

Federal Reserve Bank of Dallas
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**Online Appendix for
Product Turnover and the Cost of Living Index:
Quality vs. Fashion Effects***

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January 2018

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1 Other Stylized Facts

Further Evidence of Stylized Fact 2

In the main analysis, we linked products at the 3-digit product category. However, we recognize that products can vary massively in their quality even within the same 3-digit product category. We therefore check the robustness of our result by linking products only if the successor product appeared in the market one month after the predecessor product exited from the market and if these predecessor and successor products were produced *by the same manufacturer*. However, we allow predecessor and successor products to belong to different 3-digit product categories in order to ensure a sufficient number of observations. Figure 1 shows developments in prices and quantities at product turnover, which is very similar to that we reported in Figure 6 in the main paper.

Stylized Fact 4:

The turnover rate is procyclical, as in the United States.

We investigate the relationship between product turnover rates and business cycles. Broda and Weinstein (2010) examine the cyclicity of creation and destruction rates at the product category level by regressing them with the growth rate of consumption in each product group. They find that net creation is procyclical. We apply their method by using the growth rate of sales, instead of consumption, at the 3-digit product category level.

Table 1 shows the estimation result. Coefficients are all significant at the one percent level, suggesting that net creation is procyclical, while creation is strongly procyclical and destruction is countercyclical. This result is consistent with that reported by Broda and Weinstein (2010).

Stylized Fact 5:

The fraction of products whose price declined over their life span increased as deflation became more ingrained.

We compare the prices of each product between two points in time: when it enters and when it exits the market. Figure 2 shows developments during our observation period in the fractions of products that experienced a price increase ($dp > 0$ in the graph), a price decrease ($dp < 0$), or no price change ($dp = 0$). The horizontal axis represents the year

in which products exited. For example, the values for 2000 are for products that were destroyed in 2000 and created before (or in) 2000.

The figure shows that even in the period of inflation in the early 1990s, many products experienced a price decline over their life span. The early 1990s were a period when the overall CPI inflation rate was still relatively high at around 3 percent. In this period, the fraction of products experiencing a price decline or increase was very similar at around 20 percent.

However, from around the early 1990s, the fraction of products that experienced a price decline started to increase, while that of products that experienced an increase started to decline, so that the former began to exceed the latter. While the latter settled down at about 15 percent from 1995 onward, the fraction of products whose price declined continued to rise until the 2000s and since then has been in the range of 30 percent. Developments in the latter fraction closely mirror developments in the aggregate CPI: CPI inflation fell below 1 percent in 1994 and turned negative in 2000. Meanwhile, the fraction of products whose price at exit was unchanged from the price at entry gradually declined from about 70 percent to 50 percent over the roughly two decades.

Next, we look at the size of price changes over products' lives. Figure 3 shows the probability density function (PDF) of price changes over products' lives. The horizontal axis represents the size of the price change from entry to exit in logarithm. A positive value indicates that a product experienced a price increase over its life span and vice versa.

There is a sharp peak at zero, indicating that for a large number products the price at exit is the same as it was at entry. Of course, this does not necessarily mean that the prices of such products remained unchanged throughout their lives. However, it is unlikely that the prices of all these products experience a large number of revisions and then happen to revert to their original level. From this perspective, the observed pattern implies strong price stickiness. In fact, this result is in line with Nakamura and Steinsson's (2011) finding that 40 percent of products do not experience a single price change during their life span.

Taking a closer look, we further find that the PDF is asymmetric. The left tail of the PDF is much thicker than the right tail, suggesting that many products end their lives at a lower price. The second highest mode is observed at $\log(0.5) = -0.69$, indicating

that over their life span the price of many products falls to half of their initial price, which partly reflects stock clearance sales.¹

Stylized Fact 6:

The size of price changes over products' lives is independent of their life span. The speed of price decline over products' lives is higher the shorter their life span.

To examine whether products' life span affects their price, we calculate the correlation between a product's life span and the following two variables that are associated with the price change over a product's life. The first variable is the price change over the product's life, while the second variable is the first variable divided by a product's life span, which indicates the monthly speed of price change over the product's life.

Figure 4 presents developments in the correlation over time. Specifically, the line with circles shows the correlation between the life span and the price change over the product's life, while the line with triangles shows the correlation between the life span and the monthly speed of price change over the product's life. The horizontal axis represents the year when a product exited the market.

In the figure, the line with circles is not significantly different from zero, suggesting that how much the price of a product changes over its life is independent of its life span. By contrast, the line with triangles is significantly negative, that is, the speed of price change over a product's life is negatively correlated with its life span. This suggests that products with a shorter life span tend to experience a faster price decline over their life.

This creates heterogeneous inflation developments across products with different life spans. To illustrate this, Figure 5 plots developments in price changes for products categorized in terms of their life span. We find that the shortest-lived products with a life span of 16 to 31 months experience the highest speed of price decline. What is more, the speed of price decline of such products accelerated during the 1990s, exceeding 5 percent from the second half of the decade onward. On the other hand, the speed of price decline of longer-lived products has been milder and more stable. As a result, the

¹We also find that the size of price declines increased as deflation became more entrenched, as indicated by the fact that for 2005 the left tail is thicker than for 1995. Thus, taken together the results indicate that more products experienced a price decline and that the size of the price decline over products' life span increased.

difference in the speed of price decline between short- and long-lived products increased under deflation. Together with the steady increase in the exit rate, this result suggests that deflation at the aggregate level may have accelerated due to the increase in short-lived products in the late 1990s and early 2000s.

2 The COLI

In the main part of the paper, we did not show the figure of the COLI based on Redding and Weinstein (2016) and the price based on the 12-month matched sample, although we provided their means and standard deviations in Table 4. Figure 6 shows the annual change in their price index over time.

3 Quality and Fashion Effects

Table 2 shows how the estimated quality and fashion effects change when we change the duration of the fashion effect, τ . We calculate the cross-section (3-digit product category) median of quality and fashion effects for each month and then take its time-series mean and standard deviation (shown in parenthesis in the table).

The table shows, first, that the rate of change in quality, $b_i/b_{i'}$, is around 1.5 and increases with τ , while the standard deviation also increases with τ . Because we limit products' life span to τ or longer when estimating the rate of change in quality, if such products have greater quality improvement compared to their predecessors, it is not surprising to have this relationship between $b_i/b_{i'}$ and τ .

Second, the fashion effect, $\phi_i(0)$, is around 2.5, which is almost unchanged for $\tau \geq 4$. This result is consistent with our previous finding that the COLI is almost unchanged for $\tau \geq 4$. When $\tau = 1$, the fashion effect decreases to 1.8 but is still above one.

Table 3 provides the full list of creation and destruction rates as well as the estimated quality and fashion effects for each 3-digit product category. It is shown in the descending order with respect to the creation rate. The 3-digit product of “chocolate,” which embeds “Kit Kat” shown in Figure 3 in the main paper, has the second highest creation rate. It also has a relatively high fashion effect, $\phi_i(0) = 7.0$. The 3-digit product of “electric storage media” has relatively high rates of not only creation but also change in quality, which is 10.0. On the other hand, “suger, sweetners” and “salt” have relatively low rates

of creation as well as change in quality, which is less than one.

Table 1: Cyclicity at the 3-digit Product Category Level

	Net creation	Creation	Destruction
Sales growth	0.427***	0.286***	-0.141***
(Standard errors)	(0.008)	(0.007)	(0.007)
Observations	4944	4944	4944
3-digit codes	206	206	206
R^2	0.381	0.258	0.072

Note: *** represents significance at the 1 percent level.

Table 2: Quality and Fashion Effects for Different τ

τ	$b_i/b_{i'}$	$\phi_i(0)$
1	1.396 (0.346)	1.754 (0.091)
4	1.492 (0.495)	2.334 (0.347)
7	1.500 (0.570)	2.568 (0.420)
14	1.725 (1.098)	2.422 (0.344)

Note: Standard deviation in parentheses.

Table 3: Full List of Creation and Destruction Rates and Quality and Fashion Effects at the 3-digit Product Category Level

3-digit product	Creation rate	Destruction rate	Sales share	$b_i/b_{i'}$	$\phi_i(0)$
Steamed bread and pastry	0.704	0.675	0.02	0.944	2.592
Chocolate	0.645	0.626	0.014	1.123	6.936
Delicatessen, lunch boxes	0.632	0.608	0.016	0.994	1.544
Chilled cake	0.622	0.59	0.004	0.893	2.413
Assortments of sweets	0.622	0.64	0.001	0.069	3.083
Special dietary requirement food	0.618	0.369	0	-	-
Wine	0.616	0.509	0.004	1.704	3.455
Fragrances	0.615	0.505	0.001	36.678	7.149
Instant cup noodles	0.606	0.586	0.011	1.073	3.172
Gift certificates, gift sets	0.599	0.49	0.024	0.072	3.521
Confectionery with toys	0.58	0.584	0.003	1.197	17.471
Instant cup raw noodles	0.568	0.569	0	4.046	1.858
Leisure food products	0.564	0.519	0.002	1.641	4.057
Painting supplies	0.562	0.402	0	-	-
Cocktail drinks	0.544	0.446	0.004	1.11	2.533
Consumable houseware gift sets	0.542	0.521	0.002	0.756	3.439
Candy, candy confections	0.541	0.535	0.007	1.47	3.343
Writing utensils	0.529	0.523	0.003	1	4.213
Shampoo	0.522	0.498	0.009	2.719	2.782
Prepared bread meals	0.52	0.517	0.002	1.077	1.516
Baked western confectionery	0.519	0.511	0.009	1.24	4.248
Snack foods	0.519	0.511	0.009	1.377	2.96
Dessert cake	0.516	0.516	0.007	0.791	3.539
Fruit juice beverages	0.515	0.512	0.006	1.659	3.21
Food containers	0.512	0.418	0	-	-
Tea beverages	0.51	0.509	0.002	1.918	2.133
Herbal tea beverages	0.506	0.444	0.003	3.762	2.073
Chilled dessert	0.504	0.517	0.007	2.422	2.274
Japanese-style confectionery	0.496	0.501	0.01	0.951	2.677
Nutrition supplement foods	0.494	0.452	0.003	10.244	3.627
Green tea beverages	0.491	0.408	0.004	1.05	2.807
Ice cream	0.478	0.458	0.012	0.939	3.899
Bottled meat	0.477	0.273	0	-	-
Electronic storage media	0.475	0.419	0.002	10.042	2.949
Washing and drying equipment	0.466	0.469	0.001	1.634	2.252
Cosmetics for women	0.459	0.458	0.021	3.559	6.363
Japanese traditional treats	0.455	0.453	0.004	1.063	2.99
Premium ice cream	0.455	0.414	0.003	0.851	3.538
Toilet and bath products	0.454	0.504	0.001	4.34	2.395
Cocoa and chocolate beverages	0.449	0.454	0	-	-
Meat products	0.448	0.403	0.01	1.715	2.647
Office paperwork organization supplies	0.443	0.45	0.001	0.405	3.855
Carbonated beverages	0.442	0.441	0.009	2.535	3.285
Low alcohol drinks	0.439	0.369	0	-	-
Processed seafood	0.437	0.421	0.007	1.06	2.375

Table 3: Full List of Creation and Destruction Rates and Quality and Fashion Effects at the 3-digit Product Category Level

3-digit product	Creation rate	Destruction rate	Sales share	$b_i/b_{i'}$	$\phi_i(0)$
Frozen staple foods	0.433	0.421	0.005	1.252	2.233
Fried fish paste products	0.432	0.434	0.005	1.001	2.168
Sink accessories	0.431	0.478	0	0.439	2.039
Bath salts	0.425	0.398	0.002	1.385	6.015
Coffee beverages	0.422	0.401	0.005	1.447	2.645
Whiskey, brandy (liquors)	0.415	0.388	0.003	4.776	2.718
Disposable diapers	0.413	0.417	0.007	1.08	2.105
Soap	0.399	0.37	0.006	3.497	3.086
Meat delicacies	0.397	0.368	0	0.296	1.632
Bread (croissant, baguette, muffin, etc.)	0.395	0.407	0.006	0.81	1.537
Rice crackers	0.394	0.388	0.009	0.916	2.08
Stationery and paper products	0.394	0.401	0.001	1.138	3.651
Office automation supplies	0.392	0.267	0.002	18.755	2.636
Cosmetic accessories	0.391	0.369	0.004	2.405	5.478
Dried fruit	0.391	0.367	0.001	0.615	2.468
Etiquette products	0.385	0.369	0.002	0.656	5.701
Diluted beverages	0.383	0.344	0.001	14.376	9.91
Yogurt	0.381	0.361	0.017	1.4	1.954
Sports drinks, isotonic drinks	0.379	0.294	0.005	20.994	2.96
Marine delicacies	0.378	0.412	0.003	0.909	1.728
Barley tea beverages	0.377	0.346	0.001	-	-
Low-malt beer	0.375	0.355	0.024	0.392	2.31
100% fruit juice beverages	0.37	0.317	0.005	1.628	1.952
Instant soup cups	0.363	0.257	0	0.59	2.629
Nutrition support drinks	0.362	0.333	0.005	8.498	3.373
Deodorant, odor neutralizer, disinfectant	0.362	0.331	0.003	2.319	3.977
Toilet cleaning supplies	0.361	0.378	0	0.379	2.717
Dog food	0.36	0.345	0.003	2.84	2.498
Vegetable juice	0.358	0.326	0.005	5.256	2.17
Basic skin care for women	0.357	0.314	0.028	8.891	3.962
Frozen meals	0.356	0.344	0.027	1.217	2.631
Portable sanitary sets	0.356	0.391	0	1.805	2.463
Instant foods	0.348	0.302	0.004	0.629	4.011
Chilled semi-finished products	0.342	0.361	0.017	1.086	3.181
Liqueur	0.342	0.294	0.001	0.222	2.532
Sanitary feminine products	0.341	0.353	0.006	0.301	2.007
Nuts	0.339	0.349	0.002	1.41	1.637
Cereal grains	0.338	0.286	0.037	1.271	1.45
Batteries	0.338	0.254	0.002	2.994	2.035
Canned side dishes	0.337	0.358	0	-	-
Japanese sake	0.335	0.246	0.006	2.312	2.383
Pickled vegetables	0.332	0.342	0.022	1.435	1.699
Water	0.331	0.25	0.003	0.197	1.723
Cereals	0.329	0.321	0.002	4.198	1.614
Laundry detergent	0.327	0.278	0.01	1.438	1.937
Bean snacks	0.327	0.298	0.002	0.689	1.768

Table 3: Full List of Creation and Destruction Rates and Quality and Fashion Effects at the 3-digit Product Category Level

3-digit product	Creation rate	Destruction rate	Sales share	$b_i/b_{i'}$	$\phi_i(0)$
Lactic acid bacteria beverages	0.324	0.313	0.005	0.659	2.526
Women's hair care products	0.321	0.291	0.006	3.525	3.016
Toothbrushes	0.321	0.271	0.003	4.902	2.641
Beer	0.32	0.284	0.013	2.158	3.655
Ham, bacon	0.316	0.339	0.013	1.189	1.807
Chewing gum	0.314	0.293	0.004	3.965	2.834
Sausages	0.312	0.336	0.016	1.363	1.977
Mops	0.312	0.378	0	0.022	5.582
Natural cheese	0.31	0.284	0.004	0.479	2.657
Pet sanitary products	0.31	0.288	0.001	1.436	2.365
Cat food	0.309	0.303	0.003	2.145	1.835
Paper products for daily use	0.305	0.31	0.01	1.673	2.383
Fresh noodles, boiled noodles	0.304	0.307	0.016	1.045	2.337
Regular coffee	0.304	0.316	0.003	1.23	2.4
Milk beverages	0.298	0.266	0.007	1.109	1.647
Care, hygiene products	0.296	0.245	0.001	5.307	2.387
Cake and bread ingredients	0.291	0.263	0.001	7.068	2.67
Flour mixes	0.291	0.254	0.001	0.768	4.404
Toothpaste	0.289	0.249	0.003	3.754	2.685
Household cleaner	0.288	0.24	0.003	1.717	2.649
Packaged instant noodles	0.285	0.267	0.006	1.385	2.298
Chikuwa (tube-like food product made from fish)	0.283	0.31	0.004	0.446	1.531
Hanging hooks	0.283	0.285	0	4.815	2.288
Egg products	0.282	0.27	0.003	0.646	1.701
Mouth freshener	0.281	0.224	0	2.23	2.749
Kitchen detergent	0.277	0.278	0.003	1.396	2.27
Tsukudani (small seafood)	0.276	0.275	0.004	1.283	1.872
Dessert mixes	0.275	0.261	0	-	-
Insecticides, rodenticides	0.274	0.254	0.002	4.281	10.451
Maternity, baby food	0.272	0.228	0.002	1.383	2.344
Instant seasoning for rice dishes	0.271	0.271	0.003	1.575	2.912
Instant soup	0.269	0.249	0.004	1.894	2.727
Tea	0.267	0.252	0.002	3.292	2.326
Dried vegetable products	0.264	0.296	0.003	0.636	2.037
Cocoa, milk for drink mixes	0.263	0.246	0.001	9.807	4.251
Ochazuke, furikake seasoning	0.262	0.244	0.004	1.94	2.292
De-humidifier	0.258	0.267	0	-	-
Home medical supplies	0.257	0.226	0.002	3.568	3.926
Shochu	0.256	0.121	0.006	1.303	2.275
Simmered soy beans and sweetened mash	0.256	0.283	0.003	0.489	1.646
Sausages stuffed with fish paste products	0.255	0.26	0.002	0.832	1.943
Jam	0.254	0.278	0.002	1.263	2.081
Natto (fermented soybeans)	0.253	0.246	0.008	2.196	1.385
Cosmetics for men	0.252	0.216	0.001	0.593	2.766
Home cleaning products	0.25	0.253	0.002	2.136	2.647
Instant miso soup, Japanese style soup	0.248	0.214	0.002	1.734	1.891

Table 3: Full List of Creation and Destruction Rates and Quality and Fashion Effects at the 3-digit Product Category Level

3-digit product	Creation rate	Destruction rate	Sales share	$b_i/b_{i'}$	$\phi_i(0)$
Canned meat	0.247	0.228	0	-	-
Oolong tea beverages	0.246	0.227	0.003	0.452	1.401
Instant coffee	0.244	0.227	0.007	0.898	3.47
Rice cakes	0.242	0.252	0.004	-	-
Salad dressing	0.242	0.2	0.004	1.9	2.13
Pasta sauce	0.241	0.232	0.003	1.15	1.977
Kitchen sink accessories	0.237	0.229	0.003	2.096	1.863
Honey, syrup	0.236	0.199	0.001	4.751	1.881
Bread loafs	0.234	0.236	0.012	0.696	1.276
Curry	0.232	0.237	0.007	1.199	2.988
Dried marine products	0.232	0.253	0.007	1.424	1.584
Processed cheese	0.23	0.221	0.006	0.769	1.706
Cooking, kitchen supplies	0.225	0.229	0.007	1.462	2.263
Dried pasta	0.225	0.192	0.002	1.007	2.48
Oolong tea, herbal tea	0.219	0.272	0.001	0.854	3.315
Boiled fish paste products	0.216	0.236	0.003	1.296	4.631
Bottled seafood	0.216	0.235	0.001	2.221	2.524
Baby food products	0.215	0.318	0	-	-
Konjac (amorphophallus konjac)	0.212	0.241	0.005	0.532	1.785
Dried noodles	0.212	0.229	0.003	1.74	3.605
Pet food (except for dogs and cats)	0.212	0.206	0	3.884	1.69
Disposable tableware	0.211	0.223	0.001	1.548	2.393
Packaged instant raw noodles	0.21	0.206	0.001	-	-
Mothballs	0.209	0.244	0.002	3.062	1.508
Daily use stationery	0.208	0.226	0.001	1.562	2.738
Tofu, soy products	0.205	0.194	0.019	1.108	1.274
Canned seafood	0.204	0.259	0.005	0.366	2.114
Miscellaneous liquors	0.203	0.194	0	-	-
Kamaboko (fish cake)	0.199	0.24	0.006	0.932	2.007
Men's hair care products	0.199	0.186	0.002	1.99	3.434
Tomato flavored seasonings	0.198	0.155	0.002	0.397	2.167
Barley tea	0.198	0.227	0.001	-	-
Canned fruit	0.19	0.249	0.001	0.598	2.447
Green tea	0.186	0.205	0.005	1.24	1.82
Miscellaneous goods	0.186	0.15	0.001	2.442	2.991
Mixed seasonings, spices and condiments	0.185	0.168	0.001	0.352	2.08
Fresh eggs	0.183	0.079	0.014	0.119	1.262
Soy milk	0.18	0.138	0.001	2.779	1.971
Canned agricultural product	0.176	0.222	0.001	0.601	1.801
Spreads	0.176	0.161	0.001	1.506	1.879
Birth control supplies	0.176	0.219	0	6.635	5.244
Instant seasoning for cooking	0.171	0.156	0.004	0.816	2.754
Butter	0.171	0.171	0.002	-	-
Bottled agriculture product	0.171	0.173	0.001	1.066	3.514
Margarine, fat spread	0.17	0.176	0.002	0.525	1.809
Stew, hashed beef	0.168	0.151	0.002	0.908	3.077

Table 3: Full List of Creation and Destruction Rates and Quality and Fashion Effects at the 3-digit Product Category Level

3-digit product	Creation rate	Destruction rate	Sales share	$b_i/b_{i'}$	$\phi_i(0)$
Razors	0.164	0.147	0.001	2.153	2.072
Spirits	0.162	0.147	0	-	-
Cooking oil	0.161	0.191	0.006	1.821	1.776
Denture care products	0.16	0.081	0	-	-
Cooking base	0.159	0.136	0.006	1.561	3.569
Sesame seeds	0.158	0.121	0.001	-	-
Seaweed	0.15	0.193	0.004	1.736	1.702
Seasoning sauce	0.147	0.152	0.005	1.454	2.985
Canned desserts	0.147	0.188	0	1.578	2
Dried beans	0.144	0.195	0.001	-	-
Alcohol-related beverages	0.139	0.095	0	-	-
Milk	0.135	0.132	0.024	0.329	1.057
Chilled condiments	0.135	0.128	0.001	1.239	2.153
Umami seasonings (flavor enhancer)	0.131	0.076	0.001	-	-
Spices	0.12	0.092	0.004	1.613	2.312
Non-fat powdered milk, powdered cream	0.116	0.147	0.003	0.243	1.405
Vinegar, vinegar-related seasonings	0.115	0.09	0.002	0.359	5.417
Miso paste (soybean paste)	0.114	0.136	0.005	3.095	1.82
Mirin, cooking sake	0.113	0.107	0.002	7.645	1.382
Instant bouillon	0.112	0.116	0.004	0.55	1.818
Flour, dry mixtures	0.112	0.133	0.003	3.42	1.685
Tobacco, smoking accessories	0.109	0.069	0.011	196.712	1.994
Chinese liquor	0.109	0.138	0	-	-
Sugar, sweeteners	0.103	0.112	0.004	0.941	1.599
Fresh cream	0.103	0.111	0.001	-	-
Soy sauce	0.097	0.076	0.004	1.792	1.764
Ice	0.094	0.054	0.001	-	-
Mayonnaise	0.093	0.076	0.003	-	-
Salt	0.088	0.082	0.001	0.623	1.711
Table sauces (okonomiyaki, tonkatsu)	0.081	0.097	0.002	6.369	2.241
Koji (rice malt)	0.049	0.031	0	-	-

Note: It is difficult to calculate the quality and fashion effects especially, $b_i/b_{i'}$ and $\phi_i(0)$, if the number of products in a category is small or the entry/exit rate is low. We report their median values if there are over 20 month observations from 1988 to 2013.

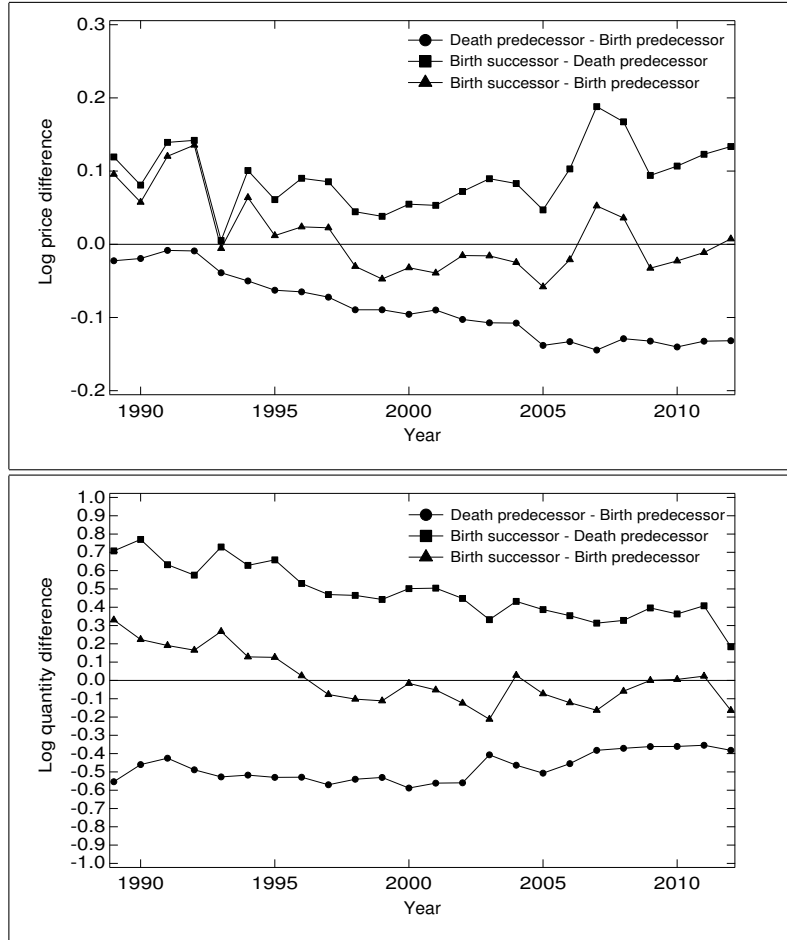


Figure 1: Price and Quantity Changes over the Product Cycle for the Products Produced by the Same Manufacturer

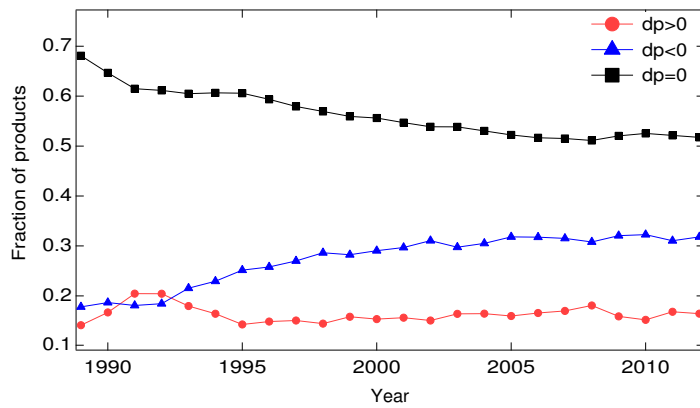


Figure 2: Fractions of Products whose Price Increases, Decreases, or Does Not Change Over their Life Span

The horizontal axis represents a year when the product was discontinued.

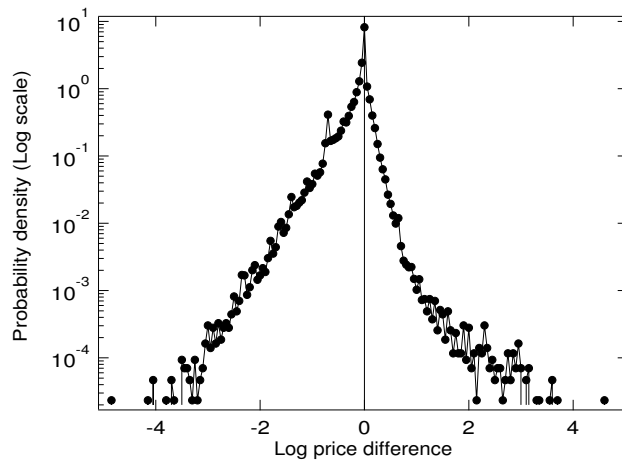


Figure 3: Probability Density Function of Price Changes over Product Life

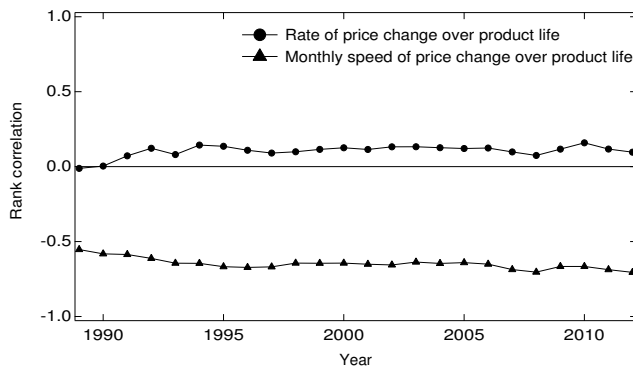


Figure 4: Correlation between the Life Span and the Rate of Price Change over Product Life

Note: The line with circles represents the correlation between the life span and the price change over the product's life in each year. The line with triangles represents the correlation between the life span and the monthly speed of price change over the product's life in each year. The horizontal axis represents a year when the product was discontinued.

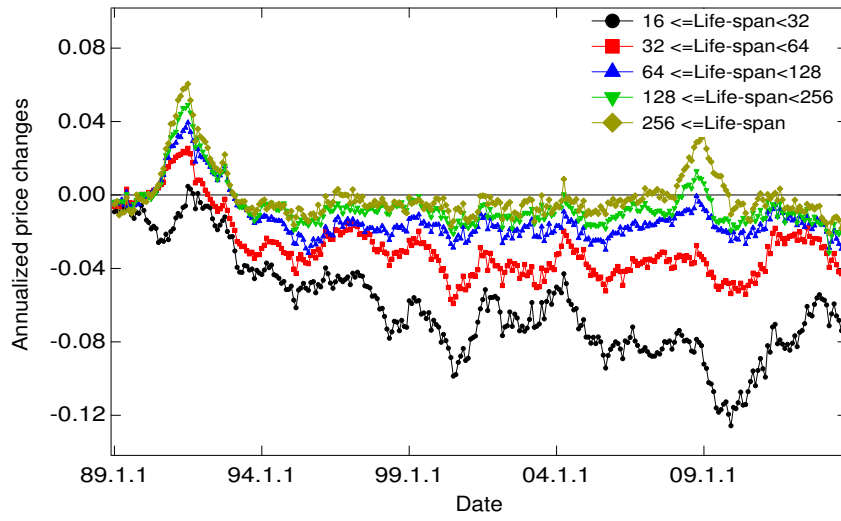


Figure 5: Annual Price Changes by Life Span

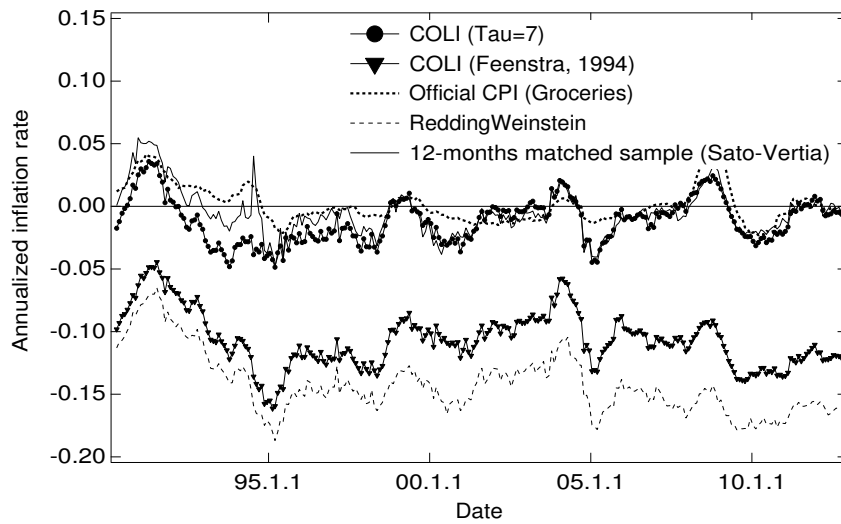


Figure 6: Inflation Estimates Based on Different Indexes