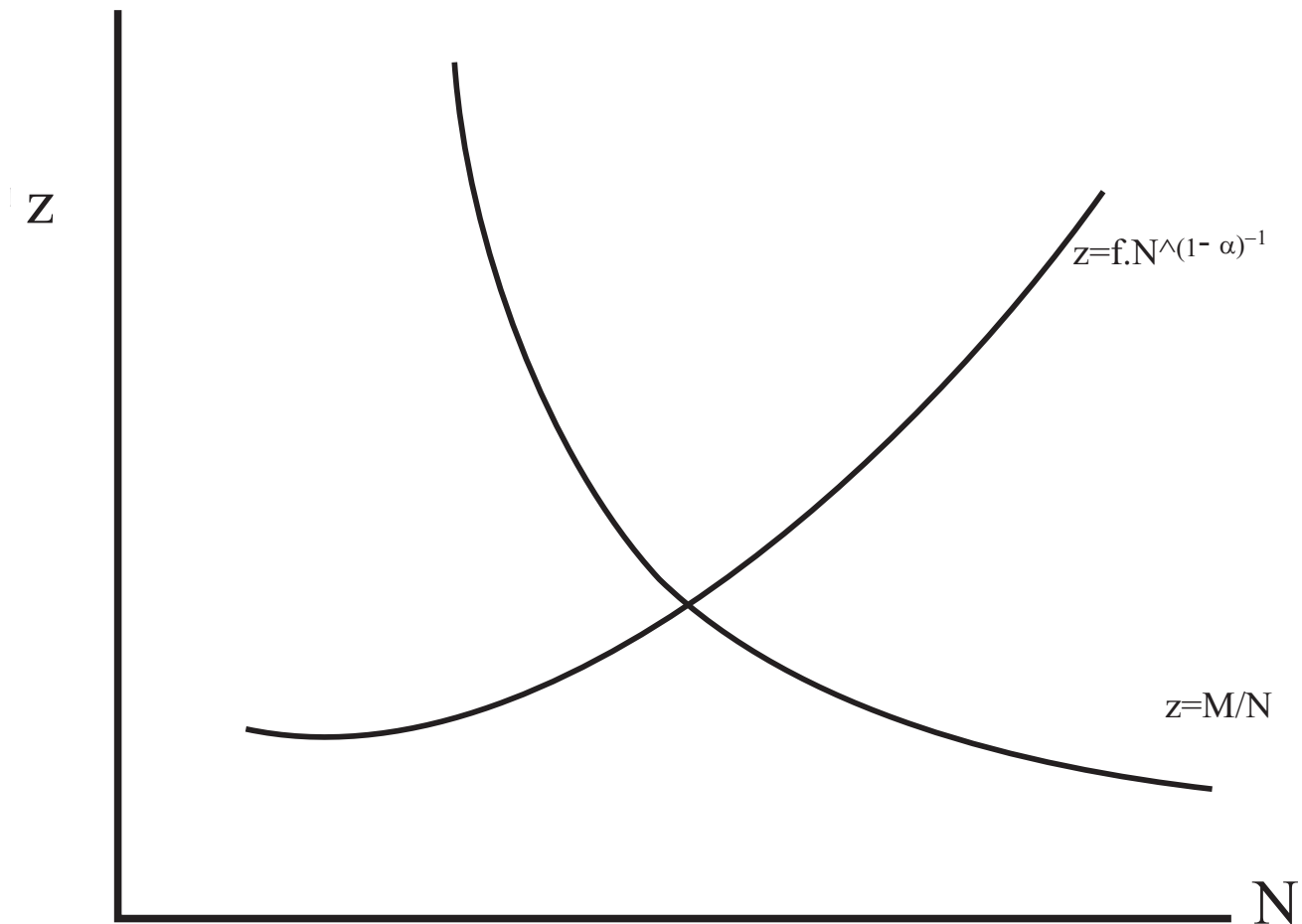
Hence

$$\frac{z}{z^{1-\alpha} f^\alpha} = \frac{M}{z}$$

$$\frac{z^{1+\alpha}}{f^\alpha} = M$$

$$z = M^{\frac{1}{1+\alpha}} f^{\frac{\alpha}{1+\alpha}}$$

If $\alpha = 0$ (i.e. no fixed prices), then $z = M$ and nominal prices are *HOD1* in money supply - output and employment fixed ($N = 1$). Also, output in the fix-price sector.



- Money non-neutral when $\alpha > 0$:

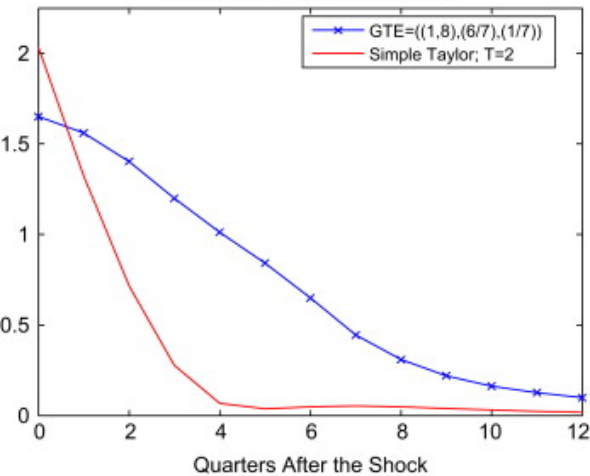
$$N = \frac{M}{M^{\frac{1}{1+\alpha}}} = M^{\frac{\alpha}{1+\alpha}} f^{-\frac{\alpha}{1+\alpha}}$$
$$\frac{d \ln N}{d \ln M} = \frac{\alpha}{1 + \alpha}$$

For example: $\alpha = 0.1$, a 10% increase in money supply (nominal demand) leads to a 9% increase in competitive output. Only a small proportion of fixed prices alters behaviour of economy. General equilibrium effect!

- Other examples? Tax, oligopoly pricing - fixed prices will spillover.
- Oligopoly: monopolistic markup affected by nominal rigidity in another sector: catching on - Klenow and Willis (2016).

- Nominal rigidity spillovers:
 - *Cost of living.* Fix price is in price index.
 - *budget share effects.* The relative price of fix price sector varies: budget shares and expenditures can alter.
 - *Elasticity markup effects:* The relative price of fix price sector varies: elasticities and markups can alter. Hence
- **Dynamic General equilibrium models?** The effect is also there (Dixon and Kara 2011, and Dixon and Le Bihan 2012). Was there is John Taylor's staggered contract model, but even bigger in "Generalized Taylor" setup. Some sectors with rigid nominal prices *slow down* the nominal responses of more flexible prices.

Response of Output (Mean 2)



- Nominal rigidity in some sectors explains the persistence of both output and inflation (Dixon and Kara 2010, 2011). If nominal prices are sluggish, means that money has real affect on output, also spreads out the response of inflation. Prices do not react immediately, but the effect happens over a longer period.

3.1 Conclusion: nominal rigidity matters!

- In a General equilibrium system, the fact that some nominal prices remain fixed can have a disproportionate effect on the rest of the economy.
- nominal rigidity will have real effects, not just "monetary policy".

4 How to measure Price rigidity.

- Look at price-setters (shops, firms) and how often they set prices: Rufus Tucker - how often you change prices over a period; More recently the proportion of prices that change per period (UK and France CPI about 20% per month).
- Average duration of prices. Average over what?
- Look at prices and price-setters (firms). N firms in economy $i = 1...F$. Each firm is "Taylor like" and sets price regularly after a number of periods - for example i periods. The obvious thing to do: *average over firms*: average duration of prices set by F firms is

$$\bar{T} = \frac{1}{F} \sum_{i=1}^F i = \frac{F+1}{2}$$

- More generally, can have a generalized Taylor economy (*GTE* or just *GT*). Lots of firms, each duration has a proportion of firms $\{\alpha_i\}_{i=1}^F$ where $\alpha_i \geq 0$ and $\sum_{i=1}^F \alpha_i = 1$.

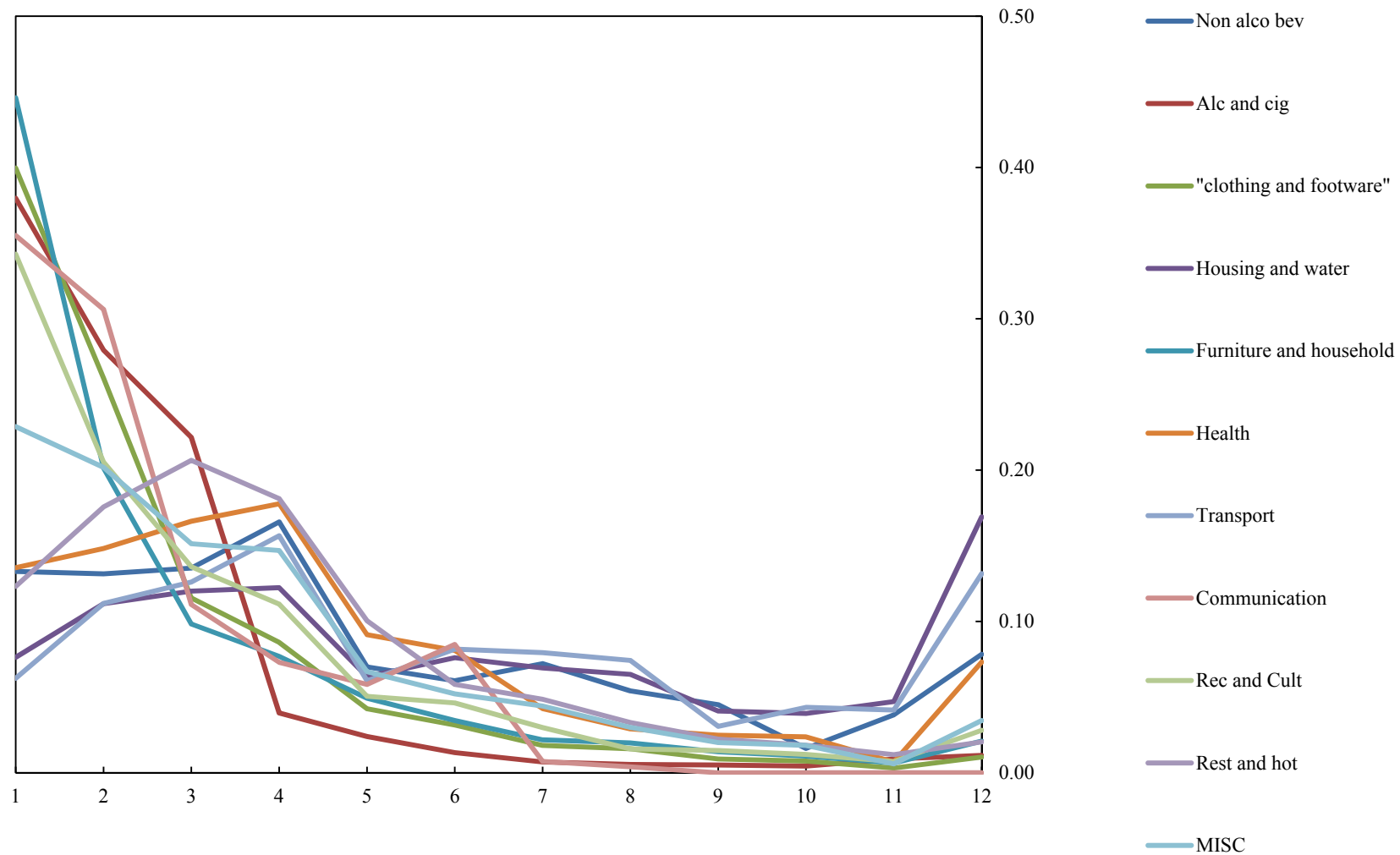
$$\bar{T} = \sum_{i=1}^F i \cdot \alpha_i$$

- OR you can have sectors in the economy, and within each sector have proportions of firms. Dixon, Franklin and Millard (2014): 12 cpi sectors cpi_s $s = 1..S$ ($S = 12$). $\sum_{s=1}^S cpi_s = 1$, each with 12 duration sectors $i = 1...F$ with $F = 12$ $\{\alpha_{is}\}$

$$\bar{T} = \sum_{i=1}^F \sum_{s=1}^S i \cdot (\alpha_{is} \cdot cpi_s)$$

- Firms are not usually "Taylor like", individual price-setters will have sequence of price-spells, some short (sales), some longer.

Chart 5: Sectoral distributions (Dixon, Franklin and Millard 2014)



5 Average Over What?

- Introduce microdata: here CPI. In UK and France, 100k price observations (quotes) across a range of 600+ items. Prices aggregated using CPI weights to get price index and construct monthly CPI inflation figures.
- monthly, going back to mid 90s. US further (late 80s): Norway even earlier.
- Panel: row - sequence of price quotes for same item/location - ("firm"). Column: one price per "firm" - the structure of the economy (*cpi* weights etc.). From price-quotes you construct *price spells*.

- Like a wall. CPI data became available in early 2000. IPN in *Euro-zone*, Pete Klenow with Bils (2004) and Kryvtsov (2008), Nakamura and Steinsson (2008) in US. Bunn and Ellis (2008), Dixon and Tian (2014) for UK.

5.1 Distribution of durations.

- Early research focussed on the distribution of durations. Ignores panel structure and essentially looks at distribution of price-spells contained in CPI panel.
- Use of frequency. If you observe a frequency of price change \bar{h} (at some degree of aggregation - from item to whole CPI). Then the mean duration

Name	ELI	Freq	Mo	Subs	NSub	Wgt	CDF	wgt	mean
Coin-operated apparel laundry and drycleaning	44012	1.2	79.9	0.53	0.17	0.148	0.21	0.0021	0.0026
Vehicle inspection	52014	1.4	69.9	0.00	0.00	0.033	0.26	0.0005	0.0007
Driver's license	52013	1.8	56.3	1.04	0.39	0.023	0.30	0.0003	0.0006
Coin operated household laundry and drycleaning	34045	2.1	46.4	0.00	0.00	0.014	0.32	0.0002	0.0004
Intracity mass transit	53031	2.5	40.2	0.66	0.14	0.223	0.64	0.0032	0.0081
Local automobile registration	52012	2.8	34.8	3.26	0.66	0.019	0.67	0.0003	0.0008
Legal fees	68011	2.9	34.3	0.48	0.37	0.289	1.09	0.0042	0.0122
Vehicle tolls	52054	3.2	31.2	0.70	0.00	0.059	1.17	0.0009	0.0027
Safe deposit box rental	68021	3.3	30.2	0.70	0.70	0.019	1.20	0.0003	0.0009
Newspapers	59011	3.3	29.9	0.56	0.31	0.245	1.56	0.0036	0.0117
Alterations and repairs	44013	3.3	29.4	0.36	0.25	0.022	1.59	0.0003	0.0011
Automobile towing charges	52055	3.4	28.7	0.56	0.00	0.017	1.61	0.0002	0.0008
Parking fees	52053	3.7	26.8	0.38	0.10	0.096	1.75	0.0014	0.0052
Haircuts and other barber shop services for males	65021	3.9	25.5	0.19	0.11	0.162	1.99	0.0024	0.0092
Beauty parlor services for females	65011	4.3	22.9	0.42	0.23	0.338	2.48	0.0049	0.0211
State automobile registration	52011	4.3	22.7	1.00	0.22	0.278	2.88	0.0040	0.0173
Services by other medical professionals	56041	4.5	22.0	0.83	0.62	0.217	3.19	0.0031	0.0142
Hearing aids	55034	4.7	20.8	1.19	0.93	0.024	3.23	0.0003	0.0016
Shoe repair and other shoe services	44011	4.8	20.4	0.63	0.57	0.009	3.24	0.0001	0.0006
Garbage and trash collection	27041	4.9	20.0	0.89	0.44	0.249	3.60	0.0036	0.0177
Pet services	62053	4.9	19.7	0.13	0.07	0.064	3.70	0.0009	0.0046
Taxi fare	53032	5.0	19.7	0.33	0.04	0.045	3.76	0.0007	0.0033
Care of invalids, elderly and convalescents in the home	34071	5.1	19.1	1.53	0.75	0.125	3.94	0.0018	0.0092
Household laundry and drycleaning, excl coin operated	34044	5.1	19.0	0.61	0.54	0.039	4.00	0.0006	0.0029
Watch and jewelry repair	44015	5.2	18.5	0.27	0.13	0.018	4.02	0.0003	0.0014
Photographic and darkroom supplies	61022	5.3	18.4	2.41	1.71	0.005	4.03	0.0001	0.0004
Physicians' services	56011	5.3	18.3	0.71	0.54	1.366	6.01	0.0198	0.1050
Film processing	62052	5.3	18.2	1.17	0.87	0.101	6.16	0.0015	0.0078
Wine away from home	20052	5.5	17.6	2.63	1.26	0.078	6.27	0.0011	0.0062
Postage	34011	5.6	17.5	0.00	0.00	0.214	6.58	0.0031	0.0174
Water softening service	34042	5.7	17.2	0.91	0.91	0.009	6.60	0.0001	0.0007
Apparel laundry and drycleaning, excl coin operated	44021	5.7	17.0	0.21	0.17	0.269	6.99	0.0039	0.0222
Plumbing supplies and equipment	24015	6.0	16.2	1.51	0.51	0.003	6.99	0.0000	0.0003
Repair of television, radio and sound equipment	34061	6.1	16.0	0.39	0.16	0.026	7.03	0.0004	0.0023
Dental services	56021	6.1	15.8	0.28	0.17	0.750	8.12	0.0109	0.0664
Other entertainment services	62055	6.2	15.7	0.90	0.53	0.260	8.49	0.0038	0.0234

Beer, ale, other alcoholic malt beverages away from home	20051	6.4	15.2	1.69	0.98	0.125	8.68	0.0018	0.0116
Checking accounts and special check services	68022	6.4	15.2	1.27	0.56	0.088	8.80	0.0013	0.0082
Intrastate telephone services	27061	6.4	15.2	0.16	0.04	0.460	9.47	0.0067	0.0427
Veterinarian services	62054	6.5	14.9	0.66	0.59	0.182	9.74	0.0026	0.0172
Domestic services	34031	6.5	14.9	0.82	0.60	0.310	10.19	0.0045	0.0292
Club membership dues and fees	62011	6.7	14.5	1.23	0.85	0.340	10.68	0.0049	0.0331
Elementary and high school books and supplies	66021	6.8	14.2	1.63	0.95	0.031	10.72	0.0004	0.0031
Fees for lessons or instructions	62041	6.9	14.0	2.53	2.19	0.211	11.03	0.0031	0.0211
Miscellaneous supplies and equipment	24041	7.1	13.7	2.26	0.93	0.044	11.09	0.0006	0.0045
Cemetery lots and cripts	68032	7.2	13.5	0.78	0.53	0.044	11.16	0.0006	0.0046
Day care and nursery school	67031	7.2	13.5	0.90	0.50	0.539	11.94	0.0078	0.0563
Encyclopedias and other sets of reference books	66022	7.5	12.9	3.70	0.09	0.005	11.95	0.0001	0.0005
Technical and business school tuition and fixed fees	67041	7.7	12.4	1.37	0.77	0.050	12.02	0.0007	0.0056
Residential water and sewer service	27021	7.9	12.1	0.86	0.41	0.663	12.98	0.0096	0.0760
Distilled spirits away from home	20053	7.9	12.1	1.10	0.58	0.114	13.15	0.0017	0.0131
Tax return preparation and other accounting fees	68023	8.3	11.6	0.76	0.61	0.147	13.36	0.0021	0.0177
Breakfast or brunch	19032	8.4	11.4	1.01	0.59	0.378	13.91	0.0055	0.0461
Magazines	59021	8.6	11.2	1.27	0.74	0.122	14.09	0.0018	0.0152
Housing at school, excl board	21031	8.7	11.0	0.83	0.45	0.197	14.37	0.0029	0.0249
Admission to movies, theaters, and concerts	62031	8.8	10.9	1.79	0.56	0.416	14.98	0.0060	0.0531
Eyeglasses and eyecare	56031	8.9	10.8	2.05	0.97	0.333	15.46	0.0048	0.0430
Lunch	19011	9.0	10.7	1.48	0.87	1.762	18.02	0.0256	0.2301
Dinner	19021	9.0	10.6	1.74	1.05	2.515	21.67	0.0365	0.3284
Nonelectric articles for the hair	64012	9.1	10.5	4.42	3.03	0.016	21.69	0.0002	0.0021
Other information processing equipment	69015	9.1	10.5	4.17	0.00	0.015	21.71	0.0002	0.0020
Photographer fees	62051	9.1	10.5	2.68	1.86	0.067	21.81	0.0010	0.0088
Nursing and convalescent home care	57022	9.2	10.4	1.12	0.72	0.024	21.85	0.0003	0.0032
Elementary and high school tuition and fixed fees	67021	9.3	10.2	0.50	0.17	0.312	22.30	0.0045	0.0421
Moving, storage, freight expense	34043	9.4	10.2	0.74	0.29	0.106	22.45	0.0015	0.0145
Tenants' insurance	35011	9.5	10.1	1.19	0.11	0.026	22.49	0.0004	0.0036
Snacks and nonalcoholic beverages	19031	9.5	10.0	1.87	1.25	0.414	23.09	0.0060	0.0571
Tools and equipment for painting	24012	9.7	9.8	4.55	1.81	0.001	23.09	0.0000	0.0001
Inside home maintenance and repair services	23011	9.8	9.7	0.96	0.60	0.085	23.21	0.0012	0.0121
Supportive and convalescent medical equipment	55033	9.8	9.7	3.14	1.58	0.013	23.23	0.0002	0.0018
Medical equipment for general use	55032	9.8	9.7	3.01	2.77	0.009	23.25	0.0001	0.0013
Clothing rental	44014	10.0	9.5	1.67	1.38	0.011	23.26	0.0002	0.0016
College tuition and fixed fees	67011	10.1	9.4	0.82	0.18	0.951	24.64	0.0138	0.1394

Intercity train fare	53022	10.2	9.3	0.07	0.05	0.068	24.74	0.0010	0.0101
Plastic dinnerware	32031	10.2	9.3	4.17	1.76	0.005	24.75	0.0001	0.0007
College textbooks	66011	10.2	9.3	2.68	1.55	0.128	24.93	0.0019	0.0189
Electrical supplies, heating and cooling equipment	24016	10.5	9.0	3.20	0.81	0.002	24.93	0.0000	0.0003
Fees for participant sports	62021	10.6	9.0	1.00	0.44	0.339	25.43	0.0049	0.0521
Reupholstery of furniture	34063	10.7	8.9	1.30	0.66	0.040	25.49	0.0006	0.0062
Interstate telephone services	27051	10.8	8.8	0.11	0.10	0.768	26.60	0.0111	0.1203
Power tools	32042	10.8	8.8	2.16	0.68	0.051	26.67	0.0007	0.0080
Other hardware	32043	10.8	8.7	2.81	1.30	0.052	26.75	0.0008	0.0081
Nonpowered hand tools	32044	10.9	8.6	2.84	1.70	0.030	26.79	0.0004	0.0047
Cosmetics, bath/nail/make-up preparations & implements	64031	11.1	8.5	2.65	1.47	0.362	27.32	0.0053	0.0583
Kitchen and dining room linens	28013	11.2	8.4	4.56	2.17	0.035	27.37	0.0005	0.0057
Blacktop and masonry materials	24014	11.2	8.4	1.36	0.00	0.001	27.37	0.0000	0.0002
Stationery, stationery supplies, giftwrap	33032	11.4	8.2	6.30	2.54	0.219	27.69	0.0032	0.0362
Records and tapes, prerecorded and blank	31033	11.4	8.2	4.95	1.03	0.179	27.95	0.0026	0.0296
Hospital services	57041	11.4	8.2	1.63	1.25	1.426	30.01	0.0207	0.2359
Gardening and lawn care services	34041	11.5	8.2	1.84	1.15	0.241	30.36	0.0035	0.0402
Automotive maintenance and servicing	49031	11.6	8.1	9.36	0.46	0.550	31.16	0.0080	0.0926
Film	61021	11.8	8.0	2.33	0.63	0.041	31.22	0.0006	0.0070
Purchase of pets, pet supplies, and accessories	61032	11.8	8.0	3.49	1.49	0.188	31.50	0.0027	0.0322
Sewing notions and patterns	42012	12.0	7.8	2.71	0.51	0.007	31.51	0.0001	0.0012
Tableware and nonelectric kitchenware	32038	12.0	7.8	5.82	3.02	0.064	31.60	0.0009	0.0111
Laundry and cleaning equipment	32014	12.3	7.6	5.55	2.44	0.042	31.66	0.0006	0.0075
Books not purchased through book clubs	59023	12.4	7.5	8.20	2.07	0.167	31.90	0.0024	0.0300
Electric personal care appliances	64017	12.6	7.4	6.26	3.39	0.014	31.92	0.0002	0.0026
Calculators, adding machines, and typewriters	69014	12.8	7.3	7.78	6.20	0.018	31.95	0.0003	0.0033
Women's hosiery	38043	12.9	7.2	2.78	0.77	0.082	32.07	0.0012	0.0153
Clocks	32021	13.0	7.2	5.92	2.74	0.012	32.08	0.0002	0.0023
Videocassettes and discs, blank and prerecorded	31022	13.0	7.2	6.66	1.68	0.084	32.21	0.0012	0.0158
Deodorant/suntan preparations, sanitary/footcare products	64016	13.2	7.1	2.39	1.04	0.090	32.34	0.0013	0.0172
Coolant, brake fluid, transmission fluid, and additives	47022	13.3	7.0	2.01	0.51	0.015	32.36	0.0002	0.0029
Paint, wallpaper and supplies	24011	13.3	7.0	1.81	0.61	0.011	32.37	0.0002	0.0021
Hard surface floor covering	24042	13.5	6.9	1.62	1.00	0.015	32.39	0.0002	0.0029
Unpowered boats and trailers	60012	13.5	6.9	4.70	0.44	0.055	32.47	0.0008	0.0108
Telephone services, local charges	27011	13.6	6.8	0.72	0.23	1.221	34.25	0.0177	0.2409
Internal and respiratory over-the-counter drugs	55021	13.7	6.8	1.82	1.35	0.257	34.62	0.0037	0.0511
Dental products, nonelectric dental articles	64014	13.8	6.7	2.30	1.24	0.078	34.73	0.0011	0.0156

Toys, games and hobbies	61011	13.9	6.7	6.58	2.67	0.403	35.32	0.0058	0.0813
Infants' and toddlers' underwear	41013	14.0	6.6	4.00	1.57	0.158	35.55	0.0023	0.0321
Topicals and dressings	55031	14.2	6.6	2.40	1.65	0.071	35.65	0.0010	0.0146
Slipcovers and decorative pillows	28015	14.2	6.5	7.69	2.28	0.015	35.67	0.0002	0.0031
Distilled spirits at home (excl whiskey)	20022	14.2	6.5	0.61	0.27	0.056	35.75	0.0008	0.0115
Replacement of installed wall to wall carpet	23013	14.3	6.5	5.61	4.48	0.024	35.79	0.0003	0.0050
Floor coverings	32011	14.4	6.4	4.19	2.17	0.057	35.87	0.0008	0.0119
Funeral expenses	68031	14.5	6.4	2.56	1.47	0.261	36.25	0.0038	0.0549
Landscaping items	24043	14.9	6.2	2.47	1.53	0.005	36.26	0.0001	0.0011
Shaving products, nonelectric shaving articles	64015	15.0	6.1	2.76	1.52	0.041	36.32	0.0006	0.0089
Products for the hair	64011	15.0	6.1	1.94	1.13	0.131	36.51	0.0019	0.0285
Whiskey at home	20021	15.3	6.0	0.54	0.25	0.050	36.58	0.0007	0.0111
Automobile insurance	50011	15.5	5.9	1.51	0.12	2.460	40.15	0.0357	0.5532
Lawn and garden supplies	33052	15.5	5.9	3.54	1.68	0.200	40.44	0.0029	0.0450
Vehicle parts and equipment other than tires	48021	15.8	5.8	3.84	1.02	0.260	40.82	0.0038	0.0596
Other laundry and cleaning products	33012	15.9	5.8	1.81	0.99	0.145	41.03	0.0021	0.0335
Infants' equipment	32013	15.9	5.8	5.32	2.48	0.013	41.04	0.0002	0.0030
Nonelectric cookingware	32037	16.1	5.7	5.28	2.30	0.034	41.09	0.0005	0.0079
Music instruments and accessories	61013	16.2	5.7	3.06	1.12	0.064	41.19	0.0009	0.0150
Photographic equipment	61023	16.4	5.6	4.47	1.58	0.042	41.25	0.0006	0.0100
Candy and chewing gum	15011	16.4	5.6	2.10	1.03	0.237	41.59	0.0034	0.0564
Computer software and accessories	69012	16.5	5.5	5.53	2.57	0.067	41.69	0.0010	0.0160
Household decorative items	32023	16.6	5.5	8.12	4.24	0.213	42.00	0.0031	0.0513
Indoor, warm weather and winter sports equipment	60021	16.6	5.5	5.01	2.12	0.255	42.37	0.0037	0.0614
Tobacco products other than cigarettes	63012	16.7	5.5	0.96	0.75	0.063	42.46	0.0009	0.0153
Prescription drugs and medical supplies	54011	16.8	5.4	1.22	0.62	0.648	43.40	0.0094	0.1580
Miscellaneous household products	33051	16.8	5.4	2.21	1.01	0.272	43.80	0.0039	0.0663
Repair of household appliances	34062	16.9	5.4	0.60	0.29	0.014	43.82	0.0002	0.0034
Fabric for making clothes	42011	17.0	5.4	3.96	0.86	0.018	43.84	0.0003	0.0044
Boys' underwear, nightwear and hosiery	37014	17.1	5.3	3.20	0.42	0.034	43.89	0.0005	0.0084
Hunting, fishing, and camping equipment	60022	17.1	5.3	4.27	1.66	0.064	43.98	0.0009	0.0159
Boys' accessories	37015	17.2	5.3	5.33	1.54	0.020	44.01	0.0003	0.0050
Infants' furniture	29042	17.5	5.2	4.76	1.60	0.025	44.05	0.0004	0.0063
Pet food	61031	17.5	5.2	2.13	0.80	0.251	44.41	0.0036	0.0637
Men's underwear and hosiery	36031	17.6	5.2	2.31	0.40	0.114	44.58	0.0017	0.0291
Salt and other seasonings and spices	18041	17.6	5.2	1.41	0.64	0.070	44.68	0.0010	0.0179
Sewing materials for household items	28016	17.7	5.1	2.45	0.71	0.036	44.73	0.0005	0.0092

Men's nightwear	36032	17.8	5.1	5.37	0.70	0.013	44.75	0.0002	0.0034
Telephone, peripheral equipment and accessories	69013	17.8	5.1	4.79	3.24	0.065	44.84	0.0009	0.0168
Books purchased through book clubs	59022	17.9	5.1	7.56	3.12	0.031	44.89	0.0004	0.0081
Indoor plants and fresh cut flowers	32061	18.0	5.0	4.88	3.07	0.164	45.13	0.0024	0.0428
Flatware	32033	18.3	4.9	3.91	1.93	0.014	45.15	0.0002	0.0037
Glassware	32034	18.4	4.9	5.12	2.44	0.014	45.17	0.0002	0.0037
Automotive brake work	49022	18.5	4.9	9.94	1.25	0.141	45.37	0.0020	0.0378
Automotive drive train repair	49021	18.5	4.9	9.65	1.13	0.178	45.63	0.0026	0.0478
Men's accessories	36033	18.7	4.8	4.62	0.78	0.130	45.82	0.0019	0.0353
Watches	43011	18.8	4.8	5.08	1.32	0.069	45.92	0.0010	0.0188
Living room tables	29032	18.8	4.8	4.13	2.55	0.063	46.01	0.0009	0.0172
Portable cool/heat equip., small electric kitchen appliances	32052	19.0	4.8	5.15	2.02	0.078	46.13	0.0011	0.0215
Soaps and detergents	33011	19.2	4.7	3.16	2.05	0.214	46.44	0.0031	0.0596
Wine at home	20031	19.3	4.7	3.24	0.84	0.187	46.71	0.0027	0.0524
Lamps and lighting fixtures	32022	19.4	4.6	6.26	2.61	0.035	46.76	0.0005	0.0099
Repair to steering, front end, cooling system and A/C	49023	19.5	4.6	10.18	1.26	0.154	46.98	0.0022	0.0436
Community antenna or cable TV	27031	19.6	4.6	1.91	0.20	0.784	48.12	0.0114	0.2230
Bicycles	60013	19.6	4.6	6.94	1.10	0.047	48.19	0.0007	0.0134
Automotive body work	49011	19.7	4.6	10.11	1.45	0.098	48.33	0.0014	0.0280
Window coverings	32012	19.9	4.5	2.13	0.71	0.038	48.39	0.0006	0.0110
Other condiments (excl olives, pickles, relishes)	18044	20.1	4.5	0.95	0.51	0.054	48.46	0.0008	0.0157
Rolls, biscuits, muffins (excl frozen)	2022	20.1	4.5	2.48	1.35	0.135	48.66	0.0020	0.0394
Intercity bus fare	53021	20.3	4.4	1.31	0.09	0.051	48.73	0.0007	0.0150
China and other dinnerware	32032	20.4	4.4	5.19	2.34	0.042	48.79	0.0006	0.0124
Outboard motors and powered sports vehicles	60011	20.5	4.3	6.98	0.96	0.176	49.05	0.0026	0.0523
Sweet rolls, coffee cake and doughnuts (excl frozen)	2063	20.6	4.3	4.06	2.68	0.073	49.16	0.0011	0.0218
Canned ham	4032	20.7	4.3	3.45	2.06	0.007	49.17	0.0001	0.0021
Bedroom furniture other than mattress and springs	29012	20.8	4.3	4.35	2.30	0.193	49.45	0.0028	0.0582
Occasional furniture	29044	20.9	4.3	4.92	3.25	0.125	49.63	0.0018	0.0379
Beer, ale, and other alcoholic malt	20011	20.9	4.3	1.03	0.36	0.308	50.07	0.0045	0.0934
Baby food	18062	20.9	4.3	1.03	0.33	0.088	50.20	0.0013	0.0267
Cakes and cupcakes (excl frozen)	2041	21.0	4.3	3.49	2.12	0.119	50.37	0.0017	0.0363
Nondairy cream substitutes	16013	21.0	4.2	1.11	0.57	0.024	50.41	0.0003	0.0073
Tea	17052	21.0	4.2	1.09	0.53	0.057	50.49	0.0008	0.0174
Automotive power plant repair	49041	21.1	4.2	10.09	1.75	0.404	51.08	0.0059	0.1237
Other noncarbonated drinks	17053	21.1	4.2	2.21	0.88	0.069	51.18	0.0010	0.0211
Lumber, paneling, wall and ceiling tile, awnings, glass	24013	21.6	4.1	1.68	0.67	0.006	51.19	0.0001	0.0019

Nuts	18032	21.6	4.1	2.28	1.23	0.062	51.28	0.0009	0.0194
Cigarettes	63011	21.6	4.1	0.35	0.22	0.801	52.44	0.0116	0.2510
Mattress and springs	29011	21.9	4.1	5.44	2.36	0.146	52.65	0.0021	0.0464
Smoking accessories	63013	21.9	4.0	3.83	0.00	0.004	52.66	0.0001	0.0013
Women's underwear	38042	22.1	4.0	3.28	0.77	0.108	52.81	0.0016	0.0346
Men's footwear	40011	22.2	4.0	4.84	0.79	0.348	53.32	0.0050	0.1121
Other sweets (excl candy and gum)	15012	22.5	3.9	1.95	1.16	0.075	53.43	0.0011	0.0245
Admission to sporting events	62032	22.6	3.9	4.80	3.64	0.155	53.65	0.0022	0.0508
Bathroom linens	28011	22.6	3.9	3.40	1.10	0.055	53.73	0.0008	0.0180
Serving pieces other than silver or glass	32036	22.9	3.9	5.30	3.98	0.005	53.74	0.0001	0.0017
Sugar and artificial sweeteners	15021	22.9	3.8	1.30	0.70	0.073	53.84	0.0011	0.0243
Girls' hosiery and accessories	39017	23.0	3.8	7.01	2.17	0.030	53.89	0.0004	0.0100
Lawn and garden equipment	32041	23.1	3.8	5.92	1.02	0.131	54.08	0.0019	0.0439
Video game hardware, software and accessories	31023	23.4	3.8	10.15	5.65	0.051	54.15	0.0007	0.0173
Jewelry	43021	23.4	3.7	4.86	1.76	0.401	54.73	0.0058	0.1361
Curtains and drapes	28014	24.0	3.6	3.25	1.08	0.057	54.81	0.0008	0.0198
Kitchen and dining room furniture	29041	24.1	3.6	5.47	3.40	0.163	55.05	0.0024	0.0570
Cleansing and toilet tissue, paper towels, napkins	33031	24.2	3.6	3.37	2.25	0.208	55.35	0.0030	0.0730
Girls' footwear	40022	24.2	3.6	7.43	1.27	0.119	55.52	0.0017	0.0418
Sofas	29021	24.2	3.6	6.73	3.50	0.277	55.93	0.0040	0.0973
New motorcycles	45031	24.3	3.6	9.30	1.31	0.082	56.04	0.0012	0.0289
Instant and freeze dried coffee	17032	24.3	3.6	1.17	0.67	0.056	56.13	0.0008	0.0197
Girls' underwear and nightwear	39016	24.4	3.6	6.80	1.77	0.026	56.16	0.0004	0.0092
Other processed vegetables	14023	24.6	3.5	2.04	0.40	0.113	56.33	0.0016	0.0403
Other fuels	25023	24.8	3.5	0.71	0.29	0.014	56.35	0.0002	0.0050
Canned and dried fruits	13031	24.9	3.5	2.10	0.68	0.068	56.45	0.0010	0.0246
Noncarbonated fruit flavored drinks	17051	25.0	3.5	2.20	0.92	0.088	56.58	0.0013	0.0319
Other fats and oils	16012	25.3	3.4	1.16	0.46	0.172	56.83	0.0025	0.0631
Outdoor equipment	32015	25.3	3.4	8.33	6.19	0.014	56.85	0.0002	0.0051
Macaroni and cornmeal	1032	25.5	3.4	1.22	0.65	0.094	56.98	0.0014	0.0348
Cereal	1021	25.5	3.4	1.69	0.87	0.333	57.47	0.0048	0.1232
Radio, phonographs and taperecorders/players	31031	25.5	3.4	7.80	4.96	0.030	57.51	0.0004	0.0111
Pies, tarts, turnovers (excl frozen)	2065	25.6	3.4	5.47	2.05	0.044	57.57	0.0006	0.0163
White bread	2011	25.7	3.4	1.48	0.83	0.124	57.75	0.0018	0.0462
Truck rental	52052	25.7	3.4	1.60	0.25	0.287	58.17	0.0042	0.1070
Canned beans other than lima beans	14021	25.8	3.3	1.79	0.37	0.037	58.22	0.0005	0.0139
Boys' suits, sportcoats, and pants	37016	25.9	3.3	4.82	1.22	0.119	58.40	0.0017	0.0447

Men's suits	36011	26.0	3.3	3.27	1.03	0.126	58.58	0.0018	0.0475
Canned and packaged soup	18011	26.3	3.3	1.48	0.69	0.108	58.73	0.0016	0.0412
Lamb, organ meats, and game	5014	26.4	3.3	1.88	0.82	0.044	58.80	0.0006	0.0169
Men's pants and shorts	36051	26.4	3.3	3.39	0.84	0.242	59.15	0.0035	0.0927
Women's accessories	38044	26.4	3.3	11.10	2.02	0.057	59.23	0.0008	0.0218
Rice	1031	26.5	3.2	1.10	0.58	0.073	59.34	0.0011	0.0281
Canned or packaged salads and desserts	18061	26.6	3.2	2.12	1.05	0.079	59.45	0.0011	0.0305
Living room chairs	29031	26.7	3.2	7.05	3.17	0.136	59.65	0.0020	0.0527
Infants' and toddlers' sleepwear	41014	26.9	3.2	7.37	1.42	0.014	59.67	0.0002	0.0055
Other dairy products	10012	26.9	3.2	1.48	0.58	0.077	59.78	0.0011	0.0301
Bedroom linens	28012	27.0	3.2	5.02	1.60	0.170	60.03	0.0025	0.0666
Prepared Flour Mixes	1012	27.1	3.2	2.14	0.85	0.043	60.09	0.0006	0.0169
Other frozen fruits and fruit juices	13012	27.1	3.2	1.28	0.55	0.025	60.13	0.0004	0.0098
Canned fish or seafood	7011	27.4	3.1	1.80	0.75	0.058	60.21	0.0008	0.0231
Sauces and gravies	18043	27.6	3.1	1.01	0.55	0.134	60.41	0.0019	0.0537
Margarine	16011	27.9	3.1	1.48	0.39	0.043	60.47	0.0006	0.0174
Bologna, liverwurst, salami	5012	28.0	3.0	2.02	1.22	0.085	60.59	0.0012	0.0345
Ship fares	53023	28.0	3.0	4.78	1.10	0.101	60.74	0.0015	0.0410
Women's footwear	40031	28.0	3.0	6.80	1.62	0.424	61.35	0.0062	0.1723
Other canned or packaged foods	18063	28.1	3.0	1.80	0.76	0.223	61.68	0.0032	0.0909
Olives, pickles, relishes	18042	28.1	3.0	1.50	0.71	0.035	61.73	0.0005	0.0143
Dryers	30022	28.5	3.0	5.43	0.21	0.042	61.79	0.0006	0.0174
Automobile finance charges	51011	28.6	3.0	1.84	0.04	0.493	62.50	0.0072	0.2046
Lunchmeats	5013	28.7	3.0	2.79	1.08	0.150	62.72	0.0022	0.0625
Microwave ovens	30032	29.0	2.9	8.16	1.39	0.030	62.77	0.0004	0.0126
Potato chips and other snacks	18031	29.1	2.9	2.62	1.57	0.212	63.07	0.0031	0.0895
Boys' footwear	40021	29.7	2.8	9.51	1.26	0.094	63.21	0.0014	0.0405
Bread other than white	2021	29.7	2.8	2.07	1.27	0.137	63.41	0.0020	0.0590
Outdoor furniture	29043	29.8	2.8	9.88	4.63	0.040	63.47	0.0006	0.0173
Window air conditioners	30034	29.9	2.8	7.22	2.00	0.039	63.52	0.0006	0.0169
Men's sportcoats and tailored jackets	36012	30.1	2.8	4.47	1.39	0.030	63.57	0.0004	0.0131
Frozen bakery products	2064	30.3	2.8	2.68	1.22	0.076	63.68	0.0011	0.0334
Tires	48011	30.5	2.7	2.72	0.58	0.290	64.10	0.0042	0.1283
Men's coats and jackets	36013	30.9	2.7	8.28	2.51	0.116	64.27	0.0017	0.0520
Frozen vegetables	14011	31.0	2.7	1.95	0.79	0.099	64.41	0.0014	0.0445
Peanut butter	16014	31.0	2.7	1.10	0.48	0.040	64.47	0.0006	0.0180
Televisions	31011	31.0	2.7	9.03	3.61	0.269	64.86	0.0039	0.1210

Ham (excl canned)	4031	50.4	1.4	4.00	2.03	0.118	90.38	0.0017	0.0863
Fuel oil	25011	52.5	1.3	0.40	0.18	0.169	90.63	0.0025	0.1287
Other fresh vegetables	12041	52.8	1.3	0.17	0.07	0.250	90.99	0.0036	0.1915
Round roast	3031	53.1	1.3	0.48	0.40	0.045	91.05	0.0007	0.0347
Chuck roast	3021	54.3	1.3	0.76	0.65	0.043	91.12	0.0006	0.0339
Oranges	11031	54.7	1.3	0.45	0.11	0.057	91.20	0.0008	0.0452
Girls' dresses and suits	39012	55.1	1.2	28.49	12.80	0.045	91.26	0.0007	0.0360
Automobile rental	52051	56.8	1.2	2.86	0.40	0.758	92.36	0.0110	0.6247
Other fresh fruits	11041	59.7	1.1	0.24	0.08	0.247	92.72	0.0036	0.2139
Other motor fuel	47018	61.8	1.0	4.46	1.80	0.032	92.77	0.0005	0.0287
Eggs	8011	61.8	1.0	0.64	0.26	0.107	92.92	0.0016	0.0959
Lettuce	12021	62.4	1.0	0.06	0.05	0.064	93.02	0.0009	0.0579
Utility natural gas service	26021	64.2	1.0	0.34	0.08	1.012	94.48	0.0147	0.9427
Airline fares	53011	69.1	0.9	0.45	0.25	0.829	95.69	0.0120	0.8311
Tomatoes	12031	71.0	0.8	0.22	0.03	0.078	95.80	0.0011	0.0804
Premium unleaded gasoline	47016	76.2	0.7	2.81	0.89	0.998	97.25	0.0145	1.1034
Mid-grade unleaded gasoline	47015	77.5	0.7	2.55	0.82	0.865	98.50	0.0126	0.9726
Regular unleaded gasoline	47014	78.9	0.6	2.56	0.83	1.031	100.00	0.0150	1.1802

of a price spell is

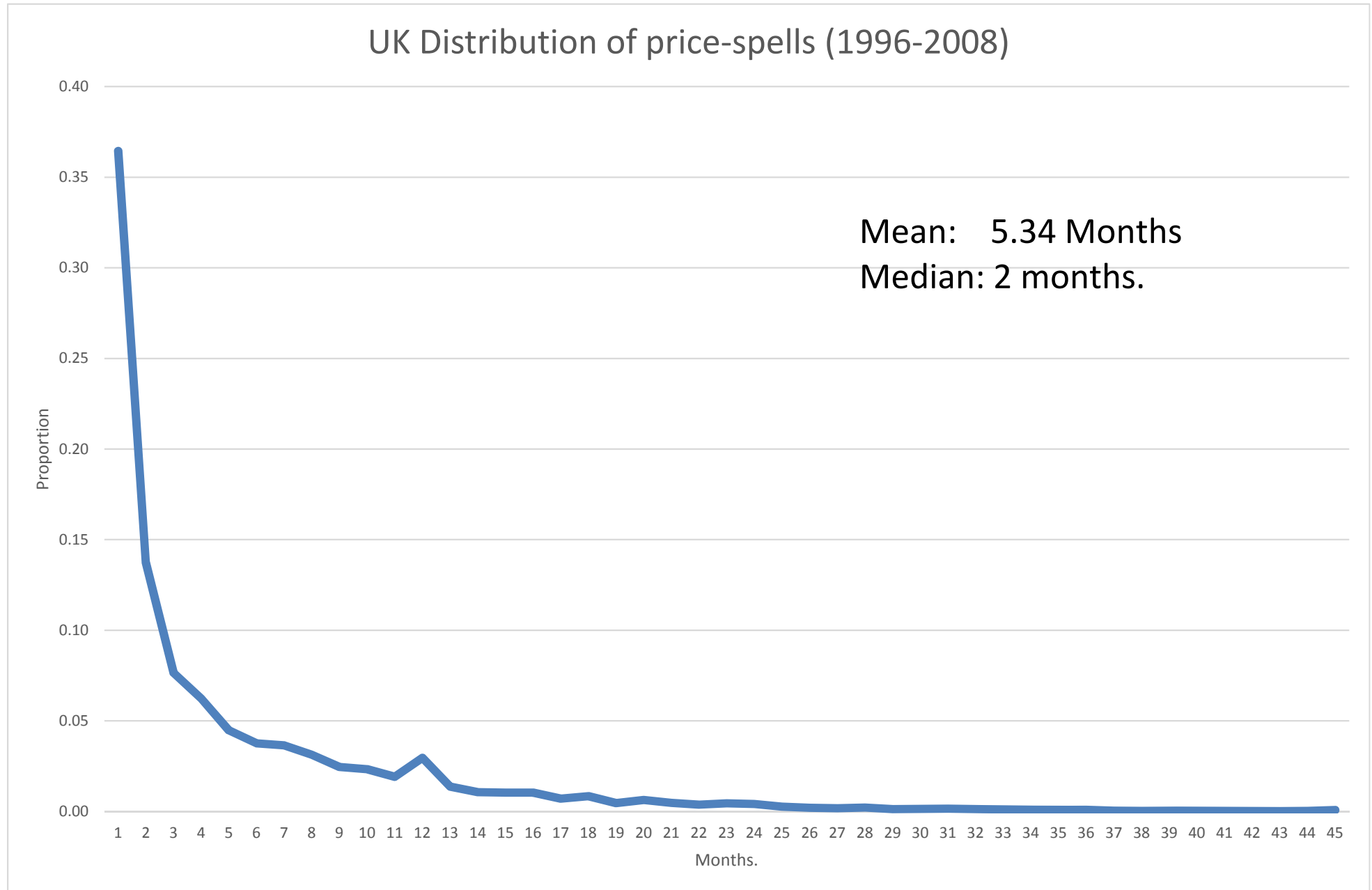
$$\bar{d} = \begin{cases} -\frac{1}{\ln(1-\bar{h})} & \text{Continuous time (at least one change)} \\ \frac{1}{\bar{h}} & \text{Discrete time (Bernoulli)} \end{cases}$$

linked by approximation $\ln(1 - \bar{h}) \simeq -\bar{h}$ for small \bar{h}

- Discrete time: UK and France (1995-2008) $\bar{h} = 0.2$; US 0.25; Germany 0.11. Implies short mean price spell UK/France: 5 months; US 4 months.....
- Nominal rigidity?
 - Patrick Kehoe 2004: Challenges for sticky price enthusiasts

“Observed price stickiness is short. On the empirical side Bils and Klenow (2003) and Klenow and Kryvtsov (2003) have dug up some interesting BLS data on individual goods price that shows that a key feature of the data is that the average time between price changes is relatively short, about 4 months. . . ”

- What does the distribution of price-spells look like? For UK. Lots of short spells, long fat tale of long spells. For PPI data less short spells, but otherwise similar.



- Over next decade, economists tried to make the mean duration of a price-spell look longer.
 - **Remove short price spells.** These were identified as "Sales". Nakamura and Steinsson, get rid of V shaped price sequences. Various "filters" suggested.
 - **Replace the actual prices with reference prices.** Eichenbaum et al 2011, Kehoe and Midrigan 2015: set all prices equal to modal price, defined over a calender period or rolling window.
- In this case, get long price spells (!?). Patrick Kehoe 2015, **Prices are sticky after all!**
 - *"Economists have interpreted the evidence that prices change every four months as implying that sticky prices cannot be important for monetary*

transmission... We predict that the stickiness of the aggregate price level matches that in a standard Calvo model or a standard menu cost model in which micro- level prices change about once a year. In this sense, prices are sticky after all..."

- **Is this the right way to look at things?**

5.2 Price spells and nominal rigidity...

- 9 firms set prices for a year (all on January 1st), but where 1 firm sets prices τ times per year each of duration τ^{-1} . There are $9 + \tau$ price spells; 10 firms.

$$\bar{d}(\tau) = \frac{9 \cdot 1 + \tau \cdot \tau^{-1}}{9 + \tau} = \frac{10}{9 + \tau}$$

$$\bar{T}(\tau) = \frac{9 + \tau^{-1}}{10}.$$

•

$$\lim_{\tau \rightarrow \infty} \bar{d}(\tau) = 0$$

$$\lim_{\tau \rightarrow \infty} \bar{T}(\tau) = 0.9$$

- short price-spells do not matter as much as long price spells. Looking at the distribution of price spell durations is a poor guide to nominal rigidity. Need to look at *cross-section, average across firms* (prices).

6 Cross-section average.

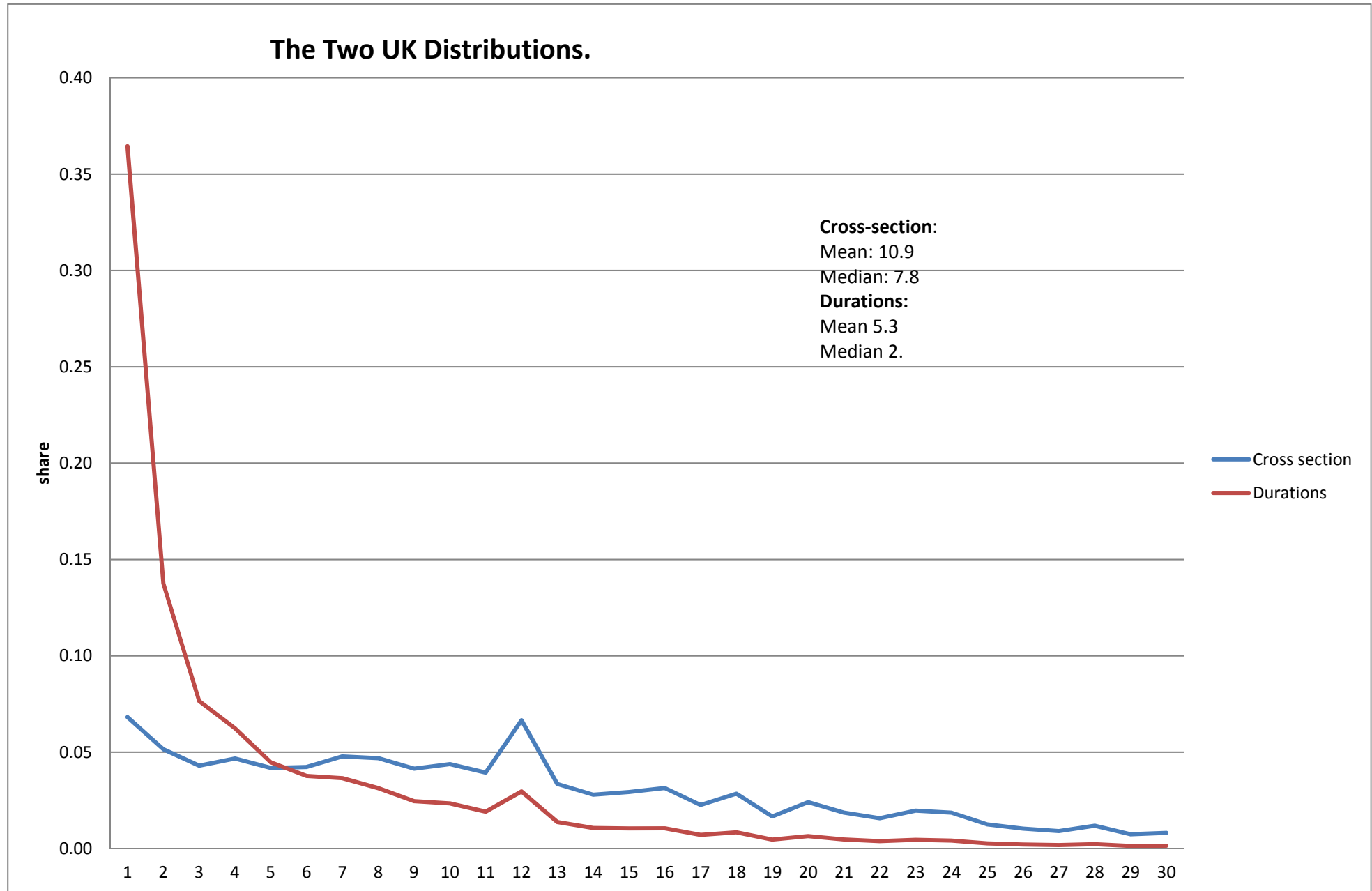
- Keep panel structure, look at cross-section.
- cross-section puts more weight on longer spells: the probability of being observed in a cross section is proportional to the length of the price spell. So sales and transient prices are still kept in sample, just given a smaller weight.

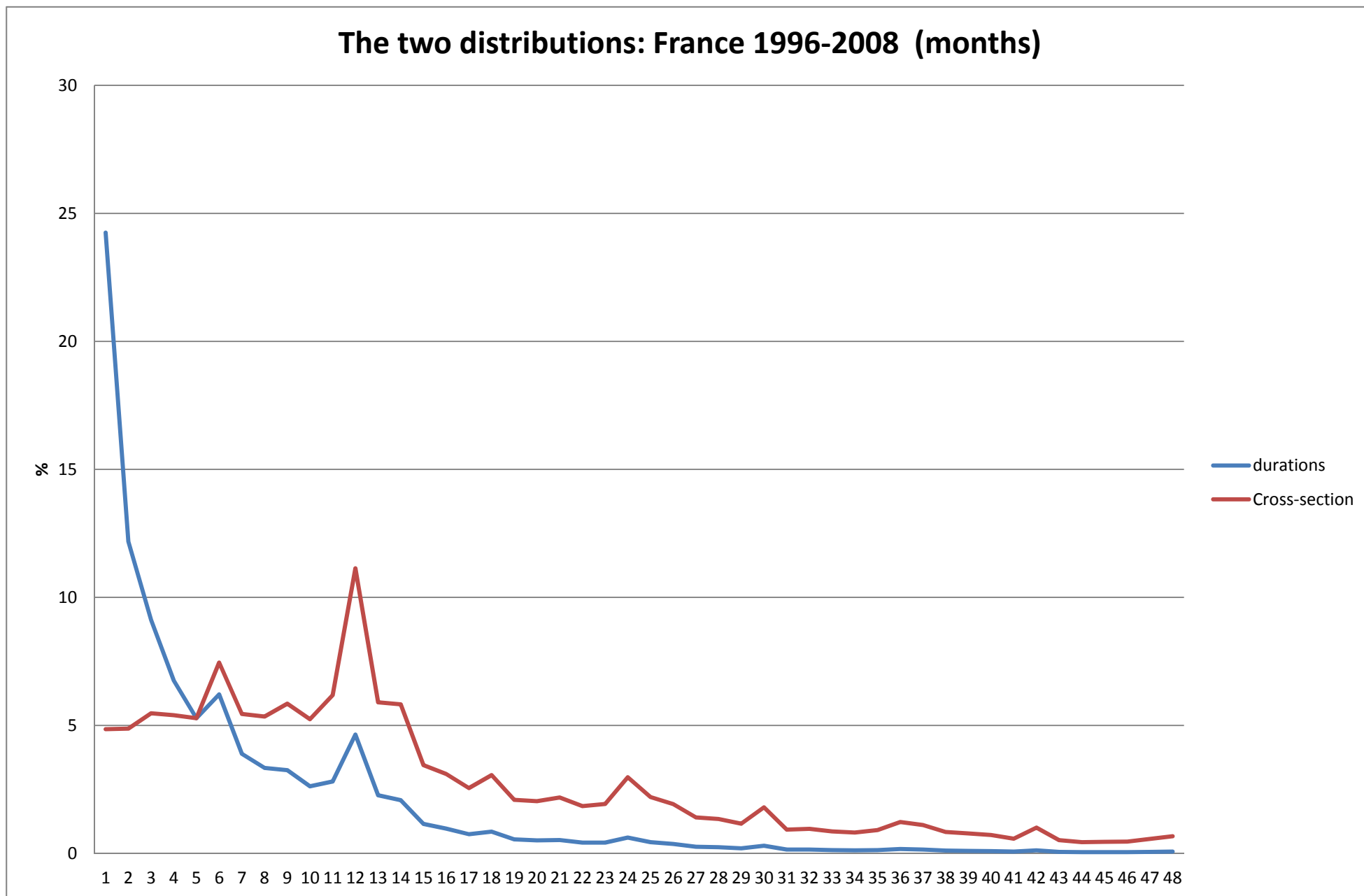
- Two distributions price spells $\{\alpha_i^d\}$ and the cross-sectional distribution across firms (prices) $\{\alpha_i\}$:

$$\begin{aligned}\alpha_i^d &= \frac{\alpha_i}{i.\bar{h}} \\ \alpha &= i.\bar{h}.\alpha_i^d\end{aligned}$$

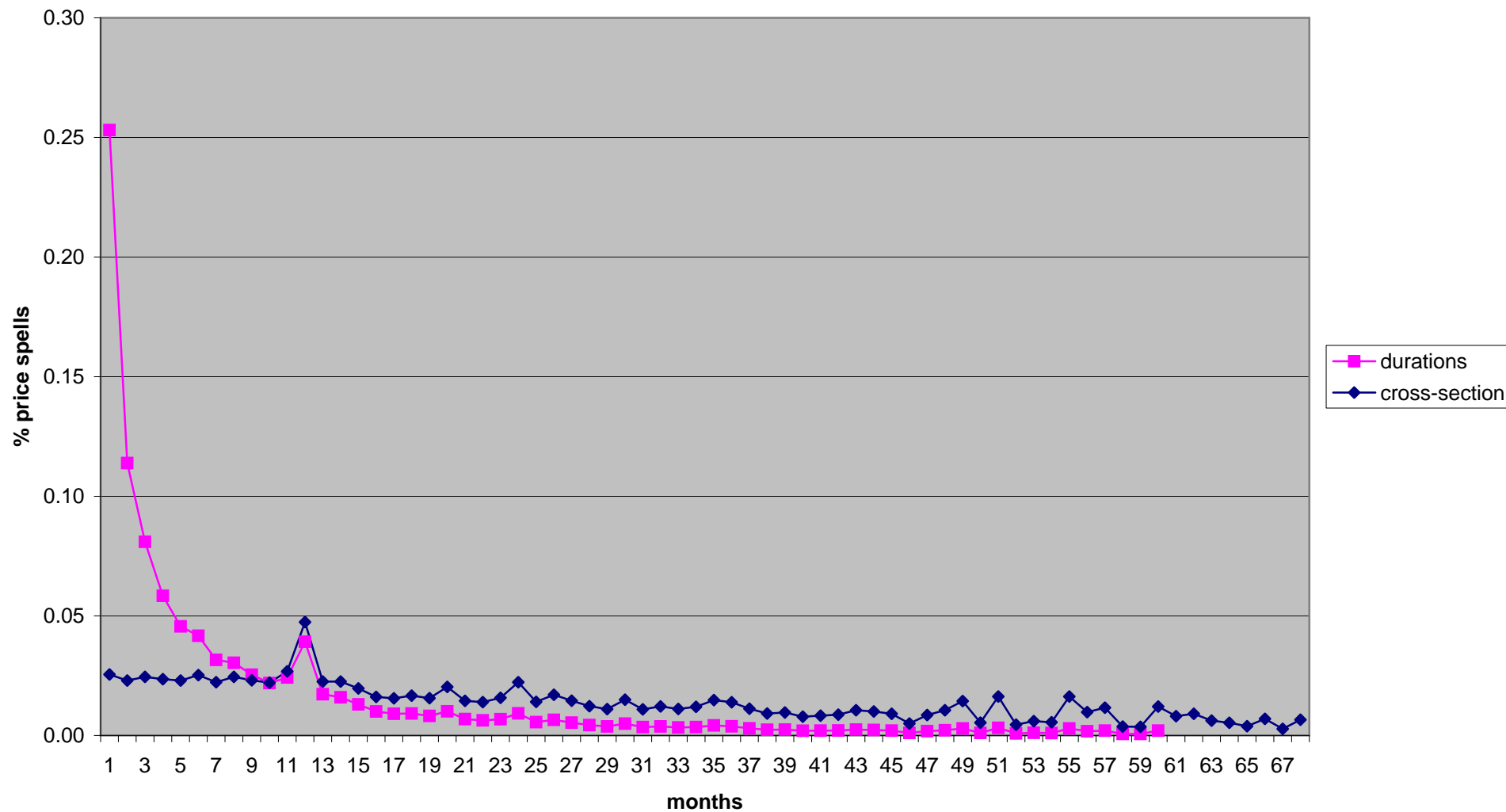
- So, for example, in French and UK data: $\bar{h} \simeq 0.2$, so we have α_i^d for months and transform it into cross-section: $\bar{d} = 5$ months, $\bar{T} = 13$ months for both UK and France (although distributions are different).
- UK: big fat tail of long durations. Cross-section: Over 40% of prices last more than 12 months; 15% more than 24 months, 3.7% more than 36 months.
- US: not been done, but cheeky use of Klenow Krvytsov (2008) chart 2...

i	$\alpha_i d$	$i \cdot \bar{h}$	α_i
1	24.25	0.2	4.85
2	12.18	0.4	4.87
3	9.12	0.6	5.47
4	6.75	0.8	5.40
5	5.28	1	5.28
6	6.21	1.2	7.45
7	3.89	1.4	5.45
8	3.34	1.6	5.34
9	3.25	1.8	5.85
10	2.62	2	5.24
11	2.81	2.2	6.18
12	4.64	2.4	11.14





US Price data (KK)



6.1 Baharad and Eden.

- In 2004, whilst Patrick Kehoe was saying that short price-spells meant there was not much rigidity, should have read a paper by two Israeli economists...published in the *review of economic dynamics*....
- What if a single firm has a variety of price-spell durations, some short and some long. How should you aggregate them up to find how much rigidity there is?
- simply taking an average over price spells will lead to too much weight on shorter spells.
- Example. One firm. Price constant for 364 days of the year.

- On the 365th day it changes its price τ times with each duration τ^{-1} of a day.
- The mean duration price-spell (in days) as:

$$\bar{d}(\tau) = \frac{364 + \tau \cdot \tau^{-1}}{364 + \tau} = \frac{365}{364 + \tau}$$

- Again, the more frenetic the price changes in the last day, the lower the mean duration: \bar{d} goes to zero as $\tau \rightarrow \infty$.
- Surely this is not a good measure of the price-stickiness: the price was constant for nearly all of the year, and what happens in the last day should not be able to wipe that out.

- Baharad and Eden propose a measure of price rigidity in which the duration of the price spell is weighted according to its duration: longer price spells occupy more of the time. The measure is the mean across time (or "per price" in their terminology):

$$BE(\tau) = \frac{364}{365}(364) + \frac{1}{365}\tau^{-1}$$

In effect, each price-spell is weighted by its duration. We can see that BE goes to 364 as $\tau \rightarrow \infty$, which is a much more accurate representation of nominal rigidity than the mean price-spell.

- Baharad and Eden measure BE and the cross-section mean \bar{T} are equivalent in steady state. $BE = \bar{T}$ (Dixon 2012).
- Patrick Kehoe would have realized that Prices were sticky after all 10 years sooner!

- No one has yet done the cross-section for *US*.....

7 Implications for Macro Theory.

- Many commonly used theories assume *perfectly flexible prices* (prices change every month/quarter). Need to be rewritten.
- **Sticky information.** Mankiw and Reis (2002): prices are perfectly flexible, but do not react to latest information.
- **Rational inattention.** Maćkowiak and Wiederholt (2008): prices are perfectly flexible, but do not react to latest information.

- **Indexation.** New Keynesian models (Smets and Wouters): prices indexed to recent inflation, so change every period.
- Sticky information and Rational inattention: need to be re-written so that they are consistent with micro evidence on prices
- Indexation? Convenient fiction....

8 Conclusion.

- Nominal rigidity matters. General equilibrium effects. Important for macro, but also any general equilibrium modelling.
- Macro: big effect on economy.
- Measuring nominal rigidity: need to look at the cross section (distribution across prices, firms), captures the structure of the economy.
- No need to filter out sales etc. Just give them a small weight - all spells weighted by length in cross section, or as in Baharad and Eden across time.

- In practice: a mixture of flexible and rigid prices - a long fat tail of rigid prices. UK: 15% last more than 24 months, 4% more than 36.
- Rufus Tucker and Gardiner Means in 1930s: nominal rigidity has been a feature of US prices for as far back as records go.
- IPN, France, UK, US. In the past people could always say sticky prices did not matter and could be ignored. Now we have the evidence: prices are sticky and you need to take account of this if you model general equilibrium systems as in macro.
- On average, across CPI data (PPI) data France and UK, average price lasts for 12 months. Lots of prices change frequently, but fat tail of long-lived prices.