ECONOMIC ANALYSIS OF PRODUCTION STRUCTURE, TECHNOLOGICAL CHANGE, AND PRODUCTIVITY GROWTH FOR THE U.S. FOOD AND KINDRED PRODUCTS SECTOR

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CHAPTER I

INTRODUCTION

Background

Productivity is an indication of efficiency in resources use because it measures output growth not attributable to input growth. More importantly, total factor productivity (TFP) growth may be the deciding factor as to whether living standards continue to improve, particularly in a mature economy such as the United States. Therefore, the contributions of capital formation, research and development, and technical change to productivity growth has become of critical concern in the study of economic growth. However, measuring the contribution of resource investments to growth of output and the rate of return on these investments, and correctly identifying the rate of technical change are still major preoccupations of academic and policy research.

The food processing industry is closely related to agriculture and a major force affecting the economic performance of the U. S. agriculture and manufacturing sector. The food processing industry added $120 billion in value to raw farm products in 1994, compared to the $160 billion value of total raw farm goods (Gallo, 1995). It accounts for 14% of the total value in manufacturing and 2% of the U.S. gross domestic product (Census of Manufactures). Barkema (1990) stated that agricultural-oriented states can no longer depend on farm production sector to fuel local economies. Moreover, food processing firms are more likely to locate plants in rural areas than are other types of manufacturing. In addition, food processing is increasingly, moving from urban to rural areas (Drabenstott et. al. 1999). This implies that the food processing industry is an important source for economic growth, particularly for agricultural oriented states. Therefore, understanding economic performance of the food processing industry is important for directing local economic growth and rural development policies.

Furthermore, several studies have suggested that permanent structural changes are affecting price behavior, productivity, scale economies, employment, and investment patterns in the food processing industry. This has implications for output growth and input demand, particularly labor demand and composition in this large and important industry.

Productivity analysis in the food and kindred products sector has received little attention compared to productivity analysis in other sectors of the economy. Several authors have analyzed growth and productivity change, and factor demand relationships including Bateman (1970); Bullock (1981); Eddleman (1982); Gisser (1982); Heien (1983); Jorgenson, Gollop and Fraumeni (1987); Huang (1991); Adelaja (1992); Goodwin and Brester (1995); Gopinath, Roe and Shane (1996); Morrison (1997); and Morrison and Siegel (1998). However, most of these empirical productivity studies suffer from (i) theoretical deficiencies in the definition of productivity, (ii) estimation methods of proposed structural models, and/or (iii) potential aggregation biases when analyzed at the industry level.

Before the 1980s, most productivity studies in food processing were based on either simple output per factor input ratios or Solow's residual, where constant returns to scale (CRS) with neutral shifts in technology and competitive markets for both inputs and outputs are assumed (Bateman (1970), Bullock (1981), Eddleman (1982), and Gisser (1982)). Such measurements of productivity are biased and ambiguous because of restrictions on production technology and normative definition of total factor productivity (TFP) or technical change index.

For example, using Solow's residual, Gisser (1982) estimated annual growth of TFP and labor productivity for selected large establishments of food processing to be in excess of 5% and 7%, respectively (1963-1972). He also found that concentration ratios had positive correlation with TFP and labor productivity (higher for the latter compared to the former). Interestingly, he showed that TFP gains were roughly sufficient to offset losses to consumers from oligopolistic power. However, Heien (1983), using the Theil-Tornqvist index which Diewert (1976) shows as the appropriate index for a translog aggregate function, estimated TFP in food processing to be only 0.007% per year (1950-1977). Clearly, Gisser overestimated TFP because technical bias and induced input due to technical change and price effects were not considered in his TFP definition.

Huang (1991) studied factor demands at the two-digit SIC level (1971-1986) using cost minimization. Based on Allen and Morishima elasticities of substitution, he found that capital, labor and energy were substitutable, especially between capital and labor, and demand for capital was more elastic than the demand for labor and energy. The Morishima elasticity of labor-capital substitution indicates a significant reduction in the cost share of labor to capital and implies that technical bias has occurred. This finding was confirmed later in studies by Goodwin and Brester (1995); Gopinath, Roe and Shane (1996); and Morrison (1997). Most of these studies found little change or a decline in TFP.

Problem Statement

Most empirical studies of food processing show significant decreases in the demand for labor and in labor's cost share. Correspondingly, several studies have found a significant increase in labor productivity but little change in total factor productivity. However, none of the studies have attempted to explain the sources of an increase in labor productivity and to reconcile the slowdown in measured growth of TFP.

After reviewing previous productivity studies in food processing, several issues/questions need to be answered: (1) what is the structure of production in the food processing industries? (2) What type of technological change (embodied, disembodied) occurs in the food processing industries? (3) What are the implications of these changes in technology on factor demands? (4) What factors are important contributors to output and labor productivity growth? (5) What are the major sources for TFP growth in the food processing industries? (6) What caused the slowdown/decline in TFP growth?

Measurement and interpretation of productivity behavior at the microeconomic and macroeconomic levels require the untangling of these many complex factors. Therefore, evaluating results from previous empirical studies of food processing is puzzling. Fortunately, while studies analyzing productivity improvement in food processing are limited, there have been major improvements in theoretical concepts, estimation methods, and availability of data. There are also numerous applications of productivity analysis for other sectors found in the literature.

Objectives of the Study

The main objectives of this study are to analyze production structure and technical behavior, examine substitutability among factor inputs, evaluate the impact of technological change and R&D on factor demands, and determine the sources of output, labor productivity, and total factor productivity growth for the food processing industry. To achieve the objectives and answer the above questions, the study is divided into two parts due to data availability.

Part I addresses the above questions at the national two-digit SIC level (SIC20: Food and Kindred Products), particularly to answer questions 1 to 4. The focus of this part is to investigate the role of labor composition (by education level) and R&D capital in increasing output and labor productivity. Specifically, the study of this part proposes to (1) examine the production structure, technology behavior, and patterns of substitution among factor inputs; (2) evaluate the impact of R&D and autonomous technological change on factor inputs, particularly labor composition; and (3) determine the sources of output and labor productivity growth.

Part II addresses the above questions at the national three-digit SIC level (SIC201: Meat products; SIC202: Dairy products; SIC203: Preserved fruits and vegetables; SIC204: Grain mill products; SIC205: Bakery products; SIC206: Sugar and confectionary products; SIC207: Fats and oils; SIC208: Beverages; and SIC209: Miscellaneous food and kindred products) for food processing, especially in answering questions 1, 2, 5, and 6.

Explicitly, this part intends to (1) empirically analyze the production structure of food processing industries at the three digit SIC level. Particular attention is focused on the technological change behavior, pattern of substitution among factor inputs, and the degree to which the industry production function is characterized by economies of scale. (2) Examine the effect of technical change and structural capital fixity on total variable cost across three digit industries. The concerns are not only the rate of technical change but also the extent to which it alters the optimal level and mix of inputs, that is, the inducement effect and factor price effect. (3) Explore the interrelationships between scale economies, marginal cost pricing internal to the food processing industries, and external technical change in determining the rate of total factor productivity growth. Specifically, we decompose the growth of TFP into direct technical change (independent of elasticity of product demand), indirect technical change (dependent on elasticity of product demand), factor prices effect, exogenous demand effect, and net scale effect.

Finally, this study (i) provides a better understanding of the structure of food processing, (ii) identifies the sources of labor productivity growth and the slowdown of total factor productivity, (iii) determines the impact of R&D and autonomous technical change on factor inputs, and (iv) discovers if there is any aggregation discrepancy between the two and three digit levels of the food and kindred products sector.

Organization of the Study

A review of literature is presented in Chapter II which emphasizes theoretical concepts, estimation methods, and applications of productivity analysis in food processing. Chapter III presents the methodology, estimation procedures, and data requirements for both parts of the study. Chapter IV presents empirical results and discussions for both parts on technological change, R&D, and labor productivity at the two digit level which answers Part I of the objectives and on technological change and total factor productivity growth at the three digit level which answers Part II of the objectives. Finally, Chapter V gives the summary, conclusions, and limitations of the study.

CHAPTER II

REVIEW OF THE LITERATURE

Theoretical Concepts of Productivity

Before the 1950s, most productivity studies/estimates were of the simple output per-worker variety. Specifically, those studies were based on labor productivity or capital productivity. Such partial measures of productivity serve particular purposes and are useful when the flow of output is related to what is considered to be a key or scarce input. However, such measures are not comprehensive and cannot be used as complete indicators of efficiency.

During the 1950s, the concept of total factor productivity (TFP) was developed and elaborated by the work of Kendrick (1951), Solow (1957), and others. Many indices of productivity were developed and each had it's own use. However, the most frequently used were the partial productivity indexes of labor and capital, and the total or multifactor productivity index. Productivity is often measured as a ratio of output to inputs. Labor and capital productivity indexes are simply the average products of labor, or capital, while TFP, often referred to as the "residual" or the index of "technical progress", is defined as output per unit of labor and capital combined.

The two indices most often used in empirical research are Kendrick's arithmetic measure (1961), which is based on a linear homogenous production function with constant elasticity of substitution and disembodied neutral technical change, and Solow's geometric index (1957), which is based on the Cobb-Douglas production function with constant returns to scale and autonomous or neutral technical change. Levhari, Kleiman, and Halevi (1966) show that under competitive equilibrium and with small changes in quantities of inputs and outputs, the two measures are equivalent. However, these conventionally measured inputs (capital and labor) left a large portion of the growth of output unexplained.

Nelson (1969) and others have pointed out that the magnitude of the residual (TFP as an index of technical change) and its stability over time depends upon: (i) the form of production function that governs the behavior of marginal product of labor and capital, (ii) proper measurement of labor and capital and adjustment for quality changes, and (iii) the importance of variables other than capital and labor that are left out of the production function.

During the 1960s and 1970s, a substantial portion of the literature on factor productivity was devoted to removing biases due to restrictive assumptions and definition of TFP, explaining the determinants of the "unbiased" rate of technical change, and searching for the factors explaining change in TFP and thus increasing our knowledge concerning sources of economic growth.

Denison, in his initial work (1962), and later updated and refined (1974), narrowed the residual in two ways: (i) included labor input measures of the effect of increased education, shortened hours of work, the changing age-sex composition of the labor force, and other factors that changed the quality of labor over time; and (ii) quantified the contributions to growth of all major factors other than advances of knowledge, so that the final residual primarily reflected the impact of basic dynamic elements.

Following Denison, Jorgenson and several collaborators-- Griliches (1966, 1967, 1972), Christensen (1969), Lau (1977) and Gollop (1980)--extended to capital the principle of weighting input components by marginal products, and used a more elaborate system than Denison in adjusting labor inputs for quality shifts. The estimates by Jorgenson and Chritensen, and by Gollop and Jorgenson show a substantially larger increase in real factor inputs and a correspondingly smaller increase in the residual compared to the results of Denison.

Kendrick (1976) measured the impact of improving quality of the factors by an approach which differed from that of both Denison (1974) and Jorgenson and Griliches (1971). He estimated the real capital stocks resulting from intangible investments designed to improve the efficiency of the factors--R&D, education and training, health and safety, and mobility. He then estimated the contribution of the growth in these intangible capitals stocks to economic growth generally, and to the productivity residual in particular.

An important contribution of Gollop (1980) and Jorgenson et al (1987) was relating gross output to total inputs including intermediate products consumed as well as factor services. They argued that for purposes of analyzing industry productivity measurements, gross output is a preferable approach because substitutions occur among all inputs in response to relative price changes, and innovation affects requirements for intermediate inputs as well as for primary factors.

To decompose factor productivity into well-specified categories is a difficult task. However, Nadiri (1970) and others, based on theoretical concepts, define two major sets of factors determining factor productivity as: (1) technical characteristics of the production process and (2) movement of the relative factor prices. The technical characteristics are:

i) efficiency of production (neutral or disembodied technical change), i.e. equally reducing unit cost of all factors of production due to better techniques;

ii) biased technical change (embodied technical change), i.e. a greater saving in one input than in another due to a new technique;

iii) elasticity of substitution, i.e. measurement of the ease of exchanging factors of production in the course of the production process;

iv) scale of operation of the production process, i.e. economies (diseconomies) that arise due to changes in the scale of operation; and

v) homotheticity of the production function, i.e. whether the returns to scale are evenly distributed among all factors of production.

Technical bias is often defined as a change in relative shares of the inputs. However, Stiglitz and Uzawa (1969) show that there are three different ways of defining technical bias:

(i) Hicksian definition which measures the bias along a constant capital-labor ratio $(\partial (F_K K/ F_L L)/\partial t)_{K/L\ \mathrm{CONSTANT}}$,

(ii) Harrodian definition which measures the bias along a constant capital-output ratio $(\partial (F_K K/ F_L L)/\partial t)_{K/Q\ \mathrm{CONSTANT}}$, and

(iii) Solow's definition which measures the bias along a constant labor-output ratio $(\partial (F_K K/ F_L L)/\partial t)_{L/Q \text{ CONSTANT}}$; where K and L are capital and labor and F_K and F_L are marginal product of capital and labor, respectively.

Other problems pointed out by Nadiri (1970) include: (i) if technical change is embodied in capital and labor, the bias in technical change will depend upon the elasticity of substitution and the differential rates of growth of labor and capital embodiment, and (ii) technical characteristics do not remain constant over time or over different productive units. The latter raises the inevitable problem of aggregation.

Sato (1969) extended the Solow-Fisher aggregation principle by showing that if capital and labor are in efficiency units, the nature of technical change at the microeconomic level is preserved at the aggregate level. However, the problem remains because the shape of the aggregate production function depends on how heterogeneous capital is distributed in efficiency units, which then suggests that the aggregate production function does not remain invariant.

As pointed out by Nadiri (1970), aggregation is a serious problem affecting the magnitude, stability, and dynamic changes of TFP. It is necessary to study the disaggregates to understand the dynamic nature of technical change, the diffusion of new techniques from firm to firm and from industry to industry and the changing linkages among economic units through externalities, etc.

In answering the question of what factors determine the direction of the bias in new techniques, Kennedy (1964) formulated induced technical change in terms of an innovation possibility curve (IPC), which is defined as the locus of all techniques available at a given time. It is considered exogenous in the sense that no resources are devoted to generating the new technique per se. The bias in technical change depends upon the proportional reduction in the requirements per unit of output of each factor due to the new technology and their relative factor shares.

Instead of quantifying the effects on economic growth and productivity of all the major causal factors, some researchers are concerned primarily with analyzing the effects of selected variables on productivity change. These authors have studied in depth the productivity effects of one or a few variables. For example, in view of the importance of R&D as a fountainhead of technological progress, Terleckyj (1980) decomposes direct and indirect effects of industrial R&D on productivity growth. His study suggests a high degree of correlation between the education level of the employees and the degree to which a firm invests in R&D. At the same time, Nadiri and Bitros (1980) analyzed R&D and productivity growth at the firm level and found that firms' decisions regarding employment, capital accumulation, and R&D are closely related in a dynamic interaction process. They conclude that both labor productivity and tangible investment demand of firms are significantly affected by the R&D outlays, particularly over the long run.

Arrow (1962) postulated that technical change might come about by a learning process, through sequencing of production and investment activities, without any identifiable expenditure of resources or influence of relative prices. Nadiri (1970) indicates that the bias due to technical change and the substitution effect due to change in factor prices may not be identifiable and may offset each other. Hirsch (1956) shows that there is considerable delay in the adoption of new techniques by learning curve studies. That raises doubt on the validity of the implicit assumption of instantaneous adoption of new techniques. This indication is also supported by Atkinson and Stiglitz (1969). They point out that technical knowledge is often specific to a particular production process; therefore, technical progress may be localized in one technique with minimal spillovers to other techniques. The productivity of the technique that is selected is further increased through learning.

The significance of learning is generally discussed in three contexts in the literature. First, the endogenous theory of technical change in knowledge, proposed by Arrow, suggests learning as the underlying force driving the intertemporal shifts in production. Second, the concept of learning is expressed in terms of improved knowledge regarding new technologies. Third, the new economics of growth literature offers an alternative view of endogenously generated long-run growth. For example, Lucas (1988) and Rome (1990) implicitly allow the prospect of knowledge generating long-term growth without relying on exogenous changes in technology or population. However, endogenous theory has not been widely used in empirical applications. This may be because the theory itself has not been completely finalized or widely understood and/or because of the need for highly complex modeling.

Recently, literature on general purpose technology (GPT) shows a number of channels through which technology affects the economy such as secondary innovations and diffusion (David, 1991; Brenahan and Trajtenberg, 1995; Hornstein and Krusell, 1996; Greenwood and Yorukolgu, 1997; Aghion and Howitt, 1998; and Helpman, 1998). Beaudry and Green (1998) have argued that declines in wages of less educated workers relative to more educated workers was mainly due to skill-biased technological choice (choices between traditional and modern techniques of production where one is more skill intensive than the other) as opposed to skill-biased technical change. They show that the endogenous choice of production techniques, in response to changes in educational attainment, offers a potential explanation for the observed movements in wages and productivity. Particularly, they explain why (1) growth in wages of both skilled and unskilled workers was less than TFP growth, (2) the returns to education increased, and (3) an economy may appear to undergo massive transformations towards more productive means of production without that change generating large increases in measures of TFP. However, these concepts are not yet widely used because of estimation complexities and limitations due to a variety of assumptions involved.

Estimation Methods of Productivity

Index number approach

Along with the development of theoretical concepts, several approaches of productivity measurements are found in the literature. They include index numbers, econometric methods, accounting methods, and nonparametric methods. Each approach has its own use and relates to theoretical concepts in its own way of specification.

Among the index numbers, the most common and widely used are Divisa index (Divisa, 1925), Tornqvist index (Tornqvist, 1936), and Malmquist index (Malmquist, 1953). The Divisia index is a theoretical construct that can be applied to decompose a value change into the price and quantity components ($PQ = \sum p_i q_i$). This is the only framework by which variations in the value of a firm's output are accurately and totally made up from variations in the price and quantity components of inputs to the firm as long as homotheticity prevails (Jorgenson and Griliches, 1971; Hulten, 1973; and

Diewert, 1980). For that reason, the Divisa index is widely used and considered as an appropriate index number for productivity measurement.

The original Divisa index was constructed based on a continuous function of time where, as output changes through infinitesimal points in time, the weights of the index are automatically adjusted to ensure they reflect the firm's product mix. Therefore, it is the integral index where the curvilinear integral index requires price and quantity data for each infinitesimal point in time.

The chained index, instead of comparing between two periods, forms a series of links by comparing period 1 with period 0 to form a first link; then comparing period 2 with period 1 to form a second link and so on; until period T is compared with period T-1 to form the Tth link. Finally, to compare between period 0 and T, each link change is combined/chained through successive multiplication.

The chain based index has received much support as the natural discrete approximation to the Divisa integral (index) because it continuously adjusts its weights over infinitesimal points of continuous time. Moreover, It provides a system of productivity indices derived from a framework that, assuming homotheticity, allows the contribution of each input to be appropriately measured, and be combined to fully account for output changes. However, as noted by Silver (1984), Forsyth and Fowler (1981) and others, the problem is the choice of formula for the links of the index as the time interval of the links become larger, and the drift may occur under conditions of quantity oscillations.

Theil (1967) and Diewert (1976) show that the Tornqvist index is a theoretically and practically safe approximation of the Divisa integral index. Furthermore, Diewert

(1978) found that the Tornqvist index is an exact and superlative index number because it provides a second-order approximation to any underlying homogeneous of degree one function. Diewert (1980) also indicates that when price and quantity changes are small Tornquist (superlative) index gives virtually the same answer even if economic agents are not engaged in optimizing behavior. Chan and Mountain (1983) show how the Divisa or Tornqvist-Theil index of TFP could be modified to account for nonconstant returns to scale.

Caves et al. (1982) and others, using the Malmquist index, developed a productivity index composed of different measures of technical efficiency. Fare et al. (1992) and others defined a generalized Malmquist productivity index that combines a technical efficiency index with a technical change index. Chambers et al. (1991) provide a framework that relates indices composed of other technical efficiency indices to many well-known indices. Their argument is that the meaning of production efficiency is less precise and its influence on productivity less well understood.

Charnes (1978) and others introduced data envelopment analysis known as DEA as a way to establish a best practice frontier without imposing restrictions on production technology. The distance from a frontier calculated by DEA and one particular observation provides a measure of Farrell's technical efficiency (Farrell, 1958). Fare (1988) shows that this estimate of technical efficiency represents the inverse of the distance function. Chambers and others show that DEA can estimate each distance function used in the Malmquist index.

Recently, Fare et al. (1994) decomposed productivity growth into two mutually exclusive components: technical change and efficiency change over time. They calculated productivity change as the geometric mean of two Malmquist productivity indexes using output distance functions. The decomposition of the Malmquist productivity index allows us to identify the contributions of catching up in efficiency and innovation in technology to the TFP growth. Moreover, using a nonparametric linear programming technique, DEA takes account of all the inputs and outputs as well as differences in technology, capacity, competition, and demographics and then compares individuals with the best practice (efficiency) frontier.

Econometric approach

The conventional indices of total factor productivity (TFP), though easy to calculate, include not only the effect of technical change but also the effects of non-constant returns to scale. The residual TFP method assumes essentially constant returns to scale and Hicks neutral technical change. Moreover, a number of productivity indices are based on restrictive assumptions about the structure of technology and inadequate definitions of output. Basu (1995) and others note that, if the constant returns to scale assumption does not hold, the standard index measure of TFP would include the effects of scale as well as the efficiency effects of technological progress. The elasticity of cost with respect to output does not equal unity, which means cost increases less (more) than proportionately with increases in output, implying the existence of scale economies (diseconomies).

Capalbo (1988) argues against the growth accounting approach in calculating TFP index by compiling detailed accounts of inputs and outputs and aggregating them into input and output indexes. Only in the absence of technological advance will the growth in total output be explained in terms of the growth in total factor input (the neoclassical theory of production and distribution--competitive equilibrium and constant returns to scale imply that payments to factors exhaust total product). However, if there was technological advance, payments to factors would not exhaust all products, and there would remain a residual output not explained by total factor input.

Basu and others have shown that with the flexible functional forms, econometric estimation of production technology does not have to impose restrictive assumptions on returns to scale; thus it enriches information on the productivity performance of an industry. It also enables us to determine the extent to which technical change alters the optimal level and mix of inputs, which is the bias of technical change. Moreover, such estimation provides us with a test of separability, which can be used to check validity of the value-added specification of output. The cost function is preferable to the production function because it places no a priori restrictions on the production structure, it allows scale economies to vary with output, and estimation of the partial elasticities of substitution is direct and simple compared to the production function where estimation requires the matrix of production coefficients to be inverted which increases estimation errors (Binswanger, 1974). Furthermore, the cost minimization approach is more appropriate than profit maximization because firms usually have a better knowledge of their cost curve than the demand curve they face and hence they do not tend to adjust their output so often to maximize profits.

Several studies have taken advantage of the econometric approach to enrich the study of productivity. Noticeably, Berndt and Khaled (1979) estimate aggregate cost function models for the U.S. manufacturing sector that simultaneously identifies substitution elasticities, scale economies, and the rate of bias of technical change. Denny, Fuss and Waverman (1981) relax the competitive equilibrium assumptions for the output market and decompose the rate of productivity growth for a regulated sector into scale effects, nonmarginal cost pricing effects, and technological change. Bauer (1990) extended the decomposition of TFP growth of Ohta (1974) and Denny, Fuss, and Waverman (1981), among others, by showing how changes in cost efficiency over time also affects TFP growth. TFP growth is decomposed into various components, roughly stemming from changes in returns to scale, cost efficiency, and technological progress. He showed both production and cost function approaches where TFP growth can be derived, using Farrel's output and input based measures of technical and cost efficiency, to decompose into technical efficiency, technological progress, and the input-specific returns to scale and cost inefficiency. Sickles (1985) utilized a structural model in which technical change was further decomposed into factor specific contributions of capital, labor, energy, and materials. Other studies introduce markup to account for the effect of market structure on TFP growth.

Morison's (1997) cost function approach incorporates capital adjustment costs and embodies both technological and price changes to the U. S. food processing industry from 1965-1991. The generalized Leontif cost function is used to allow a full range of substitution among capital and noncapital inputs, nonneutral impacts of disembodied technical change, homogeneity of degree one in prices but not in output, and variable linear input demand equations. TFP growth is estimated using the standard Solow residual approach expanded to include sub-equilibrium of some of the inputs (quasi-fixity) by evaluating the shares of the quasi-fixed factors at their shadow values. This TFP separates the impacts of both scale and sub-equilibrium from technical change.

Clark and Youngblood (1992) employed time series in the analysis of factor share bias of Canadian agriculture and examined the stationary properties of the multiplicative errors from share equation estimations. They rejected the use of time trend as a proxy for technical change because of the existence of unit roots in all dependent and independent variables. Lambert and Shonkwiler (1995) point out two problems with using time trend as a proxy for technological change: (1) it provides little added information, and (2) it introduces the unit root problem that leads to spurious results. They propose the augmentation parameters of the state of technology with the stochastic trend model (Harvey, 1991) where the state of technology variable is estimated simultaneously with the parameters of the share equations.

Nadiri and Kim (1996) argue that TFP growth is an appropriate measure of technical change under perfect competition in input and output markets, constant returns to scale technology, and the instantaneous adjustment of factors (i.e. all factors are variable and utilized at a constant rate). In contrast to traditional measures of TFP growth, their approach allows the degree of mark-up, the adjustment cost, and the degree of economies of scale to be estimated. Therefore, the traditional TFP growth is decomposed into bias ascribed to violation of assumptions and to contribution of pure technical change (i.e. a shift in production frontier itself). Their TFP growth is decomposed into five components: scale, disequilibrium, R&D, pure technical change, and mark-up. They also decompose labor productivity growth into material growth, physical capital stock, R&D capital stock, autonomous technical change, and the degree of scale.

Nonparametric approach

The econometric approach, with its advantages, suffers from (i) specification of a production technology (specific functional form of the production function is assumed) and the restrictions of parameters, and (ii) the absence of influences of production efficiency on productivity. Charnes (1978) and others introduced data envelopment analysis (DEA) as a way to avoid imposing restrictions on production technology and to provide a measure of Farrell's technical efficiency. Fare (1988) shows that this estimate of technical efficiency represents the inverse of the distance function. Charmbers, Fare, and Grosskopf (1991) show that DEA can estimate each distance function used in the Malmquist index.

The key feature to DEA is that the reference technology levels for each input and output are defined by a linear combination of sample observations on each input and a linear combination of sample observations on each output. DEA, with a mathematical programming approach, does not require any assumptions about functional form, and the efficiency of a decision making unit is measured relative to all other decision making units with the simple restriction that all decision making units lie on or below the efficiency frontier (Seiford and Thrall, 1990).

Recently, Fare et al. (1994) developed the generalized Malmquist index, which is constructed using the DEA approach, to measure contributions from progress in technology and improvement in technical efficiency to the growth of productivity. Several studies have used this approach to decompose TFP growth into technical progress (a shift in technology), technical efficiency (ability to obtain the maximum possible output from a given set of inputs), and allocation efficiency (ability to maximize profits by comparing the marginal revenue of product with the marginal cost of inputs).

Application in Food and Kindred Products Sector

Bateman (1970) used simple correlation to examine the relationships among labor productivity, output, and concentration ratio in the food processing industry. Using census data for 1954, 1958, and 1963, he found labor productivity has a negative correlation with unit cost of labor, materials price, gross margin cost, but a positive correlation with concentration ratio (output per establishment) and earnings per employee. He concluded that concentration was an alternative to growth as a means of raising productivity.

Gisser (1982) used the conventional Solow residual to investigate the linkage between factor productivity and concentration. Using four-digit SIC level data from 1963-72 for selected large establishments of food processing, he found an increase in concentration is associated with an increase in factor productivity. He also found that the increase in TFP linked to concentration changes is roughly sufficient to offset the entire loss to consumers. He concluded that, with the presence of economies of scale and a positive relation between TFP and concentration, any attempt to restructure the industry deprives society of the apparent benefits of concentration and reduces the extent to which economies of scale can be exploited.

Ball and Chambers (1982) used cost system equations to study structural characteristics of the meat processing industry over the period 1954-76. The translog cost function, with five inputs (capital equipment, capital structure, labor, materials, and energy) and time as an indication of technical change, was used to allow for variable elasticities of scale and substitution and neutral, as well as factor-using, technical change. They found increasing returns to scale in the meat processing industry and a potential noncompetitive behavior. Biased technical change was found with labor saving and materials using. Apparently, they found the rate of technical change was negative--an increasing average cost from technical change. This might be due to large structural changes in plant organization while the industry failed to grow into the adoption of new technology. Another reason they suggest is that some firms overestimated the growth in demand for their products. As technology advances, higher labor prices contribute to greater cost reduction if the firm adopts new technology with labor saving. An increase in the level of production has a positive effect on the rate of technical progress. However, an increase in the price of materials has a depressing effect on scale and productivity.

Heien (1983) used the Theil-Tornqvist index to measure productivity at the processing and distribution level of food processing for the period 1950-1977. The annual growth rate of TFP was found to be 0.007% for the entire period. However, from 1950-72 the growth rate was 0.074% per year and from 1973-1977 the growth rate was negative (-0.42% per year). A rapid growth in labor inputs (0.92% per year) occurred due to substantial increases in energy costs and farm prices, and a high degree of substitutability between labor and energy. Relatively fixed inputs and little fluctuation with output, especially for labor (labor hoarding), caused the small growth of productivity.

Lee (1988) used simultaneous equations to explain labor market phenomena (wages, employment, and labor productivity) and food prices at manufacturing and retail levels of the U. S. food industry. Using quarterly data for the period of 1960-82 and assuming product market equilibrium (supply equals demand at the manufacturing level), he defines labor productivity as the ratio of output to labor demand. He found that declining labor productivity was caused by commodity price increases that affected food demand and supply, relative input costs, and factor substitution. Increases in energy price and wage rates were found to be significant in determining food prices both in the short and long run.

Huang (1991) used Allen and Morishima elasticities of substitution (AES and MES), computed from parameters of the translog cost function, to analyze the demand for labor, capital, and energy for the two-digit SIC level of food processing industry from 1971-1986. Both AES and MES indicate a strong substitution of labor for capital due to the steady increase in the price ratio between labor and capital since 1982. This evidence supports the fact that labor input has declined about 11% (1972-1986) while capital input has increased about 63% from 1972-1984. This result is further evidenced by a significant reduction in cost share of labor compared to capital despite the relatively higher wages compared to capital price. On the other hand, the elasticity of substitution energy for labor indicates that a marginal increase in the energy price causes an increase in the cost share of energy relative to labor.

Adelaja (1992) specified a translog production function to construct factor input's productivity growth rate, which is equivalent to the Tornqvist index. Using New Jersey's food manufacturing sector (1964-1984) as a case study, he focused on materials productivity to investigate the potential gains from efficiency use of materials. At the aggregate level, materials productivity growth was at 21% between 1964-1984. Materials productivity also grew in all subsectors (meat products, grain milling, and bakery products) except beverages. This resulted from the increase in price of materials (211% between 1964-84) and output while the quantity of materials fell by 36%. Material saving technology was encouraged by rising material prices and wages, and by declining food prices. However, individual subsectors differed in their ability to substitute inputs and to implement material saving technologies. Therefore, material productivity growth was not homogenous across subsectors.

Goodwin and Brester (1995) utilized multivariate gradual swictching regression techniques and Bayesian inferential procedures to evaluate structural change in factor demand relationships in the food manufacturing industry for quarterly data from 1972-1990. They found that structural change decreased the elasticity of demand for labor, and increased elasticities of demand for materials, capital and energy that is consistent with technological changes allowing for greater input substitutability. A significant fall in labor demand with an increase in cost share of capital was also found due to an increase in the labor/capital and labor/materials price ratios.

Gopinath, Roe and Shane (1996), using sectoral gross domestic product (GDP), considered an economy comprised of primary agriculture, food processing, and nonagriculture, to derive indexes of real prices, output, input, and TFP effects on growth using the NBER productivity data base from 1959 to 1991. They found the food processing sector's GDP was negatively effected by a decline in real output prices, but growth in inputs tended to more than offset the price decline. TFP growth rate was small with a declining trend (0.8% in 1959 to 0.3% in 1991). Efficiency gains in primary agriculture were transferred to the food processing sector in the form of cheaper inputs, and in turn, efficiency gains in the food processing sector were transferred back to primary agriculture by increasing derived demand. They also found that the food processing sector is employing a declining share of the economy's resources, and thus, the sector's domestic competitiveness is declining.

Morrison (1997) used a cost-based production theory model to evaluate investment motivations for three capital components (office and information technology equipment, other equipment, and structures), to investigate the impacts of capital quasi-fixity on other capital and noncapital inputs, and to observe productivity growth accompanying changing input patterns in the U. S. food processing sector. Applying generalized Leontief variable cost and total cost functions with quasi-fixed inputs (office and information technology) and incorporating net investment to allow for adjustment cost in the two-digit data from 1965-1991, she found capital investment or fixity has fairly small impacts on multiproductivity growth due to its small cost share and rapid adjustment. On the other hand, material is a driving force for multiproductivity due to its large cost share, declining relative price, and the existence of materials-using scale bias.

Amera (1998) used translog cost function with augmented factor prices to determine R&D spillover effects from agriculture to food processing and to measure rates of return to R&D investment in food processing. He also evaluated economic development impacts of increased efficiency in the food processing sector for Oklahoma using regional computable general equilibrium methods. He found technological change material saving and labor and capital neutral. Spillovers from agriculture R&D

investment to food processing have been labor and capital using and material saving. Private rate of return to R&D investment in food processing was 11.6% over the sample period (1958-94). He concluded that increased efficiency in food processing would raise wage rate, increase labor and capital in-migration, and thus increased gross state product, employment and household income, particularly for median income groups.

CHAPTER III

METHODOLOGY

Model Construction

Technological Change, R&D, and Labor Productivity at the Two Digit Level

Model specification

The focus of this part is to investigate the role of labor composition (by education level) and R&D capital in increasing output and labor productivity. Specifically, the study of this part proposes to (1) examine the production structure, technology behavior, and patterns of substitution among factor inputs; (2) evaluate the impact of R&D and autonomous technological change on factor inputs, particularly labor composition; and (3) determine the sources of output and labor productivity growth at the two digit level of the food processing sector (SIC20). Long run production technology is expressed as

$$Y = F(H, C, K, M, R, T) \tag{1}$$

where Y is gross output, H is high school and below high school labor, C is some college and college degree labor, K is physical capital stock, M is material plus energy, R is R&D capital stock, and T is autonomous technological change, respectively. Dual to this production function is a total cost function that describes the firm's production technology.

The cost function framework allows the analysis to be expressed in the context of cost effectiveness and thus in terms of decisions about input use and mix that are consistent with the lowest cost method of production. This structure allows more specific analysis of responsiveness to technology and factor intensities than is possible using single equation regression models based on a production function. In the model specification below, because input demand behavior is embodied in the form of a cost function, it allows a more detailed evaluation of input demand and composition for any set of economic circumstances facing the firm, and thus explicitly represents the responsiveness to changes in these circumstances.

To analyze the sources of growth of productivity and output, and to estimate the contributions of factor inputs and R&D capital stock to growth of labor productivity, a variable cost function with R&D capital stock as quasi-fixed is assumed to be adequately represented by a second-order (translog) approximation expressible as:

$$ln\, G = ln\alpha_0 + \Sigma_i\alpha_i\, lnP^*_i + \tfrac{1}{2}\Sigma_i\, \Sigma_j\alpha_{ij}\, lnP^*_i\, lnP^*_j + \alpha_R\, lnR \;+ \tfrac{1}{2}\alpha_{RR}\, (lnR)^2$$

$$\Sigma_i\alpha_{iR}\, lnP^*_i\, lnR \;+ \alpha_Y\, lnY + \tfrac{1}{2}\alpha_{YY}\, (lnY)^2 + \Sigma_i\alpha_{iY}\, lnP^*_i\, lnY, \qquad (2)$$

where G is total average cost; $i, j = H, C, K, M$; and P^*_i are the augmented prices which are defined as follows:

$$P^*_i = e^{\eta_i T} P_i. \qquad (3)$$

where η_i is the rate of factor price diminution. Following Sickles (1985), Nadiri and Kim (1996), and others, let

$$\Sigma_i\alpha_i\eta_i = \gamma_T,\ \Sigma_i\alpha_{iY}\eta_i = \gamma_{YT},\ \Sigma_i\alpha_{iR}\eta_i = \gamma_{RT},\ \Sigma_i\alpha_{ji}\eta_i = \gamma_{jT}\,;\ \forall\, j, \text{ and } \Sigma_i\alpha_{iT}\eta_i = \gamma_{TT}, \qquad (4)$$

then, substituting (3) and (4) into (2), we obtain an estimable variable cost function:

$$lnG = \alpha_o + \alpha_Y lnY + ½\alpha_{YY} (lnY)^2 + \Sigma_i\alpha_{iY} lnP_i lnY + \gamma_{YT} T lnY + \alpha_R lnR$$
$$+ ½\alpha_{RR} (lnR)^2 + \Sigma_i\alpha_{iR} lnP^*_i lnR + \gamma_{RT} T lnR + \Sigma_i\alpha_i lnP_i + ½\Sigma_i\alpha_{ij} lnP_i lnP_j$$
$$+ \Sigma_i\gamma_{iT} T lnP_i + \gamma_T T + ½ \gamma_{TT} T^2. \quad (5)$$

The conditions insuring that G is linearly homogenous in input prices are:

$\Sigma_i\alpha_i = 1$, and $\Sigma_i\alpha_{ij} = \Sigma_i\alpha_{iY} = \Sigma_i\alpha_{iR} = \Sigma_i\gamma_{iT} = 0$.

Production techechnology is characterized in equation (5) by constant returns to scale if $\alpha_{iY} = \alpha_{YY} = 0$ and $\alpha_Y = 1$. Expression (5) is consistent with a homothetic technology if $\gamma_{YT} = 0$ and $\alpha_{iY} = 0$ for all i. Technical change is neutral if $\gamma_{iT} = 0$ for all i. For input i, technical change is input-saving, input-neutral, or input-using as γ_{iT} is less than, equal to, or greater than zero, respectively.

Applying Shepard's lemma to (5), we obtain the factor cost shares or conditional factor demands:

$$S_i = \alpha_i + \alpha_{iY} lnY + \alpha_{iR} lnR + \Sigma_i\alpha_{ij} lnP_j + \gamma_{iT} T, \quad (6)$$

where α_{iY}, α_{iR}, α_{ij}, and γ_{iT}, are the specific (direct) effects of output, R&D, factor inputs, and autonomous technical change on factor cost shares. The effect of factor productivity change or of changes in the prices of inputs measured in efficiency units on total variable cost is:

$$\partial lnG / \partial T = \varepsilon_{GT}$$
$$= \gamma_T + \gamma_{YT} lnY + \gamma_{RT} lnR + \Sigma_i\gamma_{iT} lnP_i + \gamma_{TT} T, \quad (7)$$

where γ_T and γ_{TT} are the neutral (unbiased) technical change parameters which shift the cost function but leave the cost shares unchanged. γ_{iT} are the biased technical change parameters, which alter the equilibrium cost shares. γ_{YT} is the scale augmenting technical change parameter. γ_{RT} is the adjustment cost augmenting technical change parameter.

Thus, ε_{GT}, the rate of technical change, is decomposed into (i) neutral (pure) technical change, (ii) biased (augmented price) technical change, (iii) scale augmenting technical change, and (iv) adjustment cost augmenting technical change.

It is important to notice that γ_T is the total of individual factor price diminutions ($\Sigma_i\alpha_i\eta_i = \gamma_T$), γ_{TT} is the total of individual factor price diminutions adjusted by the augmented technical change ($\Sigma_i\alpha_{iT}\eta_i = \gamma_{TT}$), and γ_{iT} is the total factor price diminutions adjusted by the factor biases ($\Sigma_i\alpha_{ji}\eta_i = \dot{\gamma}_{jT}$, embodied or disembodied technical change). Therefore, by using (4), (6) and (7), the rate of total cost change is the sum of the change in price of inputs measured in efficiency units weighted by input cost shares and can be written as:

$$\partial \ln G/\partial T = \varepsilon_{GT} = -\Sigma_i S_i\eta_i. \tag{8}$$

Technological progress and total factor productivity

To disentangle the contribution of each input to TFP growth we allow productivity growth for specific factors to occur at rates that, although constant, differ among factors. This formulation allows for a decomposition of productivity growth into a component identifying the pure shift of the production function unrelated to the level of factor use and a component identifying the gross scale effect due to changing factor utilization.

As noted by Morrison and Siegel (1998), Ohta's identity of primal rate of technical change equal to negative dual rate of technical change, $\varepsilon_{YT} = -\varepsilon_{GT,}$ ignores the presence of short run fixity, long run scale economy, and external factors. To allow technological change and scale to be represented independently on the cost side, the primal rate of technical change can be measured by computing the associated elasticities separately as:

$$\varepsilon_{YT} = -\varepsilon_{GT}(1 - \varepsilon_{GR}) / \varepsilon_{GY}. \tag{9}$$

This relation says that scale economies stems from differential cost and output changes causing the cost output relationship to vary. Furthermore, when factor fixity (R&D for the two digit and structural capital for the three digit) has adjusted fully, ($\varepsilon_{GR} = 0$), the dual productivity growth rate equals the negative primal rate multiplied by cost elasticity ($\varepsilon_{GT} = -\varepsilon_{YT}\,\varepsilon_{GY}$). Therefore, the primal rate of total factor productivity growth (technical progress in a constant returns case) can be defined as:

$$\begin{aligned} d\,lnY/dT &= -\varphi^{L}\,(\partial\, lnG/\partial T) \\ &= -\varphi^{L} \textstyle\sum_i S_i \eta_i, \end{aligned} \tag{10}$$

where φ^{L} is the long run scale economies defined later in equation (16). Thus, this equation expresses the rate of total factor productivity growth, $dlnY/dT$, as the negative of the scale-inflated rate of total cost diminution. Notice that in the case of constant returns to scale, the rate of growth of specific factor productivity is the negative of the rate of factor price diminution.

Capacity utilization and elasticities of substitution

As shown by Berndt and Christensen (1973), and Morrisson (1992), $1 - \varepsilon_{GR}$ is a convenient indicator of capacity utilization, expressible as

$$\kappa = 1 - \varepsilon_{GR} = (G + W_R R)/(G + P_R R), \tag{11}$$

in which $W_R = -\partial G/\partial R$ is the shadow price and P_R is the market price of the fixed factor (R&D for the two digit and structural capital for the three digit). Capital stock minimizes total cost when $W_R = P_R$; therefore, it equals unity, so $\varepsilon_{CT} = -\varepsilon_{YT}$ under long run constant returns.

The Allen partial elasticity of substitution (AES) and Morishima elasticity of substitution (MES) between two factors i and j, σ_{ij}, and the output compensated own and cross-price elasticities of factor demand, ε_{ii} and ε_{ij}, can be computed directly from the translog cost function in the following manner:

$$\sigma_{ii} = 1/S_i^2 (\alpha_{ii} + S_i^2 - S_i), \text{ for all i,}$$
$$\sigma_{ij} = \alpha_{ij} / S_i S_j + 1, \text{ for all } i \neq j. \tag{12}$$

$$\varepsilon_{ii} = \alpha_{ii} / S_i + S_i - 1 = \sigma_{ii} S_i, \text{ for all i,}$$
$$\varepsilon_{ij} = \alpha_{ij} / S_i + S_j = \sigma_{ij} S_j, \text{ for all } i \neq j. \tag{13}$$

$$MES_{ij} = (\alpha_{ij} + S_i S_j) / S_j - (\alpha_{ii} + S_i^2 - S_i) / S_i, \text{ for } i \neq j,$$
$$\text{or} \quad = \varepsilon_{ij} - \varepsilon_{jj} \tag{14}$$

Morishima elasticity of substitution (*MES*) measures the percentage change in the ratio of a pair of factors in response to a change in their relative prices. As pointed out by Ball and Chambers (1982), Blackorby and Russell (1989), and Huang (1991) the MES, in general, are better than the AES in representing factor substitution relationships. MES has capability to explicitly explain the adjustment of factor combinations in response to relative price changes, and can provide complete comparative static information about relative factor cost shares in response to a change in factor prices.

Economies of scale and mark-up

The output elasticity, obtained by the expression $\partial lnG/\partial lnY = \varepsilon_{GY}$, allows the calculation of the short run returns to scale as:

$$\varphi^{S} = 1/\varepsilon_{GY}. \tag{15}$$

Then, the long run returns to scale is calculated by:

$$\varphi^{L} = (1 - \varepsilon_{GR})/\varepsilon_{GY}, \tag{16}$$

where ε_{GY}, and ε_{GR} are output elasticity and the variable cost share of R&D capital stock, respectively, which are obtainable as:

$$\varepsilon_{GY} = \partial\, lnG/\partial\, lnY$$
$$= \alpha_{Y} + \alpha_{YY}\, lnY + \Sigma_i\alpha_{iY}\, lnP_i + \gamma_{YT}\, T, \tag{17}$$

and

$$\varepsilon_{GR} = \partial\, lnG/\partial\, lnR$$
$$= \alpha_{R} + \alpha_{RR}\, lnR + \Sigma_i\alpha_{iR}\, lnP_i + \gamma_{RT}\, T. \tag{18}$$

The degree of mark-up, π, is calculated as:

$$\pi = P_Y/AC, \tag{19}$$

where AC is the average cost.

Changes in factor demands

The impact of changes in technology and factor fixity (R&D) on factor demands, ε_{iT} and ε_{GR}, are the direct effects of technical change and R&D where output level is fixed. However, if we allow output level to vary (changes in the level of technology and or factor fixity induces changes in the level of output, which in turn induces indirect effects on demand of variable inputs and total variable cost) then the elasticities of variable factor demands and variable cost with respect to technical change and R&D capital should be modified to include the indirect effect due to changes in output. Following Nadiri and Kim (1996), these elasticities can be calculated as:

$$\varepsilon_{iT} = \varepsilon_{GT} + (1/S_i)\gamma_{iT},$$
$$\varepsilon_{iR} = \varepsilon_{GR} + (1/S_i)\alpha_{iR}, \tag{20}$$

and

$$\varepsilon_{iT|Y free} = \varepsilon_{iT} + \varepsilon_{YT}\,[\varepsilon_{GY} + (1/S_i)\alpha_{iY}],$$
$$\varepsilon_{iR|Y free} = \varepsilon_{iR} + \varepsilon_{YR}\,[\varepsilon_{GY} + (1/S_i)\alpha_{iY}], \tag{21}$$

where α_{iY}, α_{iR}, and γ_{iT} are parameters which can be retrieved from the structural parameter estimates of the restricted cost function using standard duality theory. ε_{GT}, ε_{GY}, and ε_{GR} are cost elasticities which can be calculated from equations (7), (17), and (18), respectively. ε_{YT} and ε_{YR} are the output elasticities which can be estimated from equation (9).

Output and Labor Productivity Growth

Quality improvements and adjustment cost affect the rate of factor accumulation, and thereby, output and productivity growth. Increasing factor quality raises the value of marginal product, while adjustment costs increase marginal input costs.

Output growth

The production function given in (1) can be written in logarithm with factors augmented as:

$$lnY = F\,[lnH, lnC, ln K, lnM, lnR, T] \tag{22}$$

Assume the production function takes the translog form, then applying quadratic lemma (see Diewert (1976), Denny and Fuss (1983), and Nadiri and Kim (1996)) yields:

$$\Delta lnY(t) = \tfrac{1}{2}\Sigma_i [\varepsilon_{Yi}(t) + \varepsilon_{Yi}(t-1)]\Delta lnX_i(t) + \tfrac{1}{2}[\varepsilon_{YR}(t) + \varepsilon_{YR}(t-1)]\Delta lnR(t) + \tfrac{1}{2}\Sigma [\varepsilon_{YT}(t) + \varepsilon_{YT}(t-1)] \quad (23)$$

where the X_i are variable inputs, and ε_{Yi} and ε_{YR} are output elasticities, which can be calculated by multiplying mark-up with the factor cost shares to total revenue (R_i)[1]. ε_{YT} is the primal measure of technical change, $\partial lnY/\partial T$, which can be calculated from equation (10).

Labor productivity growth

The change in labor productivity can be decomposed into factor intensity effect associated with adjustment of factor inputs, technological change effect, and economies of scale effect as:

$$\Delta ln(Y/L) = \tfrac{1}{2}\Sigma [\varepsilon_{Yi}(t) + \varepsilon_{Yi}(t-1)]\Delta ln(X_i/L) + \tfrac{1}{2}[\varepsilon_{YR}(t) + \varepsilon_{YR}(t-1)]\Delta ln(R/L) + \tfrac{1}{2}\Sigma [\varepsilon_{YT}(t) + \varepsilon_{YT}(t-1)] \quad (24)$$

Technological Change and Total Factor Productivity at the Three Digit Level

Model Specification

The focus of this part is to (1) empirically analyze the production structure of food processing industries at the three digit SIC level. Particular attention is on technological

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[1] $\in_{Yi} = (\partial Y/\partial X_i)(X_i)/Y = \pi [P_i X_i/P_Y Y] = \pi R_i$, see Basu and Fernald (1994) for further details.

behavior, pattern of substitution among factor inputs, and the degree to which the industry production function is characterized by economies of scale. (2) Examine the effect of technical change and structural capital fixity on total variable cost across three digit industries. The concerns are not only the rate of technical change but also the extent to which it alters the optimal level and mix of inputs, that is, the inducement effect and factor price effect. (3) Explore the interrelationships between scale economies, marginal cost pricing internal to the food processing industries, and external technical change in determining the rate of total factor productivity growth. Specifically, we decompose the growth of TFP into direct technical change (independent of elasticity of product demand), indirect technical change (dependent on elasticity of product demand), factor prices effect, exogenous demand effect, and net scale effect.

To understand the structure of the food processing industries, and to properly estimate the rate of technical change and TFP in each of these industries, an econometric model with translog cost function is used as in the two digit model but with different sets of inputs. These inputs are: production labor (*P*), non-production labor (*N*), material plus energy (*M*), equipment capital (E), and a quasi-fixed structural capital (*S*). Output is measured by gross output (*Y*).

Using the parameter estimates from the models, we estimate the degree of economies of scale, substitution among inputs, the adjustment cost associated with the quasi-fixed factor, and the degree of mark-up as in the two digit model. However, to gain a greater understanding of production structure and technical change behavior at the sub-industry level, this part takes one step further in the decomposing of total factor productivity by accounting for the factor inducement effect and the factor price effect.

Specifically, total factor productivity growth is decomposed into exogenous demand effect, changes in real factor price effect, indirect technical change effect, and direct technical change effect as described below.

Decomposing of TFP

Consider the production function defined over input X_i and the level of technology T (need not be identified as time),

$$Y = F(X_i, T). \tag{25}$$

Differentiating (25) with respect to time and dividing by Y, we have:

$$\overset{\circ}{Y} = \Sigma_i \left(\frac{\partial F}{\partial X_i}\frac{X_i}{Y}\right) \overset{\circ}{X}_i + \overset{\circ}{T}, \tag{26}$$

where the dot represents percentage growth rate. The cost minimization implies, $\partial F/\partial X_i = P_i/(\partial C/\partial Y)$, thus (26) can be written as:

$$\overset{\circ}{Y} = \frac{P_Y}{\partial C / \partial Y} \Sigma_i \frac{P_i X_i}{P_Y Y} \overset{\circ}{X}_i + \overset{\circ}{T}. \tag{27}$$

TFP growth rate is defined as:

$$\overset{\circ}{TFP} = \overset{\circ}{Y} - \Sigma_i \frac{P_i X_i}{P_Y Y} \overset{\circ}{X}_i, \tag{28}$$

then, substituting (27) into (28) and rearranging the terms, we have:

$$\overset{\circ}{TFP} = -\left(1 - \frac{P_Y}{\partial C / \partial Y}\right) \overset{\circ}{F} + \overset{\circ}{T}, \tag{29}$$

where $\overset{\circ}{F} = \Sigma_i \frac{P_i X_i}{C} \overset{\circ}{X}_i = \Sigma_i S_i \overset{\circ}{X}_i$.

To account for scale economies and output market structure, define output elasticity as $\varepsilon_{CY} = (\partial C/\partial Y)\ Y/C$ and use the mark-up, π, from (19), then (29) can be written as:

$$\overset{\circ}{TFP} = -\left(1 - \pi\, \varepsilon_{CY}^{-1}\right) \overset{\circ}{F} + \overset{\circ}{T}, \tag{30}$$

where $\varepsilon_{CY}^{-1} = \varphi$, scale economies, thus (30) becomes:

$$\overset{\circ}{TFP} = \left(\pi\varphi - 1\right) \overset{\circ}{F} + \overset{\circ}{T} . \tag{31}$$

Notice that in equation (31), if output price is equal to average cost ($P_Y = AC$, then $\pi = 1$) and constant returns to scale prevails ($\varphi = 1$). Input changes have no effect on TFP growth, which means TFP growth is equal to technical progress.

Input Inducement Effects

The input inducement effect or the impact of technical change on factor inputs can be divided into two parts: (1) the extra inputs required by the cost minimization to produce additional output (an increase in technological progress leads to an inward shift of the average cost curve which requires an increase in equilibrium output) and (2) the reduction of inputs because input requirements per unit of output has declined (an increase in technological progress leads to an inward shift of the isoquant which reduces the input mix requirement).

To take account of shifts in technology on equilibrium output, Nadiri and Schankerman (1981) define the relationship of the change in output price, the rate of autonomous technical change, and output as:

$$\overset{\circ}{P}_Y = -\overset{\circ}{T} + (\varepsilon_{CY} - 1)\overset{\circ}{Y}. \tag{32}$$

This expression captures the effect of technology on equilibrium output and output price that comes about because of the direct effect due to the inward shift of the average cost curve from technical change and the output expansion effects of technology (see Fig. A1 in Appendix A).

However, the relationship between the growth of output demand and price or the effect of changes in price on product demand can be stated as (Good, Nadiri, and Sickles, 1996)

$$\overset{\circ}{Y} = -\varepsilon \overset{\circ}{P}, \tag{33}$$

where ε is the elasticity of product demand.

Thus, the relation between equilibrium output and technical change can be obtained by substituting (33) into (32):

$$\overset{\circ}{Y} = \phi \overset{\circ}{T}, \tag{34}$$

where $\phi = \varepsilon /[1-\varepsilon(1-\varepsilon_{cy})]$.

Therefore, the extra inputs required by the cost minimization to produce additional output is:

$$\varepsilon_{iy} \overset{\circ}{Y} = \varepsilon_{iy} \phi \overset{\circ}{T}. \tag{35}$$

The second part of the impact includes a neutral reduction in inputs ($\varepsilon_{iy} \overset{\circ}{T}$), and a factor biased reduction in inputs (B_i) (see Figure A2 in Appendix A). So the reduction in inputs due to both neutral and factor bias technical change is: $\varepsilon_{iy} \overset{\circ}{T} + B_i$. Finally, the total effect of technical change on inputs, X_i, is:

$$\overset{\circ}{X}_i = \varepsilon_{iy} \phi \overset{\circ}{T} - (\varepsilon_{iy} \overset{\circ}{T} + B_i), \text{ or}$$

$$= \varepsilon_{iy} (\phi - 1) \overset{\circ}{T} - B_i. \tag{36}$$

Therefore, the growth in total factor input that is induced by technical change can be obtained as:

$$\overset{\circ}{F}_T = \Sigma_i S_i \varepsilon_{iy} (\phi - 1)\overset{\circ}{T} - \Sigma_i S_i B_i, \tag{37}$$

since $\Sigma_i S_i \varepsilon_{iY} = \varepsilon_{CY}$ and $\Sigma_i S_i B_i = 0$ (by definition along a given isoquant). The aggregate input inducement effect of technical change is:

$$\overset{\circ}{F}_T = \varepsilon_{cy} (\phi - 1)\overset{\circ}{T}. \tag{38}$$

Notice that in equation (38), if demand is completely inelastic ($\varepsilon = 0$, then $\phi = 0$), then $\overset{\circ}{F}_T = \varepsilon_{cy}\overset{\circ}{T}$.

Let $\overset{\circ}{F'} = \overset{\circ}{F} - \overset{\circ}{F}_T$, the growth in total factor input that is not induced by technical change, then

$$\overset{\circ}{F} = \overset{\circ}{F'} + \overset{\circ}{F}_T. \tag{39}$$

Substituting (38) and (39) into (31), and after manipulation we have

$$\overset{\circ}{TFP} = (\pi\varphi - 1)\overset{\circ}{F'} + (\pi\varphi - 1)\varepsilon_{cy}(\phi - 1)\overset{\circ}{T} + \overset{\circ}{T}. \tag{40}$$

Factor Price Effects

By the same token in deriving (32) and (33), the change in equilibrium price of output and the expansion of equilibrium output are as follow:

$$\overset{\circ}{P} = \Sigma_i S_i \overset{\circ}{P}_i + (\varepsilon_{CY} - 1)\overset{\circ}{Y}, \text{ and} \tag{41}$$

$$\overset{\circ}{Y} = -\phi \Sigma_i S_i \overset{\circ}{P}_i. \tag{42}$$

Factor price changes have two effects on the use of an input: (i) pure output expansion due to the change in equilibrium level of output induced by the shift of the cost curve, and (ii) change in optimal input mix. Using (41) and (42), these effects can be specified as:

$$\mathring{X}_i = -\varepsilon_{iy}\phi \sum_j S_j \mathring{P}_j + \sum_j \varepsilon_{ij} \mathring{P}_j, \tag{43}$$

where ε_{ij} is the output compensated cross-price elasticity of demand for input i. Thus, the impact of changing factor prices on total factor input is:

$$\mathring{F}_f = -\phi \sum_i S_i \varepsilon_{iy} \sum_j S_j \mathring{P}_j + \sum_i \sum_j S_i \varepsilon_{ij} \mathring{P}_j, \text{ or}$$

$$= -\phi\, \varepsilon_{cy} \sum_j S_j \mathring{P}_j, \tag{44}$$

since $\sum_I S_i \varepsilon_{iy} = \varepsilon_{cy}$ and $\sum_i S_i \varepsilon_{ij} = 0$. [2]

Now we can decompose factor input growth into; (i) induced by technical change, (ii) factor price change, and (iii) exogenous shifts in demand:

$$\mathring{F} = \mathring{F}_T + \mathring{F}_f + \mathring{F}_d. \tag{45}$$

Substituting (44) and (45) into (40), and after rearrangement, we have TFP growth decomposed into exogenous demand effect, changes in real factor price effect, indirect technical change effect, and direct technical change effect:

$$\mathring{TFP} = (\pi\varphi - 1)\mathring{F}_d - (\pi - \varepsilon_{cy})\phi \sum_j S_j \mathring{P}_j + (\pi - \varepsilon_{cy})(\phi - 1)\mathring{T} + \mathring{T} \tag{46}$$

[2] $\Sigma_i S_i \varepsilon_{ij} = P_j / C\ \Sigma_i P_i\, \partial X_i/\partial P_j$, $\Sigma_i P_i\, \partial X_i/\partial P_j = 0$ and $\Sigma_i P_i\, \partial X_i/\partial P_j = (\partial C/\partial Y)\Sigma_i (\partial F/\partial X_i)(\partial X_i/\partial P_j) = 0$

Estimation Procedures

There are two reasons for choosing the translog over other functional forms: (1) the parsimonious parameterization of productivity growth with the translog, and (2) the returns to scale and elasticities of substitution are estimated quite well by the translog when the underlying technology is relatively simple (Guilkey, Lovell and Sickles, 1983). Specifically, cost elasticity, elasticity of substitution among inputs, price elasticity of product demand, and cost share of inputs are estimated from parameters obtained from the cost system of equations.

Estimation of the cost share equations, (6), is not sufficient since the parameters determining the elasticity of scale (α_Y, α_{YY}, and γ_{YT}) and technical change (γ_T and γ_{TT}) only appear in the cost function, (5). Thus, additive disturbances are assumed for each share equation and the cost function. The parameters are estimated using seemingly unrelated regression estimation (SURE) on cost system equations (equations 5 and 6). Linear homogeneity in prices ($\Sigma\alpha_{ij}= 0$, $\Sigma\alpha_{iY}= 0$, $\Sigma\alpha_{iR}= 0$, and $\Sigma\gamma_{iT}= 0$), symmetry ($\alpha_{ij}= \alpha_{ji}$), adding up ($\alpha_i = 1$), and cross equation restrictions are imposed. The two common problems, serial and contemporaneous correlation, are tested and corrected which is described in the results section.

The system equation models were estimated for each industry using time series data for 1958-1994 period. The two digit level for the food and kindred products industry (SIC 20) was estimated for part I analysis and the three digit level (meat products (SIC201); dairy products (SIC202); preserved fruits and vegetables (SIC203); grain mill products (SIC204); bakery products (SIC205); sugar and confectionary products (SIC206); fats and oils (SIC207), beverages (SIC208); and miscellaneous food and kindred products (SIC209) was estimated for part II analysis. Results and discussions are presented in Chapter IV.

Elasticities of substitution among factor inputs, cost elasticity, and output elasticity are calculated from parameters estimated from the cost system equations as described in the model specification section. These elasticities are used to analyze the production structure and to decompose productivity growth as described in the model construction section. Results are presented in Chapter IV. However, for the three digit industries, there are additional factors needed to decompose TFP growth into exogenous demand effect, changes in real factor price effect, indirect technical change effect, and direct technical change effect as specified in equation (46). Those additional factors are estimated as follow: (i) $\mathring{T}$ is computed as a residual from equation (31), (ii) $\mathring{F}_T$ and $\mathring{F}_f$ are computed from equations (38) and (39), and (iii) $\mathring{F}_d$ is computed as a residual from equation (45).

The Data

The data used in this study is from the National Bureau of Economic Research (NBER) called the Manufacturing Productivity (MP) database (Bartlesman and Gray, 1996). The advantages of using the MP database are that it contains annual information on 450 manufacturing industries from 1958 to 1994, adjusts for changes in industry definitions over time accordingly to the Standard Industrial Classification definition from the Census Bureau's Annual Survey of Manufactures (ASM) and Census of

Manufactures (CM), and links to additional key variables such as price indexes and capital stock.

However, for the two digit level, the two types of labor (high school and below high school and some college and college degree) are from the Bureau of Labor and Statistics (BLS) and the R&D expenditures are from the National Science Foundation (NSF). The BLS's data contains information on four different skills of labor input (no high school, with high school, some college, and college diploma) at the two digit SIC level only, which was provided to us personally by electronic mail (Rossenblum). Due to a large number of parameters and the limited time series data, the original four different education levels were aggregated into two types of labor as stated above.

Only the price of capital investment is available in the MP database, but not the price of capital stock. Following Nadiri and Kim (1996), the rental rate of capital stock is calculated as $P_K = P_I (r + \delta_K)$, where r is the real rate of return, δ_K is the depreciation rate of capital stock, and P_I is the price of capital investment. Moody's Aaa corporate bond rate is used for r. The depreciation rate of capital stock is calculated by dividing the gross book value of depreciable assets by the depreciation charges. The gross book value of depreciable assets and the depreciation charges are from the Annual Survey of Manufactures, industry series-expenditures and assets. However, this series is only available for 1977 to 1985, 1987, and 1992. To overcome this missing data series, the depreciation rate calculated for 1977-1985 was used to regress against the capital stock series and then the regression coefficient was used to generate depreciation rate for the missing years.

The data used in this study (NBER) is compared to two other data sources (BLS's data and Jorgenson's data) found in the literature. The NBER's data is selected over the others because it contains annual information on 450 manufacturing industries from 1958 to 1994, adjusts for changes in industry definitions over time accordingly to the Standard Industrial Classification definition from the Census Bureau's Annual Survey of Manufactures (ASM) and Census of Manufactures (CM), and links to additional key variables such as price indexes and capital stock and it is also consistent with Census's data. However, the trend of these three data series is very similar (see Table A1 in Appendix A).

CHAPTER IV

RESULTS AND DISCUSSION

Technological Change, R&D, and Labor Productivity at the Two Digit Level

Research has suggested that permanent structural change affecting pricing, productivity, scale economies, employment, and investment has occurred in the food processing industry (Huang (1991); Goodwin and Brester (1995); and others. This has important implications for competitive success for firms in the industry, improvements in overall industry efficiency, and for industry labor demand and composition. The later has important welfare effects for laborers in this large and important industry.

The common perception is that observed changes in productivity (costs), and labor composition is linked to technological change and increased R&D investment in this industry. Research indicates that technological change and R&D investment have changed capital investment behavior and have had an impact on stagnation of employment and wages in the industry. These input-specific issues underlie the question of how these impacts have affected costs, and therefore productivity. For example, Nadiri and Kim (1996) show that conventional measures of total factor productivity growth fail to capture the total contribution of technical change and R&D capital on output growth.

The focus of this part of the research is to investigate the significant growth in labor productivity, the substantial reduction in labor demand and it's cost share, the changing role of labor composition, and gains in labor use efficiency. Specifically, the research proposes to (1) examine production structure, technology behavior, and patterns of substitution among factor inputs; (2) evaluate the impact of technological change and R&D on factor inputs, particularly, labor composition; and (3) determine the sources of output growth and labor productivity.

As described in the methodology chapter, to investigate whether technical change or resource investment has been the major promoter of output and productivity growth in the food and kindred products industry and to properly estimate the rate of technical change and TFP, an econometric model is used with a translog cost function that includes inputs of high school and below high school labor (*H*), some college and college degree labor (*C*), materials plus energy (*M*), physical capital (*K*), and quasi-fixed R&D capital (*R*). The output is measured by value of shipments (*Y*). Using the parameter estimates of the model, we estimate the degree of scale economies, substitution among inputs, and the adjustment cost associated with the quasi-fixed factors. The sources of output growth and labor productivity are identified.

Growth Rate of Output, Inputs, and Prices at the Two Digit Level

Annual output growth rate has declined for each period throughout the study period from 1958-94 (Table B1, Appendix B). From the first period (1958-69) to the last period (1987-94), annual growth rates of physical capital, material plus energy, and R&D capital have also declined, 3.18% to 1.40%; 2.28% to 1.61%; and 0.27% to –0.23%, respectively. There was a slight reduction in the annual growth rate of high school and below high school labor (-0.05% to –0.37%) but a significant increase in the annual growth rate of some college and college degree labor (-0.27% to 4.42%).

Average annual output price growth rate for the entire study period is 3.39% (Table B1, Appendix B). However, the growth rate has decreased from the second period (1969-78 is 7.17%) to the last period (1987-94 is 2.25%). Physical capital has the highest input price growth rate, 6.31% for the entire period. It also has a decreasing growth rate from the second period (9.54%) to the last period (2.13%). Materials plus energy, high school and below high school labor, and some college and college labor have about the same average annual price growth rate for the entire period (1958-94). Materials plus energy and high school and below high school labor follows the same trend of growth as output and capital prices (growth at a decreasing rate). Some college and college labor price growth rate seems to have a slower decrease and has the highest annual growth rate for the last period (1987-94).

Before considering effects of technical change, it appears that the declines in annual growth rate of output are associated with the decreases in annual growth rate of physical capital, material plus energy, and R&D capital. Moreover, the drastic decrease in annual output price growth rate from the second period might also explain the declines in annual output growth rate. The data also implies a structural change from reduction in capital and materials plus energy to an increase in labor, particularly labor with some college and college degree.

Empirical Results

A system of equations comprising the translog cost function and factor input cost shares (*H*, *C*, *K*, and *M*) was estimated using seemingly unrelated regression estimation in SAS as described in Chapter III. Because of the singular nature of the full system of share equations, the materials share equation was excluded. Variables are all in log form and there was no evidence of serial correlation after first differencing of the data. Contemporaneous correlation was also tested using omitted variables technique (OV version of the Hausman test) where the instrumental variables are the growth rates corresponding to the original variables (not the interaction terms) in the model. No strong evidence of contemporaneous correlation was found based on the conventional F-test and a critical value of 0.05.

Originally, the full model was estimated. However, most coefficients in the full model were not statistically significant. To overcome this problem, the square terms of output and fixed factor (R&D) were tested jointly before being imposed on the estimated cost function. The coefficients of the squared terms were not significantly different from zero based on conventional F-test and a critical value of 0.05. The significance level of most coefficients was improved substantially after excluding the squared terms. The sensitivity of excluding these squared terms was small relative to coefficient magnitudes and the signs were unaffected. The effects on estimated scale, elasticities of substitution, and productivity growth were negligible within sample levels of output and fixed factor.

Estimation results are reported in Tables 1.1 through 1.4. Table 1.1 gives the parameters estimated from the system equations model; Table 1.2 gives the cost elasticities of output, R&D, and autonomous technology; Table 1.3 gives the own and cross price elasticities of factor variable inputs; and Table 1.4 gives the Morishima elasticities of substitution. Most parameters are highly significant and their signs are as expected. The model fits the data quite well with an R-square of 0.98 for the cost function and a DW statistic of 1.83. R-squares for factor share equations are relatively low (0.32 for high school and below high school labor, 0.40 for some college and college degree labor, 0.49 for physical capital, and 0.72 for materials plus energy), however, low R-squares for the cost-share equations are normal for translog models (Denny and Fuss, 1977).

Production Structure and Technology Behavior

Two important points are noted in analyzing the production structure. First, for the translog cost function to adequately represent the underlying technology, the estimated cost function should be monotonically increasing and concave in factor prices over the range of observations. The restricted model estimates in Table 1.1 satisfy monotonicity at all sample points but concavity is violated for some years. However, the occasional failure of concavity does not preclude obtaining good parameter estimates, nor does it necessarily undermine the assumption of cost minimization (Wales, 1977). Secondly, homotheticity (inputs are normal and input ratios are independent of the level of output) and constant returns to scale are tested and indicate that homotheticity cannot be rejected but constant returns to scale is strongly rejected at the 0.05 critical value.

Autonomous technology behavior toward factor variable inputs can be inferred by the sign of the estimated parameters γ_{HT}, γ_{CT}, γ_{KT}, and γ_{MT}. A positive sign implies factor-using technology and a negative sign implies factor- saving technology toward the respective factor input. The parameter γ_{MT} in Table 1.1 implies that material plus energy is characterized as input-saving technology. The $\gamma_{MT} = -0.00011$ parameter (significantly different from zero at a probability level of 0.0001) implies that technology progresses such that less material and energy are required for the food processing industry. Physical capital ($\gamma_{KT} = -0.00009$) also has a negative sign but it is not significant at the 0.05 level. For high school and below high school labor ($\gamma_{HT} = 0.00014$) and some college and college labor ($\gamma_{CT} = 0.00005$) the signs are positive but not significant at 0.05 probability level. Therefore, technology can be described as being neutral toward physical capital and labor for the food processing industry.

These results appear reasonable when comparing the rate of growth in factor prices and relative size of factor shares. The rates of growth in price of materials plus energy and the price of labor are about equal (see Table B1 in Appendix B). However, the cost share of materials plus energy (59%) is more than five times the cost share for labor (10%) (see Table B2 in Appendix B). A greater cost saving can be achieved by adapting or investing in technologies that can reduce materials and energy relative to labor.

The negative sign on γ_{KT} may be questionable since generally high technology requires considerable capital investment. However, this result is confirmed by viewing the growth rate of both quantity and price of physical capital. The annual physical capital growth rate has declined, particularly from 1978 to 1994, with a price growth rate about two times that of other input prices (from 1969 to 1987) and its cost share (30%) is about

TABLE 1.1

PARAMETER ESTIMATES OF TRANSLOG COST FUNCTION WITH COST SHARE EQUATIONS FOR THE FOOD & KINDRED PRODUCTS SECTOR, 1958-94

Variable[1]	Parameter	Estimate	Std. Err.	P-value
Intercept	α_0	-0.07312	0.04090	0.1718
lnY	α_Y	0.26676	0.15482	0.1834
lnR	α_R	0.74756	0.14125	0.0132
$\ln P_H$	α_H	-0.00618	0.00166	0.0338
$\ln P_C$	α_C	-0.00123	0.00076	0.2050
$\ln P_K$	α_K	0.00321	0.00132	0.0922
$\ln P_M$	α_M	1.00419	0.00150	0.0001
$(\ln P_H)^2$	α_{HH}	-0.04303	0.01320	0.0471
$(\ln P_C)^2$	α_{CC}	-0.01076	0.00313	0.0412
$(\ln P_K)^2$	α_{KK}	0.00438	0.00749	0.5999
$(\ln P_M)^2$	α_{MM}	-0.08288	0.01117	0.0051
$\ln P_H \ln P_C$	α_{HC}	0.00277	0.00500	0.6187
$\ln P_H \ln P_K$	α_{HK}	-0.01471	0.00779	0.1555
$\ln P_H \ln P_M$	α_{HM}	0.05497	0.00993	0.0116
$\ln P_C \ln P_K$	α_{CK}	-0.00479	0.00344	0.2579
$\ln P_C \ln P_M$	α_{CM}	0.01278	0.00440	0.0623
$\ln P_K \ln P_M$	α_{KM}	0.01512	0.00676	0.1113
$\ln P_H \ln Y$	α_{HY}	0.07564	0.00813	0.0026
$\ln P_C \ln Y$	α_{CY}	0.01636	0.00340	0.0171
$\ln P_K \ln Y$	α_{KY}	-0.00684	0.00452	0.2269
$\ln P_M \ln Y$	α_{MY}	-0.08515	0.00760	0.0015
$\ln P_H \ln R$	α_{HR}	0.02320	0.01138	0.1342
$\ln P_C \ln R$	α_{CR}	0.00702	0.00534	0.2798
$\ln P_K \ln R$	α_{KR}	-0.00430	0.00904	0.6665
$\ln P_M \ln R$	α_{MR}	0.73575	0.10333	0.0057
$\ln P_H T$	γ_{HT}	0.00014	0.00007	0.1505
$\ln P_C T$	γ_{CT}	0.00005	0.00003	0.2064
$\ln P_K T$	γ_{KT}	-0.00009	0.00006	0.2404
$\ln P_M T$	γ_{MT}	-0.00011	0.00001	0.0001
lnY T	γ_{YT}	0.02034	0.00871	0.1016
lnR T	γ_{RT}	-0.02735	0.00538	0.0147
T	γ_T	-0.00866	0.00110	0.0042
T^2	γ_{TT}	0.00041	0.00005	0.0029

[1] Where Y, R, and T are output, fixed R&D capital, and autonomous technology; and P_H, P_C, P_K, and P_M are prices of variable factor inputs (H, C, K, and M).

half that of materials plus energy cost share (see Table B2, Appendix B). In addition, the parameter estimate is not statistically different from zero at 10 percent probability level.

The own price elasticities of factor inputs in Table 1.2 are normal (negative) and highly significant. The own price elasticities of high school and below high school labor and some college and college degree labor are greater than one in absolute value, -1.4637 and -1.3582, respectively. This suggests labor is price elastic. However, materials plus energy and physical capital are price inelastic, less than one in absolute value, -0.5565 and -0.6804, respectively. The positive values of the off-diagonal elements in Table 1.2 imply that the factors are substitutes. The substitutability between both labor groups and physical capital and between high school and below high school labor and some college and college degree labor are not statistically significant at the 0.05 critical values.

TABLE 1.2

OWN AND CROSS PRICE ELASTICITIES OF FOOD AND KIDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR 1958-94 PERIOD

Item	H	C	K	M
H	-1.4637	0.0628	0.1196	1.2787
	(0.1666)	(0.0631)	(0.0983)	(0.1253)
C	0.1786	-1.3582	0.1333	1.0438
	(0.1795)	(0.1123)	(0.1234)	(0.1579)
K	0.0311	0.0122	-0.6804	0.6347
	(0.0255)	(0.0113)	(0.0245)	(0.0222)
M	0.1732	0.0497	0.3311	-0.5565
	(0.0170)	(0.0075)	(0.0116)	(0.0195)

Note: Standard errors are reported in parentheses. Items are as follows: H, high school and below high school labor; C, some college and college degree labor; K, physical capital stock; and M, materials plus energy.

However, factor demand elasticity reflects the relative importance of that factor share in total cost which is not a good evaluation of substitution between factors.

The Morishima elasticities of substitution in Table 1.3 are more precise in the degree of substitutability among factor inputs because of the non-symmetrical responses of input ratios to factor price changes and they ignore the relative percentage input adjustments, which the Allen elasticities of substitution do not (Ball and Chambers, 1982). All Morishima elasticities of substitution reported in Table 1.3 are statistically significant at 0.05 critical values.

The Morishima elasticity of substitution between physical capital and some college and college degree labor is MES_{KC} = 1.3704 and the Morishima elasticity of substitution between some college and college degree labor and physical capital is MES_{CK} = 0.8138. This indicates that as the wage rate for some college and college degree labor increases, the physical capital to some college and college degree labor input ratio increases in percentage terms more than the ratio of some college and college degree labor to physical capital with an increase in the physical capital price. This is also true between physical capital and high school and below high school labor. Therefore, the degree of substituting capital for labor when wage rates rise is stronger than the degree of substituting labor for capital when capital price rises.

The relationship between materials plus energy and labor is the reverse of the result with physical capital, however, the difference in the degree of substitution is not as strong as in the case of capital (MES_{MC} = 1.4079 and MES_{CM} = 1.6003). That is, the degree of substituting labor for materials plus energy when materials plus energy price rises is stronger than the degree of substituting materials plus energy for labor when wage rate rises. The degree of substituting capital for materials plus energy when materials plus energy price rises is just slightly stronger than the degree of substituting materials plus energy for capital when capital price rises (MES_{MK} = 1.0115 and MES_{KM} = 1.1912).

TABLE 1.3

MORISHIMA ELASTICITIES OF SUBSTITUTION FOR THE FOOD AND KINDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR 1958-94 PERIOD

Item	H	C	K	M
H	0	1.4210	0.8001	1.8352
		(0.4188)	(0.3505)	(0.3798)
C	1.6422	0	0.8138	1.6003
	(0.4793)		(0.3846)	(0.4208)
K	1.4947	1.3704	0	1.1912
	(0.5147)	(0.4854)		(0.2032)
M	1.6369	1.4079	1.0115	0
	(0.5402)	(0.5198)	(0.2161)	

Note: Standard errors are reported in parentheses. Items are as follows: H, high school and below high school labor; C, some college and college degree labor; K, physical capital stock; and M, materials plus energy.

The ε_{CY}, ε^L_{CY}, ε_{CR}, and ε_{CT} measures presented in Table 1.4 represent different aspects of scale economies and elasticity of cost with respected to R&D and autonomous technological change. Scale economies are evident for both the short and long run. For the entire period (1958-94), output increases permit a 12% savings in total variable input costs (1- ε_{CY}) in the short run when R&D is fixed. This tendency toward unit cost savings is even stronger in the long run-- allowing more than 21% proportionate cost savings (1-ε^L_{CY}). However, looking at the mean of the entire period is somewhat misleading because for the last period (1987-94) the short run and the long run cost savings were only 5% and 14%, respectively.

TABLE 1.4

COST ELASTICITIES OF OUTPUT, R&D, AND TECHNICAL CHANGE FOR THE FOOD AND KIDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD

Period	ε_{CY}	ε^{L}_{CY}	ε_{CR}	ε_{CT}
1958-69	0.840	0.684	-0.229	0.118
1969-78	0.858	0.752	-0.141	0.121
1978-87	0.877	0.885	0.009	0.118
1987-94	0.947	0.864	-0.097	0.121
1958-94	**0.880**	**0.786**	**-0.120**	**0.120**

Note: ε_{CY}, ε^{L}_{CY}, ε_{CR}, and ε_{CT} are elasticities of scale; R&D; and technological change, respectively.

R&D had a significant cost reduction in the food processing industry over the total period 1958-94. A one percent increase in R&D expenditure allowed a 0.12 percent cost savings (ε_{CR}) for the period. However, the trend in cost saving from R&D is decreasing and even showed a dissaving in the 1978-87 period. This may be the result of more R&D investment in food safety with cost increasing rather than cost saving.

Apparently, the cost elasticity of autonomous technical change (ε_{CT}) was positive for every period. This indicates increasing average cost from autonomous technical change. It seems an implausible result. However, several reasons may support this finding. First, the food industry underwent substantial structural change as documented in the literature (Huang (1991); Goodwin and Brester (1995); and others). It is possible that the adaptation of the newer technologies is not yet reflected in the growth rates. Secondly, if the first reason is true, then the food processing industry has perhaps been operating in an unprofitable climate. This may also be reflected in the Census data which indicates a considerable decrease in the numbers of small establishments.

Change in Factor Demands

The impact of changes in autonomous technology and factor fixity (R&D) on factor demands (ε_{iT}, and ε_{iR}) are evaluated based on two sets of elasticities, one is derived when output is fixed and the other when output is allowed to vary. In the case of fixed output level, the estimated elasticities measure only the direct effects of autonomous technical change and R&D capital while for the other case, the elasticities measure the direct and indirect effect of changes in autonomous technology and R&D capital. The differences between the two elasticities are the indirect effects through output adjustment.

These elasticities are reported in Table 1.5. When output is fixed, a one percent increase in R&D capital induces a complementary increase of about 0.17%, 0.13%, and 1.13% in demand for high school and below high school labor, some college and college degree labor, and materials plus energy, respectively. The relationship with physical capital is substitutional (ε_{KR} = - 0.1345). This implies that a one percent increase in R&D capital decreases the demand for physical capital by 0.13%. Notice that in Table 1.4 a one percentage point increase in R&D capital shifts down the average variable cost by – 0.12 (1958-94).

When output is allowed to vary, the elasticities of high school and below high school labor, some college and college degree labor, and materials plus energy with respect to R&D are smaller compared to when output is fixed. This indicates that the induced output expansion effect of the increase in R&D capital is not sufficient to overcome possible substitution effects between R&D and other variable factors. As a result, the demand for high school and below high school labor, some college and college degree labor, and

TABLE 1.5

INPUT ELASTICITIES WITH RESPECT TO R&D AND AUTONOMOUS TECHNICAL CHANGE IN THE FOOD AND KIDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR 1958-94 PERIOD

	H	C	K	M
	When Output Level is Fixed			
ε_{iR}	0.1715	0.1309	-0.1345	1.1338
ε_{iT}	0.1213	0.1214	0.1192	0.1193
	When Output Level is Allowed to Vary			
ε_{iR}	0.0232	0.0070	-0.0043	0.7357
ε_{iT}	0.1189	0.1196	0.1182	0.1184

Note: H, C, K, and M are high school and below high school labor, some college and college degree labor, physical capital stock, and materials plus energy, respectively.

materials plus energy decreases when the output expansion effect is included in R&D capital increases.

For autonomous technical change, the magnitudes of the elasticities are comparatively smaller than the corresponding elasticities with respect to R&D, reflecting a more limited role played by autonomous technical change compared to R&D capital. However, the magnitude of elasticities of variable factors with respect to autonomous technical change decreases only slightly when output is allowed to vary. This indicates the induced output expansion effect of the increase in autonomous technical change is almost sufficient to offset any direct substitution effect between autonomous technical change and other variable factors. A further difference is the complementary effect of physical capital with autonomous technical change compared with the substitution effect of physical capital with R&D capital.

Sources of output and labor productivity growth

Output growth

Sources of output growth are presented in Table 1.6. The contribution of each variable from equation (25), Chapter III, is calculated as the product of the respective average growth rate per period weighted by the corresponding output elasticity (reported in Table B3, Appendix B). The most significant source of output growth was material plus energy. It was responsible for 27% of gross output in the U.S. food and kindred product sector from 1958 to 1994. The second major contribution to output growth was physical capital, which accounted for 18% of growth in gross output. In terms of the absolute size, their contributions were 0.63% and 0.42%, respectively, for material plus energy and physical capital from 1958-1994.

TABLE 1.6

SOURCES OF OUTPUT GROWTH FOR THE FOOD AND KIDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD (IN PERCENTAGE)

Period	Gross output	High school and below labor	Some college and college degree labor	Capital effect	Material Plus energy effect	R&D effect	Technical change	Residual
1958-69	3.00	-0.002	-0.002	0.267	0.400	0.001	-0.140	2.477
1969-78	2.45	0.003	0.064	0.405	0.663	0.001	-0.141	1.456
1978-87	2.05	-0.052	0.038	0.359	0.331	0.001	-0.001	1.509
1987-94	2.01	-0.022	0.485	0.453	0.939	-0.001	-0.001	0.284
1958-94	**2.33**	**-0.006**	**0.047**	**0.417**	**0.629**	**0.001**	**-0.001**	**1.379**

Note: For the entire period, the major relative contributions to output growth are as follow: some college and college degree 2%, physical capital 18%, material plus energy 27%. However, the last period (1987-94) the contributions are 24%, 23%, and 47%, respectively, for some college and college degree, physical capital, and material plus energy.

The contribution of labor input to output growth was relatively small, and for high school and below high school labor the contribution was negative. This is not an unexpected result because of the decrease in high school and below high school labor input throughout the study period (see Table B1 in Appendix B). However, some college and college degree labor proved a significant contribution to output growth. It was responsible for 2% of gross output with its small share of about 3% of the total factor inputs (Table B2 in Appendix B) for the entire period (1958-94).

However, looking at the mean of the entire period misinterprets the trend in the contribution of factor inputs to output growth. The contribution of all factor inputs (except high school and below high school labor) to output growth has increased over time, particularly, the contribution of some college and college degree labor which exceeded capital contribution for the last period (1987-94). For the last period, the contributions are 47%, 24%, and 23%, respectively, for material plus energy, some college and college degree labor, and physical capital.

The contribution of R&D to output growth was small (0.02% in relative terms for the entire period). However, with a small share (0.3%) and a small growth rate (0.3%) over the entire period, this is not unexpected. Furthermore, its growth rate was negative for the last period (-0.23%). The autonomous technical change has a negative effect on output growth. Recall that technical change is a negative of scale economies multiplied by the cost elasticity with respect to autonomous technical change (see equation 10 in Chapter III). Since the cost elasticity of autonomous technical change (ε_{CT} in Table 1.4) is positive for every period, which is discussed in the production structure and technical change behavior section, technical change has a negative effect on output. Notice that its negative effect grows smaller over time due to decreasing scale economies and cost elasticity of technical change.

Finally, what is not accounted for in the decomposing of output growth is defined as residual (unexplained factors). It is the difference between the output growth and the sum of all contributing factors. It can be described as efficiencies of management, organization, and factor inputs. Although its magnitude seems large for the first period, it decreases considerably over time and eventually becomes very small for the last period.

Labor productivity growth

Sources of labor productivity growth are reported in Table 1.7. In the decomposition of labor productivity, the most significant contribution stems from the growth of materials plus energy, about 25% in relative terms and 0.48% in absolute terms for the 1958-1994 period. The second most important factor in the growth of labor productivity is the contribution of physical capital stock. Its relative contribution is 18% and in absolute it is 0.34% for the 1958-1994 period. Some college and college degree labor also plays an important role in the U.S. food and kindred products sector, accounting for about 2% for labor productivity growth. Again, with a negative growth rate of high school and below high school labor, obviously high school and below high school labor has a negative contribution to total labor productivity growth.

However, in the last period (1987-94), the contribution of some college and college degree labor to labor productivity growth was 31% in relative terms and 0.41% in

TABLE 1.7

SOURCES OF LABOR PRODUCTIVITY GROWTH FOR THE FOOD AND KIDRED PRODUCTS SECTORS, MEAN ESTIMATE FOR PERIOD (IN PERCENTAGE)

Period	Labor productivity	High school and below labor	Some college and college degree labor	Capital effect	Materials plus energy effect	R&D effect	Technical change	Residual
1958-69	3.08	-0.001	-0.001	0.273	0.414	0.001	-0.002	2.395
1969-78	1.51	-0.032	0.053	0.265	0.397	-0.001	-0.053	0.880
1978-87	2.50	-0.028	0.048	0.474	0.540	0.002	0.025	1.438
1987-94	1.33	-0.063	0.410	0.233	0.540	-0.003	-0.137	0.350
1958-94	**1.92**	**-0.026**	**0.040**	**0.340**	**0.483**	**-0.001**	**-0.036**	**1.120**

Note: For the entire period, the major relative contributions to labor productivity are as follows: some college and college degree 2%, physical capital 18%, material plus energy 25%. However, for the last period (1987-94) the contributions are 31%, 18%, and 41%, respectively, for some college and college degree, physical capital, and material plus energy.

absolute terms, capital was 18% in relative terms and 0.23% in absolute terms, and material plus energy was 41% in relative terms and 0.54% in absolute terms. The contribution of some college and college degree labor to total labor productivity growth exceeded capital contribution due to the high growth rate of some college and college degree labor starting from the second period (1969-78) while there was a decrease in physical capital and materials plus energy growth rates (see Table B1, Appendix B).

Although the growth rates of R&D capital were positive, their magnitude is relatively small compared to total labor growth for the entire period. As a result, R&D capital has a small negative effect on labor productivity. Again, the negative technical change result from positive cost elasticity of autonomous technical change leads to a negative impact of technical change on labor productivity growth.

Technological Change and Total Factor Productivity at the Three Digit Level

The focus of this part is to (1) analyze empirically the production structure of the U. S. food processing industries at the three-digit level SIC code. Particular attention is focused on the pattern of substitution among the factor inputs and the degree to which the industry production functions are characterized by economies of scale. (2) Examine the type of technological change and its impact on the production structure of the food processing industries. The concern is not only the rate of technical change but also the extent to which it alters the optimal level and mix of inputs, that is, the factor bias of technical change. (3) Explore the interrelationship between scale economies and marginal cost pricing internal to the food processing industries and external technical change in determining the rate of total factor productivity (TFP) growth. Specifically, we decompose the growth of TFP into a part related to scale economies and markup, and a part induced by technical change.

As described in the methodology chapter, to understand the structure of the food processing industries, and to properly estimate the rate of technical change and TFP in each of these industries, an econometric model is used with a translog cost function that includes inputs of production labor (*P*), non-production labor (*N*), materials plus energy (*M*), equipment capital (*E*), and a quasi-fixed structural capital (*S*). The output (Y) is measured by value of shipments. Using the parameter estimates of the model, we estimate the degree of economies of scale, substitution among inputs, and the adjustment cost associated with the quasi-fixed factor. The sources of growth of output and productivity in each industry are identified.

Growth Rate of Output, Inputs, and Prices at the Three Digit Level

Before turning to estimation results, it is important to review the growth rates of output, inputs, and prices across the three digit industries, which is reported in Table C1 and C2 in Appendix C. The industries with the highest annual average growth rate of output for the entire period are beverages, grain milling, and preserved fruits and vegetables (3.5%, 3.1%, and 2.9%, respectively) followed by meat products, fats and oils, and miscellaneous food and kindred products (2.7%, 2.6%, and 2.3%, respectively). Sugar and confectionery products, dairy products, and bakery products have the lowest annual average growth rate of output (1.6%, 1.1%, and 0.5%, respectively), see Table C1 in Appendix C. The annual average growth rate of output for the total food and kindred products sector at the two digit level is 2.3% (see Table B1 in Appendix B).

Industries with the higher output growth rate do not necessarily have the higher growth in factor inputs. For example, dairy is in the lowest group of output growth but its equipment capital growth is 5.9% (first place), structural capital growth is 1.6% (fourth place), and material plus energy growth is 1.4% (sixth place). The beverage industry has the highest growth in output but its equipment capital growth is 1.2% (last place), structural capital growth is 0.6% (seventh place), and material plus energy growth is 3.1% (first place). Fats and oils, is the fifth in output growth but last in structural capital growth (-0.7%), next to last in equipment capital growth (1.8%), and second in material plus energy growth (2.4%). This suggests a different production structure across industry groups.

Non-production labor growth is negative or decreasing in all industry groups except miscellaneous food products. Production labor growth is negative or decreasing in all industry groups except meat products, miscellaneous food products, and preserved fruits and vegetables. However, all groups show higher (or less negative) growth in production labor for the last period (1987-94) compared to the previous period.

The annual output price growth rate for the entire period is about 5% for bakery and sugar and confectionery products industries; about 4% for dairy, preserved fruits and vegetables, fats and oils, and miscellaneous food products industries; and about 3% for meat products, grain mill products, and beverage industries. This suggests a different demand effect or market price effect on output growth and sequentially on total factor productivity growth.

The annual price growth rate of both structural capital and equipment capital are generally higher than other input prices for all industries. However, the price growth rate of structural capital is higher than equipment capital except for meat products and dairy products. Material plus energy price growth rate is about 4% for all industries except for meat products which is about 3%. Production labor wage rate growth is about 5% across industries except for meat products at 4% and beverages at 6%. Non-production labor wage rate growth is about 5% except for preserved fruits and vegetables and sugar and confectionery products which is at about 6%. This suggests a different level of substitutability of factor inputs among industry groups.

Table C3 in Appendix C reports the factor cost shares for all industries at the three digit level. It indicates that bakery is the most labor intensive but the least materials intensive industry; meat products is the most materials intensive but the least capital intensive industry; beverages is the most capital intensive industry; and fats and oils is the least labor intensive industry.

Three important results should be observed from this data. First, the growth rates of output and factor inputs are not the same and the industry with highest input growth rates does not necessarily have the highest output growth, which suggests a different production structure and technical change behavior across the three digit industries. Secondly, the different growth rates of factor prices and different levels of factor intensity across industries suggests different levels of factor price effects and inducements due to technical change. Lastly and clearly, the classification of labor into production and non-production does not detect changes in the composition of labor. At the two digit level, when labor is classified by education level, it shows a significant reduction in high school and below high school labor (-0.13%) while some college and college degree labor increases by 2.76% for the entire period (1958-94) (see Table B1 in Appendix B).

Empirical Results

The translog cost function for the three digit industries consists of six factor inputs: production labor (*P*), non-production labor (*N*), materials plus energy (*M*), equipment capital (*E*), and a quasi-fixed structural capital (*S*). A system of equations comprising the translog cost function and the factor input cost shares (*P*, *N*, *M*, and *E*) was estimated for each three digit industry using seemingly unrelated regression estimation in SAS as described in Chapter III.

The model fits the data quite well for the cost function and most of the share equations for all industries as measured by R-squares (see Table C5 in Appendix C). In general, the R-squares are about 0.98 for cost functions, 0.60 for production labor and non-production labor shares, and 0.70 for equipment capital and material plus energy. The R-squares for the cost share equations vary across industries and are relatively low, which is normal for translog models.

The monotonicity (nondecreasing in factor price) and concavity (concave in factor price) are tested for the translog cost function to determine whether it adequately represents the underlying technology. The monotonicity and concavity tests indicate that all translog cost functions of the three digit industries satisfy these conditions except miscellaneous food and kindred products which violates the monotonicity condition for a few of the later years and fats and oils which violates the concavity condition for a few of the early years.

The test for statistical significance for the square terms of output and factor fixity, homotheticity, and constant returns to scale are reported in Table 2.1. Based on the F-test statistics, we cannot reject the hypothesis that the square term is different from zero at a critical value of 0.05 probability level for all industries. Homotheticity condition holds for all industries except meat products (201) and fats and oils (207). Five (meat products, bakery products, fats and oils, beverages, and miscellaneous food products) out of nine

TABLE 2.1

F-TEST STATISTICS ON TRANSLOG COST FUNCTION FOR SQUARE TERMS, HOMOTHETICITY, AND CONSTANT RETURNS TO SCALE FOR THE THREE DIGIT INDUSTRIES

Industry	Square Terms (2)[a]	Homotheticity (5)[a]	Constant Returns (7)[a]
Meats	0.135	2.251	9.970
	(0.874)	(0.054)	(0.001)
Dairy	0.331	0.534	0.756
	(0.719)	(0.750)	(0.625)
Pres. fruits & veg.	1.812	0.016	0.775
	(0.168)	(0.412)	(0.610)
Grain milling	0.755	0.331	0.645
	(0.472)	(0.893)	(0.717)
Bakery	0.147	0.286	2.906
	(0.863)	(0.920)	(0.008)
Sugar & confect.	0.931	0.376	0.444
	(0.397)	(0.865)	(0.872)
Fats & oils	3.533	2.896	3.985
	(0.233)	(0.017)	(0.001)
Beverages	2.550	1.724	7.971
	(0.082)	(0.135)	(0.001)
Misc. food	1.000	1.230	5.390
	(0.370)	(0.300)	(0.001)

[a] Number of restrictions: Square terms ($\alpha_{YY}=0$ and $\alpha_{SS}=0$), homotheticity ($\alpha_{iY}=0$ and $\gamma_{YT}=0$), and constant returns to scale ($\alpha_{YY}=0$, $\alpha_{iY}=0$, $\gamma_{YT}=0$ and $\alpha_{Y}=1$). The coefficients refer to the estimated translog cost function reported in Table C4 Appendix C. Numbers in parentheses are P-values.

industries strongly reject the constant returns to scale test. However, four industries (dairy products, preserved fruits and vegetables, grain mill products, and sugar and confectionery products) fail to reject the constant returns to scale test.

Production Structure and Technology Behavior

Parameters estimated for the translog cost function by three digit industry are reported in Table C4, Appendix C. Most interaction terms between factors prices are statistically significant except α_{PE} and α_{NE} in six industries (201, 202, 203, 205, 206, and 209) and α_{NM} and α_{EM} in two industries (202 and 203). Only α_{PM} is significant in the miscellaneous food industry (209). This suggests that the partial elasticities of substitution are not unity and are not homogenous across industries. Most of the interaction terms of factor prices with output are statistically significant except α_{MY} in three industries (201, 202, and 206), α_{NY} in 203, and α_{EY} in 204. However, the fats and oils industry appears to be homotheticity—i.e. none of its factor price interactions with output are statistically significant. This means that input ratios are independent of output level for this industry. This is an unexpected result since the homotheticity and constant returns to scale tests were strongly rejected for the fats and oils industry. Constant returns to scale, however, is a special case of homotheticity.

Results of the parameter estimates indicate that cost shares are affected by technical change. Table 2.2 presents the technology behavior on factor inputs for all three digit industries. Although the pattern of the biased technical change is not the same across industries, technical change tends to be material plus energy and structural capital saving or neutral; labor using although fats and oils is neutral; and neutral with respect to equipment capital although meats is equipment capital using and bakery is equipment capital saving. Point estimates of γ_T (negative) and γ_{TT} (positive) indicate a downward neutral drift (at a decelerating rate) in variable cost for all industries.

TABLE 2.2

TECHNOLOGY BEHAVIOR ON FACTOR INPUTS FOR THE THREE DIGIT INDUSTRIES, 1958-1994

Industry	Structural capital	Equipment capital	Material plus energy	Production labor	Non-production labor
Meats	saving	using	saving	using	using
Dairy	saving	neutral	saving	using	using
Pres. fruits.	neutral	neutral	saving	using	using
Grain Mill.	neutral	neutral	neutral	using	using
Bakery	saving	saving	neutral	using	using
Sug. & conf.	saving	neutral	saving	using	using
Fats & oils	saving	neutral	neutral	neutral	neutral
Beverages	saving	neutral	saving	using	using
Misc. food	neutral	neutral	neutral	neutral	using

Note: This table is an interpretation from the coefficient estimates reported in Table C4 in Appendix C.

Parameter estimates are all statistically significant except miscellaneous food industry (see Table C4 in Appendix C). Recall that $\gamma_T = \Sigma_i\alpha_i\eta_i$ and $\gamma_{TT} = \Sigma_i\alpha_{iT}\,\eta_i$ (defined in equation 4, Chapter III) are independent of factor substitution or the inducement effect of technical change on factor inputs, which is the neutral shift of variable cost due to neutral technical change.

A concise description of the production structure is provided by the elasticities of factor demand and the Morishima elasticities of substitution and are reported in Tables C6 and C7 in Appendix C. The own price elasticities of factor demands in Table C6 indicate that all factor inputs are normal for all industries.

There is significant substitutability among factor inputs across industries. However, production and non-production labor are complements for most industries. Meats, grain milling, bakery, and beverages have statistically significant complementary relationship between production and non-production labor. However, preserved fruits and vegetables, sugar and confectionery, and miscellaneous food products are not statistically significant at 0.05 probability level. Although dairy and fats and oils show substitutability between production and non-production labor, the relationship is not statistically significant at 0.05 probability level.

The substitutability between non-production labor and equipment capital is not significant for most industries except for dairy, preserved fruits and vegetables, and bakery products. Fats and oils and beverage products show a complementary relationship between equipment capital and non-production labor, but it is not statistically significant. In general and for all industries, material plus energy shows a significant substitutability with labor and capital. The degree of substitution is higher for labor, particularly for production labor, than for capital. This significant substitutability suggests that the fixed coefficient (Leontief) and Cobb-Douglas models would misrepresent the substitution possibilities among factor inputs.

The Morishima elasticities of substitution (Table C7, Appendix C) provide better interpretation of the degree of substitutability among factor inputs because of the asymmetry in the responsiveness of input ratios to factor price changes. All of the Morishima elasticities of substitution are positive and statistically significant except between equipment capital and non-production labor in fats and oils. Material and energy has strong substitutability with production and non-production labor but is moderately substitutable with equipment capital for all industries.

Morishima elasticity of substitution between labor (production and non-production labor) and material plus energy (MES_{PM} and MES_{NM}) indicates that as price of labor rises, the materials-labor ratio increases; labor usage declines more percentage wise than materials usage in response to an increase in price of labor. For example, in the meat products industry, MES_{PM} = 1.45 and MES_{NM} = 1.61 but MES_{MP} = 2.40 and MES_{MN} = 2.59. The elasticity of substitution between material plus energy and equipment capital has the same relationship as labor. However, the degree of substitution is not as strong as for labor (MES_{EM} = 1.11 but MES_{ME} = 1.82). This suggests that an increase in labor and or capital price will have a stronger effect on factor intensity than an increase in material plus energy price because of the reaction to labor and or capital price changes is stronger than material plus energy price changes. This is true for all industries.

The ε_{CY}, ε^{L}_{CY}, ε_{CS}, and ε_{CT} reported in Table 2.3 are the cost elasticity with respect to output (short and long run), fixed structural capital, and technical change. Scale economies are significantly evident for all industries, and especially for grain mill industry (ε_{CY} = 0.76) —output increases require a 24% smaller increase in input costs. Grain milling, beverages, fats and oils, and miscellaneous food products industries appear

TABLE 2.3

COST ELASTICITIES OF OUTPUT, FIXED STRUCTURAL CAPITAL, AND TECHNICAL CHANGE FOR THREE DIGIT FOOD PROCESSING INDUSTRIES, MEAN ESTIMATE FOR PERIOD

Period	ε_{CY}	ε^{L}_{CY}	ε_{CS}	ε_{CT}
Meat Products (SIC 201)				
1958-69	0.895	0.894	-0.001	-0.131
1969-78	0.876	0.870	-0.007	-0.155
1978-87	0.865	0.855	-0.012	-0.164
1987-94	0.856	0.842	-0.017	-0.168
1958-94	**0.874**	**0.867**	**-0.008**	**-0.152**
Dairy Products (SIC 202)				
1958-69	0.857	0.858	0.002	-0.141
1969-78	0.848	0.843	-0.005	-0.161
1978-87	0.839	0.829	-0.012	-0.164
1987-94	0.834	0.820	-0.017	-0.161
1958-94	**0.846**	**0.840**	**-0.007**	**-0.155**
Preserved Fruits and Vegetables (SIC 203)				
1958-69	0.961	0.959	-0.002	-0.078
1969-78	0.989	0.984	-0.005	-0.088
1978-87	0.982	0.974	-0.008	-0.089
1987-94	0.979	0.968	-0.012	-0.089
1958-94	**0.987**	**0.981**	**-0.006**	**-0.085**
Grain Mill Products (SIC 204)				
1958-69	0.732	0.735	0.004	-0.035
1969-78	0.736	0.732	-0.005	-0.044
1978-87	0.738	0.729	-0.013	-0.042
1987-94	0.867	0.850	-0.020	-0.035
1958-94	**0.758**	**0.753**	**-0.007**	**-0.039**
Bakery Products (SIC 205)				
1958-69	0.917	0.915	-0.002	-0.252
1969-78	0.912	0.906	-0.007	-0.253
1978-87	0.867	0.858	-0.010	-0.247
1987-94	0.825	0.813	-0.015	-0.241
1958-94	**0.910**	**0.903**	**-0.008**	**-0.249**

Note: ε_{CY}, ε_{CS}, and ε_{CT} are cost elasticities with respect to output, fixed structural capital, and technological change; and ε^{L}_{CY} is the long run elasticities of scale ($\varepsilon^{L}_{CY} = \varepsilon_{CY}/1\text{-}\varepsilon_{CS}$).

TABLE 2.3 (CONTINUED)

COST ELASTICITIES OF OUTPUT, FIXED STRUCTURAL CAPITAL, AND TECHNICAL CHANGE FOR THREE DIGIT FOOD PROCESSING INDUSTRIES, MEAN ESTIMATE FOR PERIOD

Period	ε_{CY}	ε^{L}_{CY}	ε_{CS}	ε_{CT}
Sugar and Confectionery Products (SIC 206)				
1958-69	0.900	0.897	-0.004	-0.186
1969-78	0.895	0.887	-0.010	-0.199
1978-87	0.854	0.843	-0.013	-0.201
1987-94	0.820	0.805	-0.018	-0.201
1958-94	**0.869**	**0.860**	**-0.010**	**-0.196**
Fats and Oils (SIC 207)				
1958-69	0.760	0.745	-0.021	-0.099
1969-78	0.816	0.790	-0.033	-0.084
1978-87	0.824	0.792	-0.040	-0.075
1987-94	0.832	0.792	-0.050	-0.059
1958-94	**0.818**	**0.791**	**-0.034**	**-0.082**
Beverages (SIC 208)				
1958-69	0.817	0.824	0.008	-0.117
1969-78	0.813	0.816	-0.003	-0.122
1978-87	0.809	0.808	-0.001	-0.127
1987-94	0.810	0.806	-0.005	-0.126
1958-94	**0.813**	**0.815**	**0.002**	**-0.122**
Misc. Food and Kindred Products (SIC 209)				
1958-69	0.863	0.864	0.001	-0.154
1969-78	0.834	0.830	-0.005	-0.167
1978-87	0.806	0.798	-0.010	-0.175
1987-94	0.816	0.804	-0.014	-0.176
1958-94	**0.826**	**0.821**	**-0.006**	**-0.167**

Note: ε_{CY}, ε_{CS}, and ε_{CT} are cost elasticities with respect to output, fixed structural capital, and technological change; and ε^{L}_{CY} is the long run elasticities of scale ($\varepsilon^{L}_{CY} = \varepsilon_{CY}/1\text{-}\varepsilon_{CS}$).

to be characterized by more extensive scale economies compared to preserved fruits and vegetables, bakery, meats, dairy, and sugar and confectionary products. This pattern is consistent with the constant returns to scale test where beverages, fats and oils, and miscellaneous food products which were strongly rejected.

The cost elasticities with respect to fixed structural capital (ε_{CS}) are negative except for beverages (ε_{CS} = 0.002). This indicates a potential cost savings through structural capital expansion. Although cost elasticities with respect to fixed structural capital varied across industries, the tendency toward unit cost savings is not strongly promising in the long run for all industries due to a small adjustment cost for structural capital. The cost elsticities with respect to technology (ε_{CT}) are all negative which indicates a positive technical change has occurred. That is a cost savings has been obtained through technical change or a shift of average cost curve downward over time.

Sources of Total Factor Productivity

Total factor productivity growth for the three digit industries is decomposed into a part related to technical change and a part attributable to economies of scale. Total factor productivity is basically a measure of output per unit of total factor input. Total factor input is a weighted average of all inputs, where the weights depend on the underlying production function. If there is increasing returns to scale, part of the growth in total factor productivity will reflect the change in the scale of operation, while the remainder can be ascribed to a shift in the production frontier itself. If there is constant returns to scale, the change in total factor productivity would be identical to the technological shift (assuming other factors are exhaustive and accurately measured).

To visualize this, suppose we observe over time that the average cost of production has fallen. With constant returns to scale, the average cost does not depend on the level of output, so the average cost curve is horizontal. Therefore, the observed decline in average cost must be due solely to the shift of the average cost curve downward over time (the direct contribution of technical change is a shift from point C to C' in Figure A1 in Appendix A).

If there are economies of scale, however, average cost declines with increases in the level of output. Then the observed reduction in average cost over time is due partly to downward shifts in the curve, and partly to the movements along a given downward-sloping average cost curve (i.e. a shift from point C' to E in Figure A1, Appendix A). Technical change raises the output produced with the existing level of inputs and thereby shifts the derived demands for inputs. Therefore part of the growth in total factor input is indirectly induced by technical change (the indirect contribution of technical change). This indirect contribution of technical change illustrates an interaction between scale economies and technical change and in the presence of increasing returns the level of total factor productivity increases.

The decomposition of total factor productivity (see equation (46) in Chapter III) is comprised of four components: (1) the direct effect of technical change (which is independent of price elasticity of product demand); (2) the indirect effect of technical change (which is dependent on price elasticity of product demand and cost elasticity); (3) factor prices effect (which is the sum of all input prices growth rates weighted by corresponding input cost shares adjusted by the markup, cost elasticity, and price elasticity of product demand); and (4) exogenous demand effect (which is any change in demand of factor inputs that is not due to technical change and factor prices effect). The net scale effect is also considered in the sources of total factor productivity growth, which is the summation of factor prices effect and exogenous demand effect.

The decomposition requires a price elasticity of product demand. The price elasticity of product demand is taken as 1.00 for meats, dairy, preserved fruits and vegetables, bakery, beverage, and miscellaneous food products; 0.80 for fats and oils; 0.75 for sugar and confectionery products; and 0.50 for grain mill products.

The results of the decomposition of total factor productivity in Table 2.4 show that the direct effect of technical change (independent of elasticity of product demand) is the major contributor to total factor productivity across the three digit industries. The direct technical change has a negative effect on total factor productivity growth for the dairy and bakery industries for the average of the entire period; this is mainly due to the low output growth rates of these industries (Table C1 Appendix C) and low scale economies compared to other industries; this may imply that these two industries have limited ability to adapt to new technology.

The industries with the most significant direct technical change are beverages, preserved fruits and vegetables, meat products, fats and oils, miscellaneous food, and sugar and confectionary products. In terms of absolute value, their percentage contributions are 2.11, 1.20, 1.18, 1.10, 0.60, and 0.35, respectively, for the entire period. The relative contribution of direct technical change exceeds 100% of total factor productivity for these industries. This is possible because the factor prices effect and exogenous demand effect have significant negative effects on total factor productivity

TABLE 2.4

SOURCES OF TOTAL FACTOR PRODUCTIVITY GROWTH FOR THE THREE DIGIT INDUSTRIES, MEAN ESTIMATE FOR PERIOD (IN PERCENTAGE)

Period	TFP growth (average annual rate)	Technical change direct (a)	Technical change indirect (b)	Factor prices (c)	Exogenous demand (d)	Net scale effect (e)=(c)+(d)
Meat Products (SIC 201)						
1958-96	1.158	2.600	2.701	-1.184	-2.958	-4.142
1969-78	0.111	0.813	0.459	-2.265	1.103	-1.161
1978-87	1.001	0.944	-0.101	0.253	-0.095	0.158
1987-94	0.694	-0.019	0.009	0.352	0.353	0.705
1958-94	**0.788**	**1.179**	**0.397**	**-0.613**	**-0.175**	**-0.788**
Dairy Products (SIC 202)						
1958-96	-2.040	-0.703	-0.674	-1.351	0.688	-0.663
1969-78	0.623	1.052	0.609	-2.019	0.981	-1.038
1978-87	0.602	0.477	-0.091	0.429	-0.213	0.216
1987-94	-0.133	-0.382	0.204	0.352	-0.307	0.045
1958-94	**-0.565**	**-0.273**	**-0.076**	**-0.557**	**0.341**	**-0.216**
Preserved Fruits and Vegetables (SIC 203)						
1958-96	0.587	3.139	3.920	-2.184	-4.288	-6.472
1969-78	0.857	2.110	2.034	-4.123	0.837	-3.286
1978-87	0.700	0.735	0.079	-0.326	0.212	-0.114
1987-94	0.067	-0.555	0.271	0.518	-0.169	0.350
1958-94	**0.475**	**1.198**	**0.687**	**-1.441**	**0.031**	**-1.410**

TABLE 2.4 (CONTINUED)

SOURCES OF TOTAL FACTOR PRODUCTIVITY GROWTH FOR THE THREE DIGIT INDUSTRIES, MEAN ESTIMATE FOR PERIOD (IN PERCENTAGE)

Period	TFP growth (average annual rate)	Technical change direct (a)	Technical change indirect (b)	Factor prices (c)	Exogenous demand (d)	Net scale effect (e)=(c)+(d)
Grain Mill Products (SIC 204)						
1958-96	0.858	2.106	1.046	-0.490	-1.804	-2.294
1969-78	0.440	0.781	0.117	-0.407	-0.051	-0.458
1978-87	1.500	0.805	-0.334	0.612	0.417	1.029
1987-94	0.152	-1.010	0.575	0.576	0.012	0.588
1958-94	**0.774**	**0.696**	**-0.026**	**0.059**	**0.045**	**0.104**
Bakery Products (SIC 205)						
1958-96	-0.167	0.710	0.796	-1.844	0.171	-1.672
1969-78	-0.096	0.017	0.012	-2.801	2.677	-0.125
1978-87	0.491	0.475	-0.118	0.713	-0.578	0.134
1987-94	-1.250	-2.191	1.940	0.881	-1.879	-0.998
1958-94	**-0.360**	**-0.203**	**-0.065**	**-0.757**	**0.664**	**-0.093**
Sugar and Confectionary Products (SIC 206)						
1958-96	-0.230	1.559	1.527	-1.354	-1.962	-3.316
1969-78	-0.515	0.102	0.062	-2.432	1.753	-0.679
1978-87	0.301	0.294	-0.016	0.133	-0.112	0.022
1987-94	0.812	0.377	-0.198	0.393	0.240	0.632
1958-94	**0.008**	**0.351**	**0.112**	**-0.683**	**0.213**	**-0.470**

TABLE 2.4 (CONTINUED)

SOURCES OF TOTAL FACTOR PRODUCTIVITY GROWTH FOR THE THREE DIGIT INDUSTRIES, MEAN ESTIMATE FOR PERIOD (IN PERCENTAGE)

Period	TFP growth (average annual rate)	Technical change direct (a)	Technical change indirect (b)	Factor prices (c)	Exogenous demand (d)	Net scale effect (e)=(c)+(d)
Fats and Oils (SIC 207)						
1958-96	1.567	2.420	1.555	-0.899	-1.509	-2.408
1969-78	0.271	0.995	0.244	-1.010	0.041	-0.968
1978-87	1.633	1.532	-0.332	0.297	0.136	0.443
1987-94	0.479	0.384	-0.140	0.443	-0.208	0.234
1958-94	**0.906**	**1.096**	**0.169**	**-0.312**	**-0.047**	**-0.359**
Beverages (SIC 208)						
1958-96	3.007	4.361	3.977	-1.733	-3.598	-5.331
1969-78	1.922	3.001	1.538	-2.110	-0.507	-2.616
1978-87	0.943	0.828	-0.117	0.425	-0.193	0.232
1987-94	1.980	2.043	-1.224	0.491	0.671	1.161
1958-94	**1.833**	**2.110**	**0.520**	**-0.600**	**-0.197**	**-0.797**
Misc. Food and Kindred Products (SIC 209)						
1958-96	1.720	2.917	2.830	-4.026	-2.934	-4.125
1969-78	-2.020	-0.721	-0.376	-0.923	1.037	-0.836
1978-87	3.203	3.202	-1.132	1.133	0.242	1.131
1987-94	1.144	0.517	-0.426	1.053	0.327	1.074
1958-94	**0.408**	**0.602**	**0.094**	**-0.288**	**0.028**	**-0.288**

growth. This suggests the large contribution of technical change was offset by a decrease in product demand and increases in factor prices. Without the strong positive contribution of technical change, total factor productivity would have decreased. The technical change (direct and indirect) effect became negative on total factor productivity in the later years, particularly for industries with less extensive scale economies such as preserved fruits and vegetables, bakery, meats, and sugar and confectionary products. However, technical change effect became negative for grain milling with the most extensive scale economies but this may be due to the lowest potential cost savings from technical change (ε_{CT} = -0.039) of this industry compared to others.

The negative contribution to total factor productivity of indirect technical change for dairy and bakery products was due mainly to the low scale economies and a negative direct technical change effect. The negative indirect technical change, however, is because of low proportional increase in output compared to factor inputs. Empirically, it occurred in the industry with extensive scale economies and positive direct technical change but fails to expand its output (a shift in isoquant is dominated). Although the indirect technical change depends on the price elasticity of demand, sensitivity is not profound within the probable range of this elasticity. Alternative price elasticities of product demand are used to calculate indirect technical change effects (Table 2.5). The results show only marginal changes in indirect technical change effects.

Factor prices have a major contractionary effect on total factor productivity, particularly for preserved fruits and vegetables, sugar and confectionary, bakery, and

TABLE 2.5

SOURCES OF TOTAL FACTOR PRODUCTIVITY GROWTH UNDER ULTERNATIVE FOR THE THREE DIGIT INDUSTRIES, MEAN ESTIMATE FOR 1958-1994 (IN PERCENTAGE)

Price elasticity of demand	TFP growth (average annual rate)	Technical change direct (a)	Technical change indirect (b)	Factor prices (c)	Exogenous demand (d)	Net scale effect (e)=(c)+(d)
Meat Products (SIC 201)						
-0.6	0.788	1.179	0.327	-0.385	-0.333	-0.719
-0.8		1.179	0.363	-0.502	-0.252	-0.754
-1.0		1.179	0.397	-0.613	-0.175	-0.788
Dairy Products (SIC 202)						
-0.6	-0.565	-0.273	-0.063	-0.353	0.124	-0.292
-0.8		-0.273	-0.070	-0.458	0.236	-0.222
-1.0		-0.273	-0.076	-0.557	0.341	-0.216
Preserved Fruits and Vegetables (SIC 203)						
-0.6	0.475	1.198	0.551	-0.869	-0.405	-1.274
-0.8		1.198	0.619	-1.156	-0.186	-1.342
-1.0		1.198	0.687	-1.441	0.031	-1.410
Grain Mill Products (SIC 204)						
-0.6	0.774	0.696	-0.027	0.069	0.037	0.105
-0.8		0.696	-0.030	0.088	-0.020	0.108
-1.0		0.696	-0.032	0.106	-0.005	0.111
Bakery Products (SIC 205)						
-0.6	-0.360	-0.203	-0.053	-0.470	0.365	-0.104
-0.8		-0.203	-0.059	-0.616	0.517	-0.098
-1.0		-0.203	-0.065	-0.757	0.664	-0.093

TABLE 2.5 (CONTINUED)

SOURCES OF TOTAL FACTOR PRODUCTIVITY GROWTH UNDER ALTERNATIVE FOR THE THREE DIGIT INDUSTRIES, MEAN ESTIMATE FOR 1958-1994 (IN PERCENTAGE)

Price elasticity of demand	TFP growth (average annual rate)	Technical change direct (a)	Technical change indirect (b)	Factor prices (c)	Exogenous demand (d)	Net scale effect (e)=(c)+(d)
Sugar and Confectionary Products (SIC 206)						
-0.6	-0.008	0.351	0.104	-0.557	0.095	-0.462
-0.8		0.351	0.115	-0.725	0.251	-0.473
-1.0		0.351	0.125	-0.885	0.401	-0.484
Fats and Oils (SIC 207)						
-0.6	0.906	1.096	0.153	-0.242	-0.102	-0.343
-0.8		1.096	0.169	-0.312	-0.047	-0.359
-1.0		1.096	0.183	-0.378	0.004	-0.373
Beverages (SIC 208)						
-0.6	1.833	2.110	0.435	-0.384	-0.327	-0.711
-0.8		2.110	0.479	-0.496	-0.260	-0.756
-1.0		2.110	0.520	-0.600	-0.197	-0.797
Misc. Food and Kindred Products (SIC 209)						
-0.6	0.408	0.602	0.078	-0.201	-0.071	-0.272
-0.8		0.602	0.086	-0.260	-0.020	-0.280
-1.0		0.602	0.094	-0.316	0.028	-0.288

dairy products (the order is by percentage in relative terms). The negative effect of factor prices exceeds 100% of total factor productivity for these industries. This is not unreasonable because shifts in demand appear to be a major source of output growth and thus total factor productivity growth in these industries as evidenced by the high growth rate of output price and relatively high positive exogenous demand effect compared to other industries. The ontribution of exogenous demand shifts and factor prices depend on the price elasticity of demand. However, exogenous demand effect has a positive relation with price elasticity of demand while factor prices effect is inversely related to price elasticity of demand (see Table 2.5).

The net scale effect is presented in Table 2.4 and is the sum of the factor prices and exogenous demand effects. Empirically, the contribution of net scale effect varies with the price elasticity of demand (Table 2.5). Over the entire period, only grain milling shows a positive contribution of net scale effect of 13% in relative terms to total factor productivity because of the positive factor price and exogenous demand effects. Over the entire period all industries except grain mill products show a negative contribution for net scale effect, however, most net scale effects become positive after the second sub-period. Scale economies have become important sources of total factor productivity growth in recent periods for most three digit industries.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The food processing industry is an important source for economic growth, particularly for the agricultural-oriented states. Barkema (1990) stated that agricultural-oriented states can no longer depend on the farm production sector to fuel local economies. The food processing industry added $120 billion in value to raw farm products in 1994, compared to the $160 billion value of total raw farm goods (Gallo, 1995). The food processing industry accounts for 14% and 2% for the total value of output of manufacturing industry and gross domestic product of the United States, respectively.

The food processing industry is beneficial for rural development because food manufacturing firms are more likely to locate plants in rural areas than are other types of manufactures. Recent studies show that food manufacturing firms are moving from urban to rural areas (Drabenstott, Henry, and Mitchell, 1999). Therefore, understanding how individual industries are affected by this movement is of vital importance for local economic growth and rural development policies.

Research has suggested that permanent structural change affecting pricing, productivity, scale economies, employment, and investment have occurred in the food processing industry (Huang (1991); Goodwin and Brester (1995); Morrison (1997); and others). This has important implications for competitive success for firms in the industry, improvements in overall industry efficiency, and for industry labor demand and composition. The later has important welfare effects for laborers in this large and important industry.

Most empirical studies in the food processing industry have found significant decreases in the demand for labor and labor cost share but significant increases in labor productivity with little change in total factor productivity (Huang (1991); Goodwin and Brester (1995); Gopinath, Roe, and Shane (1996); and Morrison (1997)). However, none of the studies have attempted to explain the sources of an increase in labor productivity and to reconcile the slowdown in total factor productivity growth. Furthermore, the available studies focus only on factor demand and structural change at the two digit (SIC 20) food and kindred products industry.

Objectives of the Study

The objective of this study was to analyze the production structure, technological change, and productivity of the U.S. food and kindred products sector. To investigate if there are any misleading results from an aggregate level analysis, both the two and three digit levels were considered. The method of analyzing production structure and technical change at the two and three digit industries are very similar, however, because of the interest in labor productivity and the availability of data, the approach and analysis of productivity were slightly different.

At the two digit level, where the data on R&D capital and labor by education level are available, the effect of R&D on cost minimization, output growth, and labor productivity growth was explored. The focus of this part was to (1) analyze the production structure, technology behavior, and patterns of substitution among factor inputs; (2) evaluate the impact of R&D and autonomous technological change on factor inputs, particularly labor composition; and (3) determine the sources of output and labor productivity.

At the three digit level, structural capital and equipment capital were separated. Technical change was divided into direct (independent of elasticity of product demand) and indirect (dependent on elasticity of product demand) effects and the impact of technical change on factor inputs was separated into inducement effect and factor price effect. This part was intended to (1) analyze the production structure of the three digit industries focusing on the technological change behavior, pattern of substitution among factor inputs, and the degree to which production is characterized by economies of scale. (2) Examine the effect of technical change and structural capital fixity on variable cost across three digit industries. The concerns were not only the rate of technical change but also the extent to which it alters the optimal level and mix of inputs, that is, the inducement effect and factor price effect. (3) Explore the interrelationships between scale economies, marginal cost pricing internal to the food processing industries, and external technical change in determining the sources of total factor productivity growth. Explicitly, the sources of total factor productivity growth were decomposed into four components: direct technical change, indirect technical change, factor price effect, and exogenous demand effect.

Procedure

To achieve the objective, a translog cost function for the two and three digit industries was specified. Time series data (1958-94) for the two and three digit industries were constructed primarily from the National Bureau of Economic Research database. The time series data set for the two digit industry consisted of output (value of shipments), physical capital stock (plant plus equipment), R&D capital, high school and below high school labor, some college and college labor, materials plus energy, and output and input prices. The time series data set for the three digit industries consisted of output (value of shipments), structural capital, equipment capital, production labor, non-production labor, materials plus energy, and output and input prices. Factor cost shares, factor revenue shares, mark-up ratio, output and input growth rate, and output and input price growth rates were also constructed for both the two and three digit industries.

Econometric models were constructed for the two and three digit industries based on a system of equations consisting of a translog cost function and factor cost shares. Serial correlation was tested and corrected. Contemporaneous correlation was tested but no evidence was found. Monotonicity (nondecreasing in factor price) and concavity (concave in price) properties for the cost function were tested. Monotonicity held for all industries but a few industries at the three digit level (sugar and confectionary products, fats and oils, and miscellaneous food products) violated concavity in the early years. The two digit industry violated concavity for some years throughout the period. Square terms of output and factor fixity (R&D for the two digit and structural capital for the three digit) were tested jointly and were found not to be significantly different from zero for all industries, so the restricted cost function was specified leaving out the squared terms. Homotheticity and constant returns to scale were also tested for all industries.

Finally, the constructed data, estimated parameters, and computed elasticites were used for the analysis of production structure and technological behavior; evaluation of the effect of factor fixity and technological change; and the decomposing of output and productivity growth.

Results

Production Structure and Technology Behavior for The Two and Three Digit Levels

Scale economies were evident for both the two and three digit levels. At the two digit level, elasticity of scale (ε_{CY} = 0.880) shows that output increases require a 12% smaller increase in total variable input costs. However, at the three digit level, the elasticities of scale varied across industries. The highest economies of scale was for grain milling (ε_{CY} = 0.758) and the lowest was in preserved fruits and vegetables (ε_{CY} = 0.987). The elasticity of scale at the two digit seems to be the average of the highest and the lowest of the three digit.

The tendency toward unit cost saving was stronger in the long run for the two digit level because of the significant adjustment cost of R&D fixity (ε_{CR} = -0.12, a one percent increase in R&D reduces total average cost by 0.12% for the entire period). The trend in cost saving from R&D was decreasing and even showed cost increasing in the 1978-87 period. This may be the result of more R&D investment in food safety with cost increasing rather than cost saving. However, for the three digit industries, structural capital adjustment cost was relatively small and varied across industries. Fats and oils had the highest structural capital adjustment cost (ε_{CS} = -0.034, a one percent increase in structural capital reduced total average cost by 0.034% for the entire period) and beverages had the smallest structural capital adjustment cost (ε_{CS} = -0.002, a one percent increase in structural capital reduced total average cost by 0.002% for the entire period). Therefore, a long-run unit cost saving is not promising from increasing structural capital.

At the two digit industry, R&D was included in the model to separate induced from autonomous technical change. The cost elasticity with respect to autonomous technical change was found to be positive indicating an increasing average cost from autonomous technical change. This may be due to substantial structural change where adapted new technology is not yet reflected in output growth or where the industry has not been able to completely grow into the change. However, at the three digit level, where R&D is not available, all cost elasticities with respect to technical change are negative. This is because the effective cost saving from R&D investment is not separated from the autonomous technical change. In conclusion, R&D has significant cost saving while autonomous technical change has limited cost saving.

At the two digit level (variable inputs are high school and below high school labor; some college and college degree labor; physical capital; and materials plus energy), autonomous technical change was material plus energy-saving and capital and labor neutral. For the three digit industries (variable inputs are production labor, non-production labor, equipment capital, and materials plus energy), although the pattern of biased technical change varied across industries, in general, technical change tended to be materials plus energy saving or neutral; labor using or neutral; and mixed with respect to equipment capital. This is because of differences in factor intensity, level of factor cost shares, and changes in factor prices across industries, which limited individual industry ability to substitute inputs (inputs with high increasing price for inputs with low increasing price) to implement input saving technology.

The price elasticity and elasticity of substitution indicate that all factor inputs were normal and substitutable for the two digit industry. However, production and non-production labor were found to be complements for all three digit industries. Morishima elasticity of substitution captures the responsiveness of input ratios to different factor price changes. For the two digit industry, the Morishima elasticity of substitution showed that the degree of substituting physical capital for labor when wage rate rises was stronger than the degree of substituting of labor for physical capital when physical capital price rises. This indicates that the industry has been moving from low technology (labor intensive) to a high technology (capital intensive). The relationship between capital and materials plus energy was the same as the relationship between capital and labor, but not as strong as for the labor case. The relationship between materials plus energy and labor was the reverse of the physical capital case. However, for the three digit industries, only the relationship between capital and labor was consistent with the two digit industry. This is because of differences in factor intensity and factor price changes across the three digit industries. Therefore, the aggregated two digit model misinterprets the degree of substitutability among factor inputs.

Impacts of R&D and Autonomous Technical Change on Factor Demands at the Two Digit Level

When output was fixed, a one percent increase in R&D capital induced a complementary increase of about 0.17%, 0.13%, and 1.13% in the demand for high school and below high school labor, some college and college degree labor, and materials plus energy, respectively. When output was allowed to vary, these elasticities were smaller. This indicates that the induced output expansion effect of the increase in R&D capital was not sufficient to overcome possible substitution effects between R&D and other variable inputs. As a result, the demands for high school and below high school labor, some college and college degree labor, and materials plus energy decrease when taking into account the output expansion effect with an increase in R&D capital. The relationship of R&D with physical capital is substitutional.

For autonomous technical change, the magnitudes of the elasticities were comparatively smaller than the corresponding elasticities with respect to R&D, reflecting a relatively limited role played by autonomous technical change compared to R&D capital. However, the magnitudes of these elasticity decreases were small when output was allowed to vary. This indicates that the induced output expansion effect of the increase in autonomous technical change was almost sufficient to offset any direct substitution effect between autonomous technical change and other variable inputs.

Sources of Output and Labor Productivity Growth at the Two Digit Level

Output growth was decomposed into the contribution of factor variable inputs (high school and below high school labor, some college and college degree labor, physical capital, and materials plus energy), fixed factor input (R&D), and technical change. The contribution of each factor input was calculated as the product of the respective average growth rate of factor input per period weighted by the corresponding output elasticity.

The major sources of output growth were materials plus energy (27%), physical capital (18%), and some college and college degree labor (2%) for the entire period (1958-94). However, looking at the average of the entire period is somewhat misleading because for the last period (1987-94) their contributions were 47%, 24%, and 23%, respectively, for materials plus energy, some college and college degree labor, and physical capital. R&D capital contribution to output growth was low (0.02%) for the entire period due to its small share (0.3%) and a small growth rate (0.3%). Furthermore, its growth rate was negative for the last period (-0.23%).

High school and below high school labor had a negative contribution to output growth mainly because of its negative growth rate throughout the study period. The autonomous technical change also had a negative effect on output growth. This is because of the positive cost elasticity with respect to autonomous technical change. However, its negative effect eroded over time due to decreasing scale economies and cost elasticity of autonomous technical change.

The major sources of labor productivity growth for the entire period (1958-94) were materials plus energy (25%), physical capital (18%), and some college and college degree labor (2%). However, in the last period (1987-94), the contribution of materials plus energy was 41%, some college and college degree labor was 31%, and capital was 18%. The contribution of some college and college degree labor to labor productivity growth exceeded capital contribution due to the high growth rate of some college and college degree labor starting from the second period (1969-78) while there was a decrease in physical capital and materials plus energy growth rates (Table B1, appendix B).

High school and below high school labor had a negative contribution to labor productivity due to its negative growth rate. Although the growth rate of R&D capital was positive, its magnitude was relatively small compared to total labor growth rate for the entire period. As a result, R&D capital had a small negative effect on labor productivity growth. Again, the negative autonomous technical change contribution on labor productivity growth resulted from a positive cost elasticity.

Sources of Total Factor Productivity Growth at the Three Digit Level

Total factor productivity was decomposed into four components: (1) the direct effect of technical change (which is independent of price elasticity of product demand); (2) the indirect effect of technical change (which is dependent on price elasticity of product demand and cost elasticity); (3) factor prices effect (which is the sum of all input prices growth rates weighted by corresponding input cost shares and adjusted by the markup, cost elasticity, and price elasticity of product demand); and (4) exogenous demand effect (which is any change in demand of factor inputs that is not due to technical change and factor prices effect). The net scale effect was also considered in the sources of total factor productivity growth, which is the summation of factor prices effect and exogenous demand effect.

The major contribution to total factor productivity growth across the three digit industries was direct and indirect technical change. The industries with the most significant direct technical change were beverages, preserved fruits and vegetables, meat products, fats and oils, miscellaneous food, and sugar and confectionary products. For these industries, the direct effect of technical change exceeded 100% of the total factor productivity growth suggesting that the large contribution of technical change was offset by decreases in product demand and increases in factor prices. Without the strong positive contribution of technical change, total factor productivity would have decreased.

The direct and indirect technical change had a negative effect on total factor productivity growth for the dairy and bakery industries, which is mainly due to lower output growth rates and lower scale economies compared to other industries. These two industries may have limited ability in adapting new technology. The technical change (direct and indirect) effect became negative on total factor productivity in the later years, particularly for industries with less extensive scale economies such as preserved fruits and vegetables, bakery, meats, and sugar and confectionary products.

Factor price effects were the major contractionary effect on total factor productivity, particularly for preserved fruits and vegetables, sugar and confectionary, bakery, and dairy products. The negative effect of factor prices exceeded 100% of total factor productivity for these industries suggesting that shifts in demand were the major source of total factor productivity growth in these industries. The contribution of exogenous demand shifts and factor prices depends on the price elasticity of demand. However, exogenous demand effect has a positive relation with price elasticity of demand while factor prices effect is inversely related to price elasticity of demand

The net scale effect is the sum of the factor prices and exogenous demand effects. Empirically, the net contribution of economies of scale varies with the price elasticity of demand. Over the entire period, only grain milling showed a positive net scale contribution of 13% to total factor productivity due to the positive factor prices effect and exogenous demand effect. All other industries showed a negative contribution for net scale effect but most became positive after the second sub-period. Scale economies became important sources of total factor productivity growth in recent periods for most of the three digit industries.

Conclusions

Several conclusions can be drawn from these results. First, the analysis of production structure at the two and three digit industry levels suggests extensive scale economies thus increasing cost efficiency and productivity growth in the food industry. However, scale economies varied across industries and thus cost savings varied, which the aggregated two digit level model wasn't be able to discover.

Second, this study supports the implications of extensive technological/structural change, cost savings, and input compositional adaptations found in the literature but also suggests that this has arisen from technological changes embodied in the R&D fixed capital factor more than from autonomous technical change. When the contribution of R&D fixed capital factor was taking into account in the two digit model, autonomous technical change increased cost.

Third, based on Morishima elasticities of substitution for the three digit industry models, the degree of substituting materials plus energy for labor when wage rate rises was stronger than the degree of substituting labor for materials plus energy when materials plus energy price rises. The relationship between capital and labor was the same as the relationship between material plus energy and labor. This indicates that the industry has been moving from low technology (labor intensive) to high technology (capital intensive). The relationship between materials plus energy and capital was also the same as the relationship between materials plus energy and labor. However, at the two digit level, only the relastionship between capital and labor was found to be consistent with the three digit models. This suggests a misinterpretation of the degree of factor substitution at the aggregated level because factor intensity and factor price changes were not the same across subindustries.

Fourth, autonomous technical change was materials and energy using and neutral with respect to capital and labor. Although for the three digit industries technical change behavior toward factor inputs was found to be mixed across industries, in light of the two digit model in which R&D is separated from autonomous technical change, we believe that the mixed behavior of technical change found at the three digit level was because of the absence of R&D.

Fifth, R&D capital was an important source of inducement to increasing labor and materials plus energy demand through its effective cost savings in the short run. However, in the long run, the induced output expansion effect from the increase in R&D capital was not sufficient to overcome the substitution effect between R&D and other variable inputs. The relationship between R&D capital and physical capital was substitutional.

Sixth, autonomous technical change had a slightly smaller role in increasing factor demand compared to R&D in the short-run. However, it played an important role in the long run because its induced output expansion effect was almost sufficient to offset any direct substitution effect between autonomous technical change and other variable inputs.

Seventh, although economies of scale was revealed in the food processing industry, increased structural capital (plant expansion) does not promise cost efficiency and thus output and productivity growth. Product demand expansion and factor input prices reductions appeared to be the important factors for the food processing industry to improve its performance and competitiveness and thus local economic growth.

Eighth, the major input contributions to output growth were materials plus energy, some college and college degree labor, and physical capital. Their contributions were 47%, 24%, and 23%, respectively, for the period of 1987-94. Although the average for the entire period (1958-94) was somewhat lower, the recent period is more relevant for application. R&D capital had a small contribution (0.02%) to output growth and was even negative for the recent period (1987-94). This was due to its small share and negative growth for the recent period. It may also be due to a change in composition of R&D from output increasing to food safety.

Ninth, the major contributions to labor productivity were from materials plus energy, some college and college degree labor, and physical capital. Their contributions were 41%, 31%, and 18%, respectively for the recent period (1987-94). Again, the average of the entire period (1958-94) was somewhat smaller but the recent period is more relevant for application. R&D capital had a negative effect on labor productivity growth due to a negative growth rate for the last period.

Tenth, technical change (direct and indirect) was the major contribution to total factor productivity growth in the food processing industry. However, the industries with lesser scale economies and lower output growth rate such as dairy and bakery did not benefit from technical change. Exogenous demand was the second major contributor to total factor productivity growth for most three digit industries except for meats, beverages, and fats and oils products. However, factor prices were the major contractionary effect on total factor productivity for all industries except grain milling. Therefore, only grain milling had a positive net scale effect on total factor productivity due to positive factor price and exogenous demand effects.

Limitations of the Study

First, like any economic study at the national level, this study also suffers from aggregation criticism. In general, economic theory is based on the firm level and particularly productivity analysis is best presented at the firm level. However, firm level data is not readily available.

Second, classification of labor by production and non-production labor (three digit level) or even by education level (two digit level) is not an adequate representation of labor skills. Classification of labor by occupation or profession is a better representation of labor skills. However, even if the data is available the number of parameters would be too many to be estimated from the available annual time series data.

Third, theoretically, capital enters into a production or cost function as a flow variable, therefore, capital services is preferred to capital stock for calculating capital cost. However, capital services are not available.

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APPENDICES

APPENDIX A

GRAPHICAL EXPLANATION AND DATA COMPARISION TABLE

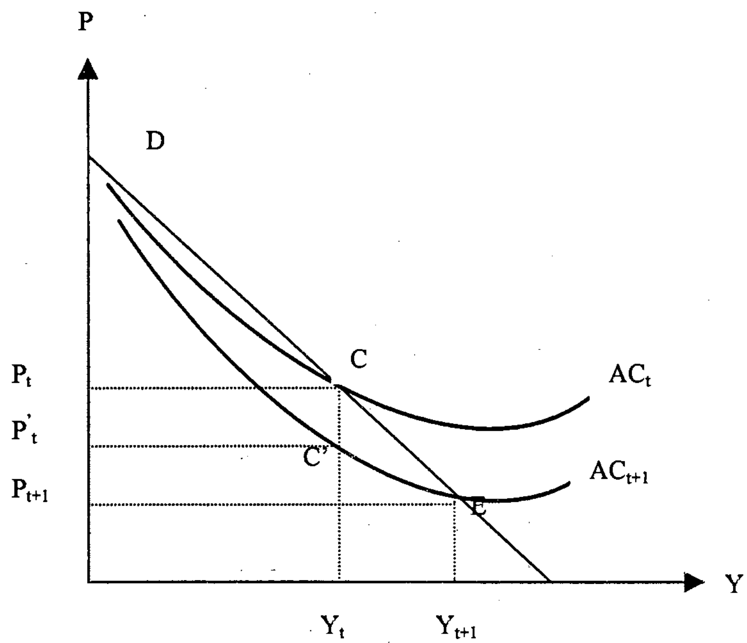

Figure A1. A Shift in Average Cost Curve Due to Technical Change

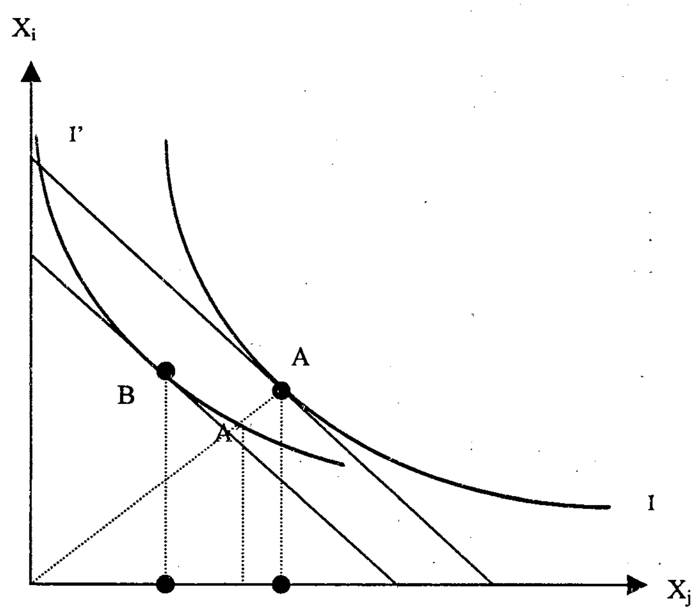

Figure A2. A Shift in Isoquant with Biased Technical Change

TABLE A1

ANNUAL PERCENTAGE GROWTH RATE OF OUTPUT, INPUTS, AND PRICES FOR THE FOOD AND KINDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD: DATA COMPARISION

Period	Output and inputs				Output and input prices			
	Output	Physical capital	Material plus energy	Total labor	Output	Physical capital	Material plus energy	Total labor
	NBER DATA							
1958-69	3.00	3.18	2.28	-0.08	1.18	5.99	1.57	-0.02
1969-78	2.45	2.73	2.34	0.94	7.17	9.54	7.93	6.60
1978-87	2.05	1.40	0.71	-0.45	3.46	7.88	3.76	6.00
1987-94	2.01	1.40	1.60	0.68	2.25	2.13	1.91	1.93
1958-94	**2.33**	**2.24**	**1.76**	**0.41**	**3.39**	**6.31**	**3.59**	**3.77**
	BLS DATA							
1949-73	2.40	1.50	1.90	-0.40	2.20	2.20	2.70	5.40
1973-79	3.00	3.50	3.30	-0.20	7.10	8.20	6.80	9.60
1979-92	2.00	2.60	1.50	-0.20	2.40	7.30	2.00	5.10
1949-92	**2.47**	**2.53**	**2.23**	**-0.27**	**3.90**	**5.90**	**3.83**	**6.70**
	JORGENSON DATA							
1958-69	2.73	1.92	2.48	1.11	1.61	4.19	1.69	3.48
1969-78	2.47	3.10	2.44	-0.52	7.34	7.41	7.74	8.68
1978-87	1.87	1.44	1.54	-0.17	3.86	8.11	3.90	6.12
1987-91	1.79	2.70	0.75	2.69	2.83	8.05	2.85	3.36
1958-91	**2.47**	**1.78**	**2.14**	**0.43**	**2.96**	**5.95**	**3.06**	**5.38**

APPENDIX B

SUPPLEMENTARY TABLES FOR TWO DIGIT INDUSTRY

TABLE B1

ANNUAL PERCENTAGE GROWTH RATE OF OUTPUT, INPUTS, AND PRICES FOR FOOD AND KINDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD

Period	Output	Physical capital stock	Material plus energy	Total labor	High school and below labor	Some college and college degree labor	R&D capital stock
	OUTPUT AND INPUTS						
1958-69	3.00	3.18	2.28	-0.08	-0.05	-0.27	0.27
1969-78	2.45	2.73	2.34	0.94	0.08	5.46	0.29
1978-87	2.05	1.40	0.71	-0.45	-0.95	1.60	0.55
1987-94	2.01	1.40	1.60	0.68	-0.37	4.42	-0.23
1958-94	**2.33**	**2.24**	**1.76**	**0.41**	**-0.13**	**2.76**	**0.28**
	OUTPUT AND INPUT PRICES						
1958-69	1.18	5.99	1.57	-0.02	0.14	-0.65	5.99
1969-78	7.17	9.54	7.93	6.60	6.53	5.98	9.54
1978-87	3.46	7.88	3.76	6.00	5.39	7.07	7.58
1987-94	2.25	2.13	1.91	1.93	1.71	2.35	2.12
1958-94	**3.39**	**6.31**	**3.59**	**3.77**	**3.59**	**3.96**	**6.31**

Sources: All data are from National Bureau of Economic Research (NBER) excepts the two types of labor by education level are from Bureau of Labor Statistics (BLS), R&D capital is from the National Science Foundation (NSF), and R&D capital price is a price deflator from Amera's dissertation.

TABLE B2

SHARE OF FACTOR INPUTS FOR THE FOOD AND KONDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD

Period	INPUT COST SHARES				
	Physical capital stock	Material plus energy	High school and below high school labor	Some college and college degree labor	R&D capital stock
1958-69	0.282	0.589	0.102	0.025	0.002
1969-78	0.308	0.589	0.077	0.024	0.002
1978-87	0.319	0.580	0.068	0.029	0.003
1987-94	0.323	0.582	0.060	0.035	0.003
1958-94	0.305	0.585	0.079	0.028	0.003

TABLE B3

OUTPUT ELASTICITIES FOR THE FOOD AND KINDRED PRODUCTS SECTOR, MEAN ESTIMATE FOR PERIOD

Period	H	C	K	M	R
1958-69	0.031	0.007	0.084	0.176	0.001
1969-78	0.037	0.012	0.148	0.284	0.001
1978-87	0.055	0.024	0.256	0.466	0.002
1987-94	0.060	0.035	0.324	0.587	0.003
1958-94	**0.049**	**0.017**	**0.186**	**0.358**	**0.002**

Note: H, C, K, M, and R are high school and below high school labor, some college and college degree labor, physical capital, material plus energy, and R&D capital, respectively.

APPENDIX C

SUPPLEMENTARY TABLES FOR THREE DIGIT INDUSTRY

TABLE C1

ANNUAL PERCENTAGE GROWTH RATE OF OUTPUT AND INPUTS FOR THE THREE DIGIT FOOD & KINDRED INDUSTRIES, MEAN ESTIMATE FOR PERIOD

Period	OUTPUT AND INPUTS					
	Output	Structural capital	Equipment capital	Material plus energy	Production labor	Non-Production labor
	Meat products (SIC 201)					
1958-69	3.52	4.02	3.78	2.38	0.45	-1.17
1969-78	2.17	3.19	4.39	1.94	0.22	-1.64
1978-87	1.87	0.73	1.87	0.74	1.41	0.20
1987-94	3.23	1.11	3.24	2.46	4.93	1.07
1958-94	**2.71**	**2.33**	**3.32**	**1.84**	**1.31**	**-0.40**
	Dairy products (sic 202)					
1958-69	0.20	4.22	15.26	1.03	-3.26	-2.56
1969-78	1.80	1.72	2.15	1.44	-1.63	-5.25
1978-87	1.63	-0.05	1.13	1.41	-0.04	-2.30
1987-94	0.59	-0.19	2.31	1.12	0.65	-1.17
1958-94	**1.08**	**1.62**	**5.93**	**1.35**	**-1.40**	**-3.03**
	Preserved fruits and vegetables (SIC 203)					
1958-69	4.44	3.30	7.30	3.72	1.29	1.10
1969-78	3.41	2.05	4.88	2.32	0.24	1.35
1978-87	1.33	0.62	2.76	-0.03	-0.84	0.93
1987-94	2.52	1.12	3.82	2.49	1.37	0.45
1958-94	**2.95**	**1.84**	**4.84**	**2.25**	**0.28**	**0.93**
	Grain mill products (SIC 204)					
1958-69	3.51	2.76	5.93	2.25	-0.41	-0.06
1969-78	2.85	2.09	5.10	1.89	0.36	0.68
1978-87	3.28	0.64	3.44	1.75	-1.31	-0.63
1987-94	2.75	0.83	3.60	2.76	1.52	0.04
1958-94	**3.08**	**1.65**	**4.63**	**2.01**	**-0.30**	**-0.21**

TABLE C1 (CONTINUED)

Period	OUTPUT AND INPUTS					
	Output	Structural capital	Equipment capital	Material plus energy	Production labor	Non-Production labor
	Bakery products (SIC 205)					
1958-69	1.21	0.80	7.11	1.04	-0.93	-1.44
1969-78	0.18	-0.08	2.83	-0.08	-1.80	-0.57
1978-87	0.60	-0.73	1.32	0.12	-0.74	-0.25
1987-94	0.38	-0.17	3.08	1.82	1.87	-0.15
1958-94	**0.50**	**0.00**	**3.77**	**0.71**	**-0.76**	**-0.98**
	Sugar and confectionary products (SIC 206)					
1958-69	2.56	1.43	8.18	2.36	0.18	-0.55
1969-78	1.02	0.76	4.12	1.21	-1.42	-0.02
1978-87	0.46	0.12	1.72	-0.23	-1.63	-1.84
1987-94	1.94	0.09	2.20	0.97	0.58	0.43
1958-94	**1.63**	**0.68**	**4.35**	**1.27**	**-0.61**	**-0.28**
	Fats and oils (SIC 207)					
1958-69	3.25	-0.97	1.77	2.58	-0.63	-0.12
1969-78	4.35	-0.22	4.03	5.15	0.62	-0.36
1978-87	2.29	-0.57	1.71	0.78	-4.26	-1.49
1987-94	0.85	-1.04	-0.68	0.96	-0.56	-4.87
1958-94	**2.62**	**-0.69**	**1.81**	**2.37**	**-1.52**	**-1.25**
	Beverages (SIC 208)					
1958-69	5.25	-0.02	0.76	5.29	0.15	1.65
1969-78	5.07	1.78	2.93	4.75	-0.99	-0.85
1978-87	2.15	1.41	1.75	1.37	-2.52	-1.35
1987-94	1.82	-0.52	-0.63	0.65	-1.53	-3.33
1958-94	**3.51**	**0.58**	**1.22**	**3.08**	**-1.14**	**-0.75**
	Miscellaneous food products (SIC209)					
1958-69	3.72	2.30	4.31	1.62	0.92	0.79
1969-78	1.84	1.37	4.18	4.83	2.01	0.76
1978-87	3.21	0.27	3.12	-1.23	0.27	1.68
1987-94	2.29	-0.09	3.40	0.29	2.41	1.92
1958-94	**2.32**	**1.09**	**3.77**	**1.70**	**1.01**	**1.01**

Sources: National Bureau of Economics Research.

TABLE C2

ANNUAL GROWTH RATE OF OUTPUT AND INPUT PRICES FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR PERIOD

Period	OUTPUT AND INPUT PRICES					
	Output	Structural capital	Equipment capital	Material plus energy	Production labor	Non-Production labor
	Meat products (SIC 201)					
SIC 201						
1958-69	0.88	3.84	6.06	1.82	3.43	4.47
1969-78	8.08	8.48	10.01	8.51	6.94	7.73
1978-87	3.51	7.55	7.72	4.61	2.92	4.88
1987-94	1.33	1.45	2.70	1.53	1.61	3.58
1958-94	**2.84**	**5.21**	**6.58**	**3.44**	**3.87**	**4.82**
	Dairy products (sic 202)					
SIC202						
1958-69	2.60	4.99	6.60	2.06	4.14	3.61
1969-78	5.97	7.42	9.08	7.18	7.65	7.86
1978-87	3.99	7.88	7.45	3.62	6.31	6.53
1987-94	2.55	3.06	2.10	1.51	2.77	3.96
1958-94	**3.74**	**5.65**	**6.32**	**3.51**	**5.28**	**5.46**
	Preserved fruits and vegetables (SIC 203)					
SIC203						
1958-69	1.23	7.75	6.28	1.43	4.38	4.09
1969-78	6.48	10.41	9.60	7.85	7.88	7.00
1978-87	5.17	8.10	7.74	4.85	6.03	6.56
1987-94	2.41	2.05	2.27	1.93	2.79	4.01
1958-94	**3.79**	**7.02**	**6.42**	**3.90**	**5.44**	**5.51**
	Grain mill products (SIC 204)					
SIC204						
1958-69	0.38	9.00	5.91	1.03	3.90	4.36
1969-78	6.78	11.56	9.54	8.05	8.18	7.15
1978-87	1.88	8.46	7.76	2.32	6.57	6.50
1987-94	3.22	2.45	2.03	3.93	1.98	4.28
1958-94	**3.07**	**7.82**	**6.25**	**3.98**	**5.38**	**5.49**

TABLE C2 (CONTINUED)

Period	OUTPUT AND INPUT PRICES					
	Output	Structural capital	Equipment capital	Material plus energy	Production labor	Non Production labor
	Bakery products (SIC 205)					
1958-69	1.81	5.34	5.05	1.32	4.34	4.09
1969-78	7.23	9.45	8.85	7.47	8.30	7.49
1978-87	5.79	8.03	7.35	4.56	5.81	5.32
1987-94	4.02	1.74	1.93	2.40	2.00	2.94
1958-94	**4.74**	**6.03**	**5.75**	**3.88**	**5.33**	**5.08**
	Sugar and confectionary products (SIC 206)					
1958-69	2.05	7.55	4.55	1.61	4.14	4.25
1969-78	9.68	10.15	8.81	10.28	7.82	7.69
1978-87	5.84	7.92	7.43	5.04	6.78	7.35
1987-94	1.82	1.69	1.62	1.84	2.55	4.43
1958-94	**4.84**	**6.81**	**5.50**	**4.69**	**5.40**	**5.67**
	Fat and oils (SIC 207)					
1958-69	0.76	10.03	6.32	0.93	4.11	3.93
1969-78	11.09	10.32	10.44	10.02	7.53	7.53
1978-87	-0.65	9.92	8.03	0.90	6.25	5.24
1987-94	3.19	8.11	1.58	2.61	1.94	5.55
1958-94	**3.68**	**9.35**	**6.55**	**3.65**	**5.13**	**5.40**
	Beverages (SIC 208)					
1958-69	1.39	6.43	5.59	1.69	3.83	3.67
1969-78	5.15	10.62	9.93	7.96	8.41	7.98
1978-87	5.18	8.58	7.94	4.97	7.34	6.39
1987-94	1.96	1.37	1.65	1.75	3.31	3.68
1958-94	**3.47**	**6.60**	**6.21**	**4.13**	**5.56**	**5.37**
	Miscellaneous products (SIC 209)					
1958-69	1.04	4.00	3.02	1.94	3.94	4.57
1969-78	10.30	8.69	7.56	7.71	7.01	7.16
1978-87	2.46	7.63	6.63	4.55	5.99	5.82
1987-94	1.69	1.70	1.10	2.19	2.23	4.57
1958-94	**4.26**	**5.34**	**4.49**	**4.03**	**4.94**	**5.39**

Sources: National Bureau of Economic Research.

TABLE C3

COST SHARE OF FACTOR INPUTS FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR PERIOD

Period	Structural capital	Equipment capital	Material plus energy	Production labor	Non production labor
	Meat products (SIC201)				
1958-69	0.070	0.062	0.778	0.067	0.024
1969-78	0.081	0.074	0.766	0.059	0.019
1978-87	0.084	0.087	0.760	0.053	0.016
1987-94	0.079	0.093	0.757	0.054	0.017
1958-94	**0.078**	**0.078**	**0.766**	**0.059**	**0.020**
	Dairy products (SIC202)				
1958-69	0.116	0.091	0.675	0.049	0.069
1969-78	0.136	0.132	0.652	0.038	0.043
1978-87	0.131	0.135	0.670	0.035	0.029
1987-94	0.115	0.140	0.682	0.036	0.027
1958-94	**0.124**	**0.121**	**0.670**	**0.040**	**0.044**
	Preserved fruits and vegetables (SIC203)				
1958-69	0.185	0.134	0.571	0.084	0.026
1969-78	0.176	0.179	0.548	0.075	0.022
1978-87	0.168	0.209	0.530	0.070	0.023
1987-94	0.156	0.235	0.514	0.069	0.026
1958-94	**0.173**	**0.184**	**0.544**	**0.075**	**0.024**
	Grain mill products (SIC 204)				
1958-69	0.156	0.143	0.618	0.530	0.030
1969-78	0.157	0.187	0.580	0.490	0.026
1978-87	0.151	0.233	0.546	0.455	0.024
1987-94	0.133	0.257	0.544	0.419	0.024
1958-94	**0.150**	**0.199**	**0.576**	**0.048**	**0.027**

TABLE C3 (CONTINUED)

Period	Structural capital	Equipment capital	Material plus energy	Production labor	Non production labor
	Bakery products (SIC 205)				
1958-69	0.227	0.147	0.402	0.119	0.106
1969-78	0.216	0.203	0.381	0.109	0.092
1978-87	0.201	0.235	0.367	0.105	0.093
1987-94	0.178	0.258	0.373	0.104	0.087
1958-94	**0.208**	**0.204**	**0.382**	**0.110**	**0.095**
	Sugar and confectionary products (SIC 206)				
1958-69	0.174	0.147	0.567	0.081	0.030
1969-78	0.158	0.210	0.536	0.069	0.027
1978-87	0.148	0.240	0.524	0.064	0.025
1987-94	0.140	0.264	0.503	0.065	0.028
1958-94	**0.157**	**0.208**	**0.536**	**0.071**	**0.028**
	Fats and oils (SIC 207)				
1958-69	0.165	0.161	0.615	0.038	0.021
1969-78	0.121	0.165	0.665	0.032	0.017
1978-87	0.100	0.186	0.674	0.026	0.015
1987-94	0.091	0.184	0.692	0.021	0.013
1958-94	**0.123**	**0.173**	**0.657**	**0.030**	**0.017**
	Beverages (SIC 208)				
1958-69	0.202	0.322	0.357	0.058	0.061
1969-78	0.171	0.287	0.442	0.047	0.053
1978-87	0.160	0.299	0.456	0.041	0.045
1987-94	0.160	0.295	0.468	0.037	0.040
1958-94	**0.176**	**0.303**	**0.423**	**0.047**	**0.051**
	Miscellaneous food and kindred products (SIC 209)				
1958-69	0.156	0.130	0.616	0.059	0.040
1969-78	0.159	0.171	0.578	0.057	0.036
1978-87	0.144	0.192	0.573	0.057	0.034
1987-94	0.130	0.228	0.541	0.061	0.040
1958-94	**0.149**	**0.175**	**0.581**	**0.058**	**0.037**

Source: National Bureau of Economic Research

TABLE C4

PARAMETER ESTIMATES OF TRANSLOG COST FUNCTION WITH COST SHARE EQUATIONS FOR THREE DIGIT FOOD PRODUCTS INDUSTRIES FOR 1958-1994 PERIOD

Variable	Parameter	Estimate	Std. Err	P-value
		Meat Products (SIC 201)		
Intercept	α_0	0.09481	0.00742	0.0010
lnY	α_Y	0.92783	0.04094	0.0002
lnS	α_S	0.36625	0.16513	0.1133
lnP_P	α_P	-0.01628	0.00072	0.0002
lnP_N	α_N	-0.00735	0.00043	0.0005
lnP_E	α_E	-0.00178	0.00060	0.0610
lnP_M	α_M	1.02542	0.00122	0.0001
$(lnP_P)^2$	α_{PP}	-0.01755	0.00332	0.0133
$(lnP_N)^2$	α_{NN}	-0.00562	0.00114	0.0163
$(lnP_E)^2$	α_{EE}	-0.00514	0.00194	0.0775
$(lnP_M)^2$	α_{MM}	-0.03916	0.00618	0.0079
$lnP_P\ lnP_N$	α_{PN}	-0.00562	0.00114	0.0163
$lnP_P\ lnP_E$	α_{PE}	-0.00012	0.00203	0.9563
$lnP_P\ lnP_M$	α_{PM}	0.02329	0.00339	0.0064
$lnP_N lnP_E$	α_{NE}	0.00031	0.00134	0.8282
$lnP_N lnP_M$	α_{NM}	0.01092	0.00183	0.0094
$lnP_E lnP_M$	α_{EM}	0.00494	0.00281	0.1776
lnP_P lnY	α_{PY}	0.02786	0.00562	0.0158
lnP_N lnY	α_{NY}	0.00768	0.00290	0.0769
lnP_E lnY	α_{EY}	-0.04309	0.00485	0.0030
lnP_M lnY	α_{MY}	0.00754	0.01033	0.5182
lnP_P lnS	α_{PS}	0.30067	0.01417	0.0002
lnP_N lnS	α_{NS}	0.13155	0.00877	0.0006
lnP_E lnS	α_{ES}	0.10820	0.01178	0.0027
lnP_M lnS	α_{MS}	-0.54043	0.02365	0.0002
lnP_P T	γ_{PT}	0.00046	0.00002	0.0005
lnP_NT	γ_{NT}	0.00019	0.00001	0.0009
lnP_ET	γ_{ET}	0.00009	0.00002	0.0284
lnP_MT	γ_{MT}	-0.00075	0.00004	0.0006
lnY T	γ_{YT}	-0.01137	0.00228	0.0156
lnS T	γ_{ST}	-0.06359	0.00880	0.0055
T	γ_T	-0.00087	0.00091	0.4081
T^2	γ_{TT}	0.00021	0.00003	0.0061

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
		Dairy Products (SIC 202)		
Intercept	α_0	0.12890	0.04078	0.0508
lnY	α_Y	0.61233	0.16801	0.0356
lnS	α_S	0.77007	0.23366	0.0459
$\ln P_P$	α_P	-0.00768	0.00090	0.0033
$\ln P_N$	α_N	-0.01394	0.00126	0.0016
$\ln P_E$	α_E	0.00412	0.00160	0.0816
$\ln P_M$	α_M	1.01750	0.00263	0.0001
$(\ln P_P)^2$	α_{PP}	-0.04467	0.00540	0.0037
$(\ln P_N)^2$	α_{NN}	0.00085	0.00319	0.8077
$(\ln P_E)^2$	α_{EE}	0.00038	0.00668	0.9586
$(\ln P_M)^2$	α_{MM}	-0.01822	0.01639	0.3472
$\ln P_P \ln P_N$	α_{PN}	0.00085	0.00319	0.8077
$\ln P_P \ln P_E$	α_{PE}	0.00583	0.00318	0.1644
$\ln P_P \ln P_M$	α_{PM}	0.03799	0.00553	0.0063
$\ln P_N \ln P_E$	α_{NE}	0.00593	0.00424	0.2562
$\ln P_N \ln P_M$	α_{NM}	-0.00762	0.00750	0.3843
$\ln P_E \ln P_M$	α_{EM}	-0.01214	0.00907	0.2731
$\ln P_P \ln Y$	α_{PY}	0.04554	0.00760	0.0093
$\ln P_N \ln Y$	α_{NY}	0.02285	0.01038	0.1151
$\ln P_E \ln Y$	α_{EY}	-0.06333	0.01320	0.0172
$\ln P_M \ln Y$	α_{MY}	-0.00506	0.02129	0.8276
$\ln P_P \ln S$	α_{PS}	0.07532	0.01610	0.0185
$\ln P_N \ln S$	α_{NS}	0.16810	0.02198	0.0046
$\ln P_E \ln S$	α_{ES}	0.12621	0.02720	0.0189
$\ln P_M \ln S$	α_{MS}	-0.36963	0.04484	0.0037
$\ln P_P$ T	γ_{PT}	0.00027	3.52E-05	0.0001
$\ln P_N$T	γ_{NT}	0.00043	5.18E-05	0.0001
$\ln P_E$T	γ_{ET}	-0.00011	0.00007	0.1953
$\ln P_M$T	γ_{MT}	-0.00059	0.00011	0.0127
lnY T	γ_{YT}	-0.00850	0.00808	0.3700
lnS T	γ_{ST}	-0.07619	0.01957	0.0300
T	γ_T	-0.00418	0.00204	0.1330
T^2	γ_{TT}	0.00029	0.00009	0.0473

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
	Preserved Fruits and Vegetables (SIC 203)			
Intercept	α_0	0.06810	0.04140	0.1985
lnY	α_Y	0.93652	0.27812	0.0435
lnS	α_S	0.22129	0.58686	0.7312
$\ln P_P$	α_P	-0.00954	0.00136	0.0059
$\ln P_N$	α_N	-0.00148	0.00062	0.0953
$\ln P_E$	α_E	0.00352	0.00195	0.1683
$\ln P_M$	α_M	1.00750	0.00283	0.0001
$(\ln P_P)^2$	α_{PP}	-0.05250	0.00918	0.0106
$(\ln P_N)^2$	α_{NN}	-0.00418	0.00214	0.1460
$(\ln P_E)^2$	α_{EE}	-0.00141	0.01176	0.9120
$(\ln P_M)^2$	α_{MM}	-0.04850	0.02466	0.1439
$\ln P_P \ln P_N$	α_{PN}	-0.00418	0.00214	0.1460
$\ln P_P \ln P_E$	α_{PE}	0.00717	0.00554	0.2863
$\ln P_P \ln P_M$	α_{PM}	0.04951	0.01098	0.0204
$\ln P_N \ln P_E$	α_{NE}	0.00181	0.00247	0.5172
$\ln P_N \ln P_M$	α_{NM}	0.00656	0.00493	0.2753
$\ln P_E \ln P_M$	α_{EM}	-0.00757	0.01558	0.6604
$\ln P_P \ln Y$	α_{PY}	0.03932	0.01341	0.0609
$\ln P_N \ln Y$	α_{NY}	0.00477	0.00596	0.4824
$\ln P_E \ln Y$	α_{EY}	-0.10621	0.02490	0.0236
$\ln P_M \ln Y$	α_{MY}	0.06212	0.03424	0.1673
$\ln P_P \ln S$	α_{PS}	0.12629	0.03272	0.0307
$\ln P_N \ln S$	α_{NS}	0.00960	0.01479	0.5626
$\ln P_E \ln S$	α_{ES}	0.19535	0.05341	0.0353
$\ln P_M \ln S$	α_{MS}	-0.33124	0.07554	0.0220
$\ln P_P$ T	γ_{PT}	0.00024	0.00005	0.0142
$\ln P_N$T	γ_{NT}	0.00004	2.04E-05	0.0687
$\ln P_E$T	γ_{ET}	0.00002	0.00008	0.7833
$\ln P_M$T	γ_{MT}	-0.00030	0.00011	0.0783
lnY T	γ_{YT}	-0.00432	0.01345	0.7693
lnS T	γ_{ST}	-0.04233	0.03354	0.2961
T	γ_T	-0.00592	0.00315	0.1567
T^2	γ_{TT}	0.00040	0.00011	0.0334

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
		Grain Mill Products (SIC 204)		
Intercept	α_0	0.04045	0.06447	0.5748
lnY	α_Y	-0.42897	0.39120	0.3530
lnS	α_S	1.20812	1.61806	0.5095
$\ln P_P$	α_P	-0.00970	0.00122	0.0042
$\ln P_N$	α_N	-0.00585	0.00078	0.0051
$\ln P_E$	α_E	0.00355	0.00369	0.4077
$\ln P_M$	α_M	1.01200	0.00446	0.0001
$(\ln P_P)^2$	α_{PP}	-0.00788	0.00371	0.1236
$(\ln P_N)^2$	α_{NN}	-0.00389	0.00129	0.0573
$(\ln P_E)^2$	α_{EE}	-0.04517	0.01333	0.0429
$(\ln P_M)^2$	α_{MM}	-0.11104	0.01923	0.0103
$\ln P_P \ln P_N$	α_{PN}	-0.00389	0.00129	0.0573
$\ln P_P \ln P_E$	α_{PE}	-0.01804	0.00416	0.0226
$\ln P_P \ln P_M$	α_{PM}	0.02983	0.00406	0.0052
$\ln P_N \ln P_E$	α_{NE}	-0.00509	0.00247	0.1319
$\ln P_N \ln P_M$	α_{NM}	0.01288	0.00247	0.0137
$\ln P_E \ln P_M$	α_{EM}	0.06832	0.01539	0.0213
$\ln P_P$ lnY	α_{PY}	0.05145	0.01287	0.0281
$\ln P_N$ lnY	α_{NY}	0.02769	0.00782	0.0383
$\ln P_E$ lnY	α_{EY}	0.04174	0.04912	0.4579
$\ln P_M$ lnY	α_{MY}	-0.12089	0.06069	0.1404
$\ln P_P$ lnS	α_{PS}	0.18688	0.03388	0.0117
$\ln P_N$ lnS	α_{NS}	0.12455	0.02165	0.0104
$\ln P_E$ lnS	α_{ES}	0.13084	0.10203	0.2898
$\ln P_M$ lnS	α_{MS}	-0.44227	0.12325	0.0371
$\ln P_P$ T	γ_{PT}	0.00021	0.00004	0.0170
$\ln P_N$T	γ_{NT}	0.00012	0.00002	0.0183
$\ln P_E$T	γ_{ET}	-0.00002	0.00016	0.8917
$\ln P_M$T	γ_{MT}	-0.00031	0.00020	0.2124
lnY T	γ_{YT}	0.03412	0.02054	0.1952
lnS T	γ_{ST}	-0.09645	0.07259	0.2760
T	γ_T	-0.00740	0.00642	0.3328
T^2	γ_{TT}	0.00044	0.00020	0.1243

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
		Bakery Products (SIC 205)		
Intercept	α_0	0.22972	0.02707	0.0034
lnY	α_Y	2.05101	0.16199	0.0011
lnS	α_S	0.20105	0.17026	0.3228
$\ln P_P$	α_P	-0.00566	0.00086	0.0072
$\ln P_N$	α_N	-0.00515	0.00108	0.0177
$\ln P_E$	α_E	0.01025	0.00098	0.0019
$\ln P_M$	α_M	1.00057	0.00170	0.0001
$(\ln P_P)^2$	α_{PP}	-0.01646	0.00729	0.1093
$(\ln P_N)^2$	α_{NN}	-0.01871	0.00448	0.0251
$(\ln P_E)^2$	α_{EE}	-0.00947	0.00677	0.2567
$(\ln P_M)^2$	α_{MM}	-0.07382	0.01512	0.0164
$\ln P_P \ln P_N$	α_{PN}	-0.01871	0.00448	0.0251
$\ln P_P \ln P_E$	α_{PE}	0.00673	0.00483	0.2577
$\ln P_P \ln P_M$	α_{PM}	0.02843	0.00724	0.0294
$\ln P_N \ln P_E$	α_{NE}	-0.00261	0.00608	0.6967
$\ln P_N \ln P_M$	α_{NM}	0.04003	0.00906	0.0215
$\ln P_E \ln P_M$	α_{EM}	0.00535	0.00773	0.5384
$\ln P_P \ln Y$	α_{PY}	0.06932	0.01522	0.0198
$\ln P_N \ln Y$	α_{NY}	0.10210	0.01904	0.0127
$\ln P_E \ln Y$	α_{EY}	-0.05748	0.01663	0.0408
$\ln P_M \ln Y$	α_{MY}	-0.11394	0.02842	0.0278
$\ln P_P \ln S$	α_{PS}	0.02347	0.03034	0.4955
$\ln P_N \ln S$	α_{NS}	0.22974	0.03779	0.0089
$\ln P_E \ln S$	α_{ES}	0.13423	0.03303	0.0269
$\ln P_M \ln S$	α_{MS}	-0.38745	0.05589	0.0062
$\ln P_P T$	γ_{PT}	0.00015	4.07E-05	0.0005
$\ln P_N T$	γ_{NT}	0.00015	5.13E-05	0.0059
$\ln P_E T$	γ_{ET}	-0.00022	0.00004	0.0177
$\ln P_M T$	γ_{MT}	-0.00009	8.71E-05	0.3610
lnY T	γ_{YT}	-0.05544	0.00683	0.0039
lnS T	γ_{ST}	-0.05085	0.01418	0.0372
T	γ_T	-0.00730	0.00061	0.0013
T^2	γ_{TT}	0.00046	0.00003	0.0007

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
	Sugar and Confectionary Products (SIC 206)			
Intercept	α_0	0.16078	0.04634	0.0404
lnY	α_Y	1.64451	0.34951	0.0182
lnS	α_S	0.33589	0.48285	0.5367
$\ln P_P$	α_P	-0.00786	0.00074	0.0018
$\ln P_N$	α_N	-0.00469	0.00077	0.0090
$\ln P_E$	α_E	0.00467	0.00223	0.1275
$\ln P_M$	α_M	1.00788	0.00285	0.0001
$(\ln P_P)^2$	α_{PP}	-0.00886	0.00412	0.1207
$(\ln P_N)^2$	α_{NN}	-0.00484	0.00225	0.1213
$(\ln P_E)^2$	α_{EE}	-0.01317	0.00906	0.2419
$(\ln P_M)^2$	α_{MM}	-0.04886	0.01230	0.0285
$\ln P_P \ln P_N$	α_{PN}	-0.00484	0.00225	0.1213
$\ln P_P \ln P_E$	α_{PE}	-0.00289	0.00359	0.4795
$\ln P_P \ln P_M$	α_{PM}	0.01661	0.00323	0.0143
$\ln P_N \ln P_E$	α_{NE}	-0.00324	0.00409	0.4859
$\ln P_N \ln P_M$	α_{NM}	0.01293	0.00322	0.0279
$\ln P_E \ln P_M$	α_{EM}	0.01932	0.00940	0.1322
$\ln P_P \ln Y$	α_{PY}	0.03389	0.00801	0.0242
$\ln P_N \ln Y$	α_{NY}	0.03268	0.00826	0.0288
$\ln P_E \ln Y$	α_{EY}	-0.05287	0.02195	0.0952
$\ln P_M \ln Y$	α_{MY}	-0.01369	0.02813	0.6597
$\ln P_P \ln S$	α_{PS}	0.18581	0.02285	0.0039
$\ln P_N \ln S$	α_{NS}	0.16184	0.02458	0.0071
$\ln P_E \ln S$	α_{ES}	0.41659	0.05790	0.0055
$\ln P_M \ln S$	α_{MS}	-0.76425	0.07085	0.0017
$\ln P_P T$	γ_{PT}	0.00021	0.00003	0.0074
$\ln P_N T$	γ_{NT}	0.00013	0.00003	0.0004
$\ln P_E T$	γ_{ET}	-0.00004	0.00010	0.6994
$\ln P_M T$	γ_{MT}	-0.00030	0.00013	0.1025
lnY T	γ_{YT}	-0.04448	0.01703	0.0796
lnS T	γ_{ST}	-0.06722	0.03940	0.1865
T	γ_T	-0.00525	0.00197	0.0766
T^2	γ_{TT}	0.00039	0.00008	0.0211

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
		Fats and Oils (SIC 207)		
Intercept	α_0	0.08477	0.07217	0.3249
lnY	α_Y	-0.02293	0.16542	0.8985
lnS	α_S	-0.04376	1.48777	0.9784
$\ln P_P$	α_P	-0.00048	0.00075	0.5669
$\ln P_N$	α_N	-0.00016	0.00039	0.7068
$\ln P_E$	α_E	0.00906	0.00344	0.0782
$\ln P_M$	α_M	0.99159	0.00404	0.0001
$(\ln P_P)^2$	α_{PP}	-0.01105	0.00434	0.0844
$(\ln P_N)^2$	α_{NN}	0.00161	0.00136	0.3212
$(\ln P_E)^2$	α_{EE}	-0.02824	0.01100	0.0828
$(\ln P_M)^2$	α_{MM}	-0.05375	0.01422	0.0324
$\ln P_P \ln P_N$	α_{PN}	0.00161	0.00136	0.3212
$\ln P_P \ln P_E$	α_{PE}	-0.00350	0.00405	0.4504
$\ln P_P \ln P_M$	α_{PM}	0.01294	0.00289	0.0208
$\ln P_N \ln P_E$	α_{NE}	-0.00614	0.00230	0.0762
$\ln P_N \ln P_M$	α_{NM}	0.00291	0.00159	0.1640
$\ln P_E \ln P_M$	α_{EM}	0.03789	0.01200	0.0510
$\ln P_P$ lnY	α_{PY}	-0.00467	0.00461	0.3862
$\ln P_N$ lnY	α_{NY}	0.00195	0.00251	0.4929
$\ln P_E$ lnY	α_{EY}	-0.02301	0.02118	0.3568
$\ln P_M$ lnY	α_{MY}	0.02573	0.02484	0.3764
$\ln P_P$ lnS	α_{PS}	0.23953	0.03777	0.0079
$\ln P_N$ lnS	α_{NS}	0.09504	0.02129	0.0210
$\ln P_E$ lnS	α_{ES}	1.01988	0.09390	0.0017
$\ln P_M$ lnS	α_{MS}	-1.35446	0.10449	0.0010
$\ln P_P$ T	γ_{PT}	0.00005	0.00003	0.1660
$\ln P_N$T	γ_{NT}	0.00001	0.00002	0.4259
$\ln P_E$T	γ_{ET}	-0.00002	0.00015	0.9169
$\ln P_M$T	γ_{MT}	-0.00005	0.00017	0.7811
lnY T	γ_{YT}	0.01054	0.01017	0.3761
lnS T	γ_{ST}	-0.15087	0.07350	0.1324
T	γ_T	-0.00798	0.00269	0.0595
T^2	γ_{TT}	0.00033	0.00011	0.0569

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
		Beverages (SIC 208)		
Intercept	α_0	0.12453	0.02051	0.0090
lnY	α_Y	0.19657	0.15320	0.2896
lnS	α_S	1.25865	0.17455	0.0055
$\ln P_P$	α_P	-0.00762	0.00064	0.0013
$\ln P_N$	α_N	-0.00634	0.00081	0.0044
$\ln P_E$	α_E	-0.00002	0.00228	0.9933
$\ln P_M$	α_M	1.01398	0.00255	0.0001
$(\ln P_P)^2$	α_{PP}	-0.00387	0.00417	0.4220
$(\ln P_N)^2$	α_{NN}	-0.01403	0.00262	0.0127
$(\ln P_E)^2$	α_{EE}	-0.00043	0.01210	0.9739
$(\ln P_M)^2$	α_{MM}	-0.08994	0.01648	0.0121
$\ln P_P \ln P_N$	α_{PN}	-0.01403	0.00262	0.0127
$\ln P_P \ln P_E$	α_{PE}	-0.00596	0.00328	0.1666
$\ln P_P \ln P_M$	α_{PM}	0.02386	0.00460	0.0139
$\ln P_N \ln P_E$	α_{NE}	-0.01582	0.00432	0.0351
$\ln P_N \ln P_M$	α_{NM}	0.04388	0.00548	0.0041
$\ln P_E \ln P_M$	α_{EM}	0.02221	0.01294	0.1847
$\ln P_P$ lnY	α_{PY}	0.07957	0.00786	0.0021
$\ln P_N$ lnY	α_{NY}	0.09990	0.00982	0.0020
$\ln P_E$ lnY	α_{EY}	-0.08901	0.02559	0.0401
$\ln P_M$ lnY	α_{MY}	-0.09046	0.02864	0.0509
$\ln P_P$ lnS	α_{PS}	0.05061	0.01314	0.0309
$\ln P_N$ lnS	α_{NS}	0.09830	0.01654	0.0095
$\ln P_E$ lnS	α_{ES}	0.17406	0.04475	0.0301
$\ln P_M$ lnS	α_{MS}	-0.32298	0.05058	0.0078
$\ln P_P$ T	γ_{PT}	0.00015	0.00002	0.0001
$\ln P_N$T	γ_{NT}	0.00007	0.00003	0.0278
$\ln P_E$T	γ_{ET}	0.00003	0.00009	0.7826
$\ln P_M$T	γ_{MT}	-0.00025	0.00010	0.0928
lnY T	γ_{YT}	-0.00311	0.00660	0.6698
lnS T	γ_{ST}	-0.05472	0.01067	0.0143
T	γ_T	-0.00667	0.00119	0.0111
T^2	γ_{TT}	0.00035	0.00005	0.0061

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C4 (CONTINUED)

Variable	Parameter	Estimate	Std. Err	P-value
	Misc. Food and kindred Products (SIC 209)			
Intercept	α_0	0.11987	0.06063	0.1425
lnY	α_Y	0.77858	0.12189	0.0078
lnS	α_S	0.51623	1.02747	0.6499
$\ln P_P$	α_P	-0.00246	0.00186	0.2781
$\ln P_N$	α_N	-0.00349	0.00149	0.1013
$\ln P_E$	α_E	-0.00142	0.00413	0.7546
$\ln P_M$	α_M	1.00737	0.00624	0.0001
$(\ln P_P)^2$	α_{PP}	-0.02901	0.01200	0.0944
$(\ln P_N)^2$	α_{NN}	-0.00801	0.00608	0.2792
$(\ln P_E)^2$	α_{EE}	-0.01175	0.02535	0.6747
$(\ln P_M)^2$	α_{MM}	-0.07245	0.06052	0.3172
$\ln P_P \ln P_N$	α_{PN}	-0.00801	0.00608	0.2792
$\ln P_P \ln P_E$	α_{PE}	-0.00121	0.00959	0.9073
$\ln P_P \ln P_M$	α_{PM}	0.03824	0.01849	0.1304
$\ln P_N \ln P_E$	α_{NE}	-0.00261	0.00757	0.7527
$\ln P_N \ln P_M$	α_{NM}	0.01864	0.01556	0.3170
$\ln P_E \ln P_M$	α_{EM}	0.01557	0.03692	0.7015
$\ln P_P \ln Y$	α_{PY}	-0.01382	0.00769	0.1702
$\ln P_N \ln Y$	α_{NY}	-0.01134	0.00617	0.1635
$\ln P_E \ln Y$	α_{EY}	-0.06634	0.01893	0.0394
$\ln P_M \ln Y$	α_{MY}	0.09150	0.02839	0.0485
$\ln P_P \ln S$	α_{PS}	0.07593	0.04591	0.1967
$\ln P_N \ln S$	α_{NS}	0.11609	0.03794	0.0550
$\ln P_E \ln S$	α_{ES}	0.24385	0.08493	0.0640
$\ln P_M \ln S$	α_{MS}	-0.43587	0.13138	0.0451
$\ln P_P T$	γ_{PT}	0.00009	0.00008	0.3311
$\ln P_N T$	γ_{NT}	0.00012	0.00006	0.1410
$\ln P_E T$	γ_{ET}	0.00022	0.00018	0.3026
$\ln P_M T$	γ_{MT}	-0.00043	0.00027	0.2077
lnY T	γ_{YT}	-0.02913	0.00907	0.0489
lnS T	γ_{ST}	-0.06009	0.06808	0.4424
T	γ_T	-0.00138	0.00486	0.7955
T^2	γ_{TT}	0.00019	0.00021	0.4385

Note: Y, S, and T are output, fixed structural capital, and technical change (time) and P_P, P_N, P_E, and P_M are prices of production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C5

R-SQUARES OF TRANSLOG COST FUNCTION AND COST SHARE EQUATIONS FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, 1958-1994

Industry	Cost function	Share equations				DW-statistics
		P	N	E	M	
Meats	0.98	0.60	0.72	0.87	0.80	1.59
Dairy	0.98	0.74	0.63	0.77	0.61	2.35
Pres. fruits & vegetables	0.98	0.43	0.59	0.47	0.35	1.83
Grain milling	0.98	0.63	0.53	0.54	0.60	2.27
Bakery	0.99	0.68	0.58	0.67	0.49	1.65
Sugar & confectionary	0.99	0.60	0.23	0.56	0.54	1.96
Fats and Oils	0.98	0.63	0.57	0.49	0.55	1.78
Beverages	0.99	0.53	0.59	0.61	0.65	2.28
Misc. food products	0.96	0.31	0.48	0.39	0.42	1.61

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C6

OWN AND CROSS PRICE ELASTICITIES FOR THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Meat Products (201)				
P	-1.2403	-0.0762	0.0754	1.1630
	(0.0566)	(0.0195)	(0.0346)	(0.0579)
N	-0.2281	-1.2672	0.0938	1.3234
	(0.0585)	(0.0585)	(0.0688)	(0.0934)
E	0.0571	0.0237	-0.9888	0.8299
	(0.0262)	(0.0174)	(0.0251)	(0.0363)
M	0.0891	0.0339	0.0840	-0.2850
	(0.0044)	(0.0024)	(0.0037)	(0.0081)
Dairy Products (202)				
P	-2.0681	0.0654	0.2686	1.6126
	(0.1339)	(0.0792)	(0.0790)	(0.1371)
N	0.0594	-0.9365	0.2574	0.4983
	(0.0719)	(0.0719)	(0.0954)	(0.1689)
E	0.0874	0.0922	-0.8731	0.5720
	(0.0257)	(0.0342)	(0.0539)	(0.0732)
M	0.0970	0.0330	0.1058	-0.3572
	(0.0082)	(0.0112)	(0.0135)	(0.0245)
Preserved Fruits and Vegetables (203)				
P	-1.6218	-0.0315	0.2790	1.2015
	(0.1220)	(0.0285)	(0.0736)	(0.1459)
N	-0.0983	-1.1495	0.2589	0.8161
	(0.0890)	(0.0890)	(0.1026)	(0.2044)
E	0.1143	0.0339	-0.8239	0.5028
	(0.0301)	(0.0135)	(0.0640)	(0.0847)
M	0.1663	0.0362	0.1699	-0.5452
	(0.0202)	(0.0091)	(0.0286)	(0.0453)

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C6 (CONTINUED)

OWN AND CROSS PRICE ELASTICITIES FOR THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Grain Mill Products (204)				
P	-1.1163	-0.0547	-0.1767	1.1972
	(0.0773)	(0.0270)	(0.0867)	(0.0846)
N	-0.0990	-1.1205	0.0070	1.0621
	(0.0489)	(0.0489)	(0.0935)	(0.0933)
E	-0.0426	0.0009	-1.0274	0.9185
	(0.0209)	(0.0124)	(0.0669)	(0.0773)
M	0.0998	0.0489	0.3180	-0.6172
	(0.0071)	(0.0043)	(0.0267)	(0.0334)
Bakery Products (205)				
P	-1.0399	-0.0748	0.2654	0.6412
	(0.0664)	(0.0408)	(0.0440)	(0.0659)
N	-0.0862	-1.1007	0.1767	0.8020
	(0.0470)	(0.0470)	(0.0638)	(0.0950)
E	0.1429	0.0826	-0.8423	0.4086
	(0.0237)	(0.0298)	(0.0332)	(0.0379)
M	0.1843	0.2001	0.2181	-0.8107
	(0.0189)	(0.0237)	(0.0202)	(0.0396)
Sugar and Confectionary Products (206)				
P	-1.0550	-0.0408	0.1671	0.7713
	(0.0584)	(0.0320)	(0.0510)	(0.0458)
N	-0.1036	-1.1464	0.0914	1.0013
	(0.0812)	((0.0812)	(0.1474)	(0.1161)
E	0.0567	0.0122	-0.8551	0.6288
	(0.0173)	(0.0197)	(0.0435)	(0.0452)
M	0.1016	0.0519	0.2443	-0.5552
	(0.0060)	(0.0060)	(0.0176)	(0.0230)

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C6 (CONTINUED)

OWN AND CROSS PRICE ELASTICITIES FOR THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Fats and Oils (207)				
P	-1.3384	0.0708	0.0559	1.0882
	(0.1448)	(0.0454)	(0.1351)	(0.0963)
N	0.1256	-0.8875	-0.1909	0.8293
	(0.0807)	(0.0807)	(0.1366)	(0.0941)
E	0.0097	-0.0187	-0.9904	0.8760
	(0.0234)	(0.0134)	(0.0637)	(0.0694)
M	0.0497	0.0213	0.2306	-0.4250
	(0.0044)	(0.0024)	(0.0183)	(0.0217)
Beverages (208)				
P	-1.0353	-0.2479	0.1763	0.9311
	(0.0887)	(0.0557)	(0.0697)	(0.0978)
N	-0.2303	-1.2267	-0.0095	1.2906
	(0.0517)	(0.0517)	(0.0853)	(0.1084)
E	0.0273	-0.0016	-0.6983	0.4967
	(0.0108)	(0.0142)	(0.0399)	(0.0427)
M	0.1034	0.1542	0.3555	-0.7890
	(0.0109)	(0.0130)	(0.0306)	(0.0389)
Misc. Food and Kindred Products (209)				
P	-1.4403	-0.1003	0.1540	1.2378
	(0.2062)	(0.1045)	(0.1648)	(0.3176)
N	-0.1561	-1.1769	0.1050	1.0792
	(0.1626)	(0.1626)	(0.2024)	(0.4161)
E	0.0513	0.0225	-0.8923	0.6698
	(0.0549)	(0.0433)	(0.1449)	(0.2111)
M	0.1240	0.0695	0.2017	-0.5439
	(0.0318)	(0.0268)	(0.0636)	(0.1042)

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C7

MORISHIMA ELASTICITIES OF SUBSTITUTION FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Meat Products (201)				
P	0	1.1910	1.0643	1.4480
		(0.2794)	(0.2444)	(0.2578)
N	1.1642	0	1.0826	1.6085
	(0.2760)		(0.3065)	(0.3192)
E	1.3158	1.3610	0	1.1149
	(0.3021)	(0.3569)		(0.2114)
M	2.4033	2.5906	1.8187	0
	(0.3384)	(0.3897)	(0.2479)	
Dairy Products (202)				
P	0	1.0019	1.1417	1.9698
		(0.3887)	(0.3647)	(0.4040)
N	2.1335	0	1.1305	0.8555
	(0.4617)		(0.3865)	(0.4432)
E	2.3367	1.1939	0	0.9292
	(0.4615)	(0.4091)		(0.3145)
M	3.6806	1.4348	1.4451	0
	(0.5206)	(0.4908)	(0.3566)	
Preserved Fruits and Vegetables (203)				
P	0	1.1180	1.1029	1.7467
		(0.3427)	(0.3708)	(0.4406)
N	1.5904	0	1.0828	1.3613
	(0.3878)		(0.4079)	(0.5034)
E	1.9008	1.4084	0	1.0480
	(0.4422)	(0.4377)		(0.3633)
M	2.8234	1.9656	1.3267	0
	(0.5175)	(0.5417)	(0.3858)	

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C7 (CONTINUED)

MORISHIMA ELASTICITIES OF SUBSTITUTION FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Grain Mill Products (204)				
P	0	1.0659	0.8506	1.8144
		(0.2754)	(0.3918)	(0.3455
N	1.0616	0	1.0343	1.6793
	(0.3230)		(0.4004)	(0.3579)
E	0.9396	1.1275	0	1.5357
	(0.4050)	(0.3773)		(0.3352)
M	2.3135	2.1826	1.9459	0
	(0.4024)	(0.3771)	(0.3799)	
Bakery Products (205)				
P	0	1.0259	1.1077	1.4518
		(0.2963)	(0.2778)	(0.3255)
N	0.9650	0	1.0190	1.6127
	(0.3274)		(0.3116)	(0.3678)
E	1.3052	1.2774	0	1.2193
	(0.3322)	(0.3329)		(0.2787)
M	1.6810	1.9028	1.2509	0
	(0.3637)	(0.3768)	(0.2667)	
Sugar and Confectionary Products (206)				
P	0	1.1056	1.0222	1.3264
		(0.3365)	(0.3074)	(0.2631)
N	1.0142	0	0.9465	1.5565
	(0.3007)		(0.4371)	(0.3738)
E	1.2221	1.2378	0	1.1840
	(0.3308)	(0.4781)		(0.2621)
M	1.8263	2.1477	1.4839	0
	(0.3229)	(0.4442)	(0.2979)	

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

TABLE C7 (CONTINUED)

MORISHIMA ELASTICITIES OF SUBSTITUTION FOR THE THREE DIGIT FOOD PRODUCTS INDUSTRIES, MEAN ESTIMATE FOR 1958-94 PERIOD

	P	N	E	M
Fats and Oils (207)				
P	0	0.9582	1.0464	1.5133
		(0.3551)	(0.4459)	(0.3451)
N	1.4091	0	0.7996	1.2544
	(0.4362)		(0.4475)	(0.3415)
E	1.3943	0.6966	0	1.3010
	(0.5291)	(0.4661)		(0.3039)
M	2.4266	1.7168	1.8664	0
	(0.4911)	(0.4180)	(0.3649)	
Beverages (208)				
P	0	0.9788	0.8746	1.7201
		(0.3276)	(0.3310)	(0.3709)
N	0.7874	0	0.6888	2.0796
	(0.3800)		(0.3541)	(0.3846)
E	1.2116	1.2172	0	1.2857
	(0.3981)	(0.3701)		(0.2866)
M	1.9664	2.5172	1.1950	0
	(0.4319)	(0.4001)	(0.2878)	
Misc. Food and Kindred Products (209)				
P	0	1.0766	1.0463	1.7818
		(0.5168)	(0.5558)	(0.6633)
N	1.3400	0	0.9973	1.6232
	(0.5573)		(0.5885)	(0.7367)
E	1.5943	1.2819	0	1.2138
	(0.6091)	(0.6042)		(0.5734)
M	2.6781	2.2561	1.5621	0
	(0.7237)	(0.7608)	(0.5971)	

Note: P, C, E, and M are production labor, non-production labor, equipment capital, and material plus energy, respectively.

APPENDIX D

DATA

TIME SERIES DATA

Variable Descriptions

The following data set is mostly from The National Bureau of Economic Research. Labor by education level for the two digit industry is from The Bureau of Labor Statistics and R&D capital is from The National Science Foundation.

VSH: value of industry shipments (millions of 1987 dollars). These are based on net selling values, f.o.b. plant, after discounts and allowances. This includes receipts for contract work and miscellaneous services provided by the plant to others.

K: real capital stock (millions of 1987 dollars). This includes both equipment and plant capital stock.

R&D: research and development expenditures (millions of 1987 dollars).

HH: hours of high school and below high school labor (in millions of hours).

HC: hours of some college and college degree labor (in millions of hours).

ME: cost of materials plus energy (millions of 1987 dollars). This includes the total delivered cost of raw materials, parts, and supplies put into production or used for repair and maintenance, along with purchased electric energy and fuels consumed for heat and power, and contract work done by others for plant. This excludes the costs of services used, overhead costs, or expenditures related to plant expansion.

PY: price deflator for value of shipments (equals one in 1987).

PK: real rental price of capital stock (equal one in 1987).

PH: real wage rate index of high school and below high school labor (equals one in 1987).

PC: real wage rate index of some college and college degree labor (equals one in 1987).

PME: price deflator for materials plus energy (equals one in 1987).

IND: standard industrial classification code.

SK: real structural capital stock (millions of 1987 dollars).

EK: real equipment capital stock (millions of 1987 dollars).

HPL: hours of production workers (in millions of hours).

HNL: hours of non-production workers (in millions of hours).

PSK: real rental price of structural capital (equals one in 1987).

PEK: real rental price of equipment capital (equals one in 1987).

PPL: price deflator for production labor (equal one in 1987).

PNL: price deflator for non-production labor (equals one in 1987).

TWO DIGIT DATA (SIC 20)

YEAR	VSH	K	R&D	HH	HC	ME	PY	PK	PH	PC	PME
1958	162705.62	58088.20	445.00	2913.73	456.35	126507.98	0.367148	0.143563	0.332060	0.305017	0.337338
1959	174476.62	60688.80	462.00	2914.16	456.48	132855.24	0.357535	0.156384	0.331974	0.305059	0.330415
1960	180499.31	62307.40	543.00	2914.58	456.45	135213.51	0.355923	0.159939	0.331892	0.304717	0.330668
1961	184281.48	63677.10	569.00	2912.46	456.11	139500.51	0.360485	0.160233	0.332315	0.305275	0.332468
1962	190467.95	66187.60	535.00	2915.42	456.89	141415.86	0.361988	0.159683	0.331715	0.305185	0.339787
1963	188899.26	67075.50	532.00	2915.85	456.35	139744.13	0.362451	0.160455	0.331645	0.303689	0.339029
1964	198023.51	69503.70	562.00	2906.11	455.10	146856.49	0.361546	0.165691	0.333584	0.306947	0.335707
1965	198392.43	71817.00	554.00	2924.30	459.21	146380.17	0.374249	0.168760	0.329917	0.304906	0.351588
1966	200569.10	74544.50	574.00	2917.14	454.75	148454.87	0.397163	0.188083	0.331434	0.299218	0.375172
1967	216520.95	77151.70	603.00	2876.89	451.33	159058.49	0.387768	0.204211	0.339403	0.316625	0.366104
1968	220869.80	79512.70	581.00	2978.88	471.55	160609.28	0.395379	0.235296	0.318915	0.298394	0.374046
1969	224486.94	81921.70	589.00	2895.65	441.37	161651.17	0.415971	0.268191	0.335966	0.282560	0.398481
1970	227583.90	84646.00	662.00	2756.15	441.07	163652.67	0.432952	0.302601	0.363365	0.367832	0.411240
1971	234605.41	86957.10	638.00	2343.60	437.95	168960.53	0.441724	0.299847	0.397068	0.396367	0.418217
1972	247472.24	89227.00	654.00	2699.70	525.75	174208.74	0.464943	0.309116	0.422191	0.356882	0.463629
1973	231547.33	91327.40	624.00	2858.19	594.85	169135.46	0.585551	0.321790	0.427466	0.394671	0.582499
1974	244369.50	93961.60	643.00	2682.04	530.75	171700.19	0.662450	0.398114	0.470569	0.402305	0.696986
1975	245720.68	96347.90	664.00	2492.91	595.68	175476.88	0.700141	0.457087	0.538702	0.438433	0.715669
1976	266141.88	98967.10	665.00	2421.17	534.60	191330.34	0.679426	0.477962	0.565461	0.480561	0.683248
1977	269445.49	101543.70	736.00	2998.85	698.01	199167.92	0.715957	0.506525	0.596466	0.515058	0.700497
1978	279466.32	104052.30	766.00	2836.10	745.35	201677.98	0.772862	0.573404	0.596346	0.509207	0.777652
1979	279213.51	106182.00	789.00	2874.35	769.51	194801.03	0.845141	0.670991	0.629387	0.547472	0.878753
1980	284965.34	108282.50	833.00	2871.12	817.83	196570.51	0.899016	0.869498	0.711517	0.628728	0.942532
1981	289958.33	109761.70	797.00	2915.64	757.37	200172.10	0.938547	1.040298	0.764593	0.644498	0.979234
1982	299584.76	111640.50	912.00	2884.76	774.39	201052.32	0.936395	1.193231	0.853695	0.733919	0.981070
1983	299239.13	112086.50	926.00	2633.32	773.64	198620.98	0.959628	1.018232	0.884281	0.808369	1.002528
1984	301925.45	112927.20	1170.00	2613.57	722.27	198407.29	0.993661	1.099883	0.932197	0.843204	1.045660
1985	312188.20	114230.40	1205.00	2713.59	742.18	205476.31	0.965963	1.101294	0.947605	0.804859	0.985531
1986	314520.04	114995.70	1321.00	2692.17	783.56	206863.03	0.980931	0.972831	1.002493	0.943552	0.973233
1987	329725.40	116698.00	1206.00	2709.78	808.81	213426.20	1.000000	1.000000	1.000000	1.000000	1.000000
1988	336255.79	118166.60	1148.00	2629.34	1008.10	210144.71	1.045380	1.048581	1.042179	0.768339	1.086986
1989	332106.38	119514.40	1162.00	2742.78	1005.25	213264.47	1.097249	1.164470	1.072052	1.006887	1.115279
1990	338781.85	121279.10	1111.00	2801.71	938.88	219700.64	1.133499	1.067409	1.119142	1.174939	1.131677
1991	342681.04	123122.40	1085.00	2680.99	1070.02	222619.29	1.131083	1.123809	1.148920	1.013117	1.111732
1992	358657.55	125083.00	1123.00	2437.61	1106.11	230666.63	1.135226	1.092470	1.150592	1.016308	1.107823
1993	365747.30	127161.50	1039.00	2640.10	1038.34	233181.34	1.154394	1.045643	1.139265	1.066845	1.126842
1994	368271.37	128535.60	1088.00	2586.23	1071.49	234732.99	1.170316	1.133818	1.146081	1.032026	1.128315

THREE DIGIT DATA (SIC201, SIC202, SIC203, SIC204, SIC205, SIC206, SIC207, SIC 208, AND SIC 209)

YEAR	IND	VSH	SK	EK	HPL	HNL	ME	PY	PSK	PEK	PPL	PNL	PME
1958	201	36451.87	3187.90	2846.80	487.60	142.48	38512.18	0.436932	0.200000	0.134715	0.291296	0.229186	0.351546
1959	201	38916.48	3326.80	2948.30	500.30	133.12	39783.39	0.403780	0.209736	0.145609	0.296007	0.251189	0.330155
1960	201	39733.05	3462.50	3060.60	502.10	128.13	39626.34	0.399919	0.209152	0.148721	0.305730	0.267472	0.333712
1961	201	41398.13	3572.50	3149.50	498.00	128.13	41195.54	0.388204	0.206625	0.149622	0.311388	0.274598	0.326026
1962	201	42171.02	3748.90	3232.00	486.70	123.34	41572.39	0.396085	0.202329	0.150001	0.324716	0.287083	0.335706
1963	201	44683.12	3890.60	3356.10	485.50	126.88	43391.82	0.376131	0.201049	0.152498	0.333780	0.272969	0.323202
1964	201	47800.98	4016.00	3466.00	515.20	132.08	46184.30	0.368181	0.203098	0.157058	0.336569	0.283146	0.315185
1965	201	46028.35	4220.80	3647.40	488.60	128.96	44736.72	0.406760	0.202798	0.161619	0.350268	0.294633	0.351389
1966	201	45644.15	4335.70	3845.20	486.90	127.30	44800.60	0.444686	0.221286	0.179754	0.358493	0.305721	0.384903
1967	201	52274.82	4550.20	4008.20	507.80	127.50	49175.92	0.411672	0.234158	0.194551	0.377833	0.328925	0.367651
1968	201	53251.47	4661.10	4116.20	504.10	126.05	49074.04	0.421662	0.267248	0.223889	0.407181	0.327596	0.381501
1969	201	52750.04	4916.70	4281.50	510.10	124.59	49561.81	0.470193	0.298242	0.254004	0.421524	0.367161	0.420838
1970	201	53650.88	5185.00	4492.20	514.90	125.42	50242.63	0.474563	0.331359	0.286383	0.447636	0.379351	0.420866
1971	201	55582.09	5378.60	4694.80	500.10	122.72	50404.82	0.469189	0.326097	0.289030	0.481388	0.380071	0.422549
1972	201	60641.98	5585.30	4899.70	506.60	118.98	54796.78	0.519079	0.334451	0.302780	0.504953	0.428028	0.488348
1973	201	54472.22	5726.90	5101.10	491.40	117.10	50214.47	0.696531	0.347228	0.318260	0.528408	0.450535	0.647887
1974	201	59875.78	5898.00	5380.10	511.00	122.10	55078.54	0.668639	0.422353	0.388565	0.578179	0.486385	0.615127
1975	201	56359.66	6003.60	5639.60	494.00	121.26	53819.35	0.777448	0.480320	0.446654	0.641540	0.526573	0.686043
1976	201	64374.73	6129.50	5819.80	503.00	121.68	59181.35	0.711879	0.497849	0.470852	0.696536	0.566478	0.650979
1977	201	64173.28	6248.70	6104.70	499.80	114.40	59663.54	0.721115	0.525215	0.507544	0.753504	0.624919	0.656966
1978	201	64450.18	6376.90	6323.50	514.00	106.29	58600.43	0.861998	0.592366	0.572986	0.795113	0.685918	0.813837
1979	201	65907.22	6449.90	6484.90	517.80	115.44	56030.38	0.935234	0.691738	0.665232	0.853904	0.687259	0.940145
1980	201	67455.52	6518.50	6675.30	530.20	115.65	57938.79	0.933274	0.901564	0.848074	0.911900	0.741572	0.924638
1981	201	69597.25	6606.90	6808.90	518.60	109.20	60638.07	0.947006	1.079774	0.998023	0.973236	0.803787	0.928362
1982	201	69826.69	6633.90	6928.60	518.10	110.86	60022.23	0.968143	1.235352	1.150294	0.995412	0.829114	0.954841
1983	201	70431.27	6623.80	6948.80	511.60	106.91	60447.22	0.942648	1.046269	0.993348	0.975655	0.887351	0.929111
1984	201	69447.88	6596.00	6957.60	497.30	102.34	59230.02	0.987473	1.130999	1.065098	0.981155	0.917395	0.971171
1985	201	71260.51	6635.30	6988.10	499.40	104.42	59993.69	0.942152	1.126222	1.079722	0.991753	0.911193	0.915478
1986	201	71276.07	6664.00	7119.30	521.30	110.86	59596.91	0.971821	0.977297	0.975038	0.992251	0.921611	0.947761
1987	201	77002.30	6715.50	7341.30	571.50	115.23	63915.00	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	201	79719.50	6749.10	7549.20	603.80	117.10	64796.08	1.018431	1.044658	1.046356	1.010208	1.026521	1.032353
1989	201	78114.48	6783.40	7721.80	621.70	115.65	63343.77	1.079703	1.154849	1.172840	1.010863	1.108201	1.086410
1990	201	78708.08	6893.40	8053.50	654.20	120.64	63039.64	1.153331	1.054044	1.083033	1.022198	1.132676	1.161347
1991	201	80249.03	7025.80	8380.60	670.30	124.18	64603.17	1.113919	1.094081	1.151268	1.049504	1.147407	1.123276
1992	201	88357.76	7184.50	8680.00	709.90	120.02	70472.50	1.065712	1.047684	1.132501	1.097628	1.173106	1.076976
1993	201	90189.46	7219.40	8934.10	738.60	118.35	71051.28	1.102592	0.990114	1.104295	1.101081	1.212883	1.121570
1994	201	91449.17	7276.20	9184.40	765.00	120.43	72052.10	1.072899	1.078540	1.190703	1.126766	1.217432	1.061170

1958	202	30845.40	3268.20	1089.70	297.60	317.41	22049.36	0.327187	0.192928	0.140815	0.189129	0.194594	0.333325
1959	202	31504.95	3298.20	1602.50	295.80	311.38	23267.91	0.332856	0.205244	0.157641	0.191492	0.225603	0.325319
1960	202	31396.67	3533.00	2164.80	278.00	317.41	23404.86	0.346384	0.209217	0.166136	0.205286	0.206731	0.333119
1961	202	31975.31	3709.30	2578.70	270.40	317.62	24640.64	0.353804	0.208270	0.168562	0.211020	0.206873	0.331262
1962	202	32201.49	3933.10	3014.40	255.80	316.16	24106.26	0.353210	0.207236	0.170839	0.223481	0.209599	0.336846
1963	202	31497.47	4129.40	3398.80	250.60	290.78	24498.55	0.356019	0.208152	0.174342	0.226301	0.223291	0.332301
1964	202	32987.48	4428.40	3776.20	249.40	285.58	25884.02	0.355602	0.212652	0.180076	0.229799	0.232460	0.328581
1965	202	32576.85	4541.10	4110.40	237.80	283.71	24221.87	0.356195	0.216241	0.184473	0.236689	0.236732	0.347294
1966	202	31176.53	4644.60	4358.00	230.40	267.90	23836.45	0.389960	0.236554	0.203214	0.247151	0.245440	0.377388
1967	202	32257.93	4825.80	4582.60	222.50	258.96	25563.90	0.397840	0.252608	0.219287	0.263634	0.261679	0.371868
1968	202	31586.69	4981.20	4731.00	209.30	247.10	25259.56	0.417796	0.284836	0.250258	0.281789	0.273360	0.387572
1969	202	31424.05	5141.80	4853.90	206.30	237.54	24451.13	0.432284	0.325442	0.281579	0.294716	0.282853	0.414169
1970	202	30806.79	5341.90	5055.70	193.30	229.22	24179.44	0.447827	0.364720	0.314934	0.325865	0.291129	0.421925
1971	202	32058.30	5419.70	5196.40	183.20	217.78	25722.28	0.462875	0.358977	0.313591	0.354673	0.312380	0.430141
1972	202	34337.96	5552.80	5381.50	189.20	199.68	26250.06	0.475841	0.360382	0.324560	0.375791	0.347267	0.473862
1973	202	34564.65	5572.40	5470.40	186.90	194.90	26701.03	0.522175	0.362207	0.335948	0.401463	0.367462	0.518501
1974	202	35956.65	5660.70	5573.30	185.90	185.74	27227.50	0.581723	0.500060	0.406898	0.440368	0.374227	0.603232
1975	202	36893.90	5693.00	5638.00	183.90	166.82	27708.61	0.615571	0.549146	0.465907	0.478561	0.441127	0.648950
1976	202	37493.61	5761.30	5692.80	183.20	158.29	29007.33	0.663537	0.532359	0.489653	0.513075	0.476936	0.687619
1977	202	38181.62	5865.80	5800.30	175.90	143.52	29243.12	0.682522	0.502339	0.522298	0.545329	0.532262	0.708950
1978	202	37619.92	5904.60	5851.90	177.00	143.31	29055.24	0.742888	0.549274	0.587564	0.588416	0.577575	0.769290
1979	202	36395.49	5914.40	5886.50	181.20	139.57	27461.37	0.831614	0.638079	0.679551	0.608197	0.590716	0.867214
1980	202	37503.36	5972.20	5951.10	175.50	131.46	28390.44	0.906466	0.806759	0.868946	0.690116	0.638684	0.951292
1981	202	38258.26	5937.70	5996.70	175.00	130.00	29336.97	0.967509	0.995454	1.024986	0.747234	0.689887	1.011441
1982	202	39597.14	5968.00	6155.70	167.50	130.21	30568.24	0.981270	1.112825	1.177276	0.828704	0.727044	1.017615
1983	202	40835.64	5947.10	6212.00	164.50	121.89	31102.91	0.986991	0.954939	1.011941	0.868792	0.782191	1.023464
1984	202	40857.88	5905.90	6218.30	168.50	117.94	30722.87	0.991084	1.055735	1.085667	0.885199	0.826602	1.031059
1985	202	41856.96	5899.70	6289.20	167.50	113.57	32090.42	0.983684	1.056794	1.095070	0.925076	0.906419	1.002362
1986	202	42975.65	5859.20	6349.30	167.90	113.57	32165.76	0.983480	0.950050	0.977458	0.953862	0.937872	0.990777
1987	202	44755.10	5834.50	6490.00	174.60	113.36	33494.90	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	202	46543.71	5803.90	6668.60	182.90	109.82	34797.74	1.008609	1.071956	1.044654	1.015436	1.046636	1.002913
1989	202	43987.87	5830.90	6797.30	176.90	109.62	33281.68	1.092221	1.158220	1.164170	1.045550	1.078287	1.086499
1990	202	43991.99	5870.70	6976.90	176.80	112.32	34456.33	1.158447	1.024840	1.066960	1.080558	1.076786	1.116053
1991	202	43962.39	5826.70	7172.40	175.90	109.20	34725.80	1.133983	1.116893	1.125639	1.114124	1.152950	1.052295
1992	202	46153.47	5782.40	7299.90	185.00	105.87	35270.08	1.173134	1.132266	1.095923	1.140449	1.209617	1.097863
1993	202	45274.79	5784.80	7503.80	183.40	102.13	35037.42	1.182269	1.081023	1.056471	1.163923	1.230514	1.090183
1994	202	44838.20	5772.20	7623.50	176.10	103.17	35065.87	1.198989	1.185227	1.137926	1.186917	1.276798	1.110439
1958	203	15373.16	3598.10	2101.10	320.70	54.91	10821.68	0.315817	0.114835	0.138392	0.184694	0.200977	0.294788
1959	203	15758.06	3697.80	2262.10	325.80	54.08	10905.81	0.315870	0.128793	0.150624	0.190384	0.218578	0.297034
1960	203	17387.88	3774.50	2408.30	333.00	54.91	11695.45	0.313857	0.131984	0.154233	0.195372	0.235965	0.295269
1961	203	17838.47	3850.30	2575.40	337.90	54.50	12364.91	0.323598	0.132340	0.155280	0.200883	0.251760	0.298490

1962	203	18770.66	4099.50	2781.20	338.40	54.70	12445.41	0.312269	0.134376	0.155545	0.210696	0.249462	0.303381
1963	203	19044.53	4264.80	2962.20	327.60	55.95	12793.23	0.327632	0.136905	0.157733	0.221134	0.245209	0.304302
1964	203	20276.40	4427.50	3179.50	333.10	58.45	13762.10	0.328776	0.143519	0.163408	0.230693	0.249040	0.305070
1965	203	21862.10	4537.10	3441.50	343.90	60.11	14163.52	0.322942	0.147235	0.167130	0.233465	0.259468	0.310509
1966	203	22647.92	4692.70	3775.60	355.30	61.15	14502.66	0.331373	0.168445	0.186589	0.244434	0.268606	0.321031
1967	203	23578.65	4852.80	4078.60	362.50	56.99	14994.93	0.332776	0.186753	0.203736	0.259821	0.300307	0.321409
1968	203	24065.37	4940.80	4316.80	361.30	60.11	16204.68	0.353155	0.219233	0.234787	0.283572	0.306434	0.328917
1969	203	24705.71	5135.90	4557.40	368.60	61.57	16108.79	0.359836	0.256240	0.266938	0.295462	0.309906	0.344098
1970	203	25212.04	5301.50	4793.70	352.20	63.02	15772.08	0.367166	0.295415	0.300196	0.317761	0.330322	0.360777
1971	203	26462.38	5406.60	5042.80	357.30	64.69	16428.46	0.378216	0.291364	0.299387	0.339011	0.340302	0.373255
1972	203	27988.15	5556.90	5367.90	363.90	64.48	16935.67	0.391676	0.302009	0.310616	0.362589	0.370855	0.398343
1973	203	29346.67	5637.20	5699.80	361.30	67.81	17609.12	0.424852	0.316357	0.324485	0.393474	0.386610	0.444281
1974	203	28970.36	5759.00	6067.10	360.30	60.53	18129.65	0.507377	0.394195	0.396281	0.427341	0.471029	0.542426
1975	203	28509.02	5836.20	6327.00	344.30	59.28	17571.45	0.559332	0.455097	0.455699	0.476460	0.500243	0.599945
1976	203	30049.84	5912.20	6508.20	334.70	59.49	18000.91	0.558362	0.476050	0.479049	0.515891	0.532885	0.591720
1977	203	31960.49	5972.00	6686.60	358.10	67.81	19861.08	0.607641	0.504239	0.510588	0.559496	0.533684	0.627780
1978	203	33541.23	6048.50	6949.00	367.90	67.60	20263.98	0.653217	0.576555	0.577118	0.604746	0.593903	0.690274
1979	203	32687.04	6152.50	7166.40	371.00	71.34	20483.66	0.720325	0.682045	0.672494	0.651809	0.605494	0.752170
1980	203	32671.95	6206.30	7269.30	357.80	73.01	19760.28	0.760640	0.901817	0.865066	0.702726	0.646132	0.829750
1981	203	31336.47	6241.50	7442.30	349.00	68.43	18981.13	0.845127	1.091282	1.027214	0.744140	0.747417	0.900995
1982	203	32293.38	6307.30	7697.60	324.60	69.68	19006.84	0.882763	1.251107	1.181390	0.848194	0.800646	0.921184
1983	203	33081.59	6296.30	7820.10	317.40	69.68	19310.93	0.901151	1.052280	1.011050	0.887467	0.855159	0.931747
1984	203	33899.51	6303.30	7995.70	326.60	68.64	20234.72	0.955728	1.139415	1.089648	0.921127	0.920997	0.980725
1985	203	34340.91	6310.80	8250.30	319.60	70.93	20285.42	0.970015	1.128738	1.096720	0.963559	0.936571	0.979422
1986	203	35368.39	6318.40	8461.80	314.00	71.97	19443.36	0.964881	0.971533	0.974541	0.985252	0.980401	0.969071
1987	203	36342.80	6351.90	8773.20	327.30	74.05	19730.60	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	203	36762.33	6399.20	9059.70	328.90	73.22	20237.06	1.041865	1.050540	1.046750	1.025766	1.039707	1.037913
1989	203	38089.57	6457.20	9342.20	338.60	75.50	21442.92	1.092887	1.162733	1.166139	1.066234	1.084343	1.079727
1990	203	39244.99	6534.00	9694.20	349.20	77.79	22519.77	1.133757	1.069151	1.071335	1.089339	1.146808	1.108573
1991	203	41603.37	6680.70	10180.80	354.90	73.84	23006.58	1.125055	1.122753	1.131415	1.116351	1.205406	1.111786
1992	203	40611.80	6814.20	10710.80	351.90	75.92	21837.34	1.142525	1.087048	1.104539	1.157346	1.271577	1.110071
1993	203	42415.60	6888.20	11089.90	348.50	77.58	22613.18	1.140741	1.029823	1.063018	1.194938	1.276913	1.119409
1994	203	43085.19	6906.40	11418.50	349.60	74.26	23572.71	1.166032	1.124759	1.148965	1.227756	1.341350	1.128029
1958	204	14602.94	3228.60	2420.90	180.10	73.63	13240.37	0.473508	0.091151	0.145368	0.179587	0.190029	0.386477
1959	204	15304.60	3369.40	2680.80	182.00	78.62	13455.87	0.460835	0.105791	0.158103	0.180156	0.187890	0.386842
1960	204	16661.14	3452.60	2894.70	181.60	75.09	13989.49	0.433812	0.109662	0.162259	0.183567	0.207223	0.376225
1961	204	16874.26	3534.80	3088.00	181.60	74.26	14216.25	0.449578	0.110121	0.162173	0.190963	0.220055	0.391868
1962	204	16954.24	3645.50	3283.90	181.20	74.46	14628.63	0.466355	0.111685	0.162258	0.194170	0.224634	0.399675
1963	204	17499.45	3721.40	3436.50	174.50	73.01	14847.02	0.468683	0.113353	0.163760	0.207753	0.218424	0.404465
1964	204	17953.31	3858.30	3609.50	170.70	71.76	14951.87	0.465630	0.120087	0.168165	0.214833	0.235986	0.405280
1965	204	17925.84	3960.10	3821.10	167.30	70.93	15112.57	0.474974	0.125088	0.171666	0.222676	0.235930	0.410076

1966	204	18459.37	4051.60	4039.20	166.50	71.97	15758.52	0.503479	0.145373	0.190565	0.230425	0.250274	0.433277
1967	204	20095.57	4155.30	4225.90	171.00	71.55	17095.60	0.495104	0.162467	0.206341	0.243771	0.272578	0.418230
1968	204	20461.72	4264.90	4380.80	167.90	70.93	16835.82	0.484446	0.194720	0.237375	0.257493	0.287537	0.414366
1969	204	21245.26	4353.80	4555.50	171.90	72.80	16862.23	0.490575	0.229691	0.269750	0.273098	0.301203	0.430791
1970	204	21456.28	4483.20	4751.20	171.50	71.55	16710.38	0.512922	0.270058	0.304440	0.298625	0.316592	0.460546
1971	204	21475.40	4622.30	4989.20	163.30	66.98	17190.04	0.526426	0.268285	0.301463	0.322263	0.332654	0.462529
1972	204	22951.14	4676.60	5216.20	173.00	70.30	17005.50	0.534976	0.277492	0.311353	0.335049	0.349914	0.511476
1973	204	21579.79	4745.50	5461.30	177.60	69.26	16713.58	0.751963	0.292813	0.324389	0.356137	0.384283	0.734708
1974	204	22612.52	4866.10	5797.10	173.30	71.55	17466.25	0.900360	0.370918	0.396803	0.394590	0.425565	0.894863
1975	204	23672.45	4885.50	6176.30	175.40	71.34	17697.65	0.879043	0.428966	0.457610	0.432442	0.452168	0.865448
1976	204	25068.22	5007.30	6454.10	174.10	72.80	18123.01	0.852498	0.454356	0.480302	0.477239	0.482969	0.857545
1977	204	26721.27	5129.70	6877.30	169.50	71.97	19156.71	0.843732	0.488675	0.512050	0.531018	0.533751	0.847066
1978	204	26924.58	5240.90	7204.70	173.20	75.50	20227.00	0.876047	0.566608	0.579751	0.564125	0.572235	0.834800
1979	204	26796.94	5285.80	7438.70	174.40	72.18	18575.89	0.971958	0.670425	0.676013	0.607380	0.612495	1.004959
1980	204	27879.46	5357.70	7682.40	171.10	72.59	18949.04	1.052122	0.892913	0.875861	0.665690	0.668923	1.097164
1981	204	29125.13	5411.40	8110.00	166.40	71.55	19446.36	1.104091	1.086153	1.046983	0.722432	0.707505	1.170584
1982	204	31115.75	5431.40	8418.90	156.40	70.72	19241.39	1.018240	1.243554	1.200704	0.797283	0.771689	1.134008
1983	204	31605.24	5417.60	8473.20	155.30	69.68	19731.38	1.063010	1.045582	1.022613	0.844241	0.802931	1.160872
1984	204	32521.31	5420.10	8594.20	148.00	69.06	17164.97	1.069459	1.131796	1.102515	0.906113	0.832888	1.372306
1985	204	35133.11	5431.30	8978.30	142.20	68.64	19470.32	0.981049	1.121995	1.104269	0.966772	0.861682	1.133063
1986	204	34509.95	5437.70	9259.50	141.50	67.18	21092.73	0.990085	0.969358	0.974897	0.995132	0.918083	0.993404
1987	204	36736.90	5468.50	9636.40	147.80	67.39	22191.00	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	204	36434.30	5535.40	9963.70	151.20	66.14	17941.24	1.123809	1.057870	1.046356	1.018813	1.084648	1.406174
1989	204	37878.85	5605.50	10434.00	151.40	68.64	21658.16	1.184666	1.180975	1.163600	1.047131	1.087466	1.287995
1990	204	39760.14	5658.20	10897.00	152.00	67.39	24713.12	1.170471	1.090370	1.068027	1.076145	1.115802	1.138986
1991	204	39729.55	5681.00	11256.50	151.70	66.77	24164.10	1.185785	1.143317	1.123359	1.119832	1.178880	1.164790
1992	204	41241.55	5671.50	11579.90	160.90	69.89	25320.24	1.213640	1.099142	1.090009	1.152881	1.196908	1.179637
1993	204	42747.27	5788.40	11996.60	161.60	67.18	25816.94	1.224249	1.060860	1.042175	1.162708	1.268827	1.182797
1994	204	42789.08	5810.50	12280.50	159.30	67.18	24959.96	1.268394	1.158484	1.128087	1.162903	1.279312	1.257394
1958	205	19726.36	4490.10	1922.70	372.10	255.42	7925.29	0.261772	0.154847	0.169177	0.185826	0.211432	0.324202
1959	205	19893.09	4655.80	2192.20	372.70	260.21	8074.77	0.269149	0.165047	0.181211	0.194756	0.218412	0.322845
1960	205	20035.70	4569.40	2433.90	375.00	263.54	8098.53	0.273587	0.169257	0.184382	0.201353	0.224410	0.328418
1961	205	19905.27	4538.70	2639.90	366.40	260.21	8089.04	0.278409	0.169382	0.184566	0.207253	0.229118	0.332054
1962	205	20281.42	4696.10	2832.10	360.50	264.16	8159.78	0.280409	0.165575	0.184039	0.216364	0.236967	0.336909
1963	205	20536.95	4662.40	3002.90	343.60	243.57	8130.59	0.281488	0.166312	0.184845	0.231187	0.248629	0.339250
1964	205	21207.95	4734.60	3160.60	348.10	242.32	8384.77	0.280513	0.169615	0.189422	0.232942	0.255935	0.338841
1965	205	21573.98	4816.50	3385.60	342.50	239.20	8484.32	0.282335	0.170372	0.191693	0.242543	0.263518	0.344577
1966	205	21819.45	4864.20	3648.80	343.40	235.66	8724.30	0.297276	0.188885	0.209835	0.252692	0.282676	0.357977
1967	205	21717.34	4850.80	3833.90	330.30	219.86	8766.80	0.305419	0.205654	0.226056	0.270879	0.297695	0.357804
1968	205	21925.65	4878.90	3970.90	328.70	212.78	8784.29	0.312023	0.237080	0.257041	0.284327	0.313741	0.360780
1969	205	22508.26	4892.20	4073.40	335.00	216.53	8877.11	0.318670	0.269841	0.287457	0.296016	0.328351	0.373973

1970	205	21673.49	4961.10	4149.20	312.90	198.64	8503.76	0.337154	0.304046	0.319192	0.320265	0.369875	0.391815
1971	205	21662.58	4967.90	4251.50	298.30	196.98	8485.09	0.351117	0.298984	0.318214	0.352221	0.384459	0.405005
1972	205	22737.38	4949.70	4396.60	295.90	194.48	8644.58	0.360763	0.306120	0.326813	0.383247	0.398324	0.418759
1973	205	22704.40	4894.60	4491.10	295.10	192.19	8904.36	0.393580	0.319220	0.337930	0.403790	0.438561	0.480563
1974	205	22296.99	4876.00	4604.90	281.30	201.97	8406.00	0.490864	0.393809	0.407934	0.448958	0.470845	0.661920
1975	205	22268.25	4826.50	4756.30	282.10	204.05	8386.40	0.546204	0.456093	0.469099	0.486101	0.512473	0.699132
1976	205	23094.07	4851.10	4976.70	293.70	205.50	8841.34	0.550921	0.475863	0.493983	0.520669	0.549796	0.654414
1977	205	22344.16	4841.30	5090.00	270.20	191.98	8766.43	0.571778	0.504232	0.527118	0.573367	0.597649	0.648018
1978	205	22249.98	4838.00	5248.40	272.10	199.26	8677.23	0.616171	0.572284	0.591118	0.629984	0.643991	0.704914
1979	205	22268.06	4768.60	5365.70	284.80	198.43	8555.53	0.679350	0.674792	0.684412	0.634693	0.689273	0.790811
1980	205	21766.16	4753.20	5391.60	286.70	193.23	8280.84	0.755655	0.887098	0.873279	0.674626	0.759237	0.897651
1981	205	21600.74	4687.20	5383.80	279.00	189.70	8308.50	0.816217	1.072523	1.029673	0.737340	0.813377	0.950351
1982	205	22048.89	4704.50	5403.90	253.40	196.56	8323.47	0.844110	1.225970	1.181997	0.837398	0.857674	0.955407
1983	205	21836.36	4628.40	5351.00	245.50	186.78	8226.07	0.875805	1.039718	1.014875	0.901920	0.894701	0.979581
1984	205	22284.24	4619.60	5439.20	249.20	188.03	8419.08	0.915091	1.123631	1.089182	0.914645	0.945170	1.015764
1985	205	22840.22	4599.90	5546.30	244.10	193.86	8761.14	0.957416	1.116675	1.096551	0.962298	0.968716	1.003352
1986	205	22812.09	4533.00	5634.20	239.40	177.63	8781.78	0.981475	0.971709	0.978700	1.011151	0.987186	0.983650
1987	205	23677.30	4497.60	5800.40	248.90	185.74	8852.80	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	205	22677.59	4485.00	6036.20	250.70	190.74	8698.60	1.065228	1.048048	1.043229	1.022950	1.017073	1.068126
1989	205	21967.75	4474.80	6178.20	247.00	183.46	9110.10	1.141036	1.158623	1.159864	1.067234	1.069050	1.117343
1990	205	22017.77	4474.40	6347.70	248.00	171.18	9342.52	1.186374	1.061181	1.061930	1.110253	1.140052	1.130219
1991	205	21519.04	4480.80	6554.70	252.00	171.39	9323.32	1.233261	1.106947	1.117631	1.117409	1.173625	1.125071
1992	205	22217.83	4488.30	6825.00	264.40	170.14	9582.69	1.282817	1.064954	1.087248	1.139328	1.241513	1.145440
1993	205	22707.63	4475.40	7010.10	268.40	172.22	10004.39	1.317174	1.006934	1.043872	1.180019	1.238212	1.159991
1994	205	23422.44	4473.20	7179.60	277.30	174.72	10128.57	1.343613	1.097543	1.123528	1.182988	1.242279	1.186999
1958	206	12263.38	2461.80	1394.60	185.30	46.59	7650.95	0.281342	0.120710	0.182525	0.179004	0.183348	0.309491
1959	206	12726.98	2503.20	1556.30	184.40	45.97	7834.73	0.279870	0.135724	0.193765	0.186358	0.193172	0.312595
1960	206	13000.22	2481.20	1639.70	182.50	47.01	7861.62	0.284557	0.137031	0.195849	0.194358	0.197478	0.311768
1961	206	13393.55	2467.10	1739.00	184.60	47.42	8060.77	0.282830	0.135784	0.194647	0.200759	0.202578	0.313444
1962	206	13912.37	2512.50	1872.00	182.80	46.38	8231.75	0.284136	0.136958	0.192596	0.206139	0.215815	0.319823
1963	206	13707.24	2517.30	2060.90	181.10	43.06	8560.13	0.320969	0.136958	0.191526	0.220179	0.212994	0.346607
1964	206	14029.77	2671.50	2307.90	185.40	44.10	8587.05	0.310532	0.148438	0.194499	0.220878	0.240208	0.336437
1965	206	14315.79	2681.20	2495.70	182.70	40.98	8426.01	0.302785	0.151124	0.195458	0.228304	0.251721	0.331640
1966	206	14969.23	2749.30	2719.10	182.40	43.47	8545.72	0.305994	0.173720	0.213519	0.238804	0.256888	0.342265
1967	206	16076.64	2753.90	2974.80	186.60	43.06	9377.71	0.313243	0.190114	0.229096	0.251315	0.265974	0.344370
1968	206	16478.45	2852.60	3154.70	186.90	42.64	9884.49	0.323489	0.227284	0.260862	0.267713	0.274151	0.350033
1969	206	16139.73	2872.50	3301.80	188.80	43.47	9845.34	0.348283	0.262697	0.293721	0.279298	0.288068	0.367199
1970	206	16363.23	2910.50	3426.70	185.90	45.55	9648.48	0.368020	0.301745	0.327810	0.290879	0.317298	0.387667
1971	206	16791.96	2955.30	3557.20	182.20	45.14	10009.37	0.378163	0.298200	0.323266	0.311528	0.331209	0.396708
1972	206	17293.53	2971.90	3732.00	175.20	42.85	10159.81	0.386000	0.305793	0.330184	0.343927	0.351209	0.423276
1973	206	18048.48	2987.40	3876.60	170.80	47.84	10446.30	0.404954	0.318988	0.341137	0.371577	0.350219	0.467783

1974	206	16430.60	3017.10	3986.60	165.90	46.38	9349.87	0.754994	0.396999	0.414662	0.412730	0.393143	0.927179
1975	206	15237.43	3018.00	4200.50	154.00	45.97	9112.48	0.755232	0.458601	0.476102	0.455908	0.409934	0.873999
1976	206	17403.40	3049.70	4470.30	165.90	46.18	10858.86	0.603347	0.482992	0.498568	0.491657	0.457774	0.652850
1977	206	18298.04	3068.30	4606.50	165.80	45.76	11349.58	0.597605	0.512975	0.528901	0.520006	0.495168	0.626182
1978	206	17886.79	3076.20	4721.40	160.90	42.02	10867.02	0.647075	0.583964	0.595623	0.566896	0.570293	0.687199
1979	206	18342.85	3076.80	4748.50	157.70	39.10	11010.82	0.695366	0.685899	0.693329	0.615594	0.604815	0.754131
1980	206	17104.53	3121.40	4860.80	154.50	39.73	11406.98	0.939523	0.911420	0.897119	0.665543	0.651734	0.934893
1981	206	19584.11	3109.00	4898.70	156.60	41.81	12322.68	0.838848	1.099327	1.070797	0.731089	0.695063	0.914444
1982	206	18923.99	3133.10	4963.30	151.20	39.73	10785.43	0.831859	1.260333	1.224676	0.786066	0.785043	0.925665
1983	206	18230.62	3102.90	5002.80	149.60	40.14	10438.60	0.911187	1.055638	1.040470	0.825761	0.803920	0.977526
1984	206	18413.40	3107.20	5073.80	150.10	41.39	11025.01	0.956423	1.142180	1.119826	0.860378	0.855876	0.995808
1985	206	18294.44	3121.60	5255.40	142.80	39.94	10440.81	0.944686	1.132986	1.115262	0.920473	0.880788	0.980470
1986	206	18159.64	3110.60	5341.70	140.40	39.52	10636.80	0.979271	0.974331	0.977387	0.960613	0.925026	0.979552
1987	206	18886.90	3105.50	5460.80	140.40	37.65	10906.60	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	206	19394.54	3080.20	5500.90	139.90	36.61	10739.09	1.012692	1.042833	1.044963	1.026302	1.072479	1.045340
1989	206	19138.49	3060.70	5546.30	140.90	35.57	10607.90	1.054655	1.145467	1.156438	1.062821	1.118895	1.085097
1990	206	19559.68	3054.10	5673.30	145.30	39.31	10891.20	1.075918	1.047939	1.057621	1.077394	1.120648	1.103551
1991	206	19808.27	3064.30	5795.20	143.10	39.52	11156.37	1.108552	1.093809	1.105988	1.105550	1.215132	1.099990
1992	206	20588.64	3074.60	5890.20	143.50	40.98	11213.50	1.103162	1.053052	1.068074	1.111896	1.270062	1.102421
1993	206	21171.35	3109.80	6166.90	146.30	42.02	11458.61	1.113033	0.997831	1.010870	1.156561	1.221157	1.114970
1994	206	21153.11	3132.10	6354.30	147.00	40.56	11477.01	1.130477	1.096089	1.094507	1.173893	1.300857	1.132690
1958	207	7648.11	2287.90	1922.80	73.60	26.21	6919.30	0.450373	0.074799	0.128092	0.192765	0.222394	0.413828
1959	207	7891.70	2264.70	1944.20	75.00	23.92	6952.39	0.440539	0.086865	0.140154	0.195207	0.243351	0.418058
1960	207	7845.86	2237.90	1997.20	71.70	23.92	6765.65	0.417698	0.091553	0.144245	0.201369	0.247764	0.403198
1961	207	7764.28	2204.20	2023.50	69.80	24.54	7481.73	0.483200	0.095143	0.144484	0.211959	0.256825	0.423070
1962	207	9380.27	2203.40	2118.40	71.90	25.58	8276.05	0.451874	0.094304	0.145534	0.219442	0.258174	0.430930
1963	207	9050.77	2172.50	2149.10	71.60	26.62	7773.23	0.448713	0.098907	0.146920	0.223323	0.256585	0.436086
1964	207	9365.96	2141.20	2170.60	70.50	25.17	8094.47	0.452714	0.107624	0.151499	0.228858	0.277421	0.438225
1965	207	9480.09	2125.30	2174.40	71.90	25.79	8875.46	0.496957	0.112429	0.153522	0.234321	0.287957	0.440540
1966	207	9813.29	2083.20	2174.70	68.30	24.75	9383.67	0.538963	0.137035	0.170620	0.248083	0.321989	0.467248
1967	207	10468.73	2060.20	2218.00	69.10	26.42	9510.61	0.484720	0.155838	0.185800	0.267249	0.301421	0.442937
1968	207	10059.87	2069.40	2297.70	65.10	25.58	8720.70	0.471875	0.177742	0.216506	0.287075	0.321833	0.437751
1969	207	10654.72	2054.10	2330.80	68.20	25.58	8973.18	0.475592	0.209598	0.247538	0.299606	0.335685	0.455513
1970	207	10985.16	2073.40	2421.90	64.60	23.50	9729.06	0.542896	0.231657	0.282798	0.321077	0.387527	0.492165
1971	207	11681.61	2069.60	2550.80	61.80	23.71	11016.87	0.554504	0.227725	0.282306	0.352624	0.390169	0.483422
1972	207	11306.81	2047.90	2637.50	64.50	22.88	10392.63	0.611110	0.241206	0.291682	0.362519	0.412926	0.555288
1973	207	9438.27	2038.30	2763.00	69.60	23.30	10788.94	1.099555	0.254814	0.306503	0.391486	0.493589	0.803749
1974	207	12248.39	2027.80	2850.70	64.10	23.50	11005.42	1.147628	0.319568	0.377624	0.442519	0.486334	1.113433
1975	207	13121.51	2036.40	3033.30	61.90	24.13	11951.41	0.974080	0.362641	0.441398	0.482069	0.506569	0.930685
1976	207	13305.18	2031.30	3125.10	61.20	23.71	13263.30	0.962122	0.382091	0.466678	0.513884	0.541213	0.851213
1977	207	12993.20	2020.10	3215.80	64.40	24.34	12991.16	1.114429	0.412641	0.500139	0.547017	0.607273	0.973062

1978	207	14546.37	2023.20	3407.50	68.30	24.54	14201.80	1.112215	0.464973	0.572946	0.591420	0.654351	0.996430
1979	207	14504.51	2007.60	3498.50	67.80	24.75	14439.17	1.220020	0.559614	0.671805	0.645110	0.682057	1.058496
1980	207	15258.54	2019.40	3590.70	64.80	24.13	13319.87	1.195212	0.719332	0.872103	0.690892	0.775010	1.183180
1981	207	14953.73	2027.50	3718.30	61.50	23.71	13121.59	1.200289	0.858164	1.045560	0.766517	0.811183	1.176527
1982	207	15394.69	2035.70	3832.70	58.00	23.71	13774.40	1.088161	0.970849	1.205735	0.820915	0.891316	1.048133
1983	207	13545.24	2014.90	3852.00	53.30	22.26	11137.76	1.260435	0.841032	1.030604	0.864913	0.942512	1.327404
1984	207	15357.03	1990.70	3879.00	51.40	23.50	14228.63	1.273110	0.939024	1.108502	0.908323	0.984216	1.194838
1985	207	16556.20	1981.40	3906.30	46.80	22.88	14652.41	1.057296	0.948783	1.112264	0.948999	0.964262	1.031796
1986	207	16421.43	1940.00	3840.30	43.00	24.13	13410.43	0.950088	0.906263	0.980621	0.987138	0.919074	0.975390
1987	207	15880.50	1907.50	3802.60	41.30	20.59	13134.60	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	207	16627.88	1877.20	3768.80	43.20	21.01	14018.59	1.233892	1.125998	1.041253	1.014027	1.079977	1.231586
1989	207	17274.30	1862.40	3776.10	43.10	20.59	13949.14	1.169043	1.307146	1.155617	1.020852	1.124130	1.176668
1990	207	17625.89	1840.10	3734.90	40.90	20.38	14039.64	1.106282	1.277106	1.054326	1.038059	1.146698	1.126525
1991	207	17892.80	1823.10	3718.90	39.70	19.76	14122.50	1.047097	1.427249	1.104862	1.082060	1.136356	1.083257
1992	207	18038.82	1821.60	3714.90	42.10	18.10	14232.00	1.039048	1.406360	1.069950	1.105311	1.232099	1.079258
1993	207	17859.72	1806.10	3669.10	41.30	17.26	14342.56	1.123646	1.446636	1.016281	1.106651	1.354370	1.144852
1994	207	17523.04	1784.10	3637.20	40.90	16.02	14445.91	1.185605	1.663535	1.094321	1.149994	1.409060	1.168206
1958	208	15599.09	6973.50	10230.40	226.40	190.11	9237.36	0.347373	0.127010	0.144017	0.170957	0.193981	0.284605
1959	208	16194.42	6880.10	10727.70	231.40	193.44	9577.50	0.357475	0.139096	0.157761	0.174097	0.203209	0.288927
1960	208	16590.26	6730.50	10646.60	235.00	197.81	9714.03	0.358397	0.139619	0.159755	0.176009	0.207011	0.290744
1961	208	17006.73	6562.20	10578.20	230.20	199.26	10055.24	0.359893	0.137024	0.159102	0.181247	0.214091	0.292753
1962	208	17796.39	6518.30	10548.90	232.00	199.47	10464.60	0.362360	0.135218	0.157584	0.186159	0.223433	0.296380
1963	208	18683.41	6238.20	9871.50	218.50	199.68	10616.33	0.369204	0.132286	0.154891	0.199479	0.225962	0.304559
1964	208	19961.91	6186.30	9943.50	221.50	208.42	11327.74	0.373015	0.135984	0.159295	0.205970	0.234140	0.305551
1965	208	20595.18	6178.30	10057.90	220.10	213.41	12004.37	0.375229	0.138057	0.161792	0.211611	0.239202	0.307713
1966	208	22188.36	6266.10	10393.90	225.40	219.23	12838.11	0.376193	0.157593	0.180423	0.222910	0.245258	0.315560
1967	208	23798.04	6394.50	10575.10	226.70	223.18	13887.81	0.382506	0.173960	0.195524	0.231092	0.260062	0.320007
1968	208	25456.06	6657.60	10798.30	227.70	221.31	14965.88	0.393140	0.207433	0.225356	0.241621	0.273604	0.329583
1969	208	27322.50	6931.10	11073.00	229.40	227.34	16239.31	0.404033	0.244995	0.257466	0.258119	0.287886	0.342059
1970	208	29673.29	7135.50	11303.70	236.30	230.67	17710.00	0.416984	0.284539	0.290620	0.269650	0.314997	0.357713
1971	208	30870.16	7221.70	11458.00	221.20	224.64	18386.60	0.431834	0.278879	0.288260	0.298406	0.346709	0.378542
1972	208	31687.50	7235.10	11690.30	214.10	219.23	18722.32	0.437693	0.285564	0.297745	0.320747	0.357975	0.395827
1973	208	33087.32	7277.40	12103.10	211.30	206.54	19009.98	0.443152	0.297886	0.311190	0.342016	0.383232	0.432778
1974	208	34280.48	7374.70	12554.60	204.70	212.99	17649.92	0.518537	0.372255	0.381659	0.380594	0.400380	0.604541
1975	208	33679.95	7447.40	12920.00	199.70	212.37	19031.53	0.605562	0.431077	0.441401	0.410915	0.437496	0.656316
1976	208	35407.56	7640.10	13429.80	199.90	217.15	20428.99	0.595034	0.453163	0.467370	0.441281	0.470256	0.611254
1977	208	38395.33	7806.50	13915.10	200.10	199.06	22203.36	0.607600	0.482721	0.502060	0.493924	0.539541	0.621388
1978	208	41576.14	7934.80	14412.10	205.40	201.76	23540.47	0.639232	0.554419	0.570291	0.540558	0.587328	0.674239
1979	208	42422.16	8062.10	15145.30	207.20	204.46	23833.96	0.691681	0.657224	0.670004	0.591100	0.617564	0.737381
1980	208	42522.50	8177.60	15735.60	201.70	205.50	23769.06	0.777029	0.874408	0.866159	0.630059	0.666054	0.839949
1981	208	41596.98	8422.80	15978.40	194.90	210.08	24244.30	0.867248	1.068915	1.027090	0.698539	0.709462	0.901400

1982	208	43252.86	8579.90	16333.30	189.50	205.30	24490.75	0.897069	1.229510	1.184099	0.762457	0.792752	0.929730
1983	208	43474.21	8764.30	16479.90	185.40	200.93	24626.86	0.926687	1.042248	1.016576	0.799999	0.830098	0.931227
1984	208	43042.67	8852.90	16631.60	178.90	199.26	24043.91	0.956737	1.133448	1.095858	0.854172	0.853487	0.982527
1985	208	44620.76	8858.10	16611.40	177.10	200.10	25078.79	0.969141	1.123287	1.101727	0.883322	0.891273	0.983221
1986	208	46205.24	8892.00	16490.40	168.00	186.99	25556.70	0.986618	0.969814	0.978865	0.910408	0.943139	0.990797
1987	208	47327.20	8976.60	16524.00	154.40	172.85	25366.40	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	208	48844.80	8943.20	16474.70	151.30	170.14	25584.80	1.017965	1.046006	1.041945	1.018532	1.030945	1.035619
1989	208	47387.73	8869.90	16470.00	147.20	157.46	24445.05	1.057938	1.150082	1.157427	1.044057	1.072688	1.081589
1990	208	48076.60	8834.90	16320.00	145.90	151.84	24976.28	1.085724	1.051566	1.056603	1.071226	1.115612	1.109713
1991	208	48517.37	8753.30	16054.70	145.10	149.55	25195.70	1.125578	1.090954	1.105492	1.105399	1.150047	1.128871
1992	208	50832.67	8691.40	15942.90	148.00	146.43	26114.60	1.139806	1.044253	1.071216	1.137263	1.215824	1.127208
1993	208	51022.13	8629.50	15857.40	153.20	148.72	26281.75	1.147775	0.978238	1.023679	1.123454	1.240488	1.124788
1994	208	53283.17	8527.20	15677.70	147.80	142.06	26856.30	1.151345	1.063427	1.099396	1.177203	1.257853	1.137256
1958	209	16128.71	2642.40	2020.70	171.50	69.26	10628.62	0.277201	0.194517	0.245867	0.206591	0.211795	0.287027
1959	209	22067.13	2692.10	2086.60	193.60	80.50	13701.31	0.270493	0.205448	0.255208	0.207664	0.233669	0.293308
1960	209	22309.80	2698.90	2121.10	206.40	78.21	14619.25	0.286399	0.208238	0.257420	0.210512	0.266871	0.294885
1961	209	23200.56	2717.50	2148.30	197.00	76.75	14117.17	0.279554	0.207059	0.256357	0.222313	0.271933	0.297715
1962	209	24479.82	2875.00	2272.40	192.90	78.62	14172.26	0.276726	0.199290	0.250503	0.234400	0.281975	0.303621
1963	209	18303.97	2935.60	2305.30	175.20	74.88	9740.99	0.265811	0.197225	0.250316	0.236830	0.250039	0.304445
1964	209	18476.41	2976.40	2449.70	175.80	78.42	10595.08	0.283973	0.200631	0.250408	0.240841	0.261747	0.306038
1965	209	19158.96	3065.70	2556.90	178.80	71.55	10904.35	0.286164	0.200302	0.249971	0.251150	0.267608	0.313306
1966	209	19676.01	3186.50	2716.10	178.80	75.71	10683.84	0.289795	0.215754	0.264573	0.260560	0.272342	0.326596
1967	209	20813.08	3296.10	2915.00	182.20	76.13	11072.23	0.286570	0.229647	0.277357	0.279866	0.285224	0.329979
1968	209	21799.63	3339.90	3099.90	182.40	71.34	11413.04	0.290753	0.262124	0.307521	0.296439	0.319352	0.339804
1969	209	21989.03	3388.20	3208.10	186.80	73.84	11425.60	0.308354	0.294829	0.338164	0.315201	0.338826	0.354143
1970	209	21536.45	3497.90	3361.70	184.50	82.58	11894.83	0.341152	0.328560	0.369557	0.325469	0.336052	0.367504
1971	209	21436.57	3594.90	3579.80	178.00	79.87	11768.31	0.356176	0.320773	0.363569	0.358406	0.362209	0.384363
1972	209	22560.92	3622.50	3706.60	184.80	73.84	12233.11	0.369901	0.328010	0.370971	0.387514	0.402989	0.410623
1973	209	23161.69	3638.50	3842.80	193.60	78.42	12798.00	0.414987	0.340496	0.380438	0.409103	0.409883	0.466948
1974	209	21045.48	3661.60	4006.20	178.10	66.14	12077.06	0.507948	0.416490	0.452355	0.450000	0.482836	0.558662
1975	209	21159.86	3720.00	4190.30	173.10	70.10	11762.90	0.562811	0.476354	0.512755	0.497192	0.505689	0.627396
1976	209	24235.79	3752.50	4355.30	187.10	68.85	15102.92	0.613795	0.495749	0.533974	0.534039	0.556007	0.622999
1977	209	21597.64	3793.20	4501.80	208.60	74.05	18073.82	0.791262	0.522406	0.564411	0.561032	0.572229	0.645492
1978	209	25288.57	3824.20	4666.50	219.20	74.67	17480.02	0.749319	0.591138	0.627972	0.581973	0.630474	0.704313
1979	209	24614.46	3915.30	4814.50	216.00	71.97	16159.03	0.794533	0.687286	0.721347	0.619876	0.708840	0.785146
1980	209	25600.35	4026.30	4973.10	212.10	76.54	15968.94	0.830383	0.894784	0.914766	0.697608	0.723630	0.857001
1981	209	25943.78	3965.00	5015.60	213.80	75.71	14914.24	0.866975	1.082129	1.077470	0.746035	0.794262	0.920402
1982	209	28213.44	3972.90	5139.80	215.50	81.33	15409.14	0.849762	1.237382	1.231485	0.821940	0.801541	0.931662
1983	209	27761.68	3958.20	5193.20	208.40	82.37	15108.78	0.862992	1.044644	1.053475	0.835971	0.879994	0.943167
1984	209	26987.26	3956.90	5385.20	207.10	79.66	15103.66	0.927337	1.128566	1.123538	0.872161	0.899391	0.974029
1985	209	27324.02	3939.90	5627.10	201.20	78.21	15140.42	0.935909	1.121240	1.120068	0.915886	0.909594	0.969683

1986	209	26860.58	3910.00	5834.30	196.70	80.50	16180.74	1.017614	0.972723	0.987884	0.968750	0.939664	0.971420
1987	209	29116.40	3893.40	6118.30	213.00	86.74	15834.30	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1988	209	29781.52	3891.60	6380.00	209.60	87.36	15122.34	1.010647	1.047279	1.034729	1.033416	1.057901	1.066079
1989	209	28467.00	3855.00	6448.70	212.30	85.70	15784.74	1.051706	1.160590	1.146077	1.015158	1.053187	1.094772
1990	209	30030.59	3839.20	6582.60	226.60	90.06	15797.64	1.078054	1.064220	1.044536	0.997806	1.147514	1.123003
1991	209	29773.67	3868.80	6804.10	222.50	88.61	16405.37	1.094853	1.107844	1.089139	1.064409	1.183956	1.106790
1992	209	31587.36	3871.50	7039.40	239.70	91.94	16704.18	1.092212	1.065848	1.047858	1.106868	1.277037	1.117930
1993	209	33221.88	3866.40	7365.60	235.50	91.52	16566.93	1.096404	1.005544	0.988978	1.142215	1.312079	1.126352
1994	209	31935.15	3881.40	7616.60	236.40	93.39	16509.07	1.161701	1.094931	1.061843	1.152556	1.339121	1.153227

VITA

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Doctor of Philosophy

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