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Prices and demand: New evidence from micro data

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Abstract

Micro-level demand studies typically do not have price information. As an approximation, it is frequently assumed that households face the same set of prices at a given point in time, and these prices are taken to be national indexes such as implicit price deflators in the national accounts. I find that this source of measurement error leads to severely distorted estimates of demand parameters.

Keywords: Regions; Prices; Demand; Elasticity

JEL classification: C81; D12; D91

1. Introduction

What do we know about individuals' behavioral responses to prices? Prior to 1980, most empirical demand studies for the United States used Personal Consumption Expenditures (PCE) from the National Income and Product Accounts. These models assumed the existence of a representative consumer, and price effects were identified exclusively from the temporal covariation of aggregate prices and expenditures.[1] Demand modeling since the early 1980s has moved away from the use of national accounts data due to the increased availability of micro-level expenditure surveys. These surveys make it

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[1] See Deaton and Muellbauer (1980) for a survey of these studies.

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unnecessary to make implausible aggregation assumptions, and the larger sample sizes provide flexibility in accounting for household heterogeneity in modeling demand behavior.[2] While these data have greatly enhanced our understanding of the determinants of demand, an important gap remains. Budget surveys provide little or no information related to the prices paid for most goods and services.

As a result, the estimation of demand systems based on household-level data requires the integration of prices from external data sources. The PCE implicit price deflators are often used for this purpose even though they are aggregate indexes with no information related to geographic price variation. In this paper, I integrate alternative estimates of prices developed by Kokoski et al. (1994) with household-level data from the *Consumer Expenditure Surveys* (CEX). While this exercise yields more accurate estimates of the prices faced by households, the practical question is whether it matters for the estimation of critical parameters. That is, are the magnitudes of the biases that result from this source of measurement error empirically important?

2. The data

While the Bureau of Labor Statistics (BLS) does not provide official estimates of price levels across different regions of the U.S., Kokoski et al. (1994) (KCM) use the 1988–1989 CPI database to estimate price levels for a variety of goods and services across 44 urban areas. I use their estimates of prices for rental housing, owner-occupied housing, food at home, food away from home, alcohol and tobacco, household fuels (electricity and piped natural gas), gasoline and motor oil, household furnishings, apparel, new vehicles, professional medical services, and entertainment. These items constitute, on average, approximately 75% of all household expenditures. Prices both before and after 1988–1989 are extrapolated using indexes published by the BLS. Most of these indexes cover the period from December 1977 to the present at either monthly or bimonthly frequencies depending on the year and the commodity group.[3]

These prices are integrated with household-level expenditure data reported in the CEX. These surveys are nationally representative samples that were administered approximately every 10 years until 1980 and subsequently conducted annually. Expenditures after 1980 were recorded on a quarterly basis and sample sizes ranged from 4000 to 7500 households. Although KCM provide price estimates for a cross-section of urban areas, the publicly available CEX data do not report households' cities of residence in an effort to preserve the confidentiality of survey participants. This necessitates aggregation across urban areas to yield prices for five regions: the urban Northeast, urban Midwest, urban South, urban West and rural areas.[4]

Prices are linked to households in the CEX by region of residence, housing tenure (i.e., owner versus renter), and the date at which they were interviewed. Expenditures represent the spending over the previous 3 months, and the prices for each commodity group is computed as a simple average over the 3-month period. If a household living in the urban South was interviewed in May of 1986, for example, the prices paid are assumed to be the (unweighted) average of the February, March and April prices prevailing in the South at that time. To avoid issues of seasonality, I restrict the sample to include only

[2] See, for example, Blundell et al. (1993) as a representative example.

[3] A detailed description of the construction of these price data can be found in Slesnick (2002).

[4] Because the CPI is constructed only for urban households, I approximate rural price levels using the estimates for Class D-sized urban areas. These areas correspond to non-metropolitan urban areas and are cities with less than 50,000 persons.

Table 1
Means and variances of log prices

Good	Regional prices		National prices	
	Mean log	Variance log	Mean log	Variance log
Energy	0.1168	0.0169	0.1054	0.0082
Food	−0.0127	0.0395	−0.0118	0.0377
Consumer goods	−0.0177	0.0188	−0.0171	0.0168
Durables	0.0037	0.0183	0.0012	0.0150
Housing	−0.2639	0.1175	−0.2499	0.0601
Consumer services	0.0288	0.0801	0.0271	0.0714

households that were interviewed in the second quarter of each year. This yields a sample of approximately 110,000 households covering the 21 years between 1980 and 2000.[5]

We compare the means and variances of log prices for six commodity groups: energy, food, consumer goods, durable services, housing services, and consumer services. For each commodity, prices are normalized to 1.0 in January 1989 for those living in the urban Northeast. In Table 1, I present the tabulations of prices that vary across geographic regions (classified as "regional prices") with those linked to the CEX under the assumption that all households at a given point of time face the same set of prices ("national prices").

As one might expect, the average price levels between the two sets of estimates do not differ significantly. More interesting for our purposes is the relationship between the variances of the regional and national prices. Dispersion of the latter series is due exclusively to temporal variation between 1980 and 2000, and consumer services and housing show the greatest variation of all of the commodity groups. Differences in the variances between these and the regional prices are due to the incremental effect of geographic dispersion. This turns out to be particularly important for housing prices, but less of a factor for food and consumer goods.[6]

In Table 2, I present coefficients of a simple regression of the log demands (constructed from expenditure data in the CEX) on their respective log prices for each commodity group. The regressions are estimated using, separately, the national and regional prices. The differences in the coefficient estimates are most pronounced for the goods with the most geographic price dispersion. The coefficients for energy, housing and consumer services differ markedly depending on the prices used in the regressions. In fact, the correlation between housing demand and prices is negative using regional prices, but positive for national prices. This suggests that this source of measurement error could have a significant effect on conclusions concerning the relationships between prices and demands in fully specified demand models. This issue is considered in the next section.

3. Prices and demand

How does the introduction of regional price variation influence estimated price elasticities? To address this issue directly, I use the rank three translog demand system developed by Lewbel (2001) to estimate

[5] Nicol (2001) uses state and city size information in the CEX to obtain a much more detailed match of prices (from a nonscientific survey of prices conducted by the American Chamber of Commerce Research Association) to selected urban households in the CEX. His results suggest that substantial measurement error persists within regions over and above the regional price variation identified in this paper.

[6] Time series of each set of prices are presented in Slesnick (2002).

Table 2
Price–quantity regression coefficients

Commodity	Regional prices		National prices	
	Price coefficient	Standard error	Price coefficient	Standard error
Energy	−0.9015	0.019	−0.0917	0.027
Food	−0.1414	0.011	−0.1584	0.011
Consumer goods	0.1229	0.031	0.1484	0.033
Durables	1.0926	0.021	1.2578	0.023
Housing	−0.1490	0.007	0.2153	0.010
Consumer services	0.0336	0.010	0.0944	0.011

the behavioral responses to price movements. In this framework, the demand equations for household k facing the vector of prices $\mathbf{p_k}$ with demographic characteristics $\mathbf{A_k}$ and total expenditure M_k is given by:

$$\mathbf{wk} = \frac{1}{D(\mathbf{p_k})}\left(\alpha_{\mathbf{p}} + B_{\mathrm{pp}}\ln\frac{\mathbf{p_k}}{M_k} + B_{\mathrm{pA}}\mathbf{A_k} + \gamma_{\mathbf{p}}[\ln G_k]^2\right)$$

where

$$\ln G_k = \alpha_0 + \ln\left(\frac{\mathbf{p_k}}{\mathbf{M_k}}\right)'\alpha_{\mathbf{p}} + \frac{1}{2}\ln\left(\frac{\mathbf{p_k}}{\mathbf{M_k}}\right)'B_{\mathrm{pp}}\ln\left(\frac{\mathbf{p_k}}{\mathbf{M_k}}\right) + \ln\left(\frac{\mathbf{p_k}}{\mathbf{M_k}}\right)'B_{\mathrm{pA}}\mathbf{A_k}$$

and $\mathbf{w_k}$ is a vector of budget shares for the six commodities, $D(\mathbf{p_k}) = -1 + \iota' B_{\mathrm{pp}} \ln p_k$, $B_{\mathrm{pp}} = B_{\mathrm{pp}}'$, $\iota' B_{\mathrm{pA}} = 0$, $\iota' B_{\mathrm{pp}}\, \iota = 0$, $\iota'\alpha_{\mathbf{p}} = -1$ and $\iota'\gamma_{\mathbf{p}} = 0$. The unknown parameters to be estimated are α_{p}, B_{pp}, B_{pA} and $\gamma_{\mathbf{p}}$.

Using the CEX sample of households described previously, I estimate the demand system for the six commodity groups subject to the integrability restrictions of summability, symmetry, and homogeneity. Following standard practice, one equation is dropped and the remaining five are estimated using nonlinear multivariate regression. The demographic characteristics used to control for household heterogeneity include the number of adults, the number of children under 18, gender of the head of the household, race of the head of the household, and region of residence.

The full set of estimated parameters are reported in Appendix Tables A1 and A2 using, separately, the regional and national prices. The parameter estimates are quite different even for nonprice variables such as total expenditure and the regional dummy variables. One gets a better sense of the magnitude of these differences by comparing price elasticities. In Table 3, I present compensated and uncompensated price elasticities for a reference household with $35,000 in 1989.

The compensated and uncompensated price elasticities are understated for all goods except consumer services when the national prices are used as arguments of the demand system. The largest proportional

Table 3
Compensated and uncompensated price elasticities (references: 2 adults, 2 children, male head, white, urban NE)

Commodity	Regional prices		National prices		Region–national ratio	
	Uncomp	Comp	Uncomp	Comp	Uncomp	Comp
Energy	−0.2032	−0.1462	−0.1413	−0.0916	1.44	1.60
Food	−0.7197	−0.5435	−0.3772	−0.2127	1.91	2.56
Consumer goods	−0.8692	−0.7876	−0.1731	−0.1030	5.02	7.65
Durables	−1.0725	−0.9007	−0.9218	−0.7411	1.16	1.22
Housing	−1.1293	−0.8528	−0.6273	−0.3330	1.80	2.56
Consumer services	−0.4239	−0.1163	−0.6119	−0.2907	0.69	0.40

difference between the estimated elasticities occurs with consumer goods; the uncompensated price elasticity obtained using regional prices is over five times larger than that obtained using national prices. The corresponding elasticities for housing and food differ by almost a factor of two. The smallest differences are for consumer durables where the ratio is 1.16 for the uncompensated elasticity and 1.22 for the compensated elasticity. It is evident that failure to account for differences in price levels across the U.S. leads to distorted estimates of demand parameters and price elasticities.

4. Summary and conclusion

The absence of data on price levels has, in the past, limited our ability to make definitive statements concerning the magnitude of basic parameters in static demand models. To fill this void, I have constructed estimates of regional prices for a number of commodity groups and integrated them with expenditures reported by households in the CEX. Price variation across regions was substantial for items such as energy, housing, consumer services and, to a lesser extent, consumer durables. Failure to account for this variation leads to biased estimates of key demand parameters and the associated price elasticities. For a translog demand system, this form of price-related measurement error has the effect of lowering the estimated elasticities for all goods except consumer services.

Appendix A.

Table A1
Estimated demand parameters—regional prices

Variable	Energy		Food		Consumer goods		Durables		Housing		Consumer services	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
CONSTANT	−1.0964	0.0243	0.0859	0.0307	0.6602	0.0166	−0.3360	0.0157	−1.7765	0.0393	1.4628	0.0337
PENERGY	−0.1107	0.0020	−0.0372	0.0032	0.0069	0.0017	0.0042	0.0015	0.0217	0.0025	0.0201	0.0026
PFOOD	−0.0372	0.0032	−0.0961	0.0103	0.0099	0.0042	0.0336	0.0036	−0.0640	0.0039	0.1664	0.0064
PCG	0.0069	0.0017	0.0099	0.0042	−0.0036	0.0029	−0.0109	0.0021	0.0155	0.0021	0.0460	0.0028
PDUR	0.0042	0.0015	0.0336	0.0036	−0.0109	0.0021	0.0003	0.0024	−0.0333	0.0022	−0.0089	0.0027
PHOUS	0.0217	0.0025	−0.0640	0.0039	0.0155	0.0021	−0.0333	0.0022	−0.0499	0.0055	−0.0106	0.0041
PCS	0.0201	0.0026	0.1664	0.0064	0.0460	0.0028	−0.0089	0.0027	−0.0106	0.0041	−0.0591	0.0059
EXPEND	0.0950	0.0020	−0.0128	0.0025	−0.0640	0.0013	0.0151	0.0013	0.1206	0.0031	−0.1540	0.0027
CHILD	−0.0067	0.0003	−0.0221	0.0005	−0.0056	0.0003	−0.0041	0.0003	0.0255	0.0006	0.0130	0.0007
CHILDSQ	0.0007	0.00007	0.0011	0.0001	0.0008	0.00008	0.0006	0.00007	−0.0028	0.0001	−0.0005	0.0002
ADULT	−0.0243	0.0006	−0.0176	0.0011	0.0047	0.0006	−0.0006	0.0006	0.0338	0.0013	0.0039	0.0015
ADULTSQ	0.0023	0.0001	0.0005	0.0002	−0.0002	0.0001	−0.00001	0.0001	−0.0027	0.0003	0.0002	0.0003
MW	0.0101	0.0006	−0.0143	0.0012	0.0014	0.0007	−0.0133	0.0007	0.0324	0.0012	−0.0163	0.0013
SOUTH	0.0317	0.0007	−0.0186	0.0014	−0.0015	0.0008	−0.0179	0.0008	0.0345	0.0016	−0.0282	0.0016
WEST	0.0195	0.0006	−0.0075	0.0013	−0.0024	0.0006	0.0032	0.0006	−0.0250	0.0010	0.0122	0.0013
NONWHITE	0.0023	0.0005	0.0048	0.0008	0.0008	0.0004	−0.0083	0.0005	−0.0006	0.0008	0.0008	0.0010
FEMALE	0.0033	0.0004	0.0250	0.0007	−0.0049	0.0004	0.0279	0.0004	−0.0297	0.0007	−0.0217	0.0009
RURAL	−0.0215	0.0008	−0.0168	0.0019	0.0033	0.0009	0.0164	0.0008	0.0617	0.0015	−0.0430	0.0016
EXPENDSQ	0.0120	0.0002	−0.0161	0.0003	−0.0094	0.0001	0.0062	0.0002	0.0261	0.0004	−0.0188	0.0004

A0 = −12.8211 (0.0737).

Table A2
Estimated demand parameters—national prices

Variable	Energy		Food		Consumer goods		Durables		Housing		Consumer services	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
CONSTANT	0.1028	0.0625	−1.5325	0.0850	−0.2344	0.0467	0.2846	0.0352	0.7750	0.1328	−0.3954	0.0985
PENERGY	−0.0812	0.0031	−0.0236	0.0047	0.0016	0.0024	0.0208	0.0027	0.0728	0.0068	0.0284	0.0038
PFOOD	−0.0236	0.0047	−0.3091	0.0173	−0.0371	0.0067	0.0693	0.0056	0.0591	0.0117	0.0979	0.0106
PCG	0.0016	0.0024	−0.0371	0.0067	−0.0370	0.0044	−0.0011	0.0031	0.0457	0.0064	0.0051	0.0055
PDUR	0.0208	0.0027	0.0693	0.0056	−0.0011	0.0031	0.0025	0.0036	−0.0160	0.0070	−0.0301	0.0049
PHOUS	0.0728	0.0068	0.0591	0.0117	0.0457	0.0064	−0.0160	0.0070	0.0067	0.0193	−0.0432	0.0117
PCS	0.0284	0.0038	0.0979	0.0106	0.0051	0.0055	−0.0301	0.0049	−0.0432	0.0117	−0.0812	0.0117
EXPEND	−0.0189	0.0077	0.1435	0.0104	0.0228	0.0058	−0.0454	0.0043	−0.1252	0.0163	0.0232	0.0121
CHILD	−0.0059	0.0003	−0.0248	0.0006	−0.0066	0.0003	−0.0038	0.0003	0.0291	0.0007	0.0121	0.0008
CHILDSQ	0.0007	0.00007	0.0013	0.0001	0.0009	0.00008	0.0006	0.00008	−0.0032	0.0002	−0.0003	0.0002
ADULT	−0.0259	0.0006	−0.0182	0.0012	0.0045	0.0007	−0.0002	0.0007	0.0361	0.0015	0.0037	0.0016
ADULTSQ	0.0025	0.0001	0.0004	0.0002	−0.0002	0.0001	−0.00004	0.0001	−0.0028	0.0003	0.0002	0.0003
MW	−0.0046	0.0005	0.0119	0.0009	−0.0027	0.0005	−0.0128	0.0005	0.0227	0.0010	−0.0145	0.0011
SOUTH	0.0008	0.0005	0.0094	0.0009	−0.0018	0.0005	−0.0170	0.0005	0.0256	0.0010	−0.0170	0.0011
WEST	0.0163	0.0006	0.0084	0.0009	−0.0010	0.0005	0.0022	0.0006	−0.0247	0.0010	−0.0012	0.0012
NONWHITE	0.0022	0.0005	0.0048	0.0008	0.0012	0.0005	−0.0087	0.0005	−0.0012	0.0009	0.0016	0.0011
FEMALE	0.0024	0.0004	0.0279	0.0007	−0.0044	0.0004	0.0288	0.0005	−0.0340	0.0009	−0.0207	0.0009
RURAL	−0.0335	0.0005	0.0024	0.0010	−0.0023	0.0006	0.0178	0.0006	0.0409	0.0012	−0.0254	0.0012
EXPENDSQ	0.0119	0.0002	−0.0155	0.0003	−0.0088	0.0002	0.0064	0.0002	0.0249	0.0004	−0.0188	0.0004

A0 = −8.0606 (0.3136).

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