NBER WORKING PAPERS SERIES

ERRORS IN OUTPUT DEFLATORS REVISITED: UNIT VALUES AND THE PPI

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Working Paper No. 3935

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 1991

This paper is part of NBER's research program in Productivity. Any opinions expressed are those of the author and not those of the National Science Foundation, the Bureau of Labor Statistics, or of the National Bureau of Economic Research.

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ABSTRACT

Extending a methodology developed by Lichtenberg and Griliches (1989), we examine the extent of measurement error in two independent indicators of price change: the producer price index (PPI) and the U.S. Census Bureau's unit value relative (UVR). Estimation of factor analytic models is improved by the availability of more accurate and comprehensive proxies for price and quality change within industries and a more complete specification of the econometric model. We find that the UVR is a "noisier" measure of price change than the PPI and that the PPI adjusts for approximately 57% of product quality change.

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I. INTRODUCTION

The major difficulty associated with the accurate measurement of industrial prices is the adjustment of price indexes to reflect quality change.[1] Improper measurement of quality change can distort estimates of important economic variables, such as real output or productivity growth. A recent paper by Lichtenberg and Griliches (1989), (henceforth L-G), based on detailed price data, finds that the Producer Price Index (PPI) adjusts for only about two thirds of quality change, resulting in an underestimation of "true" (quality-adjusted) TFP growth over the sample period (1972-1977) by about 34%.

The purpose of this study is to extend this work on measurement error in output prices, examining two independent indicators of price change-the BLS's PPI and the Census Unit Value Relative (UVR). Our analysis is based on detailed product-level data derived from the 1982 Indexes of Production (the L-G study was based exclusively on the 1977 Indexes of Production data). Thus, we can determine whether the PPI was a "better" indicator of price change than the UVR (a key finding of the earlier study) during the later period and whether recent changes in the manufacturing sector have exacerbated errors in price measurement. Estimation of factor analytic models of price determination is improved by the availability of more accurate

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[1]For discussions about quality adjustment of price indexes, as well as the effects of using erroneous deflators on productivity growth, see Griliches [1971, 1989], Berndt and Griliches [1989], and Lichtenberg and Siegel [1991].

and comprehensive proxies for price and quality change within industries. We also propose modifications to the econometric model of long-run price and quality formation and estimate these models at both the industry (4-digit SIC) and product (7-digit SIC) levels. Our comparison of the two price indicators also includes an analysis of a set of unit values that are representative of a central tendency in the data.[2] The remainder of this paper is organized as follows: Section Two describes the versions of the multiple indicators, multiple causes (MIMIC) models we propose to estimate. The next section contains a discussion of the data. Empirical results are presented in Section Four. Conclusions and suggestions for additional research are contained in the final section.

II. MODEL

The focus of L-G was to derive an empirical estimate of long-run errors of measurement of price change in the manufacturing sector. In their view, the major source of such errors is unmeasured or imperfectly measured changes in product quality. Factor analytic models of price change were estimated using two independent indicators of price movements, the PPI and the UVR. Weighted averages (by shipments) of price changes between 1972 and 1977 of 7-digit SIC products (the finest level of disaggregation of Census data) were calculated at the 4-digit

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[2]L-G analyzed all available unit values with a corresponding PPI.

SIC industry level.[3]

In L-G, the following MIMIC model was estimated:

IIA. MIMIC Model

(1) $PPI = P^* + \alpha_1 Z^* + \varepsilon_1$

(2) $UVR = P^* + Z^* + \varepsilon_2$

(3) $NEW = Z^* + \varepsilon_3$

(4) $P^* = \varepsilon_4$

(5) $Z^* = \alpha_2 OWNRD + \alpha_3 SUPRD + \varepsilon_5$

or in matrix form:

$$\begin{bmatrix} PPI \\ UVR \\ NEW \end{bmatrix} = \begin{bmatrix} 1 & \alpha_1 \\ 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} P^* \\ Z^* \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{bmatrix} \quad \text{measurement model}$$

$$\begin{bmatrix} P^* \\ Z^* \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ \alpha_2 & \alpha_3 \end{bmatrix} \begin{bmatrix} OWNRD \\ SUPRD \end{bmatrix} + \begin{bmatrix} \varepsilon_4 \\ \varepsilon_5 \end{bmatrix} \quad \text{structural model}$$

where PPI is the producer price index collected by the Bureau of Labor Statistics and UVR is the unit value relative collected by the Bureau of the Census, defined as the ratio of the value of shipments for a given product to its quantity, divided by the same ratio in the previous quinquennial Census of Manufactures.[4] P^* represents true but unobservable industry price change and ε_i $(i= 1,...,6)$ are classical disturbance terms.

In the MIMIC model, it is assumed that there are multiple

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[3]Given that a primary objective of the paper was to determine whether the PPI was a "better" measure of price change than the UVR, only those products (about 2100 out of 11,000) having both a PPI and a UVR were included in the analysis.

[4]By virtue of its definition, the UVR cannot be calculated for products whose producers do not report quantities, do not report them accurately, or in situations where reporting quantities would violate confidentiality standards.

indicators of two latent variables, P* and Z*, the growth in product quality, which is "caused" by a set of R&D variables. where the growth rate of product quality, Z^*, is expressed as $Z^* = Q^* - Q$, where Q^* denotes the growth rate of the effective quantity of output, and Q denotes the growth rate of number of units sold. The effective quantity of output is the quantity of output that would have resulted if the value of shipments had been deflated by a true quality adjusted price index.[5] Thus, the effective quantity of output is the ratio of the value of shipments to quality adjusted price, while Q refers to the ratio of value of shipments to either PPI or UVR. Therefore, the difference between Q^* and Q is defined as the product quality.

The specifications of the PPI and UVR equations reflect the fact that the former includes an adjustment for quality change, while the latter does not. The UVR is a measure of the change in revenue per unit sold and does not include an explicit quality adjustment.[6] On the other hand, the PPI includes some adjustment for quality change because the BLS authorities periodically change the list of goods included in the indexes to reflect major changes in the range of products sold and their characteristics.[7] BLS also adjusts prices when a change in

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[5]Q^* can be thought of as a quality-adjusted measure of the growth in quantity.

[6]Actually, the measure is often based on a mix of goods that are classified as one, based on an establishment's primary product.

[7]For example, new products are added to the index, while discontinued products are eliminated from the price series.

quality is reflected in a change in cost. These facts lead us to expect that $0 < \alpha_1 < 1$.

In L-G, the variable NEW, which is assumed to be an indicator of product quality, was defined as the fraction of new products introduced within a two-digit SIC sector during the period Jan.1967-Jan.1975, as compiled by Ruggles (1977). This measure is problematic because it is calculated in different units than the price measures. In estimating the MIMIC model, L-G normalized the parameter on Z* to be one, which would be plausible if the indicator was measured as a growth rate. The authors do not explain why this constraint should be imposed. Estimates of this simple model are quite sensitive to this assumption. In fact, we find that this model cannot be estimated when we allow this parameter to be free. To address this problem, we have constructed indicators of quality change that are based on the price changes of new products.[8]

The specification of the Z* equation is based on the assumption that product, rather than process, innovation is the chief source of improvements in quality.[9] OWNRD and SUPRD are

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[8]Note also that in L-G, P* was specified as a stochastic exogenous variable. It is probably more plausible to assume that the change in output price is determined by changes in input prices and the R&D intensity, or the ratio of R&D to sales. This relationship is the dual of an equation relating growth in total factor productivity to R&D investment. See Lichtenberg-Siegel (1991) and Mairesse-Sassenou (1991) for surveys of these studies.

[9]We find that when process R&D is included as an additional regressor, its coefficient is close to zero and statistically insignificant.

expenditures for product-oriented R&D conducted within the industry and by the industry's suppliers of capital and materials respectively, based on data from Scherer (1984) on interindustry technology flows. Thus, the change in output quality is assumed to be a function of R&D that is performed both inside and outside a given industry.

We believe that equations (1) and (2) should be specified as follows:

(6) $PPI = P^* + \alpha_1 Z^* + \alpha_2 S^* + \varepsilon_1$

(7) $UVR = P^* + Z^* + \alpha_3 S^* + \varepsilon_2$

Both price measures are assumed to reflect the effects of an additional latent variable, S^*, an industry-specific "supply shock," or shift in the industry supply curve. Stigler and Kindahl (1970) and others have examined the relationship between short run movements in prices and oscillations in economic activity. Although we focus on long-run estimates of price change (over a five year interval), these measures are also sensitive to fluctuations in industry supply and demand. We believe that the distinction in the economic environment that existed in 1977 (a relatively "normal" year) and business conditions in 1982 (a year of severe recession in many heavy manufacturing industries) underscores the importance of controlling for these effects. It is expected that the UVR is more sensitive to these fluctuations ($0 < \alpha_2 < \alpha_3$) because it comes closer to representing a true transactions price.[10] Gordon (1990) finds that the logarithmic difference between the PPI and Unit Value indexes is positively correlated with a variable measuring excess aggregate demand.[11]

IIB. Alternative Specifications of MIMIC Model

We propose to estimate the following expanded versions of the original MIMIC model:

Version 1

(7) $DIFF = LOG(PPI/UVR) = \beta_1 Z^* + \varepsilon_1$

(8) $PPINEW = \beta_2 Z^* + \varepsilon_2$

(9) $UVRNEW = Z^* + \varepsilon_3$

(10) $Z^* = \beta_3 OWNRD + \beta_4 SUPRD + \varepsilon_5$

and a variant of the model that incorporates an industry "supply shock":

Version 2

(11) $DIFF = LOG(PPI/UVR) = \beta_1 Z^* + \beta_2 S^* + \varepsilon_1$

(12) $PPINEW = \beta_3 Z^* + \varepsilon_2$

(13) $UVRNEW = Z^* + \varepsilon_3$

(14) $DCU = S^* + \varepsilon_4$

(15) $Z^* = \beta_4 OWNRD + \beta_5 SUPRD + \varepsilon_5$

(16) $S^* = \beta_6 PMAT + \beta_7 PENERGY + \beta_8 PWAGES + \varepsilon_6$

Note that inflation (P^*) is "differenced" out of these

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[10]The unit value is derived from census data on the quantity and value of shipments (actual transactions), while the PPI can be based on list, rather than transactions, prices.

[11]On the other hand, Searle (1970) finds that the ratio of the price measures is basically uncorrelated with fluctuations in industry output.

versions of the model due to our use of the logarithmic difference between the two price indicators as the dependent variable. In the context of the previous model, $-\beta_1$ is a measure of $(1-\alpha_1)$, the extent to which the PPI is adjusted to reflect changes in product quality. Our previous discussion leads us to expect that $-1 < \beta_1 < 0$. Given our hypothesis that the UVR is more sensitive to fluctuations in industry supply and demand, we expect that the difference between the PPI and UVR will be inversely correlated with the industry supply shock, or $\beta_2 < 0$.

PPINEW and UVRNEW are two additional indicators of quality change based on the price changes of new products. PPINEW is defined as the difference between the Divisia index of PPIs (at the 4-Digit SIC level) for products having both price measures and the Divisia index of PPIs for new products. UVRNEW is based on corresponding calculations for the unit value relative. Both measures are adjusted for coverage in terms of shipments. In contrast to the two-digit specific indicators of improvements in quality used in L-G, we have constructed proxies that are based on the number of new products created in each 4-digit SIC industry.[12] The corresponding price measures for these new products are available to us because Census officials have provided us with the complete universe of product prices.[13] As discussed in the previous section, the BLS partially adjusts the

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[12]We discuss these calculations in full detail in the next section of the paper.

[13]As described in the next section of the paper, only a small fraction of products (9.3%) that have both price measures are new.

PPI to reflect changes in quality. It is highly likely that the quality adjustment problem is more severe for new, as opposed to existing, products. Thus, we expect that $0 < (-\beta_1) < \beta_3$.

The change in the capacity utilization rate (DCU) is hypothesized to be an indicator of the industry supply shock. Our construction of this measure is based on the assumption that energy, materials, and production labor are variable factors of production, while non-production labor and capital are fixed. It is computed as the (unweighted) sum of changes in the cost shares of the variable factors divided by the average (1977 and 1982) cost share of the fixed factors (industry subscripts are omitted).

$$DCU_t = \frac{\sum_{i=1}^{3} (S_{it} - S_{it-1})}{\sum_{j=1}^{2} (S_{jt} + S_{jt-1})/2}$$

where

S_{it} = share of variable factor i in total cost at time t.
S_{jt} = share of fixed factor j in total cost at time t.[14]

We conjecture that changes in the prices of the variable inputs: materials, energy, and production labor are determinants of the industry-specific "supply shock," S*, or shift in the industry supply curve. The coefficients on these variables

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[14]In future, we hope to estimate economic measures of capacity utilization at the detailed industry level (4-digit SIC) based on explicit cost function measures (see Morrison (1988)). One drawback of this approach is that it still requires the use of (error-ridden) output price deflators.

should all have positive signs.

In the next section, we describe our data and the calculation of new, more comprehensive measures of quality change.

III. DESCRIPTION OF THE DATA

As in L-G, the major source of our data is a Special Census Deflator Comparison File that was provided to us by the Industry Division of the Census Bureau. The Real Product Committee, a group of economists and officials from Census, BLS, BEA, and the Federal Reserve Board, used this file to construct the 1982 Indexes of Production. It contains data at the (7-digit SIC) product level on the value of shipments for the years 1977 and 1982, and all available price deflators measuring price change between 1977 and 1982, including several variants of the PPI, the UVR, and other price indexes. The file also includes information on which price measure was actually selected by the Committee and used to deflate nominal output. We have also obtained the original 1977 Indexes of Production product-level data from L-G (with measures of price change between 1972 and 1977), as well data on R&D expenditures at the industry level gathered by Scherer [1984].

Table 1 presents statistics on the percentage of shipments deflated by various price measures in the 1977 and 1982 Indexes of Production. This table shows that the PPI is the most frequently selected price measure. Over two thirds (67%) of industrial output was priced using the PPI in 1982. Prior to

1982, a "scoring" system was devised to choose between the PPI and UVR when both prices were available for a given product.[15] However, in the 1982 calculations, the PPI was always selected (over all measures) when available. Across industries, there were large increases in the percentage of output deflated by the PPI in the food, tobacco, textiles, apparel, and petroleum industries (SICs 20, 21, 22, and 29, respectively).

Still, in several sectors, price measures other than the PPI and UVR have been selected to deflate substantial percentages of nominal output. In fact, a greater percentage of output is deflated by other price measures than is deflated using the UVR. We will incorporate price measures from all available sources (i.e. Federal Reserve Board) in our statistical analysis. Given the finding that the PPI is, in general, the most reliable indicator of price change, errors in the measurement of output prices could be significantly greater in industries that have high percentages of output deflated based on alternative measures.

It is important to note that the L-G empirical results were based exclusively on a subset of all products-those for which both a PPI and UVR were available. One distinguishing feature of the data provided to us is that we have all available price information for the complete universe of Census products. Table 2 demonstrates that products with both price measures have larger

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[15]See L-G for further information on the nature of the scoring system. We will use these deflator scores to select the "best" unit values.

than average sales and tend to have established, well-defined markets. 91% of these products were "old." Products with a PPI and UVR accounted for 18.8% and 36.8% of total products and shipments, respectively, in 1982. It is obvious that a substantial percentage of industrial activity is eliminated when we restrict our analysis to those products with both price measures. We will return to this issue in Section IV, when we present results that are based on a more complete set of products.

As mentioned in the previous section, we have constructed indicators of quality change that are specific to 4-digit sectors, based on an examination of lists of products in both 1977 and 1982. Specifically, we have identified the net number of new products introduced (between the quinquennial Census of Manufactures) within a four-digit category as an indicator of the extent of quality change during the period.[16][17] Two alternative definitions of new products were used. One definition requires that a product appear for the first time in the Census

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[16]These measures were derived by analyzing the following Census Bureau publications: "1977 and 1982 Numerical List of Manufactured and Mineral Products." Appendix B of the 1982 report, entitled "Comparability of Product Codes," was used to establish matches and non-matches across Censuses. I am indebted to Zoe Georganta for performing this analysis and providing me with these data.

[17] Additonal data on manufacturing industries is provided by the NBER Productivity Database, which contains annual output and input measures for 450 manufacturing industries during the years 1958-1986. This file is an updated version of the Penn-SRI Database created at the Census Bureau in the late 1970's and is described in full detail in Siegel-Griliches (1991).

publications or had its specification changed. The term "specification," apart from denoting technical properties, also includes packaging, color, weight, and similar characteristics. The second definition also considers the economic significance of the market for a specific product. That is, a product can be defined as new as the result of a split of a product class (5-digit SIC) into a number of products, which may have existed during the previous Census (1977), but were not listed separately. Therefore, the second definition includes the products defined earlier and also products that existed during the previous period, but were not considered important enough (usually because output was relatively low) to warrant a separate listing. Similarly, we consider the antithesis of this phenomenon, or the contraction of a number of products into only one product class. The notion of an increasing demand for a product is taken to represent a quality change in the sense that an industry is providing the consumer with a new or improved product.

Table 3 contains examples of new products created (or those that became economically significant) between 1977 and 1982 for several industries. For example, in the Biological Products industry (SIC 2831), in-vivo and in-vitro technolgies have spawned new classes of products. The introduction of computer and video technology has led to the creation of new types of "phonograph records" (SIC 3652). The third industry cited, Cheese Natural and Processed (SIC 2022), provides an example of new products that resulted from market expansion. Each of these products (cheese substitutes) existed in 1977, but warranted a separate classification only when sales increased (or the number of producers increased) substantially during the period between Censuses.

We have calculated estimates of the number of new products created within 4-digit SIC industries during two periods: 1972-1977 and 1977-1982. Table 4 presents statistics on this phenomenon aggregated to the two-digit SIC level. For the entire manufacturing sector, there was a 25% increase in new products generated during the latter period. However, new products as a percentage of all products declined from 26.1% to 18.8%. These figures demonstrate that new products consititute a fairly significant percentage of industry revenue. In SICs 35 and 38 (two sectors with many high-tech industries), new products accounted for 26.3% and 32.0%, respectively, of 1982 sales.

In the next section, we present descriptive statistics on product and industry prices and discuss our econometric findings.

IV. EMPIRICAL RESULTS

We begin by constructing estimates of price change for products having both price measures. To compare our findings to the previous study, we calculate weighted averages of these product prices at the (4-digit SIC) industry level, using the value of shipments as weights. Summary statistics for the resulting sample of 269 industries are presented in Table 6. We have also calculated estimates of changes in the PPI and UVR at the industry level based on products for which at least one of these measures is reported (N=391 and N=324, respectively). Results for the balanced set of industries but unbalanced set of products (N=307) are also included in the table. Note also that we have included descriptive statistics on (7-digit SIC) product prices as well. Descriptive statistics are presented for products having both price measures (N=2048 and N=2045) and for the entire set of PPIs and UVRs (N=5908 and N=3411, respectively). Although the MIMIC model was estimated at the 4-digit SIC level in the previous study, we will also estimate our version of this model using product-level data.

It is important to note that many of the unit value measures in these large samples may also reflect changes in product mix and other elements of noise assoicated with the reporting of physical quantities of output.[18] This raises the issue of whether the complete set of unit values should be exmained or if an attempt should be made to select those unit values that are most likely to reflect true changes in prices. Gordon (1990) criticises the L-G study for its analysis of all available unit values with a corresponding PPI. He argues that meaningful comparisons of these two price indicators must be based on a small set of simple basic goods with few quality dimensions.

To identify unit values that are less likely to be prone to measurement error, we have constructed a sample that consists of

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[18]Recall that the unit value measure is based on the ratio of value of shipments to quantity of shipments.

measures that satisfy the following set of conditions:

a) Products that received a unit value score of 1 in 1977- As described in U.S. Bureau of the Census (1983), the criterion used to assess the homogeneity of a product (and thus, the desirability or "score" or the UVR) is the dispersion in prices reported by individual establishments around the industry mean UVR.[19] If there is a small degree of within-industry dispersion and this variable has not changed substantially over time, then the product is assumed to be relatively homogeneous. Unit values with a score of 1 (on a scale of 1 to 6) have a very small and stable rate of industry dispersion in UVRs: 90 to 100 percent of product shipments have establishment-level unit values falling within 0.8 and 1.2 times the industry mean unit value and the 1977 rate of dispersion differs from the 1972 rate of dispersion by less than 5 percentage points.[20]

b) Products having downward-sloping demand curves-For those products reporting unit values, we observe the quantity demanded (shipped) and implicit price of output in 1977 and 1982. This allows us to calculate the price elasticity of demand. We restrict our sample to those unit values with a negative elasticity.

c) Products within (4-digit SIC) industries that do not exhibit

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[19] See L-G (1989) pp. 15-17 for further details.

[20] Unfortunately, unit value scores for 1982 were not available because of the change in decison rule in constructing the Indexes of Production (PPI always accepted over UVR) described in Section III. Thus, we assume that the 1982 unit values would receive the same score as in 1977.

extreme variation in prices-Products within the same industry should experience price changes that are roughly similar. Unusually high variance in UVRs within an industry is likely to be due to measurement error.[21] We calculate the UVR price variation within a four digit sector and eliminate those industries that have unusually high (in excess of three standard deviations from the mean) within industry variance in prices.

d) Products within (4-digit SIC) industries having at least eight product categories-The concept behind this restriction is that products that are narrowly defined are likely to be relatively homogeneous. For example, the Census Bureau may list a number of different size classes for compressors, screws, and other industrial products.[22] Restricting the sample to "good" unit values with a corresponding PPI yields a sample size of 359 products and 37 industries. We have also constructed samples that allow us to compare the PPI to "good" unit values and other price deflators as well (N=1928 products and N=348 industries).

Table 6 shows that the average change in output price between 1977 and 1982 based on the PPI is higher than the corresponding figure based on the UVR (.367 versus .342). For the large industry and product-level samples ("balanced" and "unbalanced" sets of products and industries), the differences in

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[21]One might argue that high variance may also be due to technological change within the industry, although as mentioned earlier, only a very small percentage of new products have UVRs.

[22]The choice of eight products as a limit is admittedly arbitrary.

mean values of the PPI and the UVR are positive and significantly different from zero (t=2.05 in the industry cases, t=5.30 in the product case). In the previous period, L-G found that the mean value of the UVR was higher than the PPI. This difference was also found to be significantly different from zero.

In the context of the simple MIMIC model, the sign of the difference between the two measures is important if we wish to calculate a global estimate of the growth in quality. From equations (1) and (2), we observe that the mean difference between the two price indexes can be expressed as:

$$\Delta_1 = \text{PPI-UVR} = (\alpha_1 - 1)Z^* \text{ or } Z^* = \Delta_1/(\alpha_1 - 1)$$

Assuming that $0 < \alpha_1 < 1$, it is clear that the sign of Δ_1 determines the sign of the estimate of the change in product quality. Based on estimated values of α_1 and Δ_1 of .369 and -.028, L-G calculate that (unmeasured) product quality increased by 4.5% during 1972-1977. We will not attempt a similar calculation because we will estimate the two alternative econometric models described in the previous section.

We do observe one finding that is consistent across periods: the UVR appears to be a "noisier" indicator of price change. In the earlier period, the standard deviation of the UVR was 45% greater than the corresponding figure for the PPI. For the period 1977-1982, we find similar results: the standard deviation of the UVR exceeds that of the PPI by 42%, by 47% when we use <u>all</u> available data on the PPI and UVR), and by 14% for the smallest sample.

The product-level values are consistent with the industry figures. Except for the smallest sample, we again find that the sign of the difference in the mean values of the PPI and the UVR changes across periods and that the latter measure has a substantially higher standard deviation.[23] Not surprisingly, we observe that the magnitudes of the differences in the means and variances of PPI and UVR are smaller for the samples of "homogeneous" products and industries.

Table 6 also includes descriptive statistics for the variables PPINEW and UVRNEW. Not suprisingly, the estimated price changes at the industry level based on new products (those that have probably experienced substantial unmeasured improvements in quality) exceed corresponding estimates based on products that have both price indicators (these tend to be "old" or established products). There is reason to suspect that conventional measures of price change in innovative industries may be overstated (see Trajtenberg (1990)) because of the great difficulty adjusting price indices to reflect changes in the characteristics of output.[24]

Table 7 presents moment matrices that can be used to construct estimates of the ratio of the sample variances. As in the previous period, the UVR measurement error variance (σ_2^2) is

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[23]Note that for the small sample that the median value of the PPI exceeds that of the UVR .

[24]For the case of CT scanners, Trajtenberg (1990) demonstrates that even the so-called quality-adjusted or hedonic price indices overestimate "true" price change.

significantly higher than the PPI measurement error variance (σ_1^2). Our estimates of the ratio of the variances (1977-1982) at the industry level are 3.4, 3.8, and 4.0 (6.3 and 10.5 at the product level) and we can decisively reject the hypothesis of equality of variances ($\sigma_1^2=\sigma_2^2$).

We have used the LISREL modelling framework to compute parameter estimates and standard errors of the MIMIC models described in the previous section:[25] For example, the expanded version of the MIMIC model can be expressed as:

$$\begin{bmatrix} DIFF \\ PPINEW \\ UVRNEW \\ CU \end{bmatrix} = \begin{bmatrix} 1 & \beta_1 \\ \beta_2 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} Z^* \\ S^* \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{bmatrix} \qquad \text{measurement model}$$

$$\begin{bmatrix} Z^* \\ S^* \end{bmatrix} = \begin{bmatrix} \beta_3 & \beta_4 & 0 & 0 & 0 \\ 0 & 0 & \beta_5 & \beta_6 & \beta_7 \end{bmatrix} \begin{bmatrix} OWNRD \\ SUPRD \\ PMAT \\ PENERGY \\ PWAGES \end{bmatrix} + \begin{bmatrix} \varepsilon_5 \\ \varepsilon_6 \end{bmatrix} \qquad \text{structural model}$$

Under the assumption that the ε's are mutually independent, the above model is overidentified, with 45 sample moments and 22 independent parameters.[26] In estimating this model, it is important to relax one of the orthogonality assumptions associated with the disturbance terms. It is possible that product quality (Z*), as well as price, is affected by the determinants of shifts in the industry supply curve. For example, an increase in the price of materials may reflect an

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[25] See Joreskog and Sorbom [1984] for further details.

[26] The parameters we estimate include the covariance matrix of the "causes" of Z* and S*, β_1-β_6, and σ_i^2 = var(ε_i), i= 1,...,6.

increase in the quality of materials input, which may be reflected in an improvement in the quality of output. Thus, we do not assume that ε_5 and ε_6 are uncorrelated and σ_{56} is treated as a free parameter.

Maximum likelihood estimates of an expanded version of the MIMIC model are shown in Table 8.[27] This version comes closest to the model estimated in L-G. An important parameter is β_1, given that $-\beta_1$ is an estimate of the extent to which the PPI is adjusted for product-quality change. As in the previous study, we find that $-\beta_1$ is between 0 and 1, or that the PPI adjusts for some, but not all, quality change.[28]

Before discussing our results, we note that the L-G estimate of $-\beta_1$, based on price changes over the period 1972-1977, is .631, implying that the PPI adjusts for about 63% of the change in product quality. Point estimates from our model, based on the 1977-1982 data, range from .53 to .67, with an average value of .616. Thus, our results are quite similar to those of the previous study, especially when the model is estimated at the industry level. Note that the estimate of the quality adjustment parameter is slightly higher when the samples include industries that have at least one product with both price measures (N=307) and all available price deflators (N=348), including non-UVR

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[27]As noted earlier, estimates from the simple MIMIC model may not be desirable because the indicator of Z*, NEW, has been measured in different units.

[28]In all instances, we find that $-\beta_1$ is significantly different from both 0 and 1.

measures. By including products with only one price deflator, we observe a greater proportion of "new" products and in general, have a better measure of the industry's true price change. As discussed in the previous section, goods that have both a PPI and UVR are highly likely to be "old" products. This pattern is somewhat surprising since we expected to find that the quality adjustment process is more complete for existing goods with stable demand.[29] However, it is important to note that our results do not change considerably when based on non-UVR prices (N=1928 and N=348).

Estimates of β_2, the quality adjustment parameter associated with the PPI price differential, exceed those of β_1, although we cannot reject equality of these point estimates. Coefficients on the R&D variables (β_3 and β_4) are both positive and significant, consistent with the L-G results from the earlier period. This signifies that product-oriented R&D, particularly R&D that is performed by an industry's suppliers, is an important determinant of quality change. We find that our estimates of σ_1 are reduced when we (imperfectly, no doubt) control for quality change, as compared to corresponding estimates from the simple factor analysis model (see Table 7). Note also that the fit of the model improves when we use product-level data.

Table 9 presents point estimates from the MIMIC model that includes an additional latent variable, an industry "supply shock," and its determinants. The coefficients again have the

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[29] In principle, we could test this hypothesis.

expected signs. Estimates of the quality adjustment parameter, -β_1, are slightly lower than those presented in the previous table, with an average value of .573.[30] We also find that the parameter estimates do not vary substantially when the model is estimated at different levels of aggregation.

As expected, β_2, the coefficient on S^*, is negative and significant. This indicates that the UVR is significantly more sensitive than the PPI to shifts in the industry supply curve. Point estimates on the PPI quality change indicator and the R&D variables, β_3, β_4, and β_5, respectively, are similar to those in the previous table. With the exception of the change in energy prices, we find that the coefficients on the "causes" of the industry supply shock are positive and significant. The change in production wages is the most important determinant of S^*, while the change in materials price also has a strong impact on this variable. Our estimates of σ_{56} are generally positive and marginally significant, suggesting that it is appropriate to assume that ε_5 and ε_6 are correlated.

V. CONCLUSIONS

Extending a framework developed by L-G, we have examined two independent indicators of price change, the PPI and the UVR, for the period 1977-1982. Our analysis is based on more comprehensive data and an econometric model that incorporates the effects of an industry "supply shock." As in L-G, we find that

[30] An exception is when we restrict our analysis to a small sample of relatively homogenous products (N=359).

the UVR is a "noisier" indicator of price change than the PPI, given that the ratio of their sample variances is approximately 4 to 1. We also find that the quality adjustment parameter associated with the PPI has declined somewhat during 1977-1982, relative to 1972-1977. Maximum likelihood estimates of an expanded MIMIC model imply that about 57% of the change in product quality was reflected in the PPI during the later period. The corresponding estimate from L-G (based on data from 1972-1977) was approximately 63%. Our results do not vary greatly when based on all available price deflators (including price measures other than the UVR), suggesting that sample selection bias may not be a serious problem.

One of our key assumptions is that the PPI adjusts for some, but not all, quality change. Beginning in the early 1980's, the PPI was revised. One aspect of this revision was a change in the nature of quality adjustment, which is now based on the theory of output price indexes.[31] These indexes measure the ratio of (maximum) revenues associated with remaining on the same production possibility curve in two or more periods. Thus, the output price index holds inputs and technology constant.[32]

In view of the different treatment of quality change in the revised PPI, Triplett [1988] discusses the possibility that the downward bias introduced by a likely substantial increase in the

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[31] See Fisher and Shell [1972], Diewert [1983], and Triplett [1988].

[32] Based on recommendations outlined in Ruggles (1977).

linking procedure (an "overadjustment" for quality change) may cancel out the upward bias found by L-G for the earlier period. In principle, however, we could test this hypothesis more directly by examining the extent to which the PPI revisions have been incorporated into the 1982 Indexes of Production.

Several important caveats must be mentioned. The LISREL modeling framework assumes that all random variables have zero means. We plan to reestimate the econometric models allowing for intercepts, which is available in the latest version of LISREL (Joreskog and Sorbom (1989)). Also, estimates of these models may be senstitive to assumptions concerning the error structure. We also plan to reestimate the models allowing for non-zero correlation between the disturbance terms from the price deflator equation and those from the corresponding quality indicator equations ($\varepsilon_1, \varepsilon_2$ and $\varepsilon_1, \varepsilon_3$ in the MIMIC model). Finally, although it is interesting to have an estimate of the global impact of bias in the price statistics, it would be even more useful to examine the variation in errors of measurement across industries.

Table 1

Percentage of Shipments Deflated by Various Price Measures
1977 and 1982 Indexes of Production

2-digit SIC	Industry Name	1977 UVR	1977 PPI	1977 Other	1977 Implicitly Deflated	1982 UVR	1982 PPI	1982 Other	1982 Implicitly Deflated
	Total Manufacturing	17	60	13	10	8	67	19	6
20	Food	35	56	0	9	14	81	0	15
21	Tobacco	65	34	0	1	0	100	0	0
22	Textiles	28	26	40	6	24	61	12	3
23	Apparel	51	5	31	13	8	35	56	1
24	Lumber	22	60	0	8	10	81	2	7
25	Furniture	4	81	0	15	0	91	4	5
26	Paper	19	72	0	9	10	68	18	4
27	Printing	1	0	82	17	2	11	80	7
28	Chemicals	10	73	0	17	9	68	19	4
29	Petroleum	61	33	0	6	1	97	0	2
30	Rubber	1	52	33	14	3	68	2	27
31	Leather	13	68	0	19	6	91	0	3
32	Stone, Clay, Glass	6	77	2	15	18	68	2	12
33	Primary Metals	12	84	1	3	8	79	8	5
34	Fabricated Metals	3	66	16	15	6	65	19	10
35	Nonelectric Machinery	5	70	11	14	7	58	29	6
36	Electric Machinery	7	56	31	6	4	46	45	5
37	Transportation Equipment	1	76	20	3	12	53	23	12
38	Instruments	1	85	0	14	2	54	35	9
39	Miscellaneous Manufacturing	3	78	0	19	3	83	9	5

Source: For 1977 values - 1977 Indexes of Production
For 1982 values - Authors' calculations (preliminary)
UVR is defined as $(VS_t/Q_t)/(VS_{t-5}/Q_{t-5})$
where t represents a year in which the Census of Manufactures is conducted.
where VS=value of shipments
Q=quantity of shipments

Table 2
Manufacturing Products (7-digit SIC) and Assigned Price Deflators
-Indexes of Production-1982

Assigned Prices	All Products: # of Products	All Products: Mean Price Change	All Products: Mean (1982) Shipments ($ mil)	All Products: % of All	Old Products: # of Products	Old Products: Mean Price Change	Old Products: Mean (1982) Shipments ($ mil)	Old Products: % of Old	New Products: New Products	New Products: Mean Price Change	New Products: Mean (1982) Shipments ($ mil)	New Products: % of New
No PPI No UVR	3625	.359	1027	33.3 (24.6)	2859	.353	854	32.2 (19.9)	766	.381	1692	37.8 (44.3)
PPI No UVR	3863	.387	887	35.4 (22.6)	2930	.388	826	33.0 (19.8)	933	.385	1518	46.0 (34.7)
No PPI UVR	1366	.372	1770	12.5 (16.0)	1226	.372	1799	13.8 (18.0)	140	.376	1075	6.9 (7.4)
PPI UVR	2045	.382	2726	18.8 (36.8)	1857	.384	2791	20.9 (42.3)	188	.337	2090	9.3 (13.6)
	10899				8872				2027			

(percentages in parentheses are weighted by the value of shipments)

Table 3

Examples of New Products Created in Selected Industries 1977-1982

Industry (4-Digit SIC)	New Products (7-digit SIC)
1. Biological Products (SIC 2831)	In vitro diagnostics-clinical chemistry reagents
	In vitro diagnostics-clinical chemistry standards and controls
	In vitro diagnostics-blood bank products
	In vitro diagnostics-hematology products
	In vitro diagnostics-coagulation products
	In vitro diagnostics-microbiology, virology, and serology products
	In vitro diagnostics-cytology and histology products
	In vitro diagnostics-other
	In vivo diagnostics-agiourographic agents
	In vivo diagnostics-other iodinated agents
	In vivo diagnostics-barium agents and all others
	In vivo radioactive reagents-technetium products
	In vivo radioactive reagents-cold kits for technetium
	In vivo radioactive reagents-all others
	Other in vivo diagnostics
2. Phonograph Records (SIC 3652)	Video tapes prerecorded for home entertainment
	Magnetic disks with prerecorded computer programs (pcp)
	Magnetic tapes (reel) with pcp
	Magnetic tapes (cassette and cartridge) with pcp
3. Cheese Natural and Processed (SIC 2022)	Products substituting for natural cheese
	Products substituting for processed cheese or related products

Table 4

New Products Generated Within Two-Digit SIC Sectors

Two Digit SIC	Industry Name	1972-1977 New Products Created	1972-1977 New Prods as a % of Total Products	1977-1982 New Products Created	1977-1982 New Prods as a %of Total Products	1977-1982 % of 1982 Shipments Devoted to New Prods #
	Total Manufacturing	1616	26.1%	2027	18.6%	19.1%
20	Food	171	13.9%	169	19.1%	18.3%
21	Tobacco	2	11.1%	2	12.5%	10.5%
22	Textiles	33	14.1%	105	28.6%	12.3%
23	Apparel	14	9.4%	45	4.9%	12.3%
24	Lumber	86	36.0%	44	17.3%	12.3%
25	Furniture	11	7.4%	46	24.9%	13.4%
26	Paper	31	11.7%	77	23.9%	15.8%
27	Printing	74	26.9%	84	23.0%	12.2%
28	Chemicals	136	26.8%	116	14.7%	13.4%
29	Petroleum	26	38.2%	22	30.1%	15.6%
30	Rubber	30	23.1%	52	28.0%	13.1%
31	Leather	18	28.6%	5	6.7%	10.8%
32	Stone, Clay, Glass	36	15.2%	71	16.9%	12.3%
33	Primary Metals	66	22.8%	62	13.8%	6.6%
34	Fabricated Metals	211	36.5%	156	19.4%	14.8%
35	Nonelectric Machinery	314	32.9%	461	21.0%	26.3%
36	Electric Machinery	86	25.1%	167	12.6%	9.0%
37	Transportation Equipment	91	28.4%	165	38.6%	20.6%
38	Instruments	101	47.2%	105	20.8%	32.0%
39	Miscellaneous Manufacturing	79	26.8%	73	22.6%	23.5%

Source: Authors' calculations based on analysis on lists of manufacturing products in 1972, 1977, and 1982 (preliminary).
#-corresponding figures for 1977 were not available

Table 5

Industries Generating The Largest Number of New Products (1977-1982)

4-digit SIC	Industry Name	# of New Products	Total # of Products	% of New Products	% of Shipments Devoted to New Products
3494	Valves and Pipe Fittings	62	135	45.9	29.4
3714	Motor Vehicle Parts & Accessories	59	115	51.3	67.6
3531	Construction Machinery & Equipment	34	219	15.5	15.5
2211	Weaving Mills, Manmade Fiber & Silk	32	34	94.1	94.1
3561	Pumps and Pumping Equipment	32	97	33.0	19.9
3612	Power, Distribution, and Specialty Transformers	31	83	37.3	37.0
3732	Boat Building & Repair	29	43	67.4	58.8
3585	Air Conditioning and Warm Air Heating Equipment and Comml and Indl Refrig Equip.	29	231	12.6	19.0
2752	Commercial Printing, Lithograph	27	57	47.4	27.0
3293	Gaskets, Packing & Sealing Devices	26	35	74.3	69.0
3079	Misc Plastic Products	25	35	71.4	69.6
2621	Paper Mills, Except Building Paper Mills	24	74	32.4	49.7
2392	Housefurnishing, Except Curtains and Draperies	24	64	37.5	16.2
3573	Electronic Computing Equipment	23	55	41.8	41.0
3861	Photographic Equipment	23	61	37.7	40.7
3532	Mining Machinery and Equipment, Except Oil Field Machinery and Equipment	22	71	31.0	69.6
3541	Machine Tools, Metal Cutting Types	22	111	19.8	24.5
2521	Wood Office Furniture	21	31	67.7	97.0
2732	Book Printing	21	23	91.3	93.1
3533	Oil Field Machinery	19	54	35.2	17.3
3551	Farm Products Machinery	18	45	40.0	32.6

Table 6

Summary Statistics for Logarithmic Changes in PPI and UVR, for 4-digit SIC Manufacturing Industries and 7-digit Manufacturing Products

Industry Level:

Variable			Mean	Median	Std.Dev.	Minimum	Maximum
PPI	72-77	N=238	.434	.436	.178	-.112	1.30
UVR	72-77	N=238	.462	.440	.258	-.118	1.46
PPI	77-82	N=269	.367	.384	.146	-.159	.91
UVR	77-82	N=269	.342	.353	.208	-.381	.93
PPI	77-82	N=391	.370	.388	.136	-.269	.90
UVR	77-82	N=324	.333	.353	.200	-.679	.93
PPI	77-82	N=307	.361	.373	.139	-.269	.90
UVR	77-82	N=307	.340	.357	.190	-.309	.93
PPI	77-82	N=37	.420	.416	.163	-.053	.90
UVR	77-82	N=37	.411	.430	.186	-.173	.93
PPI-UVR	72-77	N=238	-.028	-.032	.228	-.999	.77
PPI-UVR	77-82	N=269	.025	.019	.202	-.662	.72
PPI-UVR	77-82	N=307	.021	.025	.184	-.534	.69
PPI-UVR	77-82	N=37	.010	-.001	.119	-.258	.28
PPINEW	77-82	N=269	-.005	0	.078	-.414	.58
UVRNEW	77-82	N=269	-.022	0	.123	-.651	.29

Product Level:

Variable			Mean	Median	Std.Dev.	Minimum	Maximum
PPI	72-77	N=2048	.448	.442	.180	-.232	1.58
UVR	72-77	N=2048	.466	.472	.409	-.378	2.18
PPI	77-82	N=2045	.377	.403	.155	-.159	.91
UVR	77-82	N=2045	.337	.355	.280	-.381	.93
PPI	77-82	N=5908	.388	.409	.138	-.478	1.03
UVR	77-82	N=3411	.343	.357	.415	-.679	2.25
PPI	77-82	N=359	.437	.450	.139	-.037	1.02
UVR	77-82	N=359	.453	.442	.228	-.286	.98
PPI-UVR	72-77	N=2048	-.018	-.030	.393	-2.03	1.82
PPI-UVR	77-82	N=2045	.040	.026	.274	-1.04	1.13
PPI-UVR	77-82	N=359	-.016	-.021	.199	-.50	.49

Table 7

Covariance Matrices for Logarithmic Changes in PPI and UVR, for 4-digit SIC Manufacturing Industries and 7-digit Manufacturing Products

Industry Level:

	PPI 1972-1977	UVR 1972-1977 (N=238)
PPI 1972-1977	.0316	.0231
UVR 1972-1977	.0231	.0668

	PPI 1977-1982	UVR 1977-1982 (N=269)
PPI 1977-1982	.0212	.0119
UVR 1977-1982	.0119	.0432

	PPI 1977-1982	UVR 1977-1982 (N=307)
PPI 1977-1982	.0186	.0109
UVR 1977-1982	.0109	.0401

	PPI 1977-1982	UVR 1977-1982 (N=37)
PPI 1977-1982	.0266	.0235
UVR 1977-1982	.0235	.0358

The parameter estimates implied by these sample moments are:

1972-1977 (N=238#)	1977-1982 (N=269)	1977-1982 (N=307)	1977-1982 (N=37)
$\sigma_{\cdot}^2$ = .0231	$\sigma_{\cdot}^2$ = .0119	$\sigma_{\cdot}^2$ = .0109	$\sigma_{\cdot}^2$ = .0235
σ_1^2 = .0085	σ_1^2 = .0093	σ_1^2 = .0077	σ_1^2 = .0031
σ_2^2 = .0437	σ_2^2 = .0313	σ_2^2 = .0292	σ_2^2 = .0123

Product Level:

	PPI 1972-1977	UVR 1972-1977 (N=2043)
PPI 1972-1977	.0324	.0234
UVR 1972-1977	.0234	.1682

	PPI 1977-1982	UVR 1977-1982 (N=2045)
PPI 1977-1982	.0241	.0139
UVR 1977-1982	.0139	.0785

	PPI 1977-1982	UVR 1977-1982 (N=359)
PPI 1977-1982	.0190	.0158
UVR 1977-1982	.0158	.0494

The parameter estimates implied by these sample moments are:

1972-1977 (N=2048)	1977-1982 (N=2045)	1977-1982 (N=359)
$\sigma_{\cdot}^2$ = .0234	$\sigma_{\cdot}^2$ = .0139	$\sigma_{\cdot}^2$ = .0158
σ_1^2 = .0090	σ_1^2 = .0102	σ_1^2 = .0032
σ_2^2 = .1248	σ_2^2 = .0646	σ_2^2 = .0336

#The results for 1972-1977 are based on findings reported in Lichtenberg-Griliches (1989).

Table 8

Maximum Likelihood Estimates of an Expanded MIMIC Model (Version 1)

	Industry Level:			Product Level:		
	(N=269)	(N=307)	(N=348)	(N=2045)	(N=1928)	(N=359)
Parameter Estimates	77-82	77-82	77-82	77-82	77-82	77-82
β_1	-.6064	-.6751	-.6731	-.5300	-.5968	-.6146
	(.2427)	(.3307)	(.3212)	(.1364)	(.1234)	(.2935)
β_2	.7903	.9400	.8735	.9142	.8555	.8672
	(.3137)	(.4360)	(.4079)	(.2131)	(.2706)	(.3128)
β_3	.3888	.0787	.1102	.0442	.1009	.1552
	(.1307)	(.0453)	(.0623)	(.0248)	(.0766)	(.0877)
β_4	2.8328	.8397	.8734	1.2032	.9367	.8641
	(.9104)	(.3563)	(.3118)	(.1934)	(.3571)	(.3222)
σ_1	.0167	.0082	.0094	.0244	.0156	.0169
	(.0016)	(.0007)	(.0011)	(.0008)	(.0015)	(.0028)
σ_2	.0271	.0108	.0124	.0525	.0249	.0278
	(.0027)	(.0011)	(.0015)	(.0018)	(.0062)	(.0072)
σ_3	.0791	.0358	.0423	.0446	.0348	.0456
	(.0072)	(.0029)	(.0034)	(.0016)	(.0053)	(.0056)
σ_4	.0010	.0004	.0006	.0007	.0008	.0006
	(.0020)	(.0007)	(.0008)	(.0008)	(.0006)	(.0007)

df	4	4	4	4	4	4
chi-squ	7.79	12.1	13.6	33.53	45.28	17.24

Equation	R^2					
PPI-UVR	.0786	.0594	.0634	.0491	.0713	.0658
PPINEW	.0821	.0848	.0910	.0262	.0645	.0577
UVRNEW	.0467	.0308	.0369	.0365	.0486	.0436
Z*	.7415	.6309	.6423	.5681	.5453	.4701

Note: standard errors in parenthesis

Table 9

Maximum Likelihood Estimates of an Expanded MIMIC Model with Industry "Supply Shock" (Version 2)

Parameter Estimates	Industry Level: (N=269) 77-82	(N=307) 77-82	(N=348) 77-82	Product Level: (N=2045) 77-82	(N=1928) 77-82	(N=359) 77-82
β_1	-.5257	-.6126	-.5678	-.5208	-.5127	-.6995
	(.2135)	(.3054)	(.1345)	(.0345)	(.0980)	(.3544)
β_2	-.2678	-.2335	-.2967	-.3292	-.2856	-.1751
	(.1103)	(.1079)	(.1079)	(.0900)	(.1123)	(.0939)
β_3	.8567	1.27091	.8456	1.2403	.6108	1.3272
	(.4011)	(.3882)	(.0574)	(.3563)	(.0831)	(.4835)
β_4	.0647	.0346	.0789	-.0085	.0767	.0558
	(.0423)	(.0443)	(.0453)	(.0183)	(.0182)	(.0421)
β_5	.8346	1.5883	.9456	.7001	1.8420	.8222
	(.2567)	(.4041)	(.3245)	(.1643)	(.1726)	(.2667)
β_6	.3080	.3636	.2678	.2566	.1750	.3845
	(.0748)	(.0692)	(.0457)	(.0355)	(.0459)	(.0594)
β_7	.0678	.0440	.0754	.0759	.0921	.0018
	(.0345)	(.0593)	(.0438)	(.0237)	(.0288)	(.0513)
β_8	.8245	1.2239	.6578	.3502	.3124	1.0823
	(.3324)	(.4532)	(.2368)	(.1331)	(.1440)	(.3971)
σ_1	.0245	.0265	.0238	.0274	.0238	.0248
	(.0034)	(.0023)	(.0031)	(.0009)	(.0006)	(.0021)
σ_2	.0199	.0217	.0214	.0281	.0150	.0319
	(.0098)	(.0056)	(.0045)	(.0011)	(.0100)	(.0032)
σ_3	.0248	.0292	.0256	.0306	.0269	.0299
	(.0069)	(.0027)	(.0078)	(.0011)	(.0010)	(.0026)
σ_4	.0354	.0392	.0467	.0632	.0533	.0052
	(.0074)	(.0165)	(.0159)	(.0037)	(.0005)	(.0294)
σ_5	.0046	.0013	.0041	.0020	.0024	.0017
	(.0031)	(.0013)	(.0012)	(.0005)	(.0011)	(.0013)
σ_6	.0218	.0275	.0268	.0017	.0236	.0511
	(.0087)	(.0164)	(.0118)	(.0031)	(.0101)	(.0296)
σ_{56}	.0021	.0046	.0017	.0010	.0015	.0038
	(.0013)	(.0019)	(.0011)	(.0006)	(.0008)	(.0017)
df	15	15	15	15	15	15
chi-squ	15.16	189.39	13.81	212.18	405.46	157.24

Equation	R^2					
PPI-UVR	.0713	.0487	.0613	.0486	.0785	.0745
PPINEW	.0897	.1215	.0910	.0253	.0496	.1174
UVRNEW	.0615	.0851	.0589	.0153	.0724	.0745
CU	.1123	.4778	.2110	.0559	.3174	.9188
Z*	.4235	.5113	.3899	.5735	.8833	.2954
S*	.2145	.2347	.2678	.5580	.0477	.1343

Note: standard errors in parenthesis

ACKNOWLEDGEMENTS

I would like to thank Zvi Griliches and seminar participants at the 1991 NBER Summer Institute for helpful comments. Some of this work is based on previous joint work with Zoe Georganta and I am grateful to her for helpful discussions. This paper is based upon work supported by the National Science Foundation under grant SES-9001399, "On-Site Research to Improve the Quality of Labor Statistics." This research was conducted at the U.S. Bureau of Labor Statistics while the author was a participant in the American Statistical Association/Bureau of Labor Statistics Research Program, which is supported by the Bureau of Labor Statistics through the NSF grant.

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