The Acceleration in Variety Growth

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The expansion of variety in consumer and intermediate goods plays a central role in many theoretical models of growth. Examples include Paul M. Romer (1990), Gene M. Grossman and Elhanan Helpman (1991 Ch. 3), and Robert J. Barro and Xavier Sala-i-Martin (1995 Ch. 6). In contrast, evidence on variety growth is very sparse. Jerry A. Hausman (1997) and Amil Petrin (1999) estimate the consumer gains to the introduction of specific brands of specific products (Apple-Cinnamon Cheerios and minivans, respectively). Similarly, Manuel Trajtenberg (1989) and Hausman (1999) estimate the gains from computed tomography (CT) scanners and cellular phones, respectively. However, quantifying the aggregate importance of new products on a good-by-good basis is probably not feasible. In particular, it is not possible to obtain data to estimate consumer surplus from the myriad of new models and features that are continually introduced.[1] Reflecting these problems, the Boskin Commission (1996) offers only a few, often speculative, calculations in addressing the issue of variety gains.

We take an indirect approach. We exploit how new varieties alter spending patterns, drawing expenditures away from comparatively dormant categories. Table 1 illustrates for a few cases of dramatic product innovations. As the table shows, rapid growth in spending on cable television since 1980 has fueled a broad increase in spending on television, despite a relative decline in spending on television sets. Similarly, VCR's and movie rentals have spurred an increase in overall spending on movies at home and theaters, personal computers have brought about increased spending on home audio and video equipment, and cell phone services have been responsible for the increased spending on all telephone services. In the 20 years prior to the ascendance of these major new items, all of their categories were stagnant or in relative decline.

More generally, we find that consumers have been rapidly shifting away from "static" categories (i.e., those in which there has been little variety or quality gain). This shift far exceeds what can be explained by the impact of relative Engel curves or relative price changes. Our results suggest that variety has increased by perhaps 1 percent per year over the past 40 years. More striking is that most of this growth occurs in just the past 20 years—explaining our title.

Looking across 106 more detailed categories, we relate share changes to U.S. Bureau of Labor Statistics (BLS) item-substitution rates. Item-substitution rates measure how often the BLS replaces an item in the pricing basket with another model because the former has disappeared from a sample outlet. Frequent BLS item substitutions predict increased spending on a category, even after controlling for Engel-curve, price, and demographic effects. This suggests that new varieties do increase spending on a category, as well as drive out or replace incumbent varieties. Compared to Engel curves, we find that item-substitution rates are a more reliable predictor of shifts in spending shares across goods. Related to this, we question Bruce W. Hamilton (1998) and Dora Costa's (2000) reliance on food's share and food's Engel curve to measure the true rate of U.S. economic growth.

I. Consumer Decisions

To illustrate the impact of variety on spending choices, consider the consumer problem

$$\max_{\{c, x_{it}\}} \frac{c_t^{1-1/\sigma}}{1-1/\sigma} + v_t \sum_{i=1}^{N_t} \frac{x_{it}^{1-1/\sigma_x}}{1-1/\sigma_x}$$

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[1] Improvements in existing models (e.g., the addition of anti-lock brakes on car models) are often referred to as "quality growth" rather than "variety growth." If the new model is imperfectly substitutable for the previous model, however, then a more accurate description may be "variety growth." Thus, what we refer to as "variety growth" can take the form of added features to existing products as well as entirely new products.

TABLE 1—THE IMPACT OF SELECTED NEW VARIETIES

	Nominal spending share (percentage)		
Category	1980	1999	Change
Televisions/recreation	5.0	3.5	−1.5
Cable television/recreation	1.7	5.5	3.8
Total television/recreation	6.7	9.0	2.3
Movies/recreation	1.9	1.2	−0.7
(VCR's + rentals)/recreation	1.0	3.6	2.6
(Movies + VCR's + rentals)/recreation	2.9	4.8	1.9
Audio and video (excluding computers)/recreation	14.9	10.6	−4.3
Computers/recreation	0.1	6.2	6.1
Total audio and video/recreation	15.0	16.8	1.8
Telephone (excluding cell phone)/services	3.2	2.6	−0.6
Cellular phone charges/services	0.0	0.7	0.7
Total phone charges/services	3.2	3.3	0.1

Notes: "Computers" = hardware, software, and Internet connections; "recreation" = NIPA recreation expenditures plus NIPA purchases of audio and video products; "telephone" includes local, long distance, and cellular charges.
Source: National Income and Product Accounts (NIPA), Bureau of Economic Analysis, U.S. Department of Commerce.

subject to

$$c_t + \sum_{i=1}^{N_t} p_t x_{it} = y_t.$$

We refer to c as a static good (or set of goods), for which variety is expanding slowly or not at all. The x_i's denote amounts of various varieties in a dynamic category in which the number of varieties, N_t, is expanding. For instance, the x_i could be viewed as amounts of various entertainment goods, with (for example) the introduction of DVD's expanding N_t. We let v_t represent a preference parameter.

Spending on the two categories of goods must equal y_t, denoting income minus changes in assets. Prices are normalized to the price of the static good, with a symmetric relative price of p_t for each of the dynamic goods. Although we depict the consumer as choosing simply between a nondurable static good and nondurable varieties, the empirical tables anticipate a straightforward extension to a number of static and dynamic categories.

Optimal spending on the dynamic category is related to static spending by

$$(1) \quad p_t X_t = \sum_{i=1}^{N_t} p_t x_{it} = N_t c_t^{\sigma_x/\sigma} p_t^{1-\sigma_x} v_t^{\sigma_x}.$$

Let Δz denote the annualized percentage growth rate for variable z over some period of interest. The growth rate of spending on the dynamic good, relative to the static good, is

$$(2) \quad \Delta(pX) - \Delta c = \frac{\sigma_x - \sigma}{\sigma} \Delta c + (1 - \sigma_x)\Delta p + \Delta N + \sigma_x \Delta v.$$

As (2) shows, variety growth expands the share of the dynamic category relative to the static share. The dynamic share also rises when static consumption grows if the dynamic good has a steeper Engel curve than does the static good ($\sigma_x > \sigma$). Likewise, the dynamic share rises if its relative price is rising (falling) and σ_x is less than 1 (greater than 1). Finally, a preference shift toward the dynamic good, perhaps reflecting demographic changes, could expand its share.

II. Evidence on Growth in Dynamic versus Static Spending

In Table 2 we present growth rates for dynamic versus static goods. We define milk, alcohol, gasoline, utilities, and some services, such as haircuts, as static goods (Table 2 lists the goods in detail). Although our classification of goods as static or dynamic is somewhat arbitrary, we can point to the fact that the BLS rate of noncomparable item substitutions for our static goods is 0.03 percent monthly, compared to 1.98 percent for all CPI goods. Thus, their features do not change relative to the detailed attribute lists maintained by the BLS.

The first portion of Table 2 presents the relative growth rates for dynamic versus static goods. We see that relative spending on dynamic goods has expanded by between 1.3 percent and 2.2 percent per year, depending on

TABLE 2—CHANGING SHARES OF STATIC VERSUS DYNAMIC CATEGORIES

	Relative growth rate (percent per annum)			
Category and conditions	1959–1979	1979–1999	Change	1959–1999
With no adjustments:				
Food, utilities, entertainment	0.6	1.9	1.3	1.3
Plus clothing and durable goods	0.6	2.0	1.4	1.3
All consumption	1.3	3.0	1.8	2.2
With adjustments, $\sigma_{\text{Average}} = 1$:				
Food, utilities, entertainment	0.8	1.9	1.1	1.3
Plus clothing and durable goods	0.5	2.0	1.5	1.2
All consumption	1.3	3.0	1.7	2.2
With adjustments, $\sigma_{\text{Average}} = 0.5$:				
Food, utilities, entertainment	0.8	1.7	0.9	1.2
Plus clothing and durable goods	0.9	2.2	1.3	1.6
All consumption	1.3	3.0	1.7	2.2
Mean with Adjustments	0.9	2.3	1.4	1.6

Notes: "Relative growth rate" = growth rate in spending relative to that on static goods; "static goods" = gasoline and fuel oil, alcoholic beverages, fresh milk and cream, natural gas, water and sewage treatment, domestic service, bowling and billiards, pari-mutuel net receipts, barber shops, postage, tolls, and taxicabs. Adjustments are for income effects (relative Engel curves) and substitution effects (relative price changes); σ_{Average} = the average curvature parameter across all consumer goods. We obtained relative Engel curves for individual categories using household cross sections.
Source: National Income and Product Accounts, Bureau of Economic Analysis, U.S. Department of Commerce.

the set of dynamic goods. Although this is consistent with growth in varieties of dynamic goods, this shift could alternatively reflect steeper Engel curves for dynamic goods than for static goods, or changes in their relative prices. For this reason we next report *residual* growth rates, which net off Engel-curve effects, $[(\sigma_x - \sigma)/\sigma]\Delta c$, and relative price effects, $(1 - \sigma_x)\Delta p$, yielding an estimate of the change $\Delta N + \sigma_x \Delta v$.

To construct $(\sigma_x - \sigma)/\sigma$ we estimate Engel curves for a large number of categories of spending using the 1980–1996 Consumer Expenditure Surveys (CEX) (with year dummies). For each good, an Engel curve is estimated with respect to a fairly broad aggregate of spending on nondurables and services. (The estimation is similar to that described in detail in Bils and Klenow [1998].) We then construct a weighted average both for the set of static goods and for the set of dynamic goods. Comparing these aggregates yields a value for $(\sigma_x - \sigma)/\sigma$.

Adjusting for relative price changes requires levels of $(1 - \sigma_x)$. Our estimated Engel curves only yield values for σ_x relative to a value for our broad set of nondurables and services. For 106 categories in the 1980–1996 CEX, it turns out that share changes are *positively* correlated with relative price changes (as measured by consumption deflators from the National Income and Product Accounts). This suggests that demand is typically price-inelastic (i.e., that the average value of σ falls below 1). In fact, an average value of 0.75 maximizes the correlation between $(1 - \sigma_x)\Delta p$ and share changes at 0.38 (p value = 0.0001). For calculating relative price effects we consider 1.0 and 0.5 for the average value of σ, two levels that bracket this point estimate of 0.75. The results are very similar using 0.75 (or even 0.25 or 1.25) as they are using 1.0 and 0.5.

The second panel in Table 2 nets off income and price effects, the latter using an average σ across goods of 1.0. The first row of this panel defines dynamic-good spending by spending on food, utilities, and entertainment net of any spending classified as static. We see that relative spending on dynamic goods has expanded by 1.3 percent per year, even controlling for relative Engel-curve and price effects. This represents a very sizable shift of 68 percent over the past 40 years. The table also breaks the change into the two subperiods 1959–1979 and 1979–1999. The shift from static to dynamic goods is considerably faster in the latter period, with 70 percent of the total shift occurring during these 20 years. The next row broadens the definition of dynamic goods to include spending on clothing and durables. In general, it is important to distinguish between expenditures and service flows for durable goods. Although Table 2 reflects only expenditures, we believe the calculations are still suggestive.[2] We continue to

[2] The behavior of durable expenditures is particularly informative in an environment with constant growth rates. In that case, the desired stock of the durable is given by an equation that parallels equation (1), but with v replaced by $v/[1 - (1 - \delta)/(1 + r)]$, where δ is the good's rate of depreciation and r is a real interest rate defined with respect to the good's own rate of price increase. Spending on the good will reflect the sum of depreciation and the desired increase in the stock. But in a setting with constant growth rates, the growth rate in this spending is described by equation (2) with the term Δv appropriately reinterpreted. Of course, given that changes in spending patterns accelerate circa 1979, references to a setting with constant growth rates must be taken with some skepticism.

see rapid growth in expenditures for dynamic goods. For this broader set of goods, 80 percent of relative growth is concentrated in the last 20-year period. The last row in the panel broadens the set of dynamic goods to include most nonstatic consumer expenditures (including, in particular, rental housing and medical expenditures). The residual growth rate is now very high, equaling about 2 percent per year, again with much of this focused in the past 20 years.

The third panel of Table 2 considers a lower average value for σ of 0.5. This does not affect the adjustment for relative Engel curves but does imply that rising relative prices for goods, everything else equal, will tend to increase a good's spending share [see equation (1)]. The measured shift toward dynamic goods for the entire 1959–1999 period looks very similar to that described in the middle panel. We also continue to find a striking acceleration away from the static goods over 1979–1999. It is worth noting that, consistent with an acceleration in variety growth over this period, flows of U.S. patents have taken off since the mid-1980's (Samuel Kortum and Josh Lerner, 1998).

III. Item Substitution and Changes in Spending Shares

We have stressed that the shift in spending away from static goods may reflect expanding varieties elsewhere. But it could also represent preference or demographic changes that happen to be correlated with how we have labeled goods. (Such shifts would also have to accelerate to explain the acceleration away from static goods.) To test further the idea that spending shifts reflect expanding variety, we look across 106 detailed categories and relate changes in spending shares for 1980–1996 to the rate of item substitution within each category, as recorded by the BLS for 1997.

An item substitution occurs when the BLS can no longer price an item at a particular retail outlet because it has been discontinued. We focus on those item substitutions that the BLS judges to be noncomparable (as opposed to those labeled comparable), meaning no closely similar model exists or appears in the outlet. We believe that noncomparable substitutions better fit the notion of important new varieties driving out less-important incumbent varieties. The noncomparable-item substitution rates average 3.0 percent across the 106 categories, exhibiting a standard deviation of 3.4 percent and ranging from a low of 0.0 (gasoline, airline fares) to a high of 16.0 percent (women's dresses).

Rather than distinguish a priori between static and dynamic goods, here we simply relate the differences in rates of spending growth to differences in item-substitution rates across the 106 categories. The spending shifts are based on comparing reported expenditures in the 1995–1996 CEX to those for 1980–1981. The categories correspond roughly to strata in the BLS's classification, and represent 63 percent of the weight in the 1997 CPI. We find a significantly positive correlation between a category's item-substitution rate and the rate of growth in spending on the category, equaling 0.24 (p value = 0.01) across the 106 categories.

We are concerned that BLS item substitutions are less meaningful for some goods. Of our categories, 19 are apparel, which exhibit very high item-substitution rates reflecting seasonal turnover of items. Thus, the high item-substitution rate for these goods presumably does not signal a high rate of variety growth. Rental housing is only one category, but it receives an important weight in our calculations based on its expenditure share. Every time a housing unit is replaced in CPI measurement it is labeled a noncomparable substitution, but this may not correspond well to the notion of a new type of product. Furthermore, although the item-substitution rates for the phone-service and cable-TV categories are virtually zero, cell phones and new cable channels have represented important new varieties in these categories (as we documented in Table 1 above). For this reason, we present added results excluding apparel, rent, phone service, and cable television. Eliminating these goods results in 84 categories, for which the correlation of share changes with the substitution rate becomes 0.30 (p value = 0.006).

These correlations do not control for the impact on share changes of relative Engel-curve effects or relative price changes, as dictated by equation (2). We next relate the growth in a category's spending on its item-substitution rate controlling for these effects as well as for demographic changes. The relative Engel-curve effects are calculated based on the 1980–1996 CEX in a manner analogous to the adjustments

TABLE 3—SHARE CHANGES AND ITEM-SUBSTITUTION RATES

Sample	Coefficient on the noncomparable substitution rate	Coefficient on the relative Engel curve
Full sample (106 categories)	0.12 (0.05) [t = 2.7]	1.25 (imposed)
Full sample (106 categories)	0.13 (0.06) [t = 2.2]	0.38 (0.44) [t = 0.9]
Excluding apparel and rent (86 categories)	0.16 (0.08) [t = 2.0]	0.54 (0.50) [t = 1.1]
Excluding apparel, rent, phone service, and cable TV (84 categories)	0.19 (0.07) [t = 2.5]	0.75 (0.46) [t = 1.6]

Notes. Each row is a weighted regression. Coefficients are percentages per annum. Standard errors are reported in parentheses. The weights are average 1980–1996 expenditure shares. "Item substitution rate" = fraction of CPI price quotes for which a substitute replaced the previous month's item; "Noncomparable item substitutions" are those for which the BLS could not identify a virtually identical item in the same outlet. The dependent variable is the 1980–1996 annual growth in relative spending after netting out substitution effects (using relative price changes and an average σ across all consumption categories of 0.5) and the effects of shifting demographics (region, urban vs. rural, age, age-squared, number of people per household, number of children per household, and marital status). The relative Engel-curve-independent variable is $\sigma_i/(\sigma - 1)$ for category i.
Sources: Consumer Expenditure Surveys, Bureau of Labor Statistics, U.S. Department of Labor for the 1980–1996 growth rates of expenditure shares for 106 categories; General Accounting Office, U.S. Congress for the 1997 item-substitution rates for the 106 categories.

contained in Table 2. We also adjust for relative price changes in the manner done for Table 2. To construct absolute values of the σ's across goods, as is necessary to control for price changes, we assume an average σ across goods of 0.5. (We obtain very similar results using an average σ equal to 1 or 0.25.) The demographic changes we account for include age, family status, and residence (see the notes to Table 3.) To predict the impact of these demographic changes in shifting spending, we multiply the change in each variable by the coefficient it received when employed as a control in the cross-household regressions estimating the 106 Engel curves.

The first row of Table 3 presents the result of regressing the residual share changes (share changes after removing the impact of Engel curve, price substitution, and demographic effects) with the BLS item-substitution rate for the full sample of 106 goods. As expected, the coefficient is positive, equaling 0.12 (with a standard error of 0.05).

Our Engel curves are based on a broad aggregate of nondurables (largely food, utilities, and recreation), so the adjustment for differences in Engel curves is constructed by weighting these differences by the average annual growth in that composite for 1980–1996, which equaled 1.25 percent. For this reason, the first row of Table 3 reports an imposed coefficient of 1.25 on the relative Engel curves. Hamilton (1998) points out that food, which has a low Engel curve, continued to decline rapidly as a share of consumer spending from 1974 to 1991. He infers that true growth may not have slowed during this period. Given that measured growth did fall markedly, this requires greater mismeasurement (in particular, understatement) of economic growth during this time period. Costa (2000) examines the shifting share of entertainment spending as well as that for food. She also examines a number of differing time periods. Her conclusions for the period 1972–1994 largely mirror those of Hamilton.[3] Their results suggest we may be understating the importance of differences in goods' Engel curves by ignoring unmeasured growth.

Equation (2) depicts the shift in spending on dynamic goods, pX, relative to spending on the static good, C, assuming that growth is well measured. Now consider unmeasured growth in quality equal to Δq for static goods and equal to Δq_x for dynamic goods.[4] For concreteness, think of food in the Hamilton (1998) and Costa (2000) exercise as good C, and all other goods

[3] Leonard Nakamura (1997) conducts calculations in the spirit of Hamilton (1998) and Costa (2000), but also with something in common with our own. Breaking consumption into nine categories, he finds that shifts in spending accelerated over 1974–1994 relative to 1959–1974. He infers that the true growth rate may have accelerated across the two periods, in contrast to the deceleration in measured growth. We suggest that this shift may reflect an acceleration in the arrival rate of new varieties.

[4] Accounting for these possible measurement errors in equation (2) yields a shift in measured shares of

$$\begin{aligned}\Delta(\widehat{pX}) - \Delta\hat{C} \\ &= \frac{\sigma_x - \sigma}{\sigma}(\Delta\hat{C} + \Delta q) + (1 - \sigma_x)\Delta\hat{p} \\ &\quad - (1 - \sigma_x)(\Delta q_x - \Delta q) + \Delta N + \sigma_x \Delta v.\end{aligned}$$

$\Delta\hat{Z}$ denotes measured average annual rate of growth for Z, possibly distinct from its true rate of growth.

as good X. Implicit in their exercise is that Δq_x equals Δq, and that both ΔN and Δv equal zero. If relative price changes are small or controlled for, then spending on food will decline by $[(\sigma_x - \sigma)/\sigma]$ $(\Delta\hat{C} + \Delta q)$ percent per year relative to spending on other goods. Both authors find that food's share declined considerably more than predicted by $[(\sigma_x - \sigma)/\sigma]$ $\Delta\hat{C}$, where $(\sigma_x - \sigma)/\sigma$ is based on the extent that food's share is lower in richer versus poorer households. They conclude that unmeasured growth was important.

Of course, food's share could fall faster than predicted by food's Engel curve for reasons other than unmeasured overall growth. Demographic or preference shifts could be important. Also, if unmeasured quality growth differs in importance for food versus other goods, and σ_x does not equal 1, then food's share will be affected. Finally, if variety grows more slowly for food than for other goods, then this will cause food's share to decline.

In the second row of Table 3 we redo the Hamilton-Costa exercise for our 106 spending categories.[5] The coefficient on the relative Engel curve equals 0.38 percent and is statistically insignificant. Absent measurement error, this coefficient should equal 1.25 percent. The estimate actually implies that there was an unmeasured *decline* in quality of 0.87 percent per year (1.25 − 0.38) on average for the 106 goods. By contrast, if we conduct the exercise for just food at home (which we estimate has an Engel curve of 0.53 versus all consumption), the implication is substantial *positive* unmeasured growth of 2 percent per year over 1980–1996. Thus, we are obtaining different results from Hamilton (1998) and Costa (2000) not because of the sample period, but rather because of the breadth of categories examined. To us, this suggests that their exercise is not robust to considering broader categories of goods.

Row 3 of Table 3 repeats the exercise excluding apparel and rental housing for reasons discussed above. This yields a somewhat larger, but still insignificant, coefficient for a category's relative Engel curve. The final row of Table 3 also excludes phone service and cable TV. The coefficient on a category's Engel curve is now larger and marginally statistically significant. But its magnitude, 0.75 percent, remains below the measured growth in consumption of 1.25 percent per year. Thus, it continues to suggest that unmeasured growth was negative. Finally, we note that in all cases the rate of item substitution predicts rising expenditure share.

[5] Across the 106 categories the Engel-curve slopes average 1.3, exhibit a standard deviation of 0.6, and vary from a low of 0.4 for motor oil to a high of 4.3 for housekeeping services. By having many categories, we can weaken their assumption of no differences in variety growth, preference shifts, or rates of unmeasured quality growth to an assumption that these differences are orthogonal to differences in Engel curves across the 106 goods.

IV. Summary

We find that spending shares have shifted dramatically, with these shifts poorly anticipated by relative Engel-curve or price effects. Spending has shifted rapidly away from goods that arguably show little variety change, with the shift accelerating in the last 20 years. Taken at face value, the shifts imply variety growth averaging about 1 percent per year over 1959–1999, and accelerating about 1 percent between the first and second halves of the sample (1979–1999 relative to 1959–1979).

We also find that the rate at which the BLS must substitute noncomparable items in its pricing basket predicts increased spending on a category. This provides some auxiliary support for the idea that new products have played an important role in the substantial shifts in spending. Finally we argue that variety shifts are important to consider in the exercises of Hamilton (1998) and Costa (2000), each of whom captures a rate of unmeasured growth by observing the rate at which spending shifts away from necessities toward luxuries. We also find that, for the 1980–1996 period, their calculations are not robust to considering a broad set of spending categories.

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