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Total Factor Productivity in the Federal Republic of Germany (1970-1989)

Results for Mining and Manufacturing Industries

by

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Abstract:

Total Factor Productivity in the Federal Republic of Germany (1970-1989)

Results for the Mining and Manufacturing Industries

The paper presents results for the development of total factor productivity (TFP) growth for 35 industries. It analyses the medium-term and long-term trends in these industries during the last two decades. The method used for the calculation was first proposed by Hulten (1986). It takes into account capacity utilization effects for the capital stock. Comparing the average TFP growth rates for manufacturing before, during, and after the two oil price shocks one observes that there is a steady acceleration from a fairly low 1.4 per cent rate during 1970-74 to 2 per cent during 1984-89. Contrary labour productivity, measured by annual working hours, declined. Therefore the increase in TFP growth rates has to be attributed to a marked shift in capital productivity. During the early 70ies capital productivity growth rates were negative in manufacturing supporting a hypothesis of capital using and labour saving technological progress. Since then capital productivity became positive across all major subindustries in manufacturing. This led to the up-turn in TFP growth. Four hypothesis are proposed in the paper to explain the shift in the development of capital productivity growth. In the last section a number of cross-section regressions for the 35 industries for the whole period as well as a number of subperiods are calculated. As the results show Verdooms Law seems to be valid for all periods considered. Therefore high growth industries are - with respect to gross value added - leading industries in high TFP growth as well.

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I. Introduction

Total factor productivity growth (TFP) is one of the most widely employed measures of overall productivity. Although methodological differences persist, a broad concensus has formed around the appropriateness of the *residual approach*.[1] In this model multifactor productivity growth is measured by subtracting from output growth the growth attributable to increases in inputs, derived by weighting the growth rate of each factor by its share of output.

Various studies, including Unger (1986) and Erber (1986) have provided empirical evidence for the manufacturing industries in the Federal Republic of Germany[2] for the periods 1960-81 and 1960-84, respectively. Jorgenson, Gollop, and Fraumeni (1987) analyze economic growth in the United States during the years from 1948 to 1979. In their study of 13 OECD countries Englander and Mittelstädt (1988) present sectoral TFP estimates for the period 1970-83 (see as well OECD 1987, pp. 26-29). Recently, Baumol, Blackman and Wolff (1989) reported results for the US and the INSEE (1990) for France.

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[1] Cf. Solow (1957), Jorgenson, Griliches (1967), Denison (1962), (1967), (1974), (1979a, b), Kendrick (1983), Jorgenson, Gollop, Fraumeni (1987).

[2] We will use the term Germany as an abbreviation for the Federal Republic of Germany before the unification. The German Democratic Republic (GDR) is excluded from our analysis.

To provide additional insight into productivity developments of German manufacturing, especially since the recovery after the 1982 recession, this paper analyzes the period of 1970-89. Taking into account the evidence of German manufacturing for these years we conclude that the productivity slowdown observed in industrialized market economies during the 70s has ended since the mid-80s in German manufacturing.[3]

Sectoral as well as aggregate productivity growth is analyzed by using sectoral data for 35 industries.[4] From the point of view of data availability[5] we used a value-added measure of output[6], although a gross output measure inclusive of all intermediate commodities may be superior.[7] Generally, value-added productivity measures are higher than productivity measures based on gross output measures.[8]

We present TFP growth measures for the German mining and manufacturing industries for the period 1970-89. Capacity untilization adjustments as proposed by Hulten (1986) are incorporated into our productivity growth accounting framework.

Since services and agriculture are excluded a discussion of the validity of the Clark/Fourastié 3-sector-hypothesis, which explains the overall decline in productivity growth by structural changes reducing the relative size of manufacturing - with high productivity growth - in favour of the service industries - with low productivity growth, has to be left for future research.

We compare the development of average TFP growth rates with partial factor productivities, like labour productivity and capital productivity (cf. table 1 to 4). Annual average growth rates are calculated for the periods 1970-74, 1974-84, 1984-89 and 1970-89. Short-term

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[3] Cf. Boneß, Krengel, Pischner (1980), Boneß (1981) and Pischner (1981a), (1981b).

[4] Cf. e.g. the debate on the annual meeting of the Royal Economic Society in 1982 published in the Economic Journal (Lindbeck (1983), Giersch, Wolter (1983), Denison (1983) and Morris, Prais (1983) or a review of recent research for the US by Williamson (1990).

[5] Cf. Görzig, Schintke, Schmidt (1990).

[6] Value-added based TFP measures implicitly assume that the underlying production function is additive-separable of the form $Y = VA + M$, where Y denotes the gross production value, VA denotes value added, and M denotes intermediate materials (cf. Bruno 1978, Diewert 1978).

[7] Concerning the discussion of 'value added versus gross output' see Sudit and Finger (1981).

[8] Calculations based on the gross-concept are published in Erber, Haid (1990) and Erber (1989).

fluctuations in productivity development are eliminated to a large extent by this procedure. The subperiods were chosen with a view to compare productivity gains before, during, and after the two oil price shocks of 1974 and 1979/80. It is assumed that the severe recession from the beginning of the eighties terminated in 1984.

A question raised by economists is whether in the late 80s a recovery of TFP-growth occured in mining and manufacturing after the induced structural adjustments had worked out.

In mining one observes a decline in the level of TFP after the first oil price shock in 1974, which accelerated in the late 80s (cf. table 1).

The story is different for the sectors basic materials and consumer goods where there is a significant rise in the average rate of TFP growth since 1984, with levels even higher than during the early 70s. The capital goods and food, drink, tobacco industries even improved productivity performance after the first oil price shock. The higher growth rates were sustained in the second half of the eighties. For the whole sector of manufacturing there is a steady rise in TFP growth across the three subperiods. However, using labour productivity as an indicator (cf. table 1) - calculated on the basis of effective man-hours worked - productivity growth slowed down.

Yearly growth rates for labour productivity or TFP may be even negative.[9] From a theoretical perspective this seems to be unplausible, since a decreasing level of productivity should be avoided by an appropriate adjustment in factor demand. However, market imperfections due to legal restrictions on labour contracts, quasi-fixity of the capital stock, and the presence of increasing returns to scale under conditions of decreasing production levels may be possible explanations for these results.

Among others Berndt, Fuss (1986) and Hulten (1986) have proposed simple adjustments to traditional productivity calculations to account for the effects of variations in capacity utilization on productivity. According to our findings these corrections had only a modest impact on productivity fluctuations. In a recent paper Morrison and Diewert (1990) show that imperfect competition in output and input markets appear to have a more significant impact on productivity fluctuations. This aspect will be pursued in our future research.

[9] This is the case for all measures of labour productivity or TFP (cf. e.g. Boneß, Krengel, Pischner (1980), Boneß (1981) and Pischner (1981a), (1981b)).

II. The Standard Model

Assuming a single-output production function Q(t) = A(t) F[K(t),L(t)] where Q(t) denotes output at time t, K(t) denotes the flow of capital services used at time t, L(t) is the flow of labour services, and A(t) is an efficiency parameter which allows for a Hicks-neutral shift in the production function, the growth rate of TFP, g_{TFP}, is given by

$$g_{TFP} = g_Q - \epsilon_L \cdot g_L - \epsilon_K \cdot g_K \,. \qquad (1)$$

where the growth rates of output, labour, and capital are denoted by g_Q, g_L, and g_K respectively and ϵ_L and ϵ_K are elasticities of output with respect to labour and capital:

$$\epsilon_L = \frac{\partial Q}{\partial L} \cdot \frac{L}{Q} \quad , \quad \epsilon_K = \frac{\partial Q}{\partial K} \cdot \frac{K}{Q} \quad . \qquad (2)$$

The increase in efficiency is measured by the residual of growth rate of output not explained by the Divisia Index of inputs.

ϵ_L and ϵ_K are not observable, but under the assumption that inputs are paid the value of their marginal product, ϵ_L and ϵ_K are equivalent to the income shares of labour and capital, s_L = w(t)L(t)/P(t)Q(t) and s_K = r(t)K(t)/P(t)Q(t), where P(t), w(t) and r(t) denote the prices of output, labour, and capital at time t.

g_{TFP} can be calculated using parametric and non-parametric methods. The non-parametric method or index-method allows TFP computations without resorting to the econometric estimation of the parameters of a production function. For data obtainable at yearly intervals, the most commonly used discrete approximation[10] is given by the Törnqvist approximation which uses annual differences in the logarithms, for example g_Q = log Q(t) - log Q(t-1). The cost/sales ratios are approximated by arithmetic means of successive years: s_L = 0.5 [s_L(t) + s_L(t-1)] , s_K = 0.5 [s_K(t) + s_K(t-1)].

$$g_{TFP} = g_Q - s_L \cdot g_L - s_K \cdot g_K \,. \qquad (3)$$

[10] The Törnqvist-Index is exact, if the production technology conforms to a translog specification (cd. Diewert 1976). However, if certain conditions of regularity hold, the continuous formulation of the Divisia-Index is exact for any kind of functional specification of a production technology (cf. Solow 1957, Richter 1966 and Hulten 1973).

III. Correcting for Variations in Capacity Utilization

The rate of TFP growth computed from (3) is calculated from the observed price and quantity data. However, the flow of capital services is not generally observable. This leads to the replacement of unobservable capital flows in (3) by observed capital stocks. This is based on the assumption that the flow of capital services J(t) is proportional with the stock of capital assets K(t), which implies that the rate of capital utilization U(t) = J(t)/K(t) remains constant over time. In the long-run, cyclical fluctuations in the flow of services average out, and one can take the ratio of the service flow to the capital stock to be constant. In this case, the growth rate of capital services can be estimated by the growth rate of the capital stock. In the short-run, however, the assumption of a constant utilization ratio is highly dubious. Substituting $g_J = g_U + g_K$ for g_K in (3) yields

$$g_{TFP} = g_Q - s_L \cdot g_L - s_K \cdot (g_U + g_K) \ . \tag{4}$$

Hence the residual measure of TFP growth will be biased whenever the utilization ratio U is not constant over time, that is $g_U \neq 0$.

Another source of bias are uncorrect weights s_L or s_K. Under the assumption of a competitive long-run equilibrium, the quasi-fixed capital input is optimally utilized and is paid its shadow price $z_K(t)$ which equals the market price r(t). In case of a temporary euqilibrium, however, shadow cost are not identical with market cost. In the Berndt-Fuss (1986) framework the value of services from capital stocks is altered to correct for variations in capacity utilization. Instead of s_K the shadow cost share $v_K = z_K(t)\ K(t)\ /\ P(t)\ Q(t)$ is used in (3) together with the identity $P(t)\ Q(t) = w(t)\ L(t) + z_K(t)\ K(t)$.[11]

If the parameters of the production and/or cost function were known in advance, one would be able to determine the shadow-prices of the quasi-fixed inputs directly. Since this is not

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[11] A different approach to correct the measurement of productivity for variations in capacity utilization is due to Norsworthy, Harper, Kunze (1979). In their study the analysis was restricted on time intervals where the capacity utilization U could be assumed to be equal to one (peak-to-peak-method). Jorgenson and Griliches (1967) made an attempt to estimate the varying capacity utilization directly by taking the relation between the consumption of electricity and the power of electrical motors into account.

the case the parameters must be estimated by econometric methods.[12] If constant returns to scale prevail and there is one fixed input (e. g. capital) the shadow price $z_K(t)$ can be derived as a residual (cf. Hulten, 1986) from the identity $P(t)\ Q(t) = w(t)\ L(t) + z_K(t)\ K(t)$ without resorting to econometric estimation of the parameters of the production function.

The Berndt-Fuss-concept has been implemented empirically for a number of countries (Berndt, Fuss 1986, Conrad 1988). Unexpectedly the effects from variations in capacity utilization of capital stock have shown to be of minor importance.[13]

Perhaps there may be things like imperfect competition and scale economies which will have a greater impact on productivity fluctuations (cf. Hall 1988, Morrison 1990).

If the market price of output is higher than marginal cost, cost/sales ratios will not be equal to income shares of inputs - even under conditions of long-term equilibrium. Assuming that market price equals marginal cost leads to a biased TFP growth rate. However, correct estimation of marginal cost causes severe estimation problems (cf. Morrison 1990, Flaig, Steiner 1990). Since preliminary estimations led to unsatisfactory results, we did not pursue that further.

IV. Empirical Results

The following analysis is based on the assumption of a single output - two input - production function, with capital quasi-fixed. Tables 1 to 4 show the development of the average annual percentage growth rates of labour, capital, and total factor productivity for all industries and subgroups of industries in manufacturing and mining.[14]

In the mining industries the level of TFP declined over all periods under consideration. This contrasts with manufacturing where TFP growth increased in subsequent periods. At the early 70s TFP rose by 1.4 per cent per year, in the period 1974-84 it increased to 1.6 per cent, reaching 2 per cent in the late 80s.

[12] Flexible functional forms are designed to capture input substitution patterns. The translog proposed by Christensen, Jorgenson, Lau (1973) and the Generalized Leontief (GL) function proposed by Diewert (1971) enjoy a high degree of popularity in empirical research.

[13] Econometric estimates of TFP growth for a number of industries in German manufacturing were published by Flaig and Steiner (1990) for the period 1960-86. Their approach differs in two respects: First, they do not assume constant returns to scale and second, they use capital stock data based upon the user concept.

[14] The growth rates are calculated by log-linear time trend regressions.

Table 1

Gross Value Added and Productivity Measures in Mining and Manufacturing in the Federal Republic of Germany

Average Percentage Annual Rates of Growth*) (1970–1989)

	Industry Sectors	70–74	74–84	84–89	70–89
		Gross Value Added (constant prices)			
1– 3	Mining	−2.6	−1.7	−3.3	−2.1
4–14	Manufacture of basic products	3.7	0.1	1.8	0.5
15–24	Manufacture of capital goods	1.9	1.7	4.2	2.1
25–34	Manufacture of consumer goods	1.6	−0.1	2.2	0.3
35	Food, drinks and tobacco	2.1	1.5	1.8	1.5
4–35	Manufacturing	2.3	0.9	3.1	1.3
1–35	Mining and Manufacturing	2.1	0.9	2.9	1.2
		Total Factor Productivity			
1– 3	Mining	2.8	−1.0	−1.7	−0.7
4–14	Manufacture of basic products	2.3	1.2	2.4	1.4
15–24	Manufacture of capital goods	1.0	1.8	1.8	1.8
25–34	Manufacture of consumer goods	1.5	1.1	1.6	1.3
35	Food, drinks and tobacco	−0.1	1.5	1.5	1.3
4–35	Manufacturing	1.4	1.6	2.0	1.6
1–35	Mining and Manufacturing	1.5	1.5	1.9	1.6
		Labour Productivity **)			
1– 3	Mining	4.1	0.6	1.1	1.1
4–14	Manufacture of basic products	6.4	2.9	2.9	3.2
15–24	Manufacture of capital goods	4.1	3.5	3.1	3.6
25–34	Manufacture of consumer goods	5.4	3.1	2.8	3.4
35	Food, drinks and tobacco	4.3	4.1	2.2	3.9
4–35	Manufacturing	5.0	3.3	2.8	3.5
1–35	Mining and Manufacturing	4.9	3.2	2.8	3.4
		Capital Productivity *)**			
1– 3	Mining	0.3	−3.2	−4.6	−3.0
4–14	Manufacture of basic products	−0.7	−0.2	2.0	−0.1
15–24	Manufacture of capital goods	−3.3	−1.1	0.1	−1.0
25–34	Manufacture of consumer goods	−3.1	−1.6	0.3	−1.5
35	Food, drinks and tobacco	−2.2	0.1	1.3	0.0
4–35	Manufacturing	−2.3	−0.6	1.1	−0.5
1–35	Mining and Manufacturing	−2.1	−0.6	1.0	−0.6

*) the average annual growth rates are calculated by log–linear regressions.
**) labour productivity = gross value added / annual working hours.
***) capital productivity = gross value added / capital stock.

Source: Görzig, Schintke, Schmidt 1990, own computations.

A corresponding pattern is not observed for labour productivity. This might be due to non-neutrality of technological change (capital using and labour augmenting). However, for all subgroups in manufacturing one observes an improvement of capital productivity for all subperiods. After a marked decline at the early 70s capital productivity stopped falling during the two oil price shocks. In the late 80s growth rates of capital productivity have been even positive in all subgroups of manufacturing industries.

The re-increase in capital productivity growth as observed during the last two decades might be an explanation for the diverting development in TFP growth and labour productivity growth in manufacturing. Although labour productivity growth (output-per-man-hour) has declined steadily, TFP growth increased due to higher capital productivity.

This can be explained to some extent by the stabilization of economic growth after the negative effects of the two oil price shocks. The findings on the sources of German economic growth lead to the conclusion that labour and capital productivity growth rates in the late 80s should return to the normal levels before the oil price shocks. However, the results show a different pattern so that other processes may have influenced economic performance as well.

We suggest that four major facts might have been responsible.

- **Leasing:** The capital stock data used in our calculations are based on the ownership concept. Since leasing became more and more important in Germany in the seventies and eighties, especially the leasing of buildings and whole plants, the allocation of capital stock according to the owner concept may be partially inappropriate. Therefore the effective capital stock in some industries might differ significantly from the respective capital stock data based on the ownership concept. Using capital stock data might lead to some modifications of TFP growth rates.[15]

- **Operating time of plants and machinery:** It is well known that the relation between working hours per employee and the time machines are used in production has weakened through the use of flexible time schedules for the labour force (especially the introduction of shift work in industries with high capital intensity).[16] The more intense utilization of the existing capital stock, especially machinery and equipment increased the efficiency of capital stock. This effect cannot be quantified within our capital stock

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[15] Cf. Gerstenberger et al. (1989).

[16] Cf. Stille (1988), (1991).

Table 2

Labour Productivity *) in Mining and Manufacturing in the Federal Republic of Germany

Average Annual Percentage Rates of Growth **) (1970–1989)

Industry Sectors	70–74	74–84	84–89	70–89
1 Coal mining	3.0	0.7	1.2	1.1
2 Oil and natural gas extraction	8.4	–2.4	2.8	–1.0
3 Other mining	5.8	0.8	–2.5	1.6
4 Oil refineries	4.3	–1.3	4.8	0.9
5 Stone, sand and clay industry	3.8	2.3	2.6	2.4
6 Iron and steel industry	8.7	2.6	5.6	3.7
7 Non–ferrous metal industry	7.0	5.1	4.5	4.6
8 Iron and steel industry	4.3	2.2	1.2	2.5
9 Non–ferrous metals foundries	–0.2	3.3	5.0	3.1
10 Steel drawing and cold rolling mills	5.4	4.1	2.6	3.5
11 Chemical industry	7.9	3.3	2.3	3.5
12 Sawmills and timber processing	5.9	3.7	6.1	4.6
13 Cellulose, paper and board industry	12.9	5.6	5.1	6.2
14 Rubber industry	4.5	2.6	3.2	3.3
15 Steel forging	3.3	2.9	2.8	3.1
16 Construction steel	2.0	2.4	2.1	2.0
17 Engineering	3.0	2.3	3.0	2.6
18 Vehicle building industry	3.0	2.4	2.8	2.7
19 Shipbuilding	6.2	3.4	–1.6	3.2
20 Aircraft and aerospace industry	6.5	6.2	0.9	4.8
21 Electrical equipment	6.7	4.6	3.6	4.8
22 Precision engineering, optics	3.8	2.8	2.9	3.3
23 Metal products	3.8	3.9	2.3	3.7
24 Office and data–processing machines	11.8	12.1	4.7	11.1
25 Musical instruments and toys	2.0	1.4	4.3	2.1
26 Fine ceramics	4.5	0.7	1.8	1.7
27 Glass industry	6.9	3.4	3.3	4.1
28 Wood processing	5.3	1.7	1.8	2.2
29 Paper and board	5.9	3.9	4.2	4.1
30 Printing	4.4	3.7	3.1	3.8
31 Plastics manufacturing	7.8	4.1	1.5	4.0
32 Leather and leather products	2.0	1.0	2.9	1.6
33 Textiles	6.8	3.7	2.7	4.2
34 Clothing industry	3.7	1.7	0.9	2.1
35 Food, drinks and tobacco	4.3	4.1	2.2	3.9

*) labour productivity = gross value added / annual working hours
**) the average annual growth rates are calculated by log–linear regressions.

Source: Görzig, Schintke, Schmidt 1990, own computations.

data and the data for effective man-hours worked but the impact of this organizational gain in productivity might show up in an increase in capital productivity.

- **Capacity utilization:** The extraordinary long duration of the growth period in the current business cycle may have caused a capacity utilization ratio well above the long-term average. However, after the current growth period has come to an end, a decline in capital productivity may be expected.

- **Technological change:** An important cause to be mentioned is the process of rapid technological change as it was triggered by the microelectronic revolution beginning in the eighties. Manufacturing industries have become more and more R&D intensive during the last two decades what might explain the increase in capital productivity. With the diffusion of modern information and communication technologies capital stock for production might have reduced so that Hicks-neutral technical change becomes more important relative to the non-neutral development of the sixties and seventies. An analysis on the basis of the gross-concept for TFP measurement and the explicit inclusion of non-neutral technological change in the TFP measurement may improve our understanding of the impact from these developments.

While in the early 70s the TFP growth rate of the group of basic and consumer goods industries were well above the average of all manufacturing industries the performance of capital goods and food, drink, tobacco industries was below average. This situation reversed with the beginning of the mid seventies (cf. table 1 and figure 4 in the appendix). One reason for this could be the strong growth of the real gross value added of the capital goods industry with 1.7 per cent per annum and the food, drinks, tobacco industries with 1.5 per cent in comparison with the two other subgroups of industries in manufacturing. In the second half of the eighties the output growth of the manufacturing sector accelerated considerably to an average growth rate of 3.1 per cent for the period 1984-89 after a fairly low growth period during the period of the two oil price shocks with 0.9 per cent per annum. This growth process of the eighties stimulated all subgroups in manufacturing. The strongest recovery can be observed for the capital goods industries for the second half of the 80s with an average annual growth rate of 4.2 per cent.

Table 3

Capital Productivity *) in Mining and Manufacturing in the Federal Republic of Germany

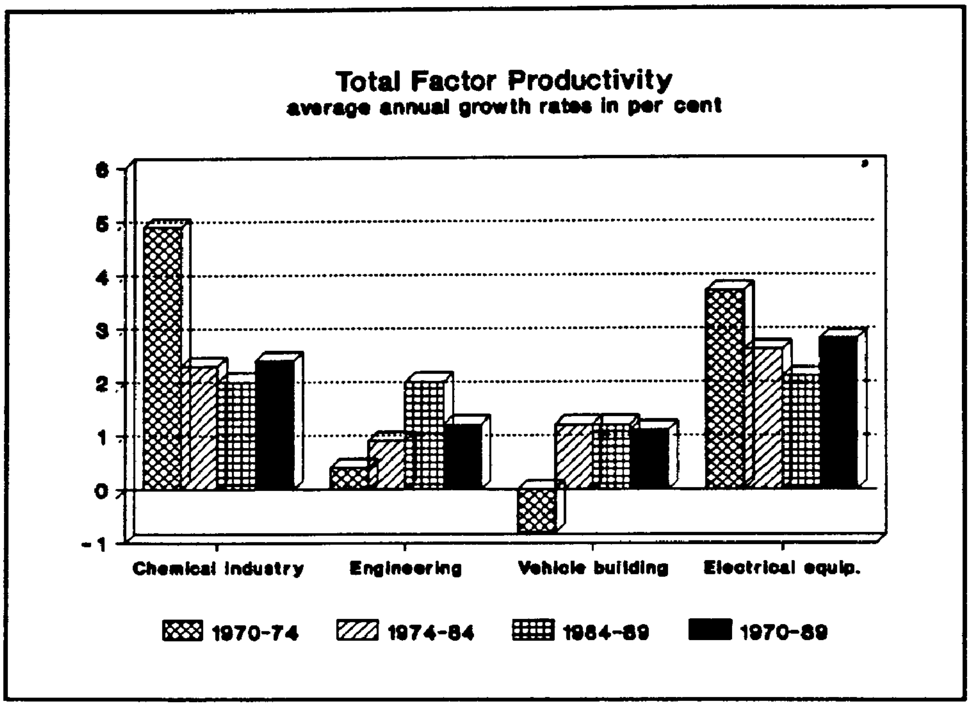
Average Annual Percentage Rates of Growth **) (1970–1989)

Industry Sectors	70–74	74–84	84–89	70–89
1 Coal mining	0.2	−3.0	−4.5	−2.8
2 Oil and natural gas extraction	4.2	−5.4	−3.8	−4.6
3 Other mining	1.5	−1.8	−5.7	−1.3
4 Oil refineries	−1.9	−0.9	3.4	−0.8
5 Stone, sand and clay industry	−4.6	−2.2	1.8	−2.4
6 Iron and steel industry	2.0	−1.7	2.6	−0.8
7 Non–ferrous metal industry	−1.4	2.6	2.5	1.5
8 Iron and steel industry	−4.0	−1.9	1.2	−1.3
9 Non–ferrous metals foundries	−3.7	1.0	4.5	1.0
10 Steel drawing and cold rolling mills	−1.9	1.0	3.6	0.5
11 Chemical industry	2.4	1.3	1.7	1.4
12 Sawmills and timber processing	−2.2	−1.3	5.4	−0.2
13 Cellulose, paper and board industry	2.8	1.6	0.4	1.5
14 Rubber industry	−6.7	0.3	1.7	0.1
15 Steel forging	−3.4	−1.4	2.9	−0.4
16 Construction steel	−4.3	−2.3	0.7	−2.5
17 Engineering	−4.2	−2.0	0.7	−1.6
18 Vehicle building industry	−4.9	−0.7	−0.5	−1.0
19 Shipbuilding	0.6	−3.4	−6.1	−3.3
20 Aircraft and aerospace industry	−2.8	−0.7	−3.2	−1.9
21 Electrical equipment	−0.3	−0.4	0.3	−0.2
22 Precision engineering, optics	−3.2	−3.2	−1.8	−2.4
23 Metal products	−4.5	−0.9	1.4	−1.1
24 Office and data–processing machines	−1.2	6.8	−3.3	4.0
25 Musical instruments and toys	−7.7	−4.5	0.8	−4.0
26 Fine ceramics	−1.9	−2.5	−0.9	−2.4
27 Glass industry	−3.2	−2.2	1.0	−1.7
28 Wood processing	−2.6	−3.3	1.5	−2.8
29 Paper and board	−3.5	−0.6	0.6	−0.9
30 Printing	−2.7	−1.8	−0.9	−1.9
31 Plastics manufacturing	−0.6	−0.1	0.6	−0.1
32 Leather and leather products	−7.8	−1.6	−2.3	−2.5
33 Textiles	−2.1	−0.3	0.9	−0.1
34 Clothing industry	−4.5	−4.0	−2.3	−3.5
35 Food, drinks and tobacco	−2.2	0.1	1.3	0.0

*) capital productivity = gross value added / capital stock.
**) the average annual growth rates are calculated by log–linear regressions.

Source: Görzig, Schintke, Schmidt 1990, own computations.

Figure 1 - Development of TFP in chemical, engineering, vehicle building, and electrical equipment industries



With respect to the 35 single industries a general secular decline in the development of TFP growth cannot be confirmed. Even the membership of single industries to one of the four subgroups of manufacturing does not necessarily imply for example that each single capital goods industry has a higher TFP growth rate then all remaining industries of the other subgroups. Remarkably, however, is the high concentration of gross value added in manufacturing and mining. Just five industries - chemicals, machinery, motor vehicles, electrical equipment and food - are responsible for about 50 per cent of the whole gross value added in manufacturing and mining. This concentration has increased even further during the last two decades. In the period 1970-74 the percentage share of these five industries is 49 per cent moving up to 56 per cent for the period of 1984-89. Only the sector of motor vehicles has a performance of TFP growth which is below the average of manufacturing (cf. figure 4 in the appendix).

Table 4

Total Factor Productivity in Mining and Manufacturing in the Federal Republic of Germany

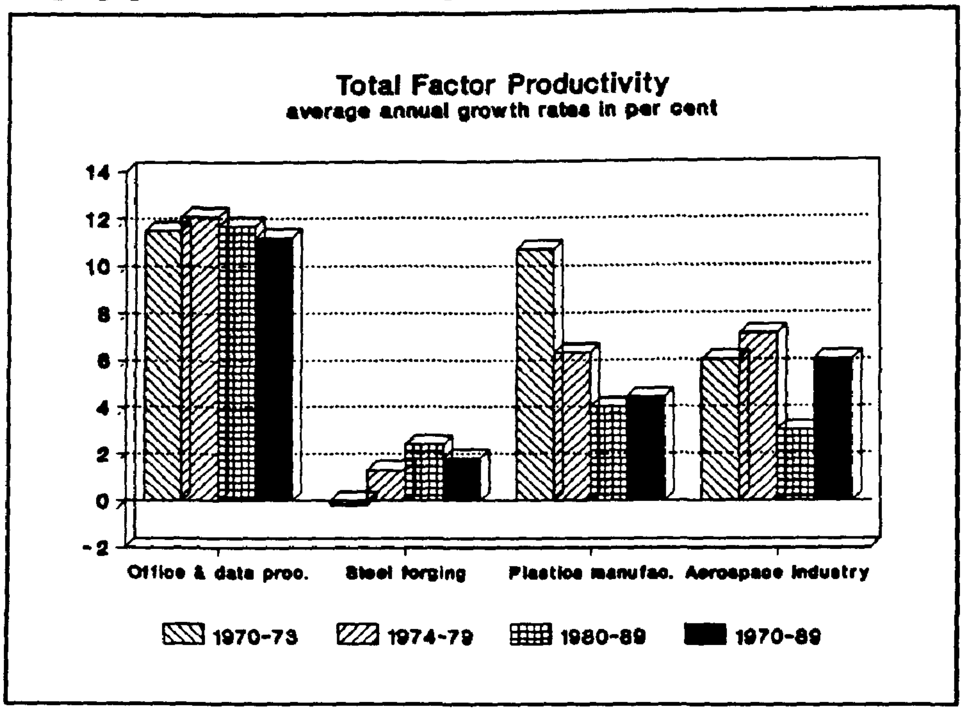
Average Annual Percentage Rates of Growth **)
(1970–1989)

Industry Sectors	70–74	74–84	84–89	70–89
1 Coal mining	2.1	–0.6	–1.6	–0.5
2 Oil and natural gas extraction	5.4	–4.8	–1.6	–3.8
3 Other mining	6.0	–0.2	–3.6	0.7
4 Oil refineries	–1.5	–0.9	3.5	–0.7
5 Stone, sand and clay industry	–0.7	0.2	2.3	0.1
6 Iron and steel industry	6.0	1.2	4.4	2.1
7 Non–ferrous metal industry	2.3	3.9	3.6	3.1
8 Iron and steel industry	1.4	0.9	1.2	1.3
9 Non–ferrous metals foundries	–2.1	2.4	4.7	2.2
10 Steel drawing and cold rolling mills	2.5	3.0	3.1	2.5
11 Chemical industry	4.9	2.3	2.0	2.4
12 Sawmills and timber processing	3.6	1.9	5.9	3.0
13 Cellulose, paper and board industry	9.2	3.7	2.2	4.0
14 Rubber industry	–0.1	1.7	2.4	2.0
15 Steel forging	0.0	1.0	2.8	1.5
16 Construction steel	–0.5	0.9	1.6	0.5
17 Engineering	0.4	0.9	2.0	1.2
18 Vehicle building industry	–0.8	1.2	1.2	1.1
19 Shipbuilding	6.4	2.8	–1.6	2.8
20 Aircraft and aerospace industry	3.8	3.5	–0.4	2.4
21 Electrical equipment	3.7	2.6	2.1	2.8
22 Precision engineering, optics	0.5	0.4	0.6	0.9
23 Metal products	0.2	1.9	1.9	1.7
24 Office and data–processing machines	6.9	10.8	2.2	9.1
25 Musical instruments and toys	–2.9	–1.6	2.3	–1.0
26 Fine ceramics	1.7	–0.5	0.7	0.0
27 Glass industry	3.1	1.1	2.5	1.9
28 Wood processing	1.8	–0.4	1.7	0.1
29 Paper and board	1.1	1.7	2.1	1.6
30 Printing	1.4	1.3	1.1	1.3
31 Plastics manufacturing	3.7	2.3	1.1	2.2
32 Leather and leather products	–3.2	–0.3	0.3	–0.4
33 Textiles	2.7	2.1	1.8	2.4
34 Clothing industry	0.2	–0.5	–0.2	–0.1
35 Food, drinks and tobacco	–0.1	1.5	1.5	1.3

**) the average annual growth rates are calculated by log–linear regressions.

Source: Görzig, Schintke, Schmidt 1990, own computations.

Figure 2 - Development of TFP in office and data-processing, steel forging, plastics manufacturing, and aerospace industries.



Short-term fluctuations of the growth rates of TFP could be attributed to impacts from the sectoral patterns of the business cycle and other factors (cf. the figures 3 to 14 for the subgroups of industries and their single branches in the appendix).

A long-term declining TFP can only be observed in six industries. Three of them are coal mining, oil and natural gas extraction in mining and oil refineries in the manufacture of basic products industry (cf. table 4 and figure 5 and 6), which are exceptions from others industries concerning the subsidies for coal mining and the high capital intensity in oil and natural gas extraction as well as oil refining. The other three industries with a long-term declining TFP are in the consumption goods industry, the leather and leather products, the clothing as well as the musical instruments and toys industries (cf. the column for the period 1970-89 in table 4).

Table 5

Gross Value Added *) in Mining and Manufacturing in the Federal Republic of Germany

Average Annual Percentage Rates of Growth **) (1970–1989)

Industry Sectors	70–74	74–84	84–89	70–89
1 Coal mining	−3.8	−1.5	−3.4	−2.1
2 Oil and natural gas extraction	5.3	−2.4	−1.0	−1.8
3 Other mining	−0.2	−2.6	−5.7	−2.1
4 Oil refineries	1.3	−1.8	−0.6	−1.7
5 Stone, sand and clay industry	0.5	−1.9	1.0	−2.0
6 Iron and steel industry	6.1	−2.2	0.5	−1.0
7 Non–ferrous metal industry	5.6	2.8	1.4	2.2
8 Iron and steel industry	−1.9	−2.8	0.0	−2.1
9 Non–ferrous metals foundries	−1.7	1.8	7.6	2.2
10 Steel drawing and cold rolling mills	1.6	0.3	3.2	0.2
11 Chemical industry	7.0	2.1	2.7	2.6
12 Sawmills and timber processing	2.8	−0.9	3.7	0.3
13 Cellulose, paper and board industry	4.9	3.3	4.5	3.3
14 Rubber industry	0.6	0.3	3.5	1.0
15 Steel forging	1.1	0.3	5.2	1.5
16 Construction steel	0.9	−0.4	1.3	−0.6
17 Engineering	0.5	0.1	3.7	0.7
18 Vehicle building industry	0.0	3.0	4.4	2.8
19 Shipbuilding	2.4	−3.0	−7.2	−2.9
20 Aircraft and aerospace industry	5.2	9.1	4.4	6.7
21 Electrical equipment	5.5	2.2	5.0	3.2
22 Precision engineering, optics	0.9	0.2	2.7	1.1
23 Metal products	1.1	1.1	3.9	1.3
24 Office and data–processing machines	8.9	12.8	5.8	11.1
25 Musical instruments and toys	−1.5	−0.6	4.0	−0.1
26 Fine ceramics	1.4	−1.5	0.2	−1.1
27 Glass industry	4.0	0.2	3.4	1.1
28 Wood processing	5.3	−1.3	1.5	−0.6
29 Paper and board	3.5	1.8	3.9	1.9
30 Printing	1.7	1.8	3.0	1.6
31 Plastics manufacturing	10.4	4.7	6.0	5.2
32 Leather and leather products	−7.2	−2.8	−3.7	−3.5
33 Textiles	−0.2	−1.7	0.0	−1.1
34 Clothing industry	−1.9	−3.6	−2.7	−3.1
35 Food, drinks and tobacco	2.1	1.5	1.8	1.5

*) at constant prices (1980=100)
**) *the average annual growth rates are calculated by log–linear regressions.*

Source: Görzig, Schintke, Schmidt 1990, own computations.

Table 6

Gross Value Added *) in Mining and Manufacturing in the Federal Republic of Germany Shares by Industry Sectors

Average Percentage Shares **) (1970–1989)

Industry Sectors	70–74	74–84	84–89	70–89
1 Coal mining	3.3	2.6	2.0	2.6
2 Oil and natural gas extraction	0.4	0.4	0.3	0.3
3 Other mining	0.3	0.3	0.2	0.3
4 Oil refineries	6.2	5.4	4.1	5.2
5 Stone, sand and clay industry	3.0	2.6	1.9	2.5
6 Iron and steel industry	3.9	3.4	2.8	3.3
7 Non–ferrous metal industry	1.1	1.2	1.3	1.2
8 Iron and steel industry	1.2	0.9	0.7	0.9
9 Non–ferrous metals foundries	0.4	0.4	0.4	0.4
10 Steel drawing and cold rolling mills	0.6	0.5	0.5	0.5
11 Chemical industry	8.1	9.1	9.9	9.1
12 Sawmills and timber processing	0.6	0.6	0.6	0.6
13 Cellulose, paper and board industry	0.7	0.8	0.9	0.8
14 Rubber industry	1.3	1.2	1.3	1.3
15 Steel forging	1.5	1.5	1.6	1.5
16 Construction steel	2.5	2.3	2.0	2.3
17 Engineering	12.6	11.9	11.7	12.0
18 Vehicle building industry	9.5	10.5	11.9	10.8
19 Shipbuilding	0.5	0.5	0.3	0.4
20 Aircraft and aerospace industry	0.6	0.9	1.2	0.9
21 Electrical equipment	10.2	11.5	13.5	11.8
22 Precision engineering, optics	1.8	1.8	1.8	1.8
23 Metal products	3.6	3.6	3.7	3.6
24 Office and data–processing machines	0.5	0.8	1.9	1.0
25 Musical instruments and toys	0.8	0.7	0.6	0.7
26 Fine ceramics	0.6	0.6	0.5	0.5
27 Glass industry	0.9	0.9	0.9	0.9
28 Wood processing	2.7	2.6	2.0	2.5
29 Paper and board	1.3	1.3	1.4	1.3
30 Printing	2.3	2.4	2.5	2.4
31 Plastics manufacturing	1.7	2.2	2.9	2.3
32 Leather and leather products	1.2	0.9	0.6	0.9
33 Textiles	3.4	2.9	2.4	2.9
34 Clothing industry	2.2	1.8	1.2	1.7
35 Food, drinks and tobacco	8.5	8.9	8.9	8.8

*) at constant prices (1980 = 100)
**) Averages calculated as arithmetic means.

Source: Görzig, Schintke, Schmidt 1990, own computations.

However, even these branches experienced an increase of their TFP rate in some subperiods.

For the sectors of other mining, stone and clay, construction steel as well as wood processing a more or less long-term stagnation of TFP emerged during the seventies and eighties. However, these industries are of minor importance for the aggregate TFP growth in mining and manufacturing in the Federal Republic of Germany and it will be even further reduced in the long-run. All other industries in manufacturing experienced an increase of their TFP after 1984.

However, even under these quite heterogeneous results of sectoral TFP growth patterns one can draw some general conclusions.

There always exists and existed possibilities for a significantly higher TFP growth in mining and manufacturing industries in the Federal Republic of Germany. In conjunction with these developments an accelerated growth of their outputs is linked. However, if in contrast to this the growth of TFP is lower as it is observed in other leading industrialized countries, for example Japan, this can be attributed to a delayed structural adjustment of the economy. Labour and capital were not sufficiently redirected towards areas of high productivity and output growth.

Having the hypothesis of the product-life-cycle (PLC) of Vernon[17] in mind, it can be argued that firms failed to restructure their activities sufficiently by cutting back their activities in aging industries and moving into typical growth sectors. Technological change may lead to higher growth in traditional industries whenever product and process innovations take place. Which industries this will be in the future cannot be predicted, however.

V. TFP-Growth and Verdoorns Law

In his study of the Italian economy Verdoorn (1949) emphazised the important relation between productivity growth and output growth.[18] In this section we show that Verdoorns Law, a label attributed to this hypothesis by Kaldor, still holds for the seventies and eighties in the

[17] Cf. Vernon (1966), Posner (1961).

[18] This kind of hypothesis even goes back to Adam Smith (cf. e.g. Hagemann (1990) p.154).

manufacturing and mining industries in the Federal Republic of Germany. While Verdoorn used the rate of labour productivity as the dependent variable, the growth rate of TFP is used in our analysis.

In the cross-section regressions the average growth rates for the four time periods in the 35 industries is used. By ordinary least squares (OLS) we tested if there exists a significant positive relation between growth rates of gross value added and TFP growth rates.[19] In this specification the constant term measures the degree of autonomous TFP growth, while the parameter β determines the contribution of output growth -measured by the average growth rate of gross value added. We expect for both parameters positive signs to be economically reasonable. For the error term the usual assumptions of the Gauss-Markoff-theorem are made.[20] The equation has the form

$$\overline{g_{TFP,i}} = \alpha + \beta \cdot \overline{g_{Q,i}} + u_i \qquad \textit{for} \quad i = 1,\ldots,35 \,. \tag{5}$$

The interpretation is: The TFP in all sectors increases on average with a growth rate of α per cent, while 1 per cent output growth of an industry leads to an average increase of β per cent of the corresponding TFP.

The parameter estimates show that there exists a positive relation for all four periods. The coefficients of determination are not less than 0.4, with a value of 0.6 the coefficient of determination is highest for the period 1974-84. The regression coefficients are statistically significant in all regressions (t-value in paranthesis) and have the expected positive sign.

$$1970\text{-}89: \qquad \overline{g_{TFP,i}} = 1.12 + \underset{(6.12)}{0.49} \cdot \overline{g_{Q,i}} + \hat{u}_i \qquad \textit{with} \quad R^2 = 0.53. \tag{6}$$

$$1970\text{-}74: \qquad \overline{g_{TFP,i}} = 0.87 + \underset{(4.97)}{0.53} \cdot \overline{g_{Q,i}} + \hat{u}_i \qquad \textit{with} \quad R^2 = 0.43. \tag{7}$$

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[19] See the data in table 4 and 5.

[20] Cf. e.g. Schneeweiß (1971).

$$1974\text{-}84: \quad \overline{g_{TFP,i}} = 1.07 + \underset{(7.08)}{0.55} \cdot \overline{g_{Q,i}} + \hat{u}_i \quad \textit{with} \quad R^2 = 0.60. \tag{8}$$

$$1984\text{-}89: \quad \overline{g_{TFP,i}} = 0.94 + \underset{(4.71)}{0.36} \cdot \overline{g_{Q,i}} + \hat{u}_i \quad \textit{with} \quad R^2 = 0.40. \tag{9}$$

$$dgf = 33$$

In all industries about 1 per cent of TFP growth is independent of output growth while an increase of 1 per cent of gross value added leads to 0.5 per cent TFP growth.

VI. Perspectives for an improved TFP Measurement

Recently attempts have been made to incorporate the impact of market imperfections recognizing that markups exists.[21] For this purpose additional information concerning market share and price-cost-differentials of the major suppliers in the industries is needed. The aggregation of firm cost, firm sales, etc. to cost and sales of an industry for example removes many significant differences of the market structure, which are necessary for an appropriate measurement of TFP. Therefore, results of sectoral TFP estimations have to be interpreted with caution and some reservations in mind, especially if these branches are quite large and heterogeneous with respect to the commodity or firm structure. Fluctuations of annual TFP growth rates are due to the composed effects of aggregation, varying capacity utilization and market imperfections. One possible strategy, would be an analysis on the basis of a representative firm panel of an industry which might give some insights not achieved by looking only at sectoral aggregates.

VII. Appendix

Our analysis is based on annual data for 35 private industrial sectors. The unit for which the data are collected are establishments. Different establishments of a firm are allocated to the corresponding industry sector according to their major activity.

The concept differs from the institutional concept of the Federal Statistical Office (FSO) in the National Accounts, where the whole company is allocated to an industrial sector according

[21] Cf. Hall (1988), Morrison (190), Flaig, Steiner (1990).

to its major activity.[22] In this case a shift of the major activity of a firm to a different industry[23] may cause structural breaks in the time series of a data base which are more severe compared with the concept of establishments. As a consequence the use of this data will lead to better results than the one based on an institutional classification if time series over a long time range are used.

Included are only companies with 20 or more employees, as they are part of the official statistic of the FSO. Gross production values are calculated by a slightly modified concept because micro data are only available for the year 1980. For this reason time series for gross production values are estimated on the basis of the gross value added/sales ratio and the available quarterly production index (Görzig 1985).

As cost components wages and salaries of all employees as well as capital user costs (profits and depreciation of fixed capital) are taken into account. According to Hulten capital costs are calculated as a residual from gross value added (in current prices) minus wages and salaries (cf. Görzig, Schintke, Schmidt (1990)). Gross value added (in constant prices of 1980) is used as output variable. Inputs are effective working hours of employees and gross fixed capital stock (at constant prices of 1980).

During the last two decades there has been a significant reduction of working hours per employee (a reduction of the weekly working hours and the length of the holidays). Using the number of employees instead of effective working hours of employees therefore would result in a downward bias of the TFP measure.

From working hours of employees time worked by self-employed and unpaid family members is excluded. This might lead to overestimation of the growth rates of labour productivity and TFP. However, the number of self-employed and helping family members in manufacturing is a negligible quantity in comparison with sectors like agriculture and the service industries where self-employed and helping family members could not be neglected.

In the mining industries the number of employees is equal to the number of persons engaged in the official statistics of the FSO (since 1960). In manufacturing the number of engaged persons accounted for 8.569 mill. while the number of employees was 8.239 mill. in the year 1988. The number of self-employed and unpaid family members in manufacturing declined

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22 Cf. FSO (1990) pp.41-116.

23 This might happen through merger and acquisition activities or diversification of a company into new areas (cf. e.g. Pischner (1981a) p.173 or Pischner (1981b) p.473 the footnote 4 in both publications).

from 769 000 persons in 1960 to 330 000 in 1988. So the influence of the group of self-employed and unpaid family members in manufacturing on productivity measurement is declining.

Figure 3 - Mining and Manufacturing

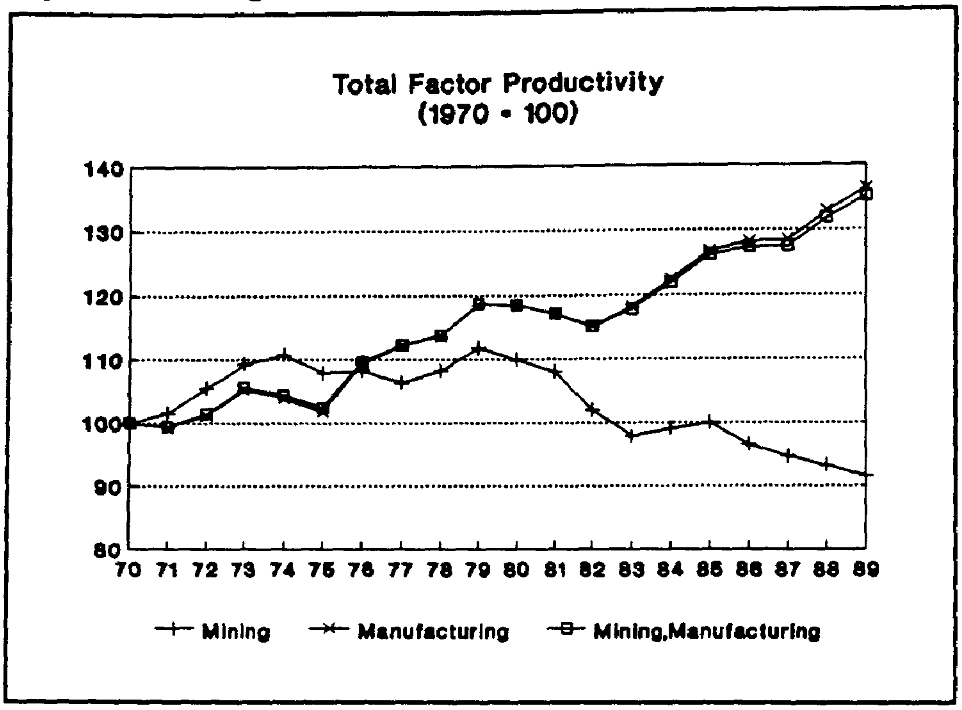


Figure 4 - Manufacturing by subgroups of industries

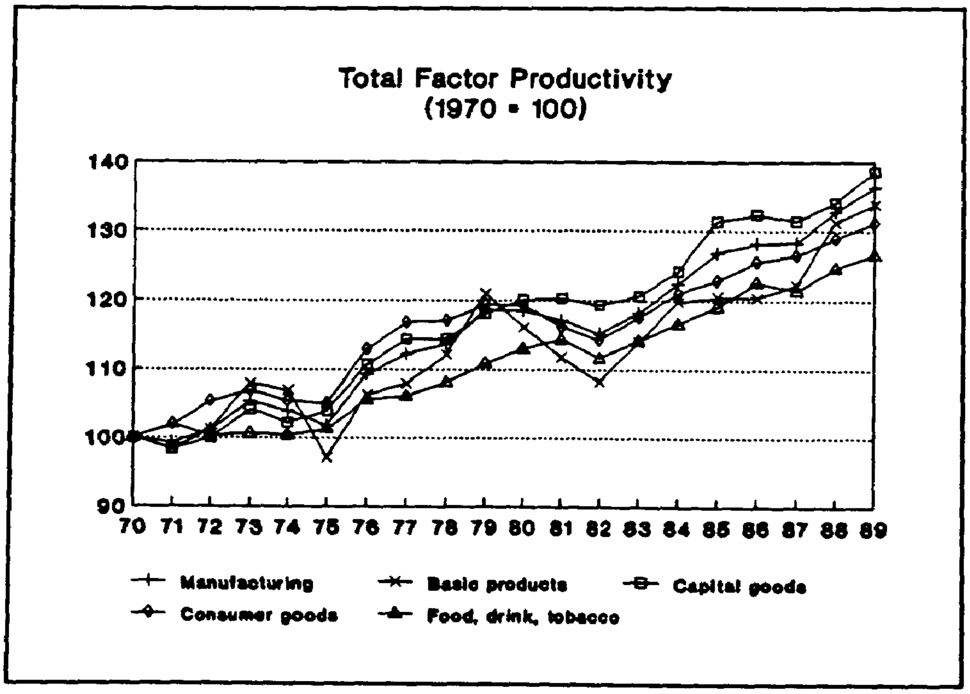


Figure 5 - Mining by industries

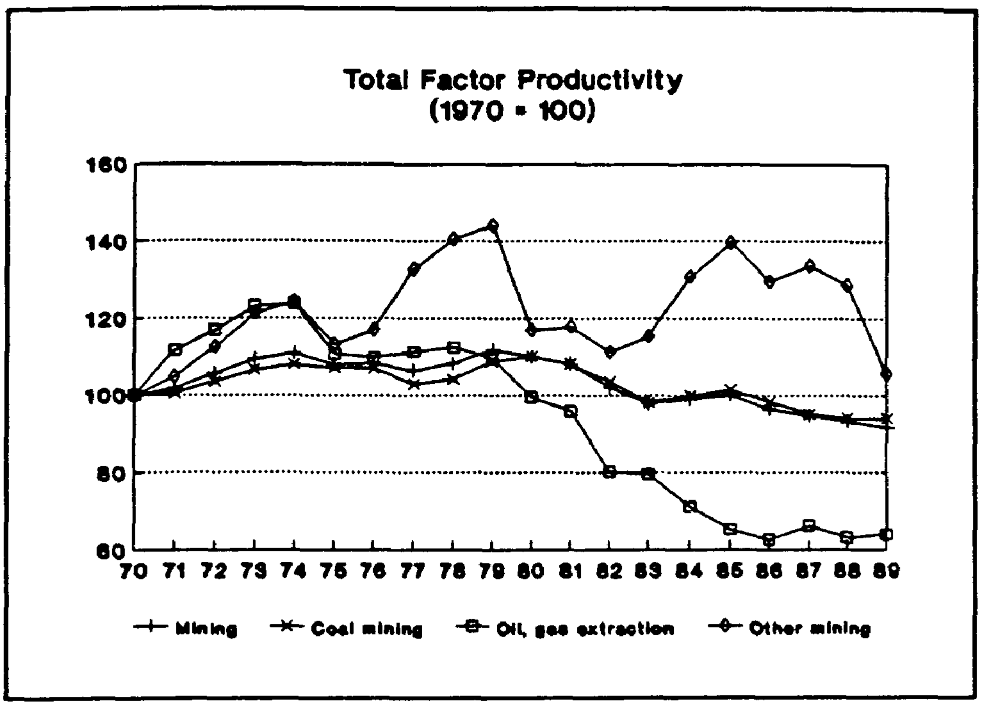


Figure 6 - Manufacture of basic products by industries

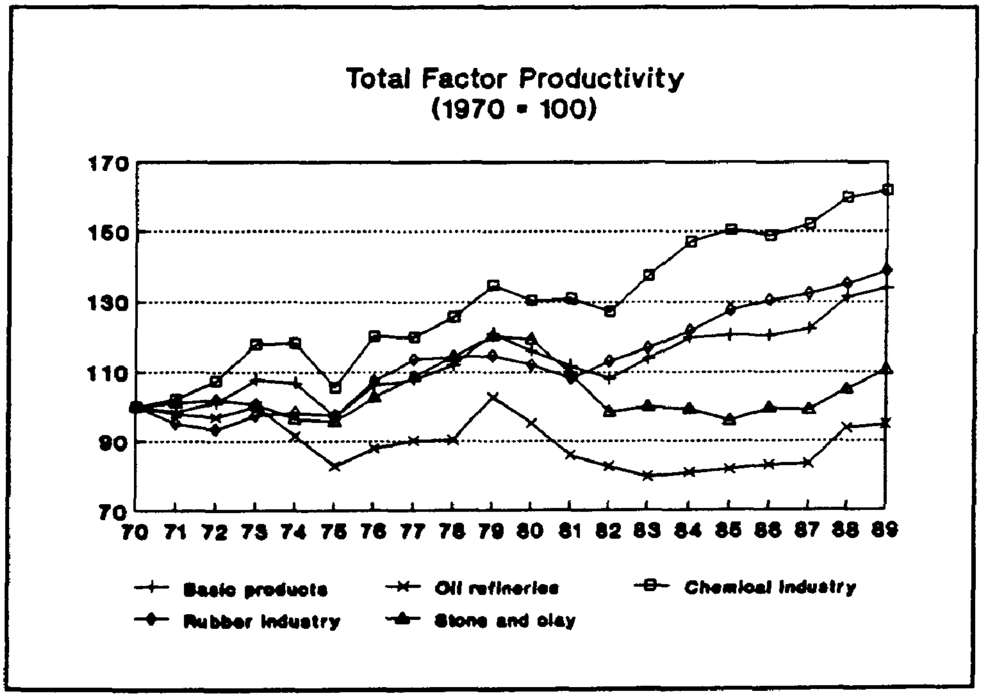


Figure 7 - Manufacture of basic products by industries

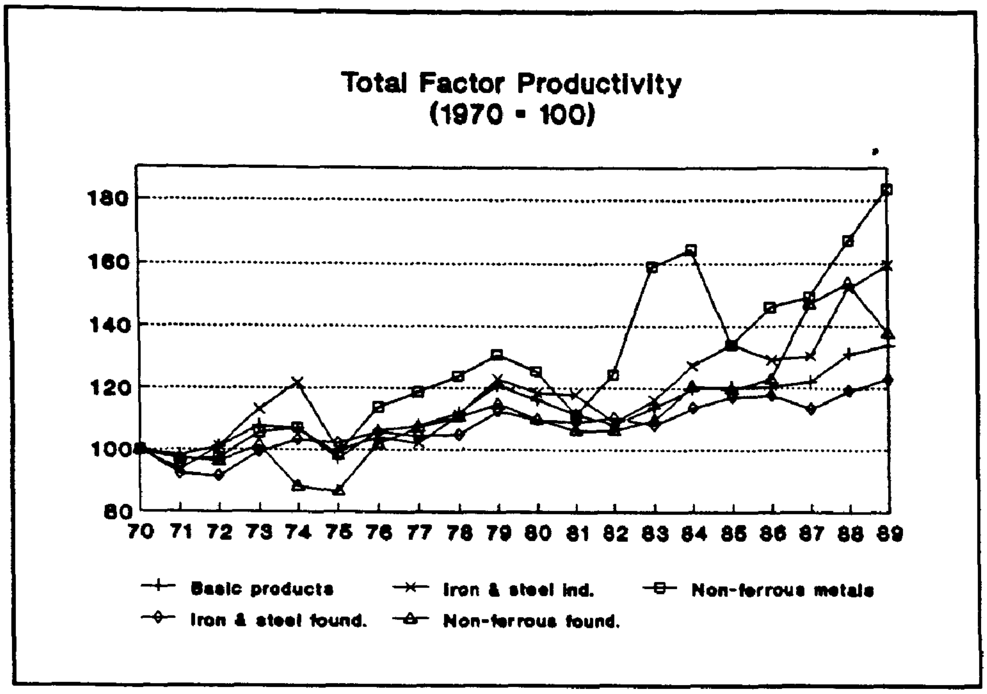


Figure 8 - Manufacture of basic products by industries

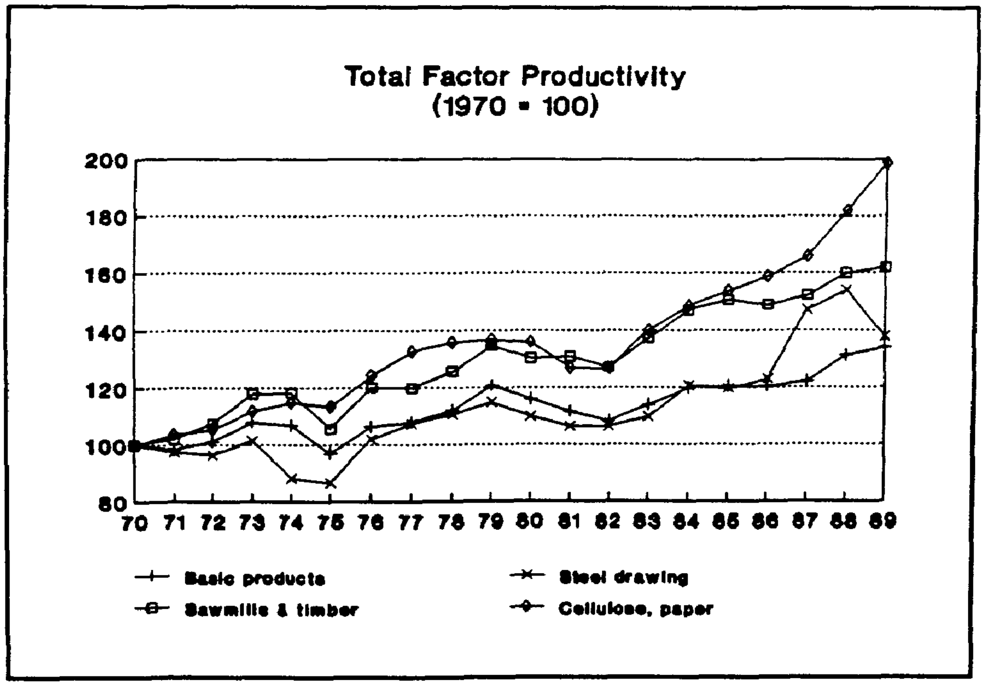


Figure 9 - Manufacture of capital goods by industries

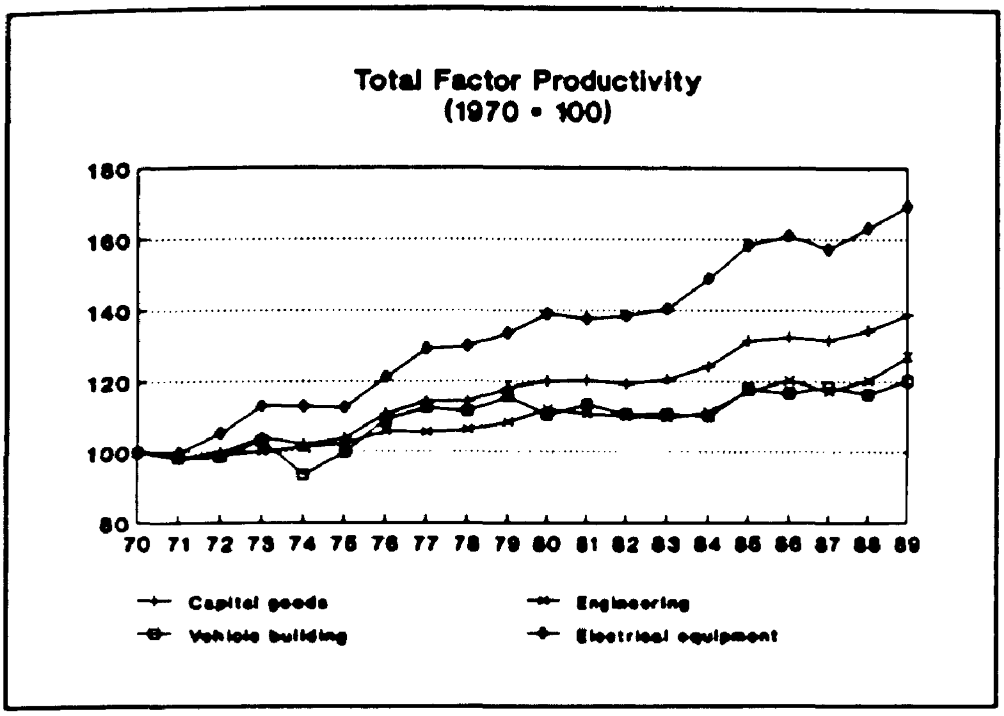


Figure 10 - Manufacture of capital goods by industries

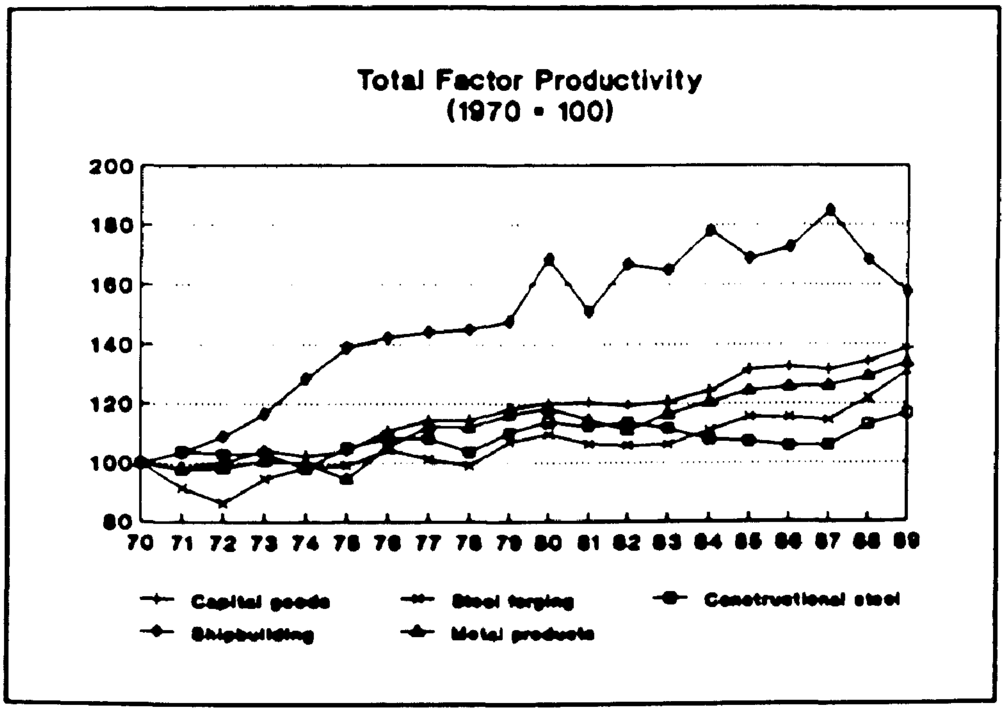


Figure 11 - Manufacture of capital goods by industry

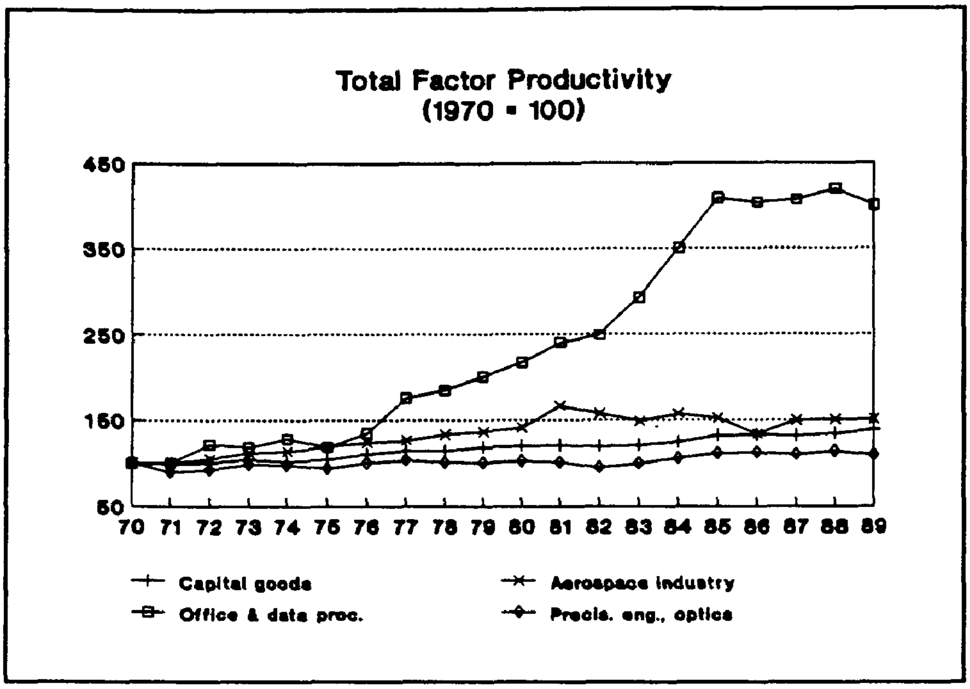


Figure 12 - Manufacture of consumer goods by industries

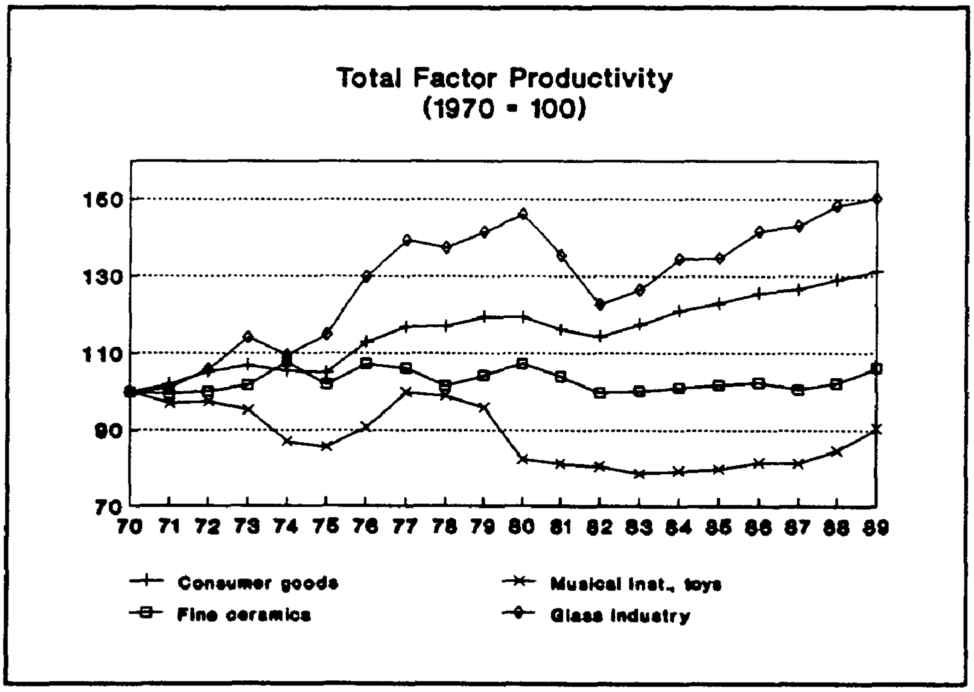


Figure 13 - Manufacture of consumer goods by industries

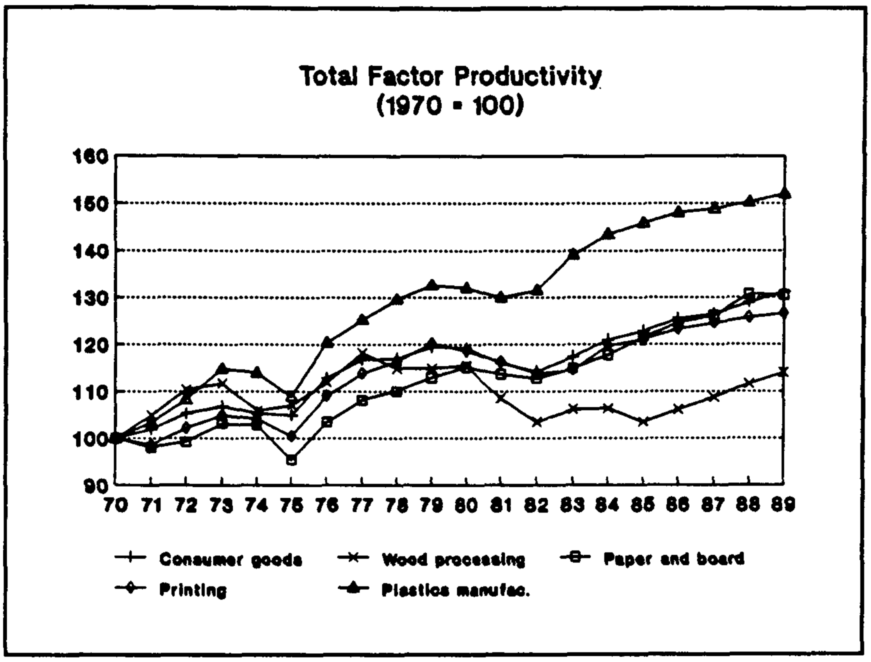
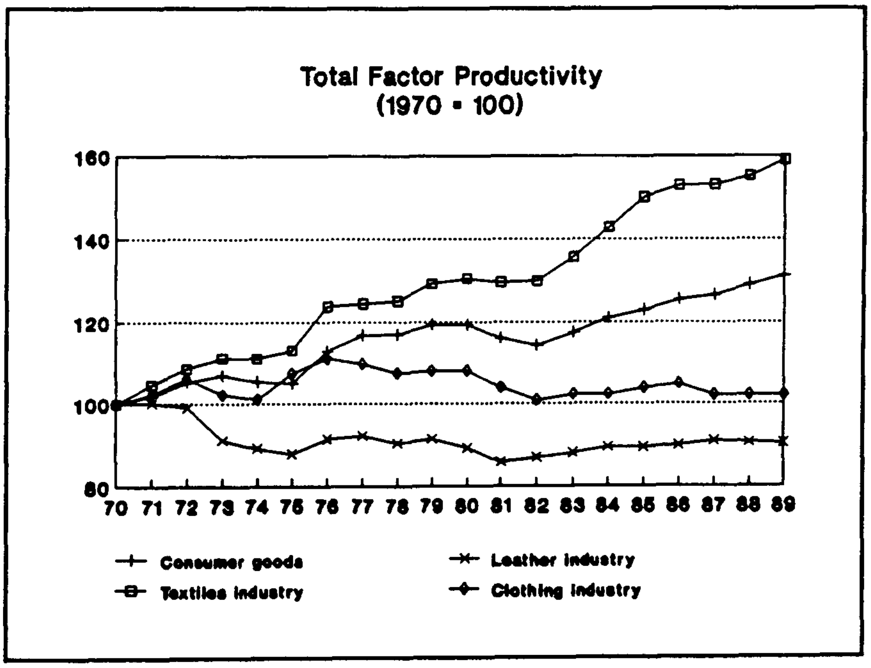


Figure 14 - Manufacture of consumer goods by industries



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Summary:

For 35 industries the development of total factor productivity (TFP) growth is analyzed. The method used was first proposed by Hulten (1986). Comparing the average TFP growth rates for manufacturing before, during, and after the oil price shocks one observes a steady acceleration of TFP growth. Contrary labour productivity, measured on the basis of annual working hours, declined. Cross-section regressions for the 35 industries support the hypothesis that Verdoorns Law is valid for all periods considered. Therefore high growth industries - with respect to gross value added - are as well leading industries in TFP growth.