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PRODUCTIVITY TRENDS AND THE COST OF REDUCING CO_2 EMISSIONS

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  The Project is attempting to develop an executive program to teach senior government officials how to assess and manage global and regional environmental problems.

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EXECUTIVE SUMMARY

How much will it cost to reduce CO_2 emissions? Increasing concern over the problem of global climate change has raised the importance of this question. Adequate control may require a significant increase in energy prices, which in turn will create long-term economic costs. The paper explores the effects of long-term productivity trends in the U.S. economy and relates them to the cost of reducing CO_2 emissions.

In the short term, the primary effect of increasing energy prices is to discourage energy use, and to encourage the use of other inputs such as capital and labor. This substitution dominates for a while the slow accumulation of many technological changes. Energy economic modelers have traditionally focused on this short-run effect. However, increases in energy prices resulting from policy responses to the global warming problem would occur over a much longer time period. When measured over decades rather than years, changes in technology -- and productivity -- would dominate the simple substitution among input factors.

Exploiting earlier work by Jorgenson and others, the authors summarize average values for productivity aggregates of energy per unit of output and per unit of GNP estimated from data for the period 1958-1979.

Technology change has been negatively correlated with energy prices and positively correlated with materials prices. Thus, if all prices remain constant, expenditures on materials per unit of output will decline, and expenditures on energy per unit of output will increase. If energy prices increase, the rate of productivity growth will decrease. This trend will be very small, if measured on an annual basis, but eventually could be quite significant.

A comparison with recent cost estimates of CO_2 emission control suggests that this otherwise ignored productivity effect could be the largest component of a complete cost analysis.

Experience in making projections over a century or more is limited. Policy makers should not dwell on the absolute numbers contained in this study, since they are a first approximation and are intended to refocus energy-economic models to give greater attention to technological and productivity changes. This is an important frontier and challenge for energy policy research.

PRODUCTIVITY TRENDS AND THE COST OF REDUCING CO_2 EMISSIONS

by

WILLIAM W. HOGAN and DALE W. JORGENSON[1]

INTRODUCTION

Recent attention devoted to the greenhouse effect and warming of the planet again has raised concerns with the evaluation of long-term energy policies. In an estimate of the total costs of CO_2 emission restrictions, Manne and Richels apply Global 2100 (a variant of the ETA-Macro model) to calculate that gradually stabilizing CO_2 emissions at 80% of the 1990 level could cost $3.6 trillion or approximately 5% of total annual macroeconomic consumption through the next century.[2] Motivated by this analysis, the present paper draws attention to questions about estimation and use of long-term productivity trends and the associated technical biases in energy-economic models. The first section reviews a basic framework for characterizing productivity trends. Then follow two implementations, first in the work of Jorgenson et al. who estimate the productivity parameters and then the Manne-Richels application of the ETA-Macro model with conventional productivity assumptions to calculate the long-run economic impacts of limitations on CO_2 emissions. A comparison of the two models illustrates the differences between empirical estimates and the usual

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1 The authors owe thanks to Peter Wilcoxen who provided the basic data and Alan Manne who reviewed an early draft and provided a number of helpful comments. The authors bear sole responsibility for any remaining errors.

2 A.S. Manne and R. G. Richels, "CO2 Emission Limits: An Economic Cost Analysis for the USA," Stanford University and the Electric Power Research Institute, November 1989, forthcoming in The Energy Journal, p. 26. All the costs reported here are for the United States alone. A true global policy for controlling greenhouse cases would cost substantially more.

maintained assumptions regarding technical biases in productivity trends. Illustrative calculations suggest that assumptions common in energy-economic models may lead to a substantial underestimate of the long-term economic impacts of restrictions on energy use. Given the great difficulty in estimating and interpreting the impacts of technology change, the results point principally to research questions that should be the subject of attention in new efforts to grapple with long term energy policies.

PRODUCTIVITY TRENDS

A focus on long-term energy-economic problems such as the possibility of global warming brings to center stage an analysis of the effects of technological change. Increases in total factor productivity -- producing more output from the same inputs -- principally through improved knowledge, unfold slowly. Over a limited span of a few years, the aggregate impact of improvements in general productivity are typically dwarfed by the more familiar effects of replacing relatively scarce inputs with relatively abundant resources. Hence the use of more capital and labor to substitute for newly expensive energy will for a time dominate the effect of a slow accumulation of the invention and discovery which allow for more output even with the same mix of inputs. As a result, many energy-economic modelers concentrate on an estimation of the effects of changing the mix in inputs and ignore any empirical estimation of the trends in technological change.

Although this simplified approach to productivity trends may be appropriate in the short run, when the relative prices driving input substitution may change by large multiples while the aggregate impact of technology change is measured in terms of tenths of a per cent per year, the long run can be a different matter. The comparative importance of productivity trends and substitution effects can change dramatically when the horizon expands

to decades or centuries. Then common sense and casual experience suggest that the change in "technology" may be the most important effect, possibly even dominating the simple substitution among input factors resulting from the scarcity of particular resources.

The significance of technology trends has been widely recognized in energy sector models where it is common to find an explicit, process-oriented description of technologies. Typically these models include new ways of producing and using energy for which there are not yet a great deal of data, for instance in the case of solar energy. The purpose of the process models is to characterize these new technologies and then to compare and analyze the impacts of scarcity in determining prices and economic activity.

But this explicit description of new or even hypothetical technologies is difficult to do for one sector, and is impossible to implement for the full complexity of the overall economy. Hence for the remainder of the economy the universal necessity has been to apply a reduced-form description of technology in terms of the trends in the use of aggregate inputs and outputs. And this naturally leads to questions about the description of technology trends and econometric estimation of the key parameters.

For econometric estimation of technology change in production of goods and services we need a generic model of a firm or sector of the economy with a description of the trends in productivity. In addition, for a full description of the economy we need a parallel description of the counterpart trends in consumption. Here we concentrate on the production model which is sufficient to illustrate the basic calculations and motivate further research.

The basic model of productivity trends follows the production function framework with the related dual cost function.[3] Suppose that for a given sector total output Y_t is related to the factor inputs x_{it} via the production function

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3 D.W. Jorgenson and B.M. Fraumeni, "Relative Prices and Technical Change," in E.R. Berndt and B. Field, eds., Modeling and Measuring Natural Resources Substitution, Cambridge, MIT Press, 1981, pp. 17-47.

(1) $$Y_t = f(x_{1t}, \dots, x_{nt}, t) .$$

If (1) is homogeneous of degree one in the inputs then the dual unit cost function defines the output price as a function of input prices in

(2) $$p_{ot} = c(p_{1t}, \dots, p_{nt}, t) .$$

Under the usual assumptions, the derivatives of the cost function give the expenditure shares as

(3) $$s_{it} \equiv \frac{p_{it}x_{it}}{\sum p_{it}x_{it}} = \frac{\partial \ln p_{ot}}{\partial \ln p_{it}} .$$

In addition, the rate of change of total factor productivity is equal to the negative of the trend in the output price, or

(4) $$-v_t \equiv \frac{-\partial \ln Y_t}{\partial t} = \frac{\partial \ln p_{ot}}{\partial t} = p_{ot}/p_{ot} .$$

For most analyses, we can stop with (3) and the associated knowledge of the factor shares and related price elasticities. But for a complete empirical analysis of (3) and (4), and for the analysis of long-run trends, which is the essence of any economic evaluation of measures to limit greenhouse gas emissions, the productivity trends could be of great importance.

In particular, consider the symmetric impacts of technology trends on the shares of inputs and the related bias in total factor productivity. Here we have

(5) $$\theta_{it} \equiv \frac{-\partial v_t}{\partial \ln p_{it}} = \frac{\partial s_{it}}{\partial t} .$$

The special interest in θ_{it} follows from this dual role. If $\theta_{it} > 0$, ($\theta_{it} < 0$) then with relative prices of inputs constant, the share of the ith input will increase (decrease) over time. And if the price of the input rises, the trend in total factor productivity will decline (rise). Furthermore, since the shares always add to unity, the technical bias across all inputs must add to zero, i.e. $\sum \theta_{it} = 0$.

The direction and magnitude of the technical bias could be of critical importance in determining the baseline projection of the demand for factor inputs. If there is a trend to greater energy use independent of prices, i.e. if $\theta_{\text{"energy"}t} > 0$, this energy-using bias could place greater pressure on the expansion of output. And the bias in factor productivity change could be a substantial contributor to the welfare evaluation of long-run energy strategies. If higher energy prices retard productivity growth, then future consumption may be reduced indirectly through the effects of price-induced energy conservation.

AGGREGATE ENERGY-GNP TRENDS

These measures of the change in the input-output coefficients by industry capture the direct effect of technological change in the use of individual input factors. However, the common discussion of aggregate technology trends combine at least two other important issues. First, the change in use of aggregate inputs is often expressed in terms of the use of input per unit of GNP, whereas the measure above is in terms of output in a particular sector. Second, the aggregate change in the use of an input includes both the direct effect measured by (5) and the indirect effects through the technology trends in input requirements in other sectors along with the change in the composition of the economy in terms of the mix of outputs of all sectors.

To obtain a complete picture of the change across the entire economy would require a general equilibrium simulation under conditions of constant relative prices to isolate the effect of changing technology. As a partial beginning, however, data on individual sectors lend themselves to a characterization of the direct effects on the ratio of inputs to GNP, the more familiar measure of "efficiency" that appears in discussions of energy economics. This simple aggregation across sectors provides some insight as to the magnitude of the productivity effects as well as a pathway for comparing assumptions in alternative models that employ different levels of aggregation of production. Hence the analysis turns to the description of the average effect of productivity trends across all sectors.

If (1) is the production function for a typical sector (firm, industry, or the entire economy), its contribution to GNP can be measured by its value added. Using the usual accounting conventions that treat value added as the payments to capital (K) and labor inputs (L), we have for sector j that

$$VA_{jt} = p_{Kjt}K_{jt} + p_{Ljt}L_{jt}. \tag{6}$$

Then the sector contribution to real GNP, expressed as real value added in base period T prices, can be defined as

$$GNP_{jt} = (p_{gT}/p_{gt})(p_{Kjt}K_{jt} + p_{Ljt}L_{jt}), \tag{7}$$

where p_{gt} is the price of the numeraire good.

With this definition $GNP_t = \sum GNP_{jt}$ and $x_{it} = \sum x_{ijt}$. Then the analog to the common energy-GNP ratio can be expressed as

$$(8) \qquad \frac{x_{it}}{GNP_t} = \sum \left[\frac{x_{ijt}}{GNP_{jt}} \right] \left[\frac{GNP_{jt}}{GNP_t} \right] .$$

The aggregate efficiency measure can be approximated in terms of x_{ijt}/GNP_{jt}. From (3) it follows that the input-output coefficients satisfy

$$(9) \qquad \frac{x_{ijt}}{Y_{jt}} = \frac{s_{ijt}p_{ojt}}{p_{ijt}} .$$

Hence, at constant input prices the trend in the use of input per unit of output satisfies

$$(10) \qquad \tau_{ijt} = \frac{\partial \ln(x_{ijt}/Y_{jt})}{\partial t} = \frac{\partial \ln s_{ijt}}{\partial t} + \frac{\partial \ln p_{ojt}}{\partial t} - \frac{\partial \ln p_{ijt}}{\partial t} ,$$

or

$$(11) \qquad \tau_{ijt} = \theta_{ijt}/s_{ijt} + \frac{\partial \ln p_{ojt}}{\partial t} .$$

The aggregate effect of productivity trends for energy inputs will be determined in part by the interindustry effects of the changes in prices of the intermediate goods, principally materials. Direct application of (11) would be adequate if the price of materials is constant or if materials constitute a small fraction of inputs. But neither will be true. Short of a full simulation of the intermediate effects, we elect here to approximate the change in output prices under the assumption that material prices are changing and that the price of materials is the same as the price of the numeraire good, p_{gt}. Then $\partial \ln p_{ojt}/\partial t = -v_{jt} + s_{Mjt}(\partial \ln p_{gt}/\partial t)$ and (11) becomes

(12) $$\tau_{ijt} \approx \theta_{ijt}/s_{ijt} - v_{jt} + s_{Mjt}\frac{\partial \ln p_{gt}}{\partial t} ,$$

For convenience we assume that $(GNP_{jt}/GNP_t) \approx (GNP_{jT}/GNP_T) = w_j$ and estimate the price of the numeraire good as $\ln p_{gt} = \sum w_j \ln p_{ojt}$; hence

(13) $$\frac{\partial \ln p_{gt}}{\partial t} = \sum w_j \frac{\partial \ln p_{ojt}}{\partial t} = \sum w_j \left[-v_{jt} + s_{Mjt} \frac{\partial \ln p_{gt}}{\partial t} \right] ,$$

or,

(14) $$\frac{\partial \ln p_{gt}}{\partial t} = p_{gt}/p_{gt} = \sum w_j(-v_{jt})/(1-\sum w_j s_{Mjt}) .$$

Now,

(15) $$\frac{x_{ijt}}{GNP_{jt}} = \frac{x_{ijt}p_{gt}}{(p_{Kjt}K_{jt} + p_{Ljt}L_{jt})p_{gT}} = \frac{x_{ijt}}{Y_{jt}} \frac{Y_{jt}p_{gt}}{(p_{Kjt}K_{jt} + p_{Ljt}L_{jt})p_{gT}} .$$

Therefore, the rate of change of the ratio of inputs to contribution to GNP must satisfy

(16) $$\Pi_{ijt} \equiv \frac{\partial \ln(x_{ijt}/GNP_{jt})}{\partial t} = \tau_{ijt} - \left[\frac{\tau_{Kjt}s_{Kjt} + \tau_{Ljt}s_{Ljt}}{s_{Kjt} + s_{Ljt}} \right] + p_{gt}/p_{gt} .$$

Hence, the trend in the direct use of input i relative to GNP is the difference in the trend in the direct use of i per unit of output and the average of the direct use of capital and labor, weighted by their shares in value added, net of the trend in total factor productivity in the output of final goods.

With (16) the trend in the total input-GNP ratio can be recovered as

(17) $$\Pi_{it} \equiv \frac{\partial \ln(x_{it}/GNP_t)}{\partial t} = \sum \Pi_{ijt} \left[\frac{x_{ijt}}{\sum x_{ijt}} \right] .$$

Finally, to obtain a summary of the productivity biases by input factor, we adopt a similar normalization. Here we normalize the bias by the share of value added to reflect the impact on GNP, and then weight the contribution across sectors according to the contribution to total value added. Hence the estimate of the aggregate bias becomes

$$(18) \qquad \theta_{it} = \frac{\partial \ln(-v_t)}{\partial \ln p_{it}} \approx \sum w_j \theta_{ijt}/(s_{KjT} + s_{LjT}) .$$

ESTIMATION OF SECTORAL PRODUCTIVITY TRENDS

Empirical estimation of θ_{it} and v_t presents a number of somewhat daunting challenges.[4] At a minimum within the cost function framework we need independent construction of the prices of the inputs and the outputs, and quantities of the inputs.[5] Given the small changes embedded in a cloud of data including substitution effects and approximation errors, there would be a great premium on disaggregation by sector, to avoid aggregation biases, and careful econometric estimation, to account for problems of simultaneity, cross-equation restrictions and other interactions. The pervasive time series analyses of energy-GNP ratios provide few if any of the necessary controls.[6] Hence most of the statistical

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4 For convenience, when the distinction is obvious from the context we drop the subscript identifying this as the cost function for the jth sector.

5 This precludes the practice of constructing aggregate output prices in terms of the prices of the inputs, or the convenience of defining inputs in terms of efficiency units. If aggregate price indexes are employed, as is inevitable, there must be great care exercised in the definition of the aggregate goods and the estimation of the prices; see E. R. Berndt, "Aggregate Energy, Efficiency, and Productivity Measurement," Annual Review of Energy, Volume 3, 1978.

6 For another attempt to extract the energy-GNP ratio from aggregate time series and cross national data, see J. R. Moroney, Output and Energy: An International Analysis", Energy Journal, Vol. 10, No. 3, July 1989.

analyses of factor biases in long-term trends in productivity, as separate from the effect of substitution among inputs, are hopelessly muddled.

A notable exception in the efforts to estimate the effects of technological change is in the body of work represented by Jorgenson and Fraumeni,[7] Jorgenson,[8] Jorgenson and Wilcoxen[9] and for the US economy; and Kuroda, Yoshioka and Jorgenson[10] or Jorgenson and Kuroda[11], for the Japanese economy. These econometric studies take on the task of disaggregation, typically with thirty five sectors for the economy, extensive data collection or assembly, and careful econometric estimation. The models give special attention to the role of energy as well as capital, labor and materials, and provide a rare if not unique attempt to obtain systematic estimates of the trends and factor biases in technical change.

Following Jorgenson and Fraumeni, define the translog approximation of the cost function as

$$\text{(19)} \qquad \ln p_{ot} = \alpha_0 + \sum \alpha_i \ln p_{it} + \alpha_t t + \tfrac{1}{2} \sum\sum \beta_{ij} \ln p_{it} \ln p_{jt} + \sum \beta_{it} \ln p_{it} t + \tfrac{1}{2} \beta_{tt} t^2 .$$

Using (3), the value share equations satisfy:

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7 D.W. Jorgenson and B.M. Fraumeni, "Relative Prices and Technical Change," in E.R. Berndt and B. Field, eds., Modeling and Measuring Natural Resources Substitution, Cambridge, MIT Press, 1981, pp. 17-47.

8 D.W. Jorgenson, "The Role of Energy in Productivity Growth," Harvard Institute of Economic Research, 1983. pp. 19-30.

9 D. W. Jorgenson and P. J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth," Harvard Institute of Economic Research, July 1989. For another application of a closely related model see Mun Sing Ho, "Effects of External Linkages on U.S. Economic Growth: A Dynamic General Equilibrium Analysis," PhD. Dissertation, Department of Economics, Harvard University, 1989.

10 M. Kuroda, K. Yoshioka and D.W. Jorgenson, "Relative Price Changes and Biases of Technical Change in Japan," Economic Studies Quarterly, Vol. 35, No. 2, June 1984.

11 D. W. Jorgenson and M. Kuroda, "Productivity and International Competitiveness in Japan and the United States," Special Report, Energy and Environmental Policy Center, Harvard University, March 1989.

(20) $$s_{it} = \alpha_i + \sum \beta_{ij} \ln p_{jt} + \beta_{it} t,$$

where s_{it} is the long-run share of expenditure on input i in period t.

In addition to the share equations, the trend in total factor productivity derived from (4) is

(21) $$\frac{\partial \ln p_{ot}}{\partial t} = -v_t = \alpha_t + \sum \beta_{it} \ln p_{it} + \beta_{tt} t.$$

Constraints on the coefficients imply that $\sum \beta_{it} = 0$. The individual coefficients β_{it} capture both the individual factor productivity change and the bias in total factor productivity change. Hence the translog model has been constructed so that $\theta_{it} = \beta_{it}$, a constant.

Using the definition in (12), the change in productivity satisfies

(22) $$\frac{\partial \ln(x_{it}/Y_t)}{\partial t} = \tau_{it} = \frac{\beta_{it}}{s_{it}} + \alpha_t + \sum \beta_{it} \ln p_{it} + \beta_{tt} t + s_{Mt} \frac{\partial \ln p_{gt}}{\partial t} .$$

Jorgenson and Fraumeni normalize the base period prices equal to one. Therefore, (22) becomes

(23) $$\tau_{it} = \frac{\beta_{it}}{\alpha_i + \beta_{it} t} + \alpha_t + \beta_{tt} t + (\alpha_M + \beta_{Mt} t)(p_{gt}/p_{gt}) .$$

At the same base period prices set to one, we calculate (16) using the values of $\alpha_K + \beta_{Kt} t$ and $\alpha_L + \beta_{Lt} t$ as the estimates of the shares of capital and labor. Then,

(24) $$\Pi_{it} = \tau_{it} - \left[\frac{\tau_{Kt}(\alpha_K + \beta_{Kt} t) + \tau_{Lt}(\alpha_L + \beta_{Lt} t)}{\alpha_K + \beta_{Kt} t + \alpha_L + \beta_{Lt} t} \right] + p_{gt}/p_{gt} ,$$

where the estimate of p_{gt}/p_{gt} is obtained from

$$(25) \qquad p_{gt}/p_{gt} = \sum w_j(-v_{jt})/(1-\sum w_j s_{Mjt}) = \sum w_j(\alpha_{jt}+\beta_{jtt}t)/(1-\sum w_j(\alpha_{Mj}+\beta_{Mjt}t)).$$

Jorgenson[12] provides a particularly convenient implementation of this model for the United States. The structure includes a disaggregation of energy into electric (E) and nonelectric (N) inputs, as well as capital (K), labor (L), and materials (M), for a thirty-five sector disaggregation of the economy. The data base covers the years from 1958 to 1979. By convention, the reference year in the data base is 1972 with $t=0$, and this is treated here as the average "time" or "technology" in the data. With this we can obtain the average trends in the input-output ratios. These data are available by sector from Jorgenson, and the resulting values for the various productivity indexes of energy per unit of output and per unit of GNP appear in Table 3 in the Appendix. If the mix across sectors is not changing, then the weighted averages of these individual growth rates are reasonable estimates of the trends in energy use in the economy.

ETA-MACRO AND PRODUCTIVITY TRENDS

The thirty-five sector Jorgenson model may be needed to ferret out the historical trends in productivity, but it requires a level of detail more difficult to employ for long-run projections and economic analysis of energy policies over a century or more. For long run

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12 D.W. Jorgenson, "The Role of Energy in Productivity Growth," Harvard Institute of Economic Research, 1983. pp. 19-30.

projections, the usual alternative has been to construct more highly aggregated descriptions of the economy, which lend themselves to easier implementation and interpretation. But these aggregate models have a description of productivity trends that we should be able to connect to the detailed empirical studies of energy-economic interactions.

The ETA-Macro model describes long-run interactions between the energy sectors and the rest of the economy.[13] The energy sectors include a description of individual technologies within an explicit optimization framework. The energy sectors link to the rest of the economy in terms of an aggregate production function. The structure lends itself to comparison with the Jorgenson model. In one implementation, the production function is of the form that starts with Cobb-Douglas aggregations of electric and nonelectric energy to form an energy aggregate, and capital and labor to form a value added aggregate. These aggregates combine in turn in a constant elasticity of substitution production function:

$$Y_t = [a_t(K_t^{\alpha}L_t^{1-\alpha})^{\rho} + b_t(E_t^{\beta}N_t^{1-\beta})^{\rho}]^{1/\rho}, \tag{26}$$

where

Y_t = aggregate output,

K_t = inputs of capital services,

L_t = inputs of labor services,

E_t = inputs of electric energy,

N_t = inputs of nonelectric energy,

ρ = $(\sigma-1)/\sigma$, and σ = elasticity of substitution between the energy aggregate and the value added aggregate,

α = share of capital in the value added aggregate, and

13 A.S. Manne and R. G. Richels, "CO2 Emission Limits: An Economic Cost Analysis for the USA," Stanford University and the Electric Power Research Institute, November 1989.

β = share of electricity in the energy aggregate.

The model in (26) offers many attractions in its simplicity and a reasonable degree of flexibility. Conveniently, there is only one final output good in this aggregate representation, so there is no need to further aggregate the productivity trends across sectors. However, the model does impose certain restrictions on the representation of trends in factor productivity. To compare with the analysis of Jorgenson et al., first we obtain the corresponding unit cost function that is dual to (26), namely:

$$p_{ot} = [a_t^{\sigma}(p_{Kt}^{\alpha}p_{Lt}^{1-\alpha})^{1-\sigma} + b_t^{\sigma}(p_{Et}^{\beta}p_{Nt}^{1-\beta})^{1-\sigma}]^{1/(1-\sigma)}, \tag{27}$$

where p_{Kt}, p_{Lt}, p_{Et}, and p_{Nt} are the input prices for capital, labor, electricity and nonelectric energy. Using p_{KLt} and p_{ENt} to represent the prices of the value-added and energy aggregates, respectively, from (27) we obtain the share equations for the four factor inputs as

$$s_{Kt} = \alpha a^{\sigma}(p_{KLt}/p_{ot})^{1-\sigma}, \tag{28}$$

$$s_{Lt} = (1-\alpha)a^{\sigma}(p_{KLt}/p_{ot})^{1-\sigma}, \tag{29}$$

$$s_{Et} = \beta b^{\sigma}(p_{ENt}/p_{ot})^{1-\sigma}, \tag{30}$$

$$s_{Nt} = (1-\beta)b^{\sigma}(p_{ENt}/p_{ot})^{1-\sigma}. \tag{31}$$

The corresponding aggregate shares are

$$s_{KLt} = a^{\sigma}(p_{KLt}/p_{ot})^{1-\sigma}, \text{ and} \tag{32}$$

(33) $$s_{ENt} = b^{\sigma}(p_{ENt}/p_{ot})^{1-\sigma} .$$

With these we obtain the individual input factor productivity biases as

(34) $$\frac{\partial s_{Kt}}{\partial t} = \theta_{Kt} = s_{Kt}[\sigma a_t/a_t + (\sigma-1)(-v_t)]$$

(35) $$\frac{\partial s_{Lt}}{\partial t} = \theta_{Lt} = s_{Lt}[\sigma a_t/a_t + (\sigma-1)(-v_t)]$$

(36) $$\frac{\partial s_{Et}}{\partial t} = \theta_{Et} = s_{Et}[\sigma b_t/b_t + (\sigma-1)(-v_t)]$$

(37) $$\frac{\partial s_{Nt}}{\partial t} = \theta_{Nt} = s_{Nt}[\sigma b_t/b_t + (\sigma-1)(-v_t)]$$

where the total factor productivity trend is

(38) $$-v_t = p_{ot}/p_{ot} = (\sigma/(\sigma-1))[s_{KLt}a_t/a_t + s_{ENt}b_t/b_t] .$$

Finally, we calculate the trends in inputs per unit of aggregate output that correspond to (10)

(39) $$\tau_{it} = \frac{\partial \ln s_{it}}{\partial t} - v_t = \theta_{it}/s_{it} - v_t \quad .$$

Similarly, the trend in the utilization of the factor inputs per unit of GNP for the ETA-Macro production function is

$$(40) \qquad \frac{\partial \ln(x_{it}/GNP_t)}{\partial t} = \Pi_{it} = \tau_{it} - \tau_{KLt} - v_t \quad .$$

COMPARISON OF PRODUCTIVITY TRENDS

From 1960 to 1986, the last year of decline, the change in the use of total primary energy per unit of GNP in the United States was -23.5% or -1.03% per year.[14] And during the period of the most precipitous decline, from 1973 to 1986, the annual rate of change was -2.3% per year.[15] This decline in energy use, or increased energy conservation, has been the subject of intense analysis. And following the events of 1973 the conventional wisdom changed slowly from the view that no decline was probable to the current view that a virtually permanent decline is inevitable.[16] By now, the bulk of the major forecasts for energy use include a substantial autonomous decline in energy inputs per unit of GNP, independent of the effect of changes in relative prices.

But the change in relative prices in the 1970s, which included a rapid and large increase in energy prices, must have contributed to this reduction in energy use. It has been argued at length elsewhere that virtually all the reduction could be attributed to relative

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14 Department Of Energy, Annual Review of Energy, 1986., pp. 5 and 270.

15 This statistic has been prominently featured in the US Department of Energy, Monthly Energy Review, Table 1.7. For example, see the issue for April 1989.

16 W. W. Hogan, "Patterns of Energy Use Revisited," Discussion Paper Series, John F. Kennedy School of Government, Harvard University, Cambridge MA, 1988, H-88-01. Abridged in W. Hogan, "A Dynamic Putty - Semi-Putty Model of Aggregate Energy Demand," Energy Economics, Vol. 11, No. 1, 1989.

price changes, and there is no necessity to appeal to an independent trend in technological change to explain the reduction in energy use relative to GNP.[17]

However, arguing plausibility is far from testing the hypothesis. For this we need an empirical estimate of the reduced-form model of productivity change. The work of Jorgenson et al. provides one such test, and the results have been contrary to the conventional wisdom. For example, Jorgenson[18] found that most sectors were "energy using" in the sense that $\theta_{ENt} > 0$, which would imply a trend contrary to the direction of the new conventional wisdom. Here we take an alternative view of the Jorgenson results by moving from the listing of energy-using and energy-saving industries to the average effect across the economy using the approximations of weighted averages across sectors for productivity biases and trends in the energy-GNP ratio.[19]

Table 1 summarizes the detail from Table 3 for the Jorgenson analysis. The first part of the Table presents the range and simple averages of the various trend parameters. The base year or average "time" in the data base is 1972 when by definition $t=0$. The most prominent feature of this Table 1 is the wide range of the individual estimates by sector. While the existence of wide outliers is not surprising in any statistical analysis, the range alerts us to the need for more careful analyses that could be the subject of future research.

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17 W. W. Hogan, "Patterns of Energy Use Revisited," Discussion Paper Series, John F. Kennedy School of Government, Harvard University, Cambridge MA, 1988, H-88-01. Abridged in W. Hogan, "A Dynamic Putty - Semi-Putty Model of Aggregate Energy Demand," Energy Economics, Vol. 11, No. 1, 1989.

18 D.W. Jorgenson, "The Role of Energy in Productivity Growth," Harvard Insttitute of Economic Research, 1983. pp. 19-30.

19 The continued focus on the technology of production implicitly assumes no change in the "technology" of consumption. The Manne-Richels model subsumes all technology changes under the aggregate production function. The Jorgenson framework applies a parallel analysis of consumer demand.

Table1
Summary of Jorgenson Productivity Trend Estimates from Table 3
Average Case for t=0 (1972)
(All figures in %)

Unweighted	Min	Max	Avg
$\partial \ln p_o/\partial t$ $(-v_t)$	-6.81	2.33	-1.54
$\partial \ln p_g/\partial t$	-7.15	1.93	-1.94
Electric (τ_{Et})	-26.84	22.28	-1.70
NonElectric (τ_{Nt})	-13.34	20.21	0.69
Capital (τ_{Kt})	-6.44	1.78	-1.66
Labor (τ_{Lt})	-10.77	7.58	-0.53
E/GNP (π_{Et})	-27.34	21.82	-1.65
N/GNP (π_{Nt})	-13.71	15.80	0.73
EN/GNP (π_{ENt})	-12.36	8.44	-0.56
Weighted	Min	Max	Sum
$w_j s_M$			40.36
$\partial \ln p_o/\partial t$ $(-v_t)$	-0.11	0.27	-0.50
$\partial \ln p_g/\partial t$	-0.12	0.22	-0.85
Electric (τ_{Et})	-1.12	2.90	0.09
NonElectric (τ_{Nt})	-1.54	0.16	-2.25
Capital (τ_{Kt})	-0.22	0.17	-0.58
Labor (τ_{Lt})	-0.12	0.88	0.87
E/GNP (π_{Et})	-1.80	2.62	-0.37
N/GNP (π_{Nt})	-0.39	0.35	-0.33
EN/GNP (π_{ENt})	-0.62	0.41	-0.34
θ_{Et}	-0.015	0.067	0.050
θ_{Nt}	-0.021	0.025	0.042
θ_{ENt}	-0.033	0.066	0.092
θ_{Kt}	-0.048	0.037	0.026
θ_{Lt}	-0.051	0.765	1.251

The more interesting part of Table 1 is in the "weighted" summary across sectors. Here the weights are taken from the relative expenditures on value added across sectors in 1982. The aggregate autonomous trends in the three energy-GNP ratios are for a reduction in energy use per unit of output at a rate of -0.34% per year. This conforms to the direction of the current conventional wisdom, although the magnitude is less than generally presumed.

More surprising is the bias in the technical change, estimated as θ_{it}. For this aggregation across sectors, weighted by value added, the average biases for capital, labor, electric and nonelectric energy are positive. Hence, on average, the technical bias is seen to be saving of materials and using of other inputs. Given the importance of materials, this highlights the need for an equilibrium simulation rather than the simple averaging done here. The technical bias in materials will lead to a slowing reducing share of expenditures on materials and a corresponding increase in expenditure shares for the remaining inputs.

For the weighted averages, the technical bias for energy poses the problem that may complicate the use of existing energy models. The positive bias, although small, implies that over time the role of energy will change to become a larger share of input expenditures. And any increase in relative energy prices will lead to a slower growth in total factor productivity. This productivity loss is not priced in the market, so the reduction in welfare is an externality that should enter into any cost-benefit analysis of the effects of global warming and the policies to limit CO_2 emissions. Currently this potentially large externality is being ignored.

A comparison with the Manne-Richels analysis with the ETA-Macro model illustrates the differences in the underlying trends in productivity and the implications for energy-economic analysis.

Table 2
Manne-Richels and ETA-Macro Model
vs.
Jorgenson Estimations

	Manne-Richels Assumptions I	II
s_{KL}	96.00%	96.00%
s_{EN}	4.00%	4.00%
σ	0.40	0.40
α	24.00%	24.00%
β	35.00%	35.00%
$\partial \ln(a)/\partial t$	-0.76%	-0.76%
$\partial \ln(b)/\partial t$	0.00%	-1.00%
a	0.9030	0.9030
b	0.0003	0.0003
s_K	23.04%	23.04%
s_L	72.96%	72.96%
s_E	1.40%	1.40%
s_N	2.60%	2.60%

Productivity Trends
(All figures in %)

	Manne-Richels		Jorgenson t = 1972	t = 1989
$\partial \ln p_{gt}/\partial t$	-0.486	-0.513	-0.846	0.013
Electric (τ_{Et})	-0.195	-0.605	0.088	0.970
NonElectric (τ_{Nt})	-0.195	-0.605	-2.246	-4.845
Capital (τ_{Kt})	-0.499	-0.509	-0.576	0.391
Labor (τ_{Lt})	-0.499	-0.509	0.871	1.680
EN (τ_{ENt})	-0.195	-0.605		
KL (τ_{KLt})	-0.499	-0.509		
E/GNP (π_{Et})	-0.182	-0.609	-0.366	0.493
N/GNP (π_{Nt})	-0.182	-0.609	-0.334	0.525
EN/GNP (π_{ENt})	-0.182	-0.609	-0.339	0.520
θ_{Et}	0.004	-0.001	0.050	0.050
θ_{Nt}	0.008	-0.002	0.042	0.042
θ_{ENt}	0.012	-0.004	0.092	0.092
θ_{Kt}	-0.003	0.001	0.026	0.026
θ_{Lt}	-0.009	0.003	1.251	1.251

Table 2 summarizes the productivity trend results from two scenarios prepared with the ETA-Macro model and compares them with two versions from the Jorgenson analysis. The scenarios for ETA-Macro differ in the assumption for the "autonomous energy efficiency index (AEEI)" used as the reduced-form summary of technological change in the use of energy. Here this index corresponds to the change in the coefficient b, or $\partial \ln(b)/\partial t$. Scenario I from ETA-Macro is the Global 2100 base case assumption of AEEI equal to zero. Scenario II is the alternative assumption of AEEI equal to -1% per year.[20]

By comparison, the first case for the Jorgenson model fixes the estimated rate of technology change at the base year 1972. But the Jorgenson model is not limited to a constant rate of change in total factor productivity, which varies with time and changing relative prices. The second case from the Jorgenson analysis illustrates the productivity trends at constant real 1972 prices but with the rate of technology change predicted for 1989.

The energy-GNP ratio trends for the base year 1972 are similar, with the ETA-Macro trends of -0.182 and -0.609%, for Scenarios I and II respectively, bracketing the base year estimate of -0.339% from the Jorgenson model. This is comforting for both models and indicates a close agreement between the conventional wisdom and the average of the data usually applied in estimating econometric energy-economy models.

But the agreement on the energy-GNP ratios does not extend to other parameters that will govern the projections outside the historical data base. In particular, the technical bias estimate for aggregate energy in the Jorgenson model is nearly eight times larger, 0.092% vs. 0.012%, when compared to Scenario I, and a different sign compared to Scenario

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20 A.S. Manne and R. G. Richels, "CO2 Emission Limits: An Economic Analysis for the USA," Stanford University and the Electric Power Research Institute, November 1989.

II for ETA-Macro. This technical bias differential implies that the two models will have different projections for productivity growth after not very many years. Of course, the ETA-Macro constant price energy-GNP trends will remain approximately the same in the projections, but not the corresponding figures from the Jorgenson model. For example, by the year 1989, the predictions of the Jorgenson model reverse sign, and by then the trend for energy-GNP ratio is estimated as +0.520%. Hence, while ETA-Macro assumes that productivity trends are constant, the empirical estimates from the Jorgenson model imply that the productivity trends would shift by nearly a full 1% per year after only two decades. The implications of a 1% per year shift in trend for the baseline projection are clear for even a few years, much less for projections over a century.

Furthermore, the difference in the technical bias of total factor productivity could lead to a substantial change in the economic evaluation of energy policies. For instance, in analyzing the impact of a limitation to a constant level of carbon emissions at 80% of the 1990 emissions, Manne and Richels estimate that there will be a 5% reduction in the annual level of total consumption through the end of the century. This is achieved in part through the effect of higher energy prices reflecting the implicit tax on carbon emissions. The ETA-Macro prediction is for a required carbon tax of about $300 per ton.

For the sake of illustration, suppose that the price of delivered energy doubles as a result of this tax, but the technical bias in total factor productivity is 0.092% rather than 0.012% as implicit in ETA-Macro. Then, other things being equal, there will be an incremental reduction of output and therefore consumption of (0.092%-0.012%)ln(2) = 0.055% per year. As compounding goes, this would imply an additional 1.6% reduction by 2020 if the tax was imposed in 1989. Simple extrapolation through the end of the century would imply a reduction in consumption of 5.9%, a difference of the same order of magnitude as the total CO_2 emissions constraint cost calculated under the ETA-Macro assumptions.

RESEARCH QUESTIONS

While simple illustrations of the power of compound interest would not persuade us yet to modify the estimates of the economic costs of CO_2 emission restrictions, the numbers do suggest a need for further research as well as a renewed evaluation of the conventional wisdom regarding productivity trends. If there are substantial endogenous effects on productivity development flowing from changes in energy prices, then this externality should be included in the cost-benefit analysis of global warming policy. The calculations here suggest but do not resolve the importance of this potential externality.

An immediate issue is the extension of the analysis to include the effects of changes in the trends in consumption. The mix of sectoral output from the production side could change, even with no change in primary input prices. The trend in productivity in each sector is different, so relative prices of outputs will change. Hence, calculation of the trend in energy per unit of GNP, even under the assumption of constant energy prices, requires a simulation of the Jorgenson model. Presumably a better experiment would be to fix energy prices, simulate the model over time, record the energy demand and the GNP, and capture the average trend in the use of energy per unit of GNP. This would be a starting point for linking the detailed sectoral analysis to the aggregate studies of energy demand.

A related problem appears in extrapolations of the model summarized in Table 3. These data come from Jorgenson and Fraumeni, who describe technology as a linear function of time.[21] If the technical bias coefficients differ from zero, eventually some

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21 D.W. Jorgenson and B.M. Fraumeni, "Relative Prices and Technical Change," in E.R. Berndt and B. Field, eds., Modeling and Measuring Natural Resources Substitution, Cambridge, MIT Press, 1981, pp. 17-47.

predicted shares will be negative or greater than one. All the analysis done here has been with constant shares based on expenditures in 1982, but allowing for the effects of β_{tt} on the aggregate productivity trend. However the share equations explode if we use the parameters β_{it} to calculate the change in the mix of inputs. This problem is well-known and motivated the work of Jorgenson and Wilcoxen where the model is reformulated to include a particular nonlinear description of technology change.[22] Near the base year of 1972 there should be little difference between the two models, but for the predictions through the end of the next century, the nonlinear technology description could be another matter.

Expanded efforts to estimate the details of the productivity parameters would be useful, but this could operate in parallel with an attempt to apply the existing Jorgenson model or simplify the model for purposes of aggregate long-run analysis of the type used in ETA-Macro. Although more is involved in using a multi-sector model, an interest in the extrapolation of technological change should justify such an effort. Or at a minimum, the detailed estimates from the Jorgenson model can be used to change the parameters of more aggregate systems like ETA-Macro.[23]

For example, we could use the Jorgenson model to generate a number of carefully designed simulations at the thirty-five sector level and then aggregate by fitting the data to a model with very few sectors. A model with three sectors - materials, electric and non-electric -- with capital and labor as the primary factors would have great appeal. Perhaps we could break out transportation which is such a big user of liquids. But we would allow for

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22 D. W. Jorgenson and P. J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth," Harvard Institute of Economic Research, July 1989.

23 This has already occurred in that the analysis summarized here was part of the motivation from moving to a base case with AEEI = 0 from an earlier version of Global 2100 with a base case AEEI = -0.5%.

the full range of substitutions without assuming the nested CES-Cobb-Douglas structure of ETA-Macro.[24]

This list of research questions is only suggestive of the problems of theory, estimation and analysis at the forefront of applied econometrics. For instance, even perfect estimation of the reduced-from model will not reveal the process by which improved technology is affected by changes in energy prices. This is a rich arena for the student of economic analysis. It is the serious attempt to analyze costs and benefits over a century that makes the same issue compelling as more than just a difficult scientific question. If we must act soon to control greenhouse gases, we need better estimates of the costs of control to slow the transition to a warmer globe.

CONCLUSION

The call for analyses of the costs and benefits of controlling greenhouse gases presents a number of challenges. Typically there is great interest in the changing mix of the economy. The model calculations call for projections over a century or more, well outside the range of historical experience. Over this long horizon, the common economic modeling assumption of constant technology, or even exogenous technological change, becomes progressively less tenable. Unfortunately, description and estimation of the likely technological changes are at or beyond the frontier of economic modeling. Simple calculation with the best available estimation results suggests that common assumptions in existing models may be missing as much as half of the total cost of controlling greenhouse gases. Given the

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24 For example, this level of aggregation performs well in an anlysis of US energy data. See W. Hogan, "A Dynamic Putty - Semi-Putty Model of Aggregate Energy Demand," Energy Economics, Vol. 11, No. 1, 1989.

simplifications applied in pointing to this conclusion, the principal implication is to refocus research and analysis with energy-economic models to give greater attention to the effects of technological change.

APPENDIX
Table 3[25]
Jorgenson Cost Functions
Average Case for t=0

PARAMETER	AGRICULTURE FORESTRY & FISHERIES	METAL MINING	COAL MINING	CRUDE PETROLEUM & NATURAL GAS
AK	0.179	0.226	0.242	0.471
AL	0.243	0.328	0.494	0.109
AE	0.00341	0.0253	0.014	0.0087
AN	0.0215	0.0143	0.102	0.0492
AM	0.553	0.407	0.148	0.362
AT	-0.0201	-0.0681	-0.0213	-0.0051
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	0.00362	0.00206	0.00923	0.00203
BLL	-0.0586	-0.422		
BLE	0.00189	-0.00217		
BLN	-0.0186	0.0294		
BLM	0.0735	0.394		
BLT	-0.00271	0.0178	0.00803	-0.000124
BEE	-0.00886	-0.0000111	-0.00024	-0.0231
BEN	0.000661	0.000151	-0.00321	0.00475
BEM	0.0063	0.00203	0.00345	0.0184
BET	-0.0000667	0.000765	-0.00083	-0.000151
BNN	-0.00484	-0.00205	-0.0429	-0.000977
BNM	0.021	-0.0275	0.0461	-0.00378
BNT	0.000714	-0.000884	-0.00612	0.00088
BMM	-0.101	-0.369	-0.0495	-0.0146
BMT	-0.00155	-0.0197	-0.0103	-0.00264
BTT	0.000868	-0.00835	-0.0013	-0.000571
1982 Weights	1	2	3	4
K	49452.04	1135.36	5000.98	62224.37
L	34246.67	2141.28	9946.85	27888.88
E	8296.37	624.2	5723.57	12426.81
M	117499.2	2385.25	7187.13	38706.68
VA	83698.71	3276.64	14947.83	90113.25
VA	3.35%	0.13%	0.60%	3.61%
Electric	1.45%	0.51%	0.88%	2.39%
NonElectric	1.93%	0.06%	1.35%	2.84%
Capital	6.29%	0.14%	0.64%	7.91%
Labor	2.00%	0.13%	0.58%	1.63%

Table 3 cont.

	AGRICULTURE FORESTRY & FISHERIES	METAL MINING	COAL MINING	CRUDE PETROLEUM & NATURAL GAS
CONSTANT SHARE VERSION				
Share:E (s_{Et})	0.34%	2.53%	1.40%	0.87%
Share:N (s_{Nt})	2.15%	1.43%	10.20%	4.92%
Share:EN (s_{ENt})	2.49%	3.96%	11.60%	5.79%
Share:K (s_{Kt})	17.90%	22.60%	24.20%	47.10%
Share:L (s_{Lt})	24.30%	32.80%	49.40%	10.90%
Share:KLEN (s_{KLENt})	44.69%	59.36%	85.20%	63.79%
$w_j s_M$	1.85%	0.05%	0.09%	1.31%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-2.01%	-6.81%	-2.13%	-0.51%
$\partial \ln p_{gt}/\partial t$-2.48%	-7.15%	-2.26%	-0.82%	
Electric (τ_{Et})	-4.43%	-4.13%	-8.18%	-2.55%
NonElectric (τ_{Nt})	0.84%	-13.34%	-8.26%	0.97%
Capital (τ_{Kt})	-0.46%	-6.24%	1.56%	-0.39%
Labor (τ_{Lt})	-3.59%	-1.73%	-0.63%	-0.93%
E/GNP (Π_{Et})	-3.02%	-1.41%	-9.12%	-2.91%
N/GNP (Π_{Nt})	2.26%	-10.61%	-9.19%	0.61%
EN/GNP (Π_{ENt})	1.54%	-4.73%	-9.18%	0.08%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.07%	-0.01%	-0.01%	-0.02%
$\partial \ln p_{gt}/\partial t$-0.08%	-0.01%	-0.01%	-0.03%	
Electric (τ_{Et})	-0.06%	-0.02%	-0.07%	-0.06%
NonElectric (τ_{Nt})	0.02%	-0.01%	-0.11%	0.03%
Capital (τ_{Kt})	-0.03%	-0.01%	0.01%	-0.03%
Labor (τ_{Lt})	-0.07%	-0.00%	-0.00%	-0.02%
E/GNP (Π_{Et})	-0.04%	-0.01%	-0.08%	-0.07%
N/GNP (Π_{Nt})	0.04%	-0.01%	-0.12%	0.02%
EN/GNP (Π_{ENt})	0.03%	-0.01%	-0.12%	0.00%
θ_{Et} -0.0005%	0.0002%	-0.0007%	-0.0009%	
θ_{Nt} 0.0057%	-0.0002%	-0.0050%	0.0055%	
θ_{ENt} 0.0051%	-0.0000%	-0.0057%	0.0045%	
θ_{Kt} 0.0288%	0.0005%	0.0075%	0.0126%	
θ_{Lt} -0.0215%	0.0042%	0.0065%	-0.0008%	

25 Estimated parameters from Jorgenson, 1983. Trend rate in input-output coefficients calculated from (21), (23), and (24). The data on the Capital, Labor, Energy and Materials in 1982 come from Wlcoxen and are used to calculate the weights for the respective aggregations across sector. The technical biases in total factor productivity have been normalized by the share of value added.

Table 3 cont.

PARAMETER	NONMETALLIC MINING	CONSTRUCTION	FOOD & KINDRED PRODUCTS	TOBACCO MANUFACTURER
AK	0.281	0.0715	0.0578	0.171
AL	0.314	0.449	0.159	0.13
AE	0.0296	0.000294	0.00441	0.00211
AN	0.0486	0.0261	0.00679	0.00121
AM	0.327	0.453	0.772	0.696
AT	-0.06	0.00585	-0.0152	-0.00138
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	0.00329	0.000667	-0.0009	0.00224
BLL	-0.377	-0.311	-0.0656	-0.133
BLE	0.0441	0.00622	-0.000209	0.0000237
BLN	-0.0131	-0.0563	0.00138	-0.000447
BLM	0.346	0.361	0.0663	0.133
BLT	0.0102	-0.00377	0.000638	0.0108
BEE	-0.00514	-0.000124	-0.000973	-0.000601
BEN	0.00153	0.00112	0.00167	-0.000962
BEM	-0.0404	-0.00722	0.0101	0.00154
BET	-0.000624	0.0000649	0.0000834	0.000127
BNN	-0.000454	-0.0102	-0.000302	-0.00154
BNM	0.012	0.0654	-0.00275	0.00295
BNT	0.00185	-0.00152	0.0000285	0.0000938
BMM	-0.318	-0.42	-0.0737	-0.138
BMT	-0.0147	0.00455	0.00015	-0.0132
BTT	-0.00657	-0.00113	-0.00162	0.00464
1982 Weights	5	6	7	8
K	1622.24	33598.8	18800.33	4245.16
L	3250.86	141664.72	37499.4	2188.67
E	1127.09	12248.59	4325.57	151.6
M	3328.12	193318.02	208174.83	12034.25
VA	4873.1	175263.52	56299.73	6433.83
VA	0.20%	7.02%	2.26%	0.26%
Electric	0.55%	0.17%	2.18%	0.12%
NonElectric	0.19%	3.26%	0.71%	0.01%
Capital	0.21%	4.27%	2.39%	0.54%
Labor	0.19%	8.29%	2.19%	0.13%

Table 3 cont.

	NONMETALLIC MINING	CONSTRUCTION	FOOD & KINDRED PRODUCTS	TOBACCO MANUFACTURER
CONSTANT SHARE				
Share:E (s_{Et})	2.96%	0.03%	0.44%	0.21%
Share:N (s_{Nt})	4.86%	2.61%	0.68%	0.12%
Share:EN (s_{ENt})	7.82%	2.64%	1.12%	0.33%
Share:K (s_{Kt})	28.10%	7.15%	5.78%	17.10%
Share:L (s_{Lt})	31.40%	44.90%	15.90%	13.00%
Share:KLEN (s_{KLENt})	67.32%	54.69%	22.80%	30.43%
$w_j s_M$	0.06%	3.18%	1.74%	0.18%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-6.00%	0.59%	-1.52%	-0.14%
$\partial \ln p_{gt}/\partial t$	-6.28%	0.20%	-2.17%	-0.73%
Electric (τ_{Et})	-8.38%	22.28%	-0.28%	5.29%
NonElectric (τ_{Nt})	-2.47%	-5.62%	-1.75%	7.03%
Capital (τ_{Kt})	-5.11%	1.13%	-3.73%	0.58%
Labor (τ_{Lt})	-3.03%	-0.64%	-1.77%	7.58%
E/GNP (π_{Et})	-5.22%	21.82%	1.17%	0.84%
N/GNP (π_{Nt})	0.69%	-6.07%	-0.31%	2.57%
EN/GNP (π_{ENt})	-1.55%	-5.76%	0.27%	1.47%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.01%	0.04%	-0.03%	-0.00%
$\partial \ln p_{gt}/\partial t$	-0.01%	0.01%	-0.05%	-0.00%
Electric (τ_{Et})	-0.05%	0.04%	-0.01%	0.01%
NonElectric (τ_{Nt})	-0.00%	-0.18%	-0.01%	0.00%
Capital (τ_{Kt})	-0.01%	0.05%	-0.09%	0.00%
Labor (τ_{Lt})	-0.01%	-0.05%	-0.04%	0.01%
E/GNP (π_{Et})	-0.03%	0.04%	0.03%	0.00%
NE/GNP (π_{Et})	0.00%	-0.20%	-0.00%	0.00%
EN/GNP (π_{ENt})	-0.00%	-0.16%	0.00%	0.00%
θ_{Et}	-0.0002%	0.0009%	0.0009%	0.0001%
θ_{Nt}	0.0006%	-0.0205%	0.0003%	0.0001%
θ_{ENt}	0.0004%	-0.0196%	0.0012%	0.0002%
θ_{Kt}	0.0011%	0.0090%	-0.0094%	0.0019%
θ_{Lt}	0.0033%	-0.0509%	0.0066%	0.0093%

Table 3 cont.

PARAMETER	TEXTILE MILL PRODUCTS	APPAREL & FABRIC TEXTILE PRODUCTS	LUMBER WOOD PRODUCTS	FURNITURE & FIXTURES
AK	0.073	0.0429	0.16	0.0675
AL	0.21	0.315	0.287	0.295
AE	0.00977	0.00414	0.0079	0.00351
AN	0.00586	0.00221	0.0109	0.00262
AM	0.701	0.636	0.534	0.631
AT	-0.0215	0.00542	-0.0308	-0.00895
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	0.00000139	0.000551	0.00586	-0.00015
BLL		-0.0775		-0.016
BLE		0.00159		0.00808
BLN		-0.00365		0.00044
BLM		0.0796		0.0075
BLT	0.00104	0.000839	0.00146	-0.00783
BEE		-0.0000324		-0.00408
BEN		0.0000747		-0.000222
BEM		-0.00163		-0.00378
BET	0.000215	0.000105	0.00028	-0.000358
BNN		-0.000402		-0.0000121
BNM		0.00398		-0.000206
BNT	0.000159	0.000202	0.000483	-0.0000593
BMM		0.082		-0.00351
BMT	-0.00142	-0.0017	-0.00808	0.0084
BTT	-0.00136	-0.000187	-0.00245	0.00109
1982 Weights	9	10	11	12
K	2898.72	3693.38	3911.96	2032.02
L	9330.49	19581.43	12255.18	8058.57
E	1222.28	786.11	1058.55	394.06
M	30098.69	38956.66	24081.37	13126.58
VA	12229.21	23274.81	16167.14	10090.59
VA	0.49%	0.93%	0.65%	0.40%
Electric	0.98%	0.66%	0.57%	0.29%
NonElectric	0.12%	0.07%	0.17%	0.05%
Capital	0.37%	0.47%	0.50%	0.26%
Labor	0.55%	1.15%	0.72%	0.47%

Table 3 cont.

	TEXTILE MILL PRODUCTS	APPAREL & FABRIC TEXTILE PRODUCTS	LUMBER WOOD PRODUCTS	FURNITURE & FIXTURES
CONSTANTSHARE				
Share:E (s_{Et})	0.98%	0.41%	0.79%	0.35%
Share:N (s_{Nt})	0.59%	0.22%	1.09%	0.26%
Share:EN (s_{ENt})	1.56%	0.64%	1.88%	0.61%
Share:K (s_{Kt})	7.30%	4.29%	16.00%	6.75%
Share:L (s_{Lt})	21.00%	31.50%	28.70%	29.50%
Share:KLEN (s_{KLENt})	29.86%	36.43%	46.58%	36.86%
$w_j s_M$	0.34%	0.59%	0.35%	0.26%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-2.15%	0.54%	-3.08%	-0.90%
$\partial \ln p_{gt}/\partial t$ -2.74%	0.00%	-3.53%	-1.43%	
Electric (τ_{Et})	-0.54%	2.54%	0.01%	-11.63%
NonElectric (τ_{Nt})	-0.03%	9.14%	0.90%	-3.69%
Capital (τ_{Kt})	-2.74%	1.29%	0.13%	-1.65%
Labor (τ_{Lt})	-2.25%	0.27%	-3.02%	-4.08%
E/GNP (π_{Et})0.99%	1.30%	1.06%	-8.84%	
N/GNP (π_{Nt})1.50%	7.91%	1.95%	-0.91%	
EN/GNP (π_{ENt})	1.18%	3.60%	1.57%	-5.45%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.01%	0.01%	-0.02%	-0.00%
$\partial \ln p_{gt}/\partial t$ -0.01%	0.00%	-0.02%	-0.01%	
Electric (τ_{Et})	-0.01%	0.02%	0.00%	-0.03%
NonElectric (τ_{Nt})	-0.00%	0.01%	0.00%	-0.00%
Capital (τ_{Kt})	-0.01%	0.01%	0.00%	-0.00%
Labor (τ_{Lt})	-0.01%	0.00%	-0.02%	-0.02%
E/GNP (π_{Et})0.01%	0.01%	0.01%	-0.03%	
NE/GNP (π_{Et})0.00%	0.01%	0.00%	-0.00%	
EN/GNP (π_{ENt})0.00%	0.01%	0.00%	-0.00%	
θ_{Et} 0.0004%	0.0003%	0.0004%	-0.0004%	
θ_{Nt} 0.0003%	0.0005%	0.0007%	-0.0001%	
θ_{ENt} 0.0006%	0.0008%	0.0011%	-0.0005%	
θ_{Kt} 0.0000%	0.0014%	0.0085%	-0.0002%	
θ_{Lt} 0.0018%	0.0022%	0.0021%	-0.0087%	

Table 3 cont.

PARAMETER	PAPER ALLIED PRODUCTS	PRINTING PUBL ALLIED	CHEMICALS ALLIED PRODUCTS	PETROLEUM REFINING
AK	0.116	0.109	0.135	0.111
AL	0.266	0.384	0.209	0.0393
AE	0.0117	0.00478	0.0191	0.00311
AN	0.0215	0.00351	0.0741	0.635
AM	0.584	0.499	0.562	0.211
AT	-0.0327	0.0103	-0.0321	-0.0433
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	-0.00137	0.00116		0.000913
BLL		-0.36		-0.35
BLE		0.00338		0.00722
BLN		-0.017		0.145
BLM		0.373		0.198
BLT	0.000649	0.0134		-0.00246
BEE		-0.00955		-0.216
BEN		0.00369		0.0149
BEM		0.00249		-0.000549
BET	0.000267	0.0000269		-0.000392
BNN		-0.00211		-0.0746
BNM		0.0154		-0.0848
BNT	0.000351	0.000688		0.00436
BMM		-0.391		-0.113
BMT	0.000104	-0.0153		-0.00243
BTT	-0.00183	0.000566		-0.00343
1982 Weights	13	14	15	16
K	8703.03	9953.73	19452.59	13036.4
L	19476.24	28519.72	27073.01	8581.01
E	5069.22	1185.5	11255.24	150108.55
M	45192.71	46226.58	76612.66	28850.71
VA	28179.27	38473.45	46525.6	21617.41
VA	1.13%	1.54%	1.86%	0.87%
Electric	2.29%	0.88%	2.95%	0.94%
NonElectric	0.88%	0.14%	2.41%	40.20%
Capital	1.11%	1.27%	2.47%	1.66%
Labor	1.14%	1.67%	1.58%	0.50%

Table 3 cont.

	PAPER ALLIED PRODUCTS	PRINTING PUBL ALLIED	CHEMICALS ALLIED PRODUCTS	PETROLEUM REFINING
CONSTANTSHARE				
Share:E (s_{Et})	1.17%	0.48%	1.91%	0.31%
Share:N (s_{Nt})	2.15%	0.35%	7.41%	63.50%
Share:EN (s_{ENt})	3.32%	0.83%	9.32%	63.81%
Share:K (s_{Kt})	11.60%	10.90%	13.50%	11.10%
Share:L (s_{Lt})	26.60%	38.40%	20.90%	3.93%
Share:KLEN (s_{KLENt})	41.52%	50.13%	43.72%	78.84%
$w_j s_M$	0.66%	0.77%	1.05%	0.18%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-3.27%	1.03%	-3.21%	-4.33%
$\partial \ln p_{gt}/\partial t$	-3.76%	0.61%	-3.69%	-4.51%
Electric (τ_{Et})	-1.48%	1.17%	-3.69%	-17.11%
NonElectric (τ_{Nt})	-2.13%	20.21%	-3.69%	-3.82%
Capital (τ_{Kt})	-4.95%	1.67%	-3.69%	-3.69%
Labor (τ_{Lt})	-3.52%	4.10%	-3.69%	-10.77%
E/GNP (π_{Et})	1.62%	-3.24%	-0.85%	-12.42%
N/GNP (π_{Nt})	0.97%	15.80%	-0.85%	0.87%
EN/GNP (π_{ENt})	1.20%	4.82%	-0.85%	0.80%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.04%	0.02%	-0.06%	-0.04%
$\partial \ln p_{gt}/\partial t$	-0.04%	0.01%	-0.07%	-0.04%
Electric (τ_{Et})	-0.03%	0.01%	-0.11%	-0.16%
NonElectric (τ_{Nt})	-0.02%	0.03%	-0.09%	-1.54%
Capital (τ_{Kt})	-0.05%	0.02%	-0.09%	-0.06%
Labor (τ_{Lt})	-0.04%	0.07%	-0.06%	-0.05%
E/GNP (π_{Et})	0.04%	-0.03%	-0.03%	-0.12%
NE/GNP (π_{Et})	0.01%	0.02%	-0.02%	0.35%
EN/GNP (π_{ENt})	0.01%	0.01%	-0.02%	0.27%
θ_{Et}	0.0008%	0.0001%	0.0000%	-0.0023%
θ_{Nt}	0.0010%	0.0022%	0.0000%	0.0251%
θ_{ENt}	0.0018%	0.0022%	0.0000%	0.0229%
θ_{Kt}	-0.0040%	0.0036%	0.0000%	0.0053%
θ_{Lt}	0.0019%	0.0419%	0.0000%	-0.0142%

Table 3 cont.

PARAMETER	RUBBER MISC PLASTIC	LEATHER & LEATHER PRODUCTS	STONE, CLAY & GLASS PRODUCTS	PRIMARY METAL INDUSTRIES
AK	0.104	0.0491	0.125	0.093
AL	0.269	0.356	0.373	0.291
AE	0.00983	0.00451	0.0156	0.0154
AN	0.0139	0.00346	0.0302	0.027
AM	0.603	0.587	0.456	0.574
AT	-0.032	-0.00547	-0.00767	-0.0135
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	-0.00284	-0.000083	-0.00323	-0.00179
BLL	-0.337		-0.44	
BLE	-0.0215		0.12	
BLN	-0.0416		-0.0202	
BLM	0.4		0.339	
BLT	0.00578	0.000452	0.0152	0.00348
BEE	-0.0075		-0.033	
BEN	-0.00228		0.00554	
BEM	0.0313		-0.093	
BET	0.000732	0.00011	-0.00303	0.000186
BNN	-0.00516		-0.00093	
BNM	0.049		0.0156	
BNT	0.00116	0.000113	0.000347	-0.000365
BMM	-0.418		-0.262	
BMT	-0.00484	-0.000592	-0.00933	-0.00151
BTT	-0.0011	-0.00128	0.000437	-0.00151
1982 Weights	17	18	19	20
K	2127.2	831.88	3547.83	2908.69
L	26023.23	3122.33	15827.79	34406.77
E	4335.17	111.86	3779.97	9686.22
M	48800.46	5394.39	20873.91	57397.81
VA	28150.43	3954.21	19375.62	37315.46
VA	1.13%	0.16%	0.78%	1.50%
Electric	2.30%	0.08%	1.65%	4.51%
NonElectric	0.68%	0.01%	0.67%	1.66%
Capital	0.27%	0.11%	0.45%	0.37%
Labor	1.52%	0.18%	0.93%	2.01%

Table 3 cont.

	RUBBER MISC PLASTIC	LEATHER & LEATHER PRODUCTS	STONE, CLAY & GLASS PRODUCTS	PRIMARY METAL INDUSTRIES
CONSTANTSHARE				
Share:E (s_{Et})	0.98%	0.45%	1.56%	1.54%
Share:N (s_{Nt})	1.39%	0.35%	3.02%	2.70%
Share:EN (s_{ENt})	2.37%	0.80%	4.58%	4.24%
Share:K (s_{Kt})	10.40%	4.91%	12.50%	9.30%
Share:L (s_{Lt})	26.90%	35.60%	37.30%	29.10%
Share:KLEN (s_{KLENt})	39.67%	41.31%	54.38%	42.64%
$w_j s_M$	0.68%	0.09%	0.35%	0.86%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-3.20%	-0.55%	-0.77%	-1.35%
$\partial \ln p_{gt}/\partial t$	-3.71%	-1.04%	-1.15%	-1.84%
Electric (τ_{Et})	3.74%	1.40%	-20.58%	-0.63%
NonElectric (τ_{Nt})	4.63%	2.22%	-0.00%	-3.19%
Capital (τ_{Kt})	-6.44%	-1.21%	-3.74%	-3.76%
Labor (τ_{Lt})	-1.56%	-0.92%	2.92%	-0.64%
E/GNP (Π_{Et})	5.81%	1.50%	-22.67%	-0.08%
N/GNP (Π_{Nt})	6.71%	2.33%	-2.10%	-2.64%
EN/GNP (Π_{ENt})	6.34%	1.86%	-9.11%	-1.71%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.04%	-0.00%	-0.01%	-0.02%
$\partial \ln p_{gt}/\partial t$	-0.04%	-0.00%	-0.01%	-0.03%
Electric (τ_{Et})	0.09%	0.00%	-0.34%	-0.03%
NonElectric (τ_{Nt})	0.03%	0.00%	-0.00%	-0.05%
Capital (τ_{Kt})	-0.02%	-0.00%	-0.02%	-0.01%
Labor (τ_{Lt})	-0.02%	-0.00%	0.03%	-0.01%
E/GNP (Π_{Et})	0.13%	0.00%	-0.37%	-0.00%
NE/GNP (Π_{Et})	0.05%	0.00%	-0.01%	-0.04%
EN/GNP (Π_{ENt})	0.06%	0.00%	-0.08%	-0.04%
θ_{Et}	0.0022%	0.0000%	-0.0047%	0.0007%
θ_{Nt}	0.0035%	0.0000%	0.0005%	-0.0014%
θ_{ENt}	0.0057%	0.0001%	-0.0042%	-0.0007%
θ_{Kt}	-0.0086%	-0.0000%	-0.0050%	-0.0070%
θ_{Lt}	0.0175%	0.0002%	0.0237%	0.0136%

Table 3 cont.

PARAMETER	FABRICATED METAL PRODUCTS	ALL MACHINERY EXCEPT ELECTRICAL	ELECTRICAL MACHINERY	MOTOR VEHICLES & EQUIPMENT
AK	0.0926	0.103	0.0978	0.115
AL	0.356	0.305	0.348	0.205
AE	0.00659	0.00441	0.00528	0.00317
AN	0.00602	0.00622	0.00491	0.00424
AM	0.538	0.581	0.544	0.673
AT	-0.00781	-0.00623	-0.00979	0.0127
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	0.00089	-0.000751		0.000385
BLL	-0.441	-0.24		-0.0023
BLE	-0.00667	0.0156		-0.0035
BLN	-0.0214	-0.0131		0.00164
BLM	0.469	0.237		0.00416
BLT	0.0135	0.00176		0.00501
BEE	-0.000101	-0.00102		-0.00532
BEN	-0.000323	0.000854		0.00249
BEM	0.00709	-0.0155		0.00633
BET	0.000297	-0.000378		0.000134
BNN	-0.000103	-0.000716		-0.00116
BNM	0.0227	0.0131		-0.00296
BNT	0.000485	0.000401		0.0000755
BMM	-0.499	-0.235		-0.00753
BMT	-0.0151	-0.00103		-0.00561
BTT	0.000575	0.000201		0.00305
1982 Weights	21	22	23	24
K	10284.04	17047.64	11159.36	3474.41
L	38701.05	66105.31	53856	26296.54
E	1918.73	2739.29	2186.12	1070.37
M	55169.02	91374.55	75434.66	80726.77
VA	48985.09	83152.95	65015.36	29770.95
VA	1.96%	3.33%	2.61%	1.19%
Electric	1.28%	1.46%	1.45%	0.59%
NonElectric	0.25%	0.43%	0.28%	0.16%
Capital	1.31%	2.17%	1.42%	0.44%
Labor	2.26%	3.87%	3.15%	1.54%

Table 3 cont.

	FABRICATED METAL PRODUCTS	ALL MACHINERY EXCEPT ELECTRICAL	ELECTRICAL MACHINERY	MOTOR VEHICLES & EQUIPMENT
CONSTANTSHARE				
Share:E (s_{Et})	0.66%	0.44%	0.53%	0.32%
Share:N (s_{Nt})	0.60%	0.62%	0.49%	0.42%
Share:EN (s_{ENt})	1.26%	1.06%	1.02%	0.74%
Share:K (s_{Kt})	9.26%	10.30%	9.78%	11.50%
Share:L (s_{Lt})	35.60%	30.50%	34.80%	20.50%
Share:KLEN (s_{KLENt})	46.12%	41.86%	45.60%	32.74%
$w_j s_M$	1.06%	1.94%	1.42%	0.80%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.78%	-0.62%	-0.98%	1.27%
$\partial \ln p_{gt}/\partial t$	-1.24%	-1.12%	-1.44%	0.70%
Electric (τ_{Et})	3.27%	-9.69%	-1.44%	4.93%
NonElectric (τ_{Nt})	6.82%	5.33%	-1.44%	2.48%
Capital (τ_{Kt})	-0.28%	-1.84%	-1.44%	1.04%
Labor (τ_{Lt})	2.56%	-0.54%	-1.44%	3.14%
E/GNP (Π_{Et})	0.45%	-9.67%	-0.85%	1.69%
N/GNP (Π_{Nt})	4.00%	5.35%	-0.85%	-0.75%
EN/GNP (Π_{ENt})	2.15%	-0.88%	-0.85%	0.29%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.02%	-0.02%	-0.03%	0.02%
$\partial \ln p_{gt}/\partial t$	-0.02%	-0.04%	-0.04%	0.01%
Electric (τ_{Et})	0.04%	-0.14%	-0.02%	0.03%
NonElectric (τ_{Nt})	0.02%	0.02%	-0.00%	0.00%
Capital (τ_{Kt})	-0.00%	-0.04%	-0.02%	0.00%
Labor (τ_{Lt})	0.06%	-0.02%	-0.05%	0.05%
E/GNP (Π_{Et})	0.01%	-0.14%	-0.01%	0.01%
NE/GNP (Π_{Et})	0.01%	0.02%	-0.00%	-0.00%
EN/GNP (Π_{ENt})	0.01%	-0.01%	-0.00%	0.00%
θ_{Et}	0.0013%	-0.0031%	0.0000%	0.0005%
θ_{Nt}	0.0021%	0.0033%	0.0000%	0.0003%
θ_{ENt}	0.0034%	0.0002%	0.0000%	0.0008%
θ_{Kt}	0.0039%	-0.0061%	0.0000%	0.0014%
θ_{Lt}	0.0591%	0.0144%	0.0000%	0.0187%

Table 3 cont.

PARAMETER	TRANSPORTATION EQUIPMENT & ORDINANCE	INSTRUMENTS	MISC. MANUFACTURING INDUSTRIES	TRANSPORTATION
AK	0.04	0.132	0.0955	0.178
AL	0.384	0.355	0.333	0.444
AE	0.00473	0.00414	0.00502	0.00374
AN	0.005	0.00278	0.00567	0.0519
AM	0.567	0.505	0.561	0.322
AT	-0.0068	-0.0179	-0.0161	-0.00181
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	-0.000224	0.000794	0.000354	
BLL	-0.674	-0.375		
BLE	-0.000538	0.00507		
BLN	-0.0101	-0.0317		
BLM	0.685	0.401		
BLT	0.014	0.00845	0.00123	
BEE	-0.00000042	-0.0000696		
BEN	-0.00000802	0.000429		
BEM	0.000546	-0.00543		
BET	0.0000842	-0.0000444	0.0000108	
BNN	-0.00015	-0.00269		
BNM	0.0102	0.034		
BNT	0.000199	0.000901	0.000784	
BMM	-0.695	-0.43		
BMT	-0.0141	-0.0101	-0.00238	
BTT	-0.000652	0.000307	0.00173	
1982 Weights	25	26	27	28
K	1125.54	4026.19	3129.65	24376.24
L	44582.21	21202.95	8002.37	81357.52
E	1662.95	753.91	467.56	17357.97
M	56857.1	23261.88	15533.47	71642.26
VA	45707.75	25229.14	11132.02	105733.76
VA	1.83%	1.01%	0.45%	4.24%
Electric	1.04%	0.58%	0.28%	1.49%
NonElectric	0.23%	0.08%	0.07%	4.36%
Capital	0.14%	0.51%	0.40%	3.10%
Labor	2.61%	1.24%	0.47%	4.76%

Table 3 cont.

	TRANSPORTATION EQUIPMENT & ORDINANCE	INSTRUMENTS	MISC. MANUFACTURING INDUSTRIES	TRANSPORTATION
CONSTANTSHARE				
Share:E (s_{Et})	0.47%	0.41%	0.50%	0.37%
Share:N (s_{Nt})	0.50%	0.28%	0.57%	5.19%
Share:EN (s_{ENt})	0.97%	0.69%	1.07%	5.56%
Share:K (s_{Kt})	4.00%	13.20%	9.55%	17.80%
Share:L (s_{Lt})	38.40%	35.50%	33.30%	44.40%
Share:KLEN (s_{KLENt})	43.37%	49.39%	43.92%	67.76%
$w_j s_M$	1.04%	0.51%	0.25%	1.37%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.68%	-1.79%	-1.61%	-0.18%
$\partial \ln p_{gt}/\partial t$	-1.16%	-2.22%	-2.08%	-0.45%
Electric (τ_{Et})	-1.16%	-0.18%	-2.97%	-0.17%
NonElectric (τ_{Nt})	-1.16%	4.94%	13.81%	1.06%
Capital (τ_{Kt})	-1.16%	-2.39%	-1.25%	-0.25%
Labor (τ_{Lt})	-1.16%	1.73%	0.45%	-0.18%
E/GNP (π_{Et})	-0.85%	-1.64%	-3.89%	-0.81%
N/GNP (π_{Nt})	-0.85%	3.48%	12.89%	0.41%
EN/GNP (π_{ENt})	-0.85%	0.42%	5.01%	0.33%
Weighted				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.01%	-0.02%	-0.01%	-0.01%
$\partial \ln p_{gt}/\partial t$	-0.02%	-0.02%	-0.01%	-0.02%
Electric (τ_{Et})	-0.01%	-0.00%	-0.01%	-0.00%
NonElectric (τ_{Nt})	-0.00%	0.00%	0.01%	0.05%
Capital (τ_{Kt})	-0.00%	-0.01%	-0.00%	-0.01%
Labor (τ_{Lt})	-0.03%	0.02%	0.00%	-0.01%
E/GNP (π_{Et})	-0.01%	-0.01%	-0.01%	-0.01%
NE/GNP (π_{Et})	-0.00%	0.00%	0.01%	0.02%
EN/GNP (π_{ENt})	-0.00%	0.00%	0.01%	0.01%
θ_{Et}	0.0000%	0.0002%	-0.0000%	0.0001%
θ_{Nt}	0.0000%	0.0004%	0.0009%	0.0053%
θ_{ENt}	0.0000%	0.0006%	0.0009%	0.0054%
θ_{Kt}	0.0000%	-0.0005%	0.0008%	0.0024%
θ_{Lt}	0.0000%	0.0291%	0.0088%	0.0084%

Table 3 cont.

PARAMETER	COMMUNICATIONS	ELECTRIC UTILITIES	GAS UTILITIES	TRADE
AK	0.353	0.342	0.22	0.154
AL	0.364	0.241	0.167	0.585
AE	0.00844	0.104	0.00347	0.0129
AN	0.00667	0.149	0.546	0.0105
AM	0.268	0.164	0.0644	0.238
AT	-0.0355	-0.0159	-0.0188	-0.00507
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	-0.0042	-0.00367	-0.00599	0.000916
BLL		-0.0901	-0.161	-1.032
BLE		-0.00168	-0.00897	0.0188
BLN		0.00984	0.0728	0.0145
BLM		0.0819	0.097	0.999
BLT	-0.00306	-0.00353	0.01	0.0355
BEE		-0.115	-0.00266	-0.000343
BEN		0.0355	0.0022	-0.000264
BEM		0.0816	0.00942	-0.0182
BET	0.000134	0.00216	0.000407	-0.000708
BNN	-0.00108	-0.0119	-0.0345	-0.000203
BNM	0.00108	-0.0335	-0.0405	-0.014
BNT	0.0000148	0.00592	0.000724	-0.000833
BMM	-0.00108	-0.13	-0.066	-0.966
BMT	0.00712	-0.000874	-0.00516	-0.0349
BTT	-0.00164	0.00198	-0.00173	0.00129
1982 Weights	29	30	31	32
K	35379.71	35161.63	14475.96	116930.41
L	44267.14	21288.69	6857.36	280610.28
E	1090.35	44768.12	83958.76	22658.5
M	24841.18	22631.65	3658.13	223304.48
VA	79646.85	56450.32	21333.32	397540.69
VA	3.19%	2.26%	0.85%	15.93%
Electric	0.78%	23.57%	0.68%	16.00%
NonElectric	0.13%	7.10%	22.45%	2.74%
Capital	4.50%	4.47%	1.84%	14.87%
Labor	2.59%	1.25%	0.40%	16.42%

Table 3 cont.

	COMMUNICATIONS	ELECTRIC UTILITIES	GAS UTILITIES	TRADE
CONSTANTSHARE				
Share:E (s_{Et})	0.84%	10.40%	0.35%	1.29%
Share:N (s_{Nt})	0.67%	14.90%	54.60%	1.05%
Share:EN (s_{ENt})	1.51%	25.30%	54.95%	2.34%
Share:K (s_{Kt})	35.30%	34.20%	22.00%	15.40%
Share:L (s_{Lt})	36.40%	24.10%	16.70%	58.50%
Share:KLEN (s_{KLENt})	73.21%	83.60%	93.65%	76.24%
$w_j s_M$	0.85%	0.37%	0.05%	3.78%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-3.55%	-1.59%	-1.88%	-0.51%
$\partial \ln p_{gt}/\partial t$	-3.78%	-1.73%	-1.93%	-0.71%
Electric (τ_{Et})	-2.19%	0.35%	9.80%	-6.20%
NonElectric (τ_{Nt})	-3.55%	2.24%	-1.80%	-8.64%
Capital (τ_{Kt})	-4.97%	-2.80%	-4.66%	-0.11%
Labor (τ_{Lt})	-4.62%	-3.19%	4.05%	5.36%
E/GNP (Π_{Et})	1.75%	2.47%	9.85%	-11.26%
N/GNP (Π_{Nt})	0.39%	4.36%	-1.75%	-13.71%
EN/GNP (Π_{ENt})	1.15%	3.58%	-1.68%	-12.36%
<u>Weighted</u>				
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	-0.11%	-0.04%	-0.02%	-0.08%
$\partial \ln p_{gt}/\partial t$	-0.12%	-0.04%	-0.02%	-0.11%
Electric (τ_{Et})	-0.02%	0.08%	0.07%	-0.99%
NonElectric (τ_{Nt})	-0.00%	0.16%	-0.40%	-0.24%
Capital (τ_{Kt})	-0.22%	-0.13%	-0.09%	-0.02%
Labor (τ_{Lt})	-0.12%	-0.04%	0.02%	0.88%
E/GNP (Π_{Et})	0.01%	0.58%	0.07%	-1.80%
NE/GNP (Π_{Et})	0.00%	0.31%	-0.39%	-0.38%
EN/GNP (Π_{ENt})	0.00%	0.36%	-0.31%	-0.62%
θ_{Et}	0.0006%	0.0084%	0.0009%	-0.0153%
θ_{Nt}	0.0001%	0.0230%	0.0016%	-0.0180%
θ_{ENt}	0.0007%	0.0314%	0.0025%	-0.0332%
θ_{Kt}	-0.0187%	-0.0142%	-0.0132%	0.0197%
θ_{Lt}	-0.0136%	-0.0137%	0.0221%	0.7652%

Table 3 cont.

PARAMETER	FINANCE INSURANCE REAL ESTATE	SERVICES	GOVERNMENT ENTERPRISES	
AK	0.26	0.103	0.105	
AL	0.254	0.538	0.597	
AE	0.00711	0.0129	0.0149	
AN	0.0115	0.00804	0.0168	
AM	0.468	0.338	0.266	
AT	0.0233	-0.00244	-0.0339	
BKK				
BKL				
BKE				
BKN				
BKM				
BKT	-0.00215	0.00125	0.00567	
BLL			-0.0435	
BLE			0.0512	
BLN			-0.029	
BLM			0.0213	
BLT	0.00255	0.00714	0.0173	
BEE			-0.0602	
BEN			0.0341	
BEM			-0.0251	
BET	0.000106	0.00225	-0.00346	
BNN			-0.0194	
BNM			0.0142	
BNT	0.000038	-0.0000313	0.0014	
BMM			-0.0104	
BMT	-0.00055	-0.00859	-0.0209	
BTT	0.00238	0.0000208	-0.0031	
1982 Weights	33	34	35	Total
K	118071.73	127720.66	14904.1	786443.98
L	167284.78	345710.25	31929.5	1709135.05
E	6437.67	21704.01	6935.16	449626
M	137055.33	268660.56	20965.79	2189362.84
VA	285356.51	473430.91	46833.6	2495579.03
VA	11.43%	18.97%	1.88%	1
Electric	3.15%	17.13%	4.18%	1
NonElectric	1.07%	2.24%	0.99%	1
Capital	15.01%	16.24%	1.90%	1
Labor	9.79%	20.23%	1.87%	1

Table 3 cont.

	FINANCE INSURANCE REAL ESTATE	SERVICES	GOVERNMENT ENTERPRISES
CONSTANTSHARE			
Share:E (s_{Et})	0.71%	1.29%	1.49%
Share:N (s_{Nt})	1.15%	0.80%	1.68%
Share:EN (s_{ENt})	1.86%	2.09%	3.17%
Share:K (s_{Kt})	26.00%	10.30%	10.50%
Share:L (s_{Lt})	25.40%	53.80%	59.70%
Share:KLEN (s_{KLENt})	53.26%	66.19%	73.37%
$w_j s_M$	5.34%	6.41%	0.50%
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	2.33%	-0.24%	-3.39%
$\partial \ln p_{gt}/\partial t$	1.93%	-0.53%	-3.62%
Electric (τ_{Et})	3.43%	16.91%	-26.84%
NonElectric (τ_{Nt})	2.26%	-0.92%	4.72%
Capital (τ_{Kt})	1.11%	0.68%	1.78%
Labor (τ_{Lt})	2.94%	0.80%	-0.72%
E/GNP (π_{Et})	0.57%	15.29%	-27.34%
N/GNP (π_{Nt})	-0.59%	-2.54%	4.21%
EN/GNP (π_{EN})	-0.15%	8.44%	-10.62%
Weighted			
$\partial \ln p_{ot}/\partial t$ ($-v_t$)	0.27%	-0.05%	-0.06%
$\partial \ln p_{gt}/\partial t$	0.22%	-0.10%	-0.07%
Electric (τ_{Et})	0.11%	2.90%	-1.12%
NonElectric (τ_{Nt})	0.02%	-0.02%	0.05%
Capital (τ_{Kt})	0.17%	0.11%	0.03%
Labor (τ_{Lt})	0.29%	0.16%	-0.01%
E/GNP (π_{Et})	0.02%	2.62%	-1.14%
NE/GNP (π_{Et})	-0.01%	-0.06%	0.04%
EN/GNP (π_{ENt})	-0.00%	0.41%	-0.16%
θ_{Et}	0.0024%	0.0666%	-0.0092%
θ_{Nt}	0.0008%	-0.0009%	0.0037%
θ_{ENt}	0.0032%	0.0657%	-0.0055%
θ_{Kt}	-0.0478%	0.0370%	0.0152%
θ_{Lt}	0.0567%	0.2113%	0.0462%