PATTERNS OF INDUSTRIAL CHANGE IN THE FEDERAL REPUBLIC OF GERMANY

Part I: Flows of Manufacturing Output and Energy Input

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PREFACE

The work on patterns of industrial change in the Federal Republic of Germany is one of a series of case studies that are underway as part of IIASA's research into economic structural change and growth. A summary of the first case study, which relates to the United States, was distributed in 1983.*

The FRG Case Study consists of two parts. Part I, which is reported here, deals with the major trends in structural change observed for the growth of capital stock and the flows of output and energy demand within the manufacturing sector of the FRG since 1950. This part was prepared by Claire Doblin. In Part II, Michael Kraus has undertaken an empirical analysis of the energy intensities of the manufacturing sector in the FRG over the same period, in which he attempts to separate the effects of structural change and technical progress in decreasing the demand for energy at both the sectoral and the industry level.

*Claire P. Doblin, *Patterns of Industrial Change in the USA Since 1970: A Preliminary Summary*. Working Paper WP-83-103. Laxenburg, Austria: International Institute for Applied Systems Analysis. November 1983.

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1. SUMMARY AND MAIN CONCLUSIONS

1.1. Growth of Capital Stock, Output, and Energy Input in the Manufacturing Sector as a Whole

During the period of economic prosperity ushered in by the reconstruction and development of the FRG following World War II, the value of manufacturing capital stock, measured in constant 1970 prices, expanded at an average annual rate of 7.8% in the 1950s (which was perhaps not a normal period) and 6.9% in the 1960s. The growth of total manufacturing output was unusually high during the 1950s (with an average annual rate of 10.3%) and continued at a somewhat reduced, but still high level during the 1960s (5.5% per annum) (see Table 1). The prime movers behind this development were the expansion of infrastructure and the growth of the chemical, automobile, and electric and electronic equipment industries. The electric equipment industry is traditionally heavily dependent on innovation, and the application of new technologies; much the same applies to a number of chemical goods, such as synthetic fibers, drugs, and pharmaceuticals.

In the 1970s, manufacturing capital stock grew at an average annual rate of no more than 3.3%, while the growth rate for total manufacturing dwindled to an annual average of only 1.8%; this was followed by cutbacks and stagnation of output through 1983, with some recovery expected in 1984. Figure 1 shows the growth of capital stock, output, and final energy demand for the manufacturing sector since 1950, expressed as indexes based on 1970 = 100. The slow growth of capital stock is also reflected in the general slowdown in annual investment and gross fixed capital formation (GFCF) in the manufacturing and other sectors of the economy. It stands to reason that these developments in investment are closely related to the growth of those basic industries, e.g. iron and steel, or stone, clay, and sand (including cement), that are both capital and energy intensive. Consequently, the slowdown in investment in the FRG has

Table 1. Summary economic indicators of growth in the FRG, 1950–83.

Year	Total economy: gross fixed capital formation		Manufacturing sector		
	Total	Public sector construction	Capital stock	Output (value added)	Final energy input (quantity)
1. Index Numbers 1970 = 100					
1950	24.0	.	24.0	21.9	40.5
1951	25.3	.	25.5	26.4	47.2
1952	27.5	.	27.1	28.3	51.3
1953	32.1	.	28.9	30.5	50.2
1954	36.2	.	30.9	34.9	54.3
1955	43.7	.	33.6	40.8	61.3
1956	47.5	.	36.9	44.2	65.0
1957	47.5	.	40.2	46.1	65.3
1958	49.4	.	43.4	47.5	63.6
1959	55.3	.	46.9	51.6	65.5
1960	64.2	45.7	51.1	58.6	73.5
1961	68.6	50.6	56.0	62.3	74.3
1962	71.4	58.6	61.1	64.7	75.2
1963	72.3	67.6	65.9	66.9	76.7
1964	80.4	82.9	70.5	73.0	82.4
1965	84.3	83.3	75.5	77.4	84.6
1966	85.3	84.2	80.6	78.2	82.1
1967	79.4	76.6	85.2	76.1	81.9
1968	82.3	82.1	89.2	83.3	88.8
1969	91.0	89.0	93.9	94.2	95.5
1970	100.0	100.0	100.0	100.0	100.0
1971	106.2	99.0	106.4	101.6	97.4
1972	108.9	96.0	112.2	105.4	98.8
1973	108.6	94.0	117.2	112.5	104.4
1974	95.2	100.0	121.6	108.0	105.4
1975	93.4	98.0	125.2	102.8	92.7
1976	97.7	95.0	128.2	109.4	98.0
1977	101.5	91.0	130.3	111.8	97.4
1978	106.4	94.0	132.6	113.1	97.9
1979	114.1	98.0	134.9	118.8	100.4
1980	117.8	99.2	137.7	119.0	97.6
1981	112.9	90.6	.	116.4	91.9
1982	107.2	82.5	.	112.9	83.9
1983	110.3	75.9	.	113.5	85.0
2. Absolute values at 1970 prices (10^9 DM)					10^6 TCE
1980	202.7	28.7	575.7	370.1	99.7
1981	194.2	26.2	.	362.7[E]	94.1
1982	184.4	23.8	.	351.6[E]	85.6
1983	189.7	21.9	.	353.0[E]	86.9[PE]
3. Average annual growth rates (%)					
1950–1960	10.3	.	7.85	10.54	6.1
1960–1970	4.5	8.145	6.94	5.49	3.12
1970–1980	1.65	−0.08	3.25	1.755	−0.064
1980–1983	−2.169	−8.54	.	−1.565	−4.503

E = estimate; PE = preliminary estimate.

Sources and Notes:

Total Gross Fixed Capital Formation (GFCF) (Anlageinvestitionen) for the economy as a whole includes equipment and construction, by private sector and government.

Data for GFCF total and public sector construction 1960 to 1981 are compiled from *Statistisches Bunesamt. Volkswirtschaftliche Gesamtrechnungen 1960–1981, op. cit.* pp. 57 and 59.

Data for 1981 to 1983 were communicated orally by the *Statistisches Bundesamt*, 12 July 1984 (Data converted from 1976 to 1970 prices).

Data for 1950 to 1960 were compiled from C. Doblin. Capital Formation, Capital Stock and Capital Output Ratios 1950–1975. IIASA Research Memorandum RM-78-70; December 1978.

Manufacturing sector capital stock, output and energy input, see Tables 7, 10, and 11.

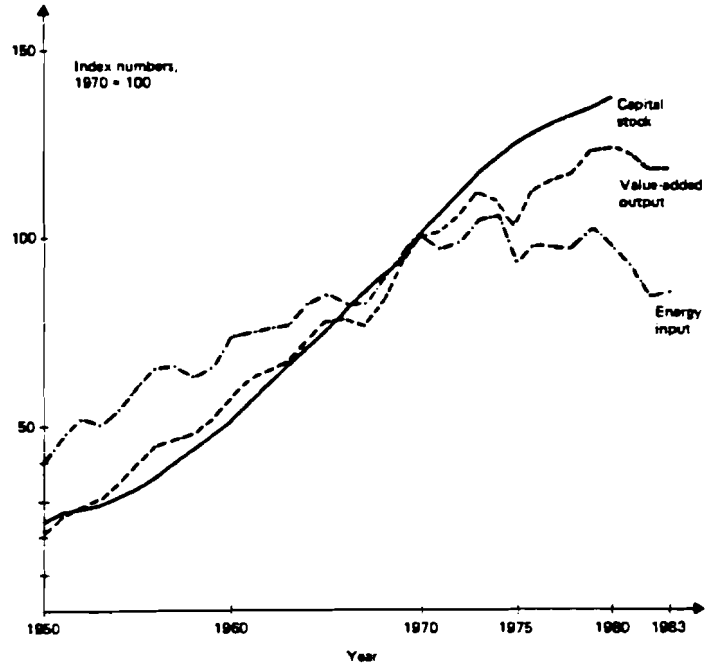

Figure 1. FRG Total Manufacturing. The Growth of Capital Stock, Output and Final Energy Input since 1950. Index Numbers, 1970 = 100.

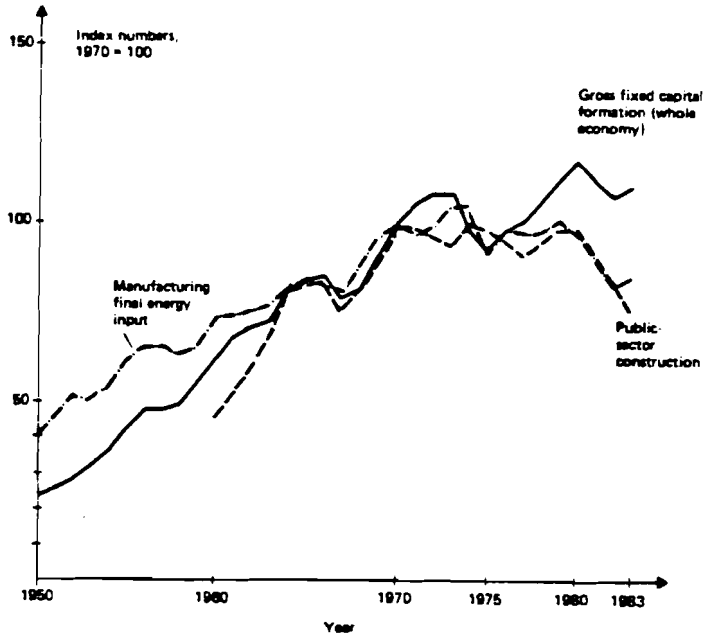

Figure 2. FRG The Growth of the Total Economy's Gross Fixed Capital Formation, Total and Public Sector Construction; and the Manufacturing Sector's Demand for Final Energy Input since 1950.

largely affected the growth of energy-intensive industries and hence the total demand for final energy by the manufacturing sector. One strong reason for the drying-up of investment in the late 1960s and early 1970s was that by that time the country's need for infrastructure expansion had become saturated. A stage was reached when major construction projects designed to extend networks of communications and transportation (such as roads, bridges, tunnels, underground railways, etc.) largely gave way to maintenance and repair work. The close links between the rise and fall of public sector investment in construction and the energy demand of the manufacturing sector can be seen from Figure 2.

The slowdown in investment imposed an additional constraint on the growth of basic producer and investment goods, e.g. iron and steel and other primary metals (excluding aluminum), stone, sand, and clay (including cement), and also the construction of certain nonelectrical machinery. For a number of reasons, such as the transition to more lightweight materials, these energy-intensive industries had already embarked on a long-term, relative decline. The growth of these industries in absolute terms was soon eclipsed by the expansion of industries less demanding in energy and yielding a higher proportion of value added. This trend was already apparent in the structural changes of industry after 1950, and became especially marked from the 1960s onward. In the 1970s and early 1980s, the slower than average growth of the basic producer- and investment-goods industries turned into no growth and the outputs of some of the industries (e.g. steel and basic chemicals) that are most energy intensive, actually fell in terms of absolute physical quantities.

The analysis of the structural changes of manufacturing in the FRG shows that there has been a long-term trend for the energy input per unit of output of the manufacturing sector as a whole to decrease. Progressive improvements in energy productivity, during periods of generally decreasing energy prices, were mainly due to two factors. Machinery and equipment embodying better technologies and with higher efficiency of fuel utilization routinely came on stream through either the normal replacement of retired equipment or the expansion of production facilities. During the recession years of the 1970s and early 1980s, overall energy productivity was further enhanced by disinvestment, or the shutdown of older equipment that was less efficient in fuel utilization. Throughout the entire period studied, starting with the 1950s, the efficiency of fuel utilization was progressively improved by interfuel substitution, the displacement of coal by oil and natural gas, and the increasing use of electricity.

The confluence in the late 1960s and early 1970s of the three trends described above, namely the slowdown of infrastructure investment, the continued displacement of basic, energy-intensive industries, and the long-term trend toward energy saving in manufacturing, explains in large measure the widening of the gap between energy input and manufacturing output in the FRG (see also Figure 1). Thus, the recessions brought on by the oil price shocks of the 1970s seem merely to have accelerated, rather than caused, the process known as the "breaking of the energy coefficient" (i.e. the observation that total primary energy demand and GDP no longer follow the same growth rates, as they did over a long period from the end of World War II until the first oil price shock of 1973).

1.2. Major Trends Within the Manufacturing Sector

The analysis concentrated on the patterns of structural change within the manufacturing sector of the FRG since the 1950s. For this purpose, the sector was disaggregated into 20 groups that roughly correspond to the groupings at the 2-digit level of the US Standard Industrial Classification (SIC). In order to broaden the analysis, we supplemented the 20 groups with 60 indexes of gross and net production and with data on physical quantities for selected industries.

The index of production for the manufacturing sector as a whole indicates what may be considered as national average growth. Deviations from this average indicate whether an industry is fast growing or slow growing. The differences in growth behavior are also reflected in the structure of the percentage shares of the various industries in total manufacturing over a period of time. Depending on whether their percentage shares in total manufacturing have been consistently rising or falling since 1950 or only since the 1970s, the industries were grouped into three categories: slow-growth industries, fast-growth industries, and former fast-growth industries.

The slow-growth category, which also includes the no-growth industries, saw its share in total manufacturing output decrease from 43% in 1950 and 35% in 1960 to 29% in 1980. The most prominent "losers" were the iron and steel industry, foundries and castings, other primary metals (except aluminum), and constructional steel. To some extent, the relative decrease in the share of these industries was due to the displacement of heavier materials by those of lighter weight. In the case of steel, for example, this meant the use of more concrete in highway bridges, more plastic in cars, and less steel in the manufacture of refrigerators, washing machines, and beer and other cans. Major users of steel and other heavy metals such as nonelectrical machinery and construction have themselves become slow-growth industries, while some steel-using activities have ceased to grow at all, such as shipbuilding, or gone out of style, as for instance railroads.

One very strong reason for the decline of the primary metals (except aluminum) as well as the stone, sand, and clay group (including cement) was that the demand for investment goods became depressed as the requirements for infrastructure building receded. This was true not only for the FRG, but for other industrialized countries, such as the United States, as well.

Besides the investment-goods industries mentioned above, there were other relative losers as the structure of industry in the FRG changed, for a variety of reasons. These included the lumber and sawmill industry (including pulp and raw paper), some of whose products may have been displaced by imports, the textiles industry, whose secular decline has long been a feature of other developed economies, and the food industry (including beverages and tobacco). The growth of food production usually lags behind growing prosperity, as it did in the FRG until the recession of the 1980s, when the sector regained some of its former relative importance. Finally, there are a number of miscellaneous consumer goods, excluding food, whose development was stunted to some extent by the inroads of foreign products into the domestic market (clothing, gloves, shoes) and/or the competition of foreign producers on the world market (optical and precision instruments, clocks and watches, toys, etc.).

The fast-growth industries increased their share in total output from 15.56% in 1950 to 31:84% in 1980. This group comprises the electric and electronic equipment industry; its share in the total *manufacturing* output of the FRG increased from 6.53 to 14.35% over the same period. For the energy requirements analysis, this industry had to be lumped together with optical and

precision instruments; this combination is not very helpful because of the opposing growth trends of the two industries. Thus, electric and electronic equipment manufacture taken alone would have followed an even higher growth path. However, not all branches of the electric and electronic equipment industry experienced the same degree of growth. For instance, during the 1970s, the manufacture of cables and other infrastructural elements connected with electric equipment experienced relative and sometimes even absolute declines. This clearly indicates the connection that exists with the construction industries. A decline was also observed for certain household appliances, such as washing machines and refrigerators, whose markets had become almost saturated. But the regression of these industries was more than compensated by the spectacular expansion of the growth industries *par excellence* that embody the application of new technologies, such as the manufacture of computers and other electronic equipment.

The chemicals and allied industry increased its share in total manufacturing output from 6.68% in 1950 to 12.44% in 1980. The chemicals group includes a variety of industries, associated with three types of product: some of these are primary or basic materials such as inorganic and organic chemicals; others are intermediate products like fertilizers, dyestuffs, and synthetic fibers; and others again are final consumer goods such as pharmaceuticals, cosmetics, paints, etc. Each of these groups differs in its energy requirements and potential for value added, with energy demand decreasing and value added increasing as we move from basic materials to final consumer goods.

Based on the FRG's census-type periodical *The Survey of Employment, Turnover, and Energy Consumption*, it is estimated that 13.3% of the final energy demand of the entire manufacturing sector in 1980 was absorbed by basic and intermediate chemicals. Bearing in mind that the quantitative output of a significant group of basic chemicals, including synthetic ammonia, methanol, and phosphate fertilizers, had ceased to grow by the early 1970s and even decreased in the late 1970s and early 1980s, it is estimated that the slow and at times negative growth of the energy-intensive basic and intermediate chemicals industry as a whole played a major role in the "breaking of the energy coefficient."

The growth in the chemical industry's production of final consumer goods was echoed in the expansion of another fast-growth industry, namely the processing of plastic and synthetic goods, whose share in total manufacturing output increased from 0.22% in 1950 to 2.81% in 1980. This development was undoubtedly due to innovation. The same seems to have been true for the recent rapid growth of the fine ceramics group, which manufactures some of the components for the computer industry. Fine ceramics (which also includes glass production and processing) was a slow-growth industry in the earlier decades, when its share in total output fell from 2.31% in 1950 to 1.31% in 1970, but subsequently its share advanced to 2.29% by 1980.

In contrast to former slow-growth industries that later became fast-growth, there are a few former fast-growth industries that seemed to lose their momentum for expansion under the impact of the oil price explosions of the 1970s. These are mineral oil refining, rubber, and asbestos (including automobile tires), and possibly the vehicles industry (including automobiles). The combined share of these groups in total manufacturing output rose from 5.68% in 1950 to 13.62% in 1970; but by 1980 the share of these industries was no higher than 13.70%.

The first and second oil price explosions had some impact on the production of distillate fuel oil; 1980 output, after a few oscillations during the

preceding decade, was only 8% above the 1970 figure. More direct and serious was the impact on residual fuels production; this fell continuously after 1974, so that by 1980 it was nearly 40% below the 1970 figure. More recent data are so far unavailable for distillate and residual fuels. In any case their development sharply contrasts with that of gasoline – where 1980 output was still 55% above the 1970 level, followed by a minor dip in 1981, recovery in 1982, and stagnation in 1983. At the same time, tire production for automobiles in 1980 was no higher than in 1970; it subsequently dropped to below the 1970 figure in 1983.

The impact of the oil price explosion on automobile production is not yet completely clear. In the 1950s and 1960s this industry expanded at about the same, high rate as total chemicals and the production of electric and electronic equipment. The latter industries continued on essentially the same growth path throughout the 1970s with only a minor disturbance in 1975 – thanks mostly to the growth of pharmaceuticals and other chemical consumer goods, and the revolution in the computer industry. However, automobile production grew only very little in the early 1970s, and in the recession years it fell to a level that was slightly below that of 1970. But since the slump of 1975 output has somewhat recovered. By 1983 the net production index (1970 = 100) for vehicles serving as investment goods had climbed to 136.9, while the gross production index (1970 = 100) for private-use vehicles stood at 121.5.

What is really in store for FRG automobile production – if the approaching saturation of the domestic market should happen to coincide with growing constraints on exports – only time will tell.

2. MANUFACTURING OUTPUT

2.1. Method and Sources

The case study on the patterns of industrial change in the Federal Republic of Germany concentrates on the manufacturing sector (*Verarbeitendes Gewerbe*). In 1980, manufacturing accounted for nearly 77% of gross value added produced by the industry sector; a further 15% came from construction, 6% from the utilities (electricity, gas, water), and only 2% from mining. Over the last two decades, both utilities and construction gained slightly, while the already low share of mining dropped continuously from 5% in 1960 to only 2% in 1980 (see Table 2).

2.1.1. Selection of Output Indicators

The analysis of structural changes in the flows of manufacturing output is mainly based on the *net production volume*, a concept used by the Deutsches Institut für Wirtschaftsforschung (DIW). This is only one of the many output measures with which the German statistical literature abounds. For a comparison of various concepts and definitions of output see Table 3, which shows the values of output at current prices for total manufacturing in 1970 and 1980. It can be seen that net production volume is somewhat higher than, but still close to gross value added. In fact, when the DIW prepared its *Net Volume of Production* series, it used the gross value added for a group of 20 manufacturing industries. Therefore, in the following analysis, the terms net production volume and gross value added are used interchangeably.

Here the question arises as to whether the analysis should have been based on *value added* instead of *gross value of production*. In this connection, it may be recalled that the first IIASA case study of structural changes, which

Table 2. The structure of the industrial sector of the FRG (gross value added in current prices), 1960, 1970, and 1980.

	1960	1970	1980	1960	1970	1980
	In 10^6 DM (current prices)			*In percent*		
Mining	8360	8220	13400	5.2	2.5	2.0
Utilities	7290	14500	37860	4.5	4.3	5.9
Construction	23290	51550	99030	14.5	15.4	15.5
Manufacturing	121860	259450	490170	75.8	77.8	76.6
Total industry	160800	333720	640460	100.0	100.0	100.0
Total GDP	611520	956600	1261800	·	·	·

Source: Compiled from *Statistisches Bundesamt Volkswirtschaftliche Gesamtrechnungen; Revidierte Ergebnisse* 1960-1981.
Fachserie 18 Reihe S 5 page 142-143.

concerned the United States, was based on *gross value of production.** The preference for gross production is based on the fact that differences in factor cost could distort the findings of the analysis of structural changes. It is undoubtedly true that the price of input materials, profits, and labor costs vary considerably between industries and products. This can be seen in the input–output analysis that has been carried out, e.g. for the United States, for close to 450 *products*. However, for input–output analysis it is also a question of the absolute values for selected years. But the FRG study of annual changes over a long-term period of the *flows* of industries attempts to measure the relative growth rather than the actual output levels of industries, and this at a fairly high level of aggregation. At this level it seems that differences in factor cost do not significantly affect the long-term growth trends of the various industries, whether measured in terms of gross or net production. This may be observed in the indexes of gross and net production compiled by the FRG statistical offices for investment goods and consumer goods, shown in Table 4.

The indexes reported in Table 4 show that the growth trends for gross production (turnover excluding sales taxes) and net production (gross value added) have been quite similar in the FRG in the past decade. This means that the share of intermediate input has remained stable for most of the period, except for some significant changes during the years of recession; these latter changes may have been due to inventory accounting or imports.

Further comparisons may be found in the computer printouts at the end of this paper, which show gross and net production at current and constant prices and the implicit price deflators for selected manufacturing industries, all for the period 1950–1980. Here it should be noted that both gross and net production figures are not always available for all industries; moreover, a gross production index has obviously not been compiled for *total* manufacturing, so as to avoid double counting.

*Claire P. Doblin, *Patterns of Industrial Change in the USA Since 1960: A Preliminary Summary.* Working Paper WP-83-103. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Table 3. The structure of the industrial sector of the FRG (gross production, gross and net value added, and net production volume all in 10^6 DM current prices), 1970 and 1980.

	1970					1980		
	Gross production	Value added (GDP)		Effective net production volume	Net production volume	Gross production	Gross value added	Effective net production volume
		Gross	Net					
Mining	15440	8220	6920	·	·	30433	13400	8987
Utilities (electricity, gas, water)	31410	14500	10330	·	·	·	37860	·
Construction	95880	51550	47640	·	·	·	99030	·
Manufacturing[a]	647990	259450	212300	335430	299498	1201913	490170	413136
Industry[b]	790720	333720	277190	·	·	·	640460	·

[a] *Verarbeitendes Gewerbe*.

[b] *Produzierdendes Gewerbe*.

Sources:

Gross Production (*Brutto Produktionswert*) excluding Sales and Value Added Tax, and adjusted for movement of stocks, see: *Statistisches Bundesamt. Statistisches Jahrbuch 1983*, p. 530 Table 23.4 and *Volkswirtschaftliche Gesamtrechungen; revidierte Ergebnisse 1960–1981. Fachserie 18, Reihe S5*, p. 152–153.

Gross Value Added (Gross Production minus cost of materials used and commission work) see: *Statistisches Jahrbuch* 1983, p. 530, Table 23.4.

Net Value Added (Gross Value Added minus overhead, amortization, indirect (production) taxes, see source for gross value added.

Effective Net Production Volume, see: Deutsches Institut für Wirtschaftsforschung (DIW) *Statistische Kennziffern 1970-1980* Berlin, October 1981; p. 5.

Net Production Volume. Data compiled by DIW for Michael Kraus.

Table 4. Comparison of production indexes in the FRG, 1970–81; index numbers, 1970 = 100.

Year	Production index for			
	Investment goods		Consumer goods	
	Gross[a]	Net[b]	Gross[a]	Net[b]
1970	93.9	91.5	92.0	92.6
1972	97.1	93.2	97.1	101.2
1974	98.7	96.8	91.5	97.7
1976	100.0	100.0	100.0	100.0
1977	101.7	104.1	106.7	102.8
1978	101.4	104.1	107.2	102.8
1979	105.9	108.9	109.1	106.3
1980	110.3	111.6	104.1	105.3
1981	112.0	111.5	99.6	100.0

[a] Gross production denotes turnover excluding sales taxes, adjusted for movement of stocks.

[b] Net production denotes gross production excluding the value of materials used; this is similar to the German gross value added.

We also examined in various ways the breakdown of 1970 production by individual industries. At a fairly disaggregated level the net volume of production is higher than the corresponding gross and net value added; the exceptions here are those industries that are subject to substantial taxes on production, such as alcohol and tobacco, and particularly mineral oil refining, where net value added is appreciably lower than either gross or net volume of production.

We also checked which specific industries were included in each of the 20 groups used for the classification of manufacturing output, energy input, and capital. The 20 groups were based on the German Standard Classification of Industries (SYPRO); they bear a considerable resemblance to the US Standard Industrial Classification (SIC) at the 2-digit level (although there are some differences in the level of detail that could be compensated for).

For 1980 it is not easy to compare net production volume with other measures of production, because the net production volume is available only at 1970 prices. Here it may be recalled that the *real* (constant price) net production volume was compiled for both total manufacturing and for individual industries from 1970 values at current prices, extrapolated back to 1960 and forward to 1980 with the help of the index of net production (*Nettoproduktionsindex*). This is an index designed to measure quantitative output changes, and is somewhat similar to the US Federal Reserve Board (FRB) index. Hence current price values and price deflators are not available in the source material from which the net production volume was compiled.

Data on manufacturing output in terms of net production volume were readily available on computer tapes; for the analysis of energy coefficients this material was prepared by the German statistical agencies, as described in Part II of this report by Michael Kraus. For this reason, the *net volume of production* is recommended for the preliminary analysis of structural changes of industry, with the proviso that a few of the manufacturing groups need first to be disaggregated. This does not, of course, exclude the possibility of repeating the exercise with *gross* production values at some future date.

A subsequent repetition of the analysis based on gross production values would be desirable for a number of reasons:

1. Compilation of capital/output ratios;
2. Utilization of a higher level of disaggregation, involving 31 or more SYPRO groups instead of 20;
3. Possibility of updating the analysis;
4. Improved comparability with the previous US study, which was based on sales values (gross production).

2.2. Changes in the Growth and Structure of Output Flows

2.2.1. The Growth of Total Manufacturing Prices and Output

Reconstruction after World War II ushered in a period of unprecedented growth for the German economy. Up until 1973, this was generally a period when production rose faster than prices, while the opposite held true after the first oil price shock and during the rampant inflation it engendered. Table 5 shows the GDP deflator and GDP at constant prices, as well as the total manufacturing sector output and producer price index since 1950. It can be seen that there was considerable agreement between the GDP deflator and the producer price index for total manufacturing during the 1970s, probably because, in times of high inflation, the data may become biased at a high level of aggregation. However, the producer prices for individual manufacturing industries at no time followed the same growth path; some dropped or stagnated, while others rose (for details see Table 6). Thus, in the pre-1973 period, producer prices for both mineral oil refining and the chemical industry *as a whole* came down while most other producer prices went up, albeit slowly.

During the 1970s and through the early 1980s crude oil led the price race. The index of the producer price for the mineral oil refining industries (based on 1970 = 100) shot up to 363.1 in 1982, before falling slightly to 351.6 in 1983. Analysis of the producer prices charged by other major industries shows that none of them matched this rate of growth. In fact, those industries that require a very high energy input saw their producer prices (not adjusted for inflation) dropping or stagnating in the period between the two oil shocks. Examples include iron and steel, nonferrous metals, and chemicals. Some of the decreases or stagnation in prices can be attributed to the strength of the D-Mark relative to the weak US Dollar used to purchase oil on the world market in the 1970s. Other industries with relatively low energy inputs experienced the highest price increases, such as the nonelectrical machinery group (where output grew relatively slowly) and the leather and shoe industry (where production actually decreased, in part because of foreign competition). On the other hand, producer prices for electrotechnical products, which also have a modest energy input, increased only slightly, while the producer price indexes for the group including office machinery, electronic equipment, and data processing actually declined from 1970 (100) to 1982 (87.6), followed by stagnation in 1983 (87.1). No separate producer price indexes are available on this group for the pre-1970 period.

2.2.2. The Presentation of Structural Change

The output of the FRG manufacturing sector as a whole shows much the same growth whether measured in terms of gross production values, gross value added, or the net production index, as can be seen in Table 5.

Table 5. Developments in the GDP and the manufacturing sector of the FRG, 1950–83; the growth of prices and production; index numbers, 1970 = 100.

Year	GDP		Manufacturing Sector			
	Deflators	Gross value added (constant prices)	Producer prices	Net production index	Net production volume	Gross production values
1950	52.3	29.3	71.8	22.5	21.9	·
1960	70.1	62.0	87.8	58.8	58.6	54.6
1970	100.0	100.0	100.0	100.0	100.0	100.0
1971	107.8	102.6	104.4	101.6	101.6	102.0
1972	113.5	105.7	107.0	104.5	105.4	105.9
1973	121.0	111.9	114.2	112.5	112.5	112.0
1974	129.2	112.9	129.4	108.0	110.2	110.2
1975	137.0	110.5	135.4	102.8	102.8	106.2
1976	141.7	116.7	140.4	109.4	112.0	114.4
1977	146.8	119.9	144.2	111.8	115.3	115.9
1978	153.1	123.7	145.9	113.1	117.0	119.4
1979	159.2	129.5	152.9	118.8	123.0	125.9
1980	166.3	131.9	164.5	119.0	123.6	126.2
1981	173.3	131.8	177.3	116.6	·	·
1982	181.7	130.5	187.7	112.9	·	·
1983	187.0	131.7	190.5	113.5	·	·

Sources:
GDP (Brutto Inlands Produkt) in constant prices and deflator compiled from *Statistisches Bundesamt Lange Reihen* 1982 p. 202; updated with *Wirtschaft und Statistik*, Feb. 1984 *Statistische Nachrichten*.

Producer prices see Table 4.
Net production volume see Table 5.
Net production index (Netto Produktions Index) see Table 6.
Gross production value (Brutto Produktions Wert) see Table 2.

For obvious reasons, growth was strongest in the 1950s, with output rising continuously from a rather low base. At the very beginning of the period, output at constant prices measured in terms of the net volume of production increased by over 20% from 1950 to 1951. For the entire decade, the average annual growth rate (net volume of production) was 10.5%. In the 1960s, the average annual growth rate was still fairly strong at 5.5%, though markedly less than in the 1950s; production stagnated somewhat in 1966, followed by a small drop in 1967.

In the 1970s, the average annual growth rate slowed to 1.76%. The 1974/75 recession that followed the first oil price shock in November 1973 cut deeper than the 1966/67 setback. However, the recession was quickly overcome, giving

Table 6. The growth of producer prices in the FRG, 1950–83; index numbers, 1970 = 100.

	1950	1960	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Producer prices total	71.8	87.8	100.0	104.4	107.0	114.2	129.4	136.4	140.4	144.2	145.9	152.9	164.5	177.3	187.7	190.5
Basic materials																
Petr. refinery products	78.4	106.2	100.0	109.5	106.6	129.8	181.9	181.5	194.6	193.2	190.7	239.7	294.7	357.5	363.1	351.6
Iron and steel	49.4	96.3	100.0	104.6	107.4	116.2	137.0	129.1	130.4	125.2	125.3	129.1	134.2	139.2	155.9	148.7
Nonferrous metals	65.1	73.3	100.0	84.4	79.3	97.5	114.2	84.2	93.7	94.4	90.0	107.0	120.7	120.0	112.5	125.0
Chemicals	103.7	106.4	100.0	100.3	100.1	103.2	129.5	131.9	133.5	132.3	130.0	140.9	151.9	165.3	172.7	173.0
Investment goods																
Machinery, non-electrical	49.6	71.7	100.0	108.4	112.9	119.1	131.1	143.0	150.4	157.9	163.5	169.6	178.6	187.7	199.0	205.4
Road vehicles	82.1	87.9	100.0	107.3	111.8	117.4	128.1	139.3	144.1	150.3	154.6	159.7	166.9	172.9	184.3	189.9
Electrotechnical products	.	91.0	100.0	103.3	105.4	108.4	116.2	120.4	122.9	124.7	125.7	127.8	132.6	137.2	142.3	146.0
Office machinery, electronic office equipment, data processing	.	.	100.0	99.3	95.9	93.6	95.6	99.5	98.9	96.1	91.4	85.8	84.2	84.6	87.6	87.1
Consumer Goods																
Total, excl. food	84.6	84.9	100.0	103.7	107.4	115.4	128.9	132.5	136.4	140.4	142.7	149.7	160.8	168.7	175.3	178.5
Leather and shoes	70.3	77.5	100.0	106.8	114.3	127.5	135.9	140.9	147.3	156.7	163.2	173.8	189.2	197.7	204.1	209.1
Clothing	85.0	82.3	100.0	104.7	108.7	115.4	123.1	127.8	131.2	136.5	140.7	144.8	151.3	159.0	165.2	170.1
Food, beverages, tobacco	86.3	89.2	100.0	103.7	107.7	116.8	123.4	128.1	133.0	142.2	141.0	141.5	144.9	151.6	160.5	164.0

Sources:
Producer Price Indices compiled from *Langs Rethen*, op. cit. pp. 176, updated with *Wirtschaft und Statistik*, February 1984, op. cit. and oral communications from FRG *Statistisches Bundesamt* 7 May 1984.

way to new growth that lasted from 1976 to 1979, until the second oil price shock gave rise to a stagnation of output (1980), followed by cutbacks in 1981 and 1982, stagnation in 1983, and an expected recovery in 1984.

Hardly any of the individual manufacturing industries increased their output at the same rate as the manufacturing sector as a whole. The differences in growth between various industries are reflected in their percentage shares in total manufacturing output over a period of time. Likewise, growth differences are manifested through the indexes of production; the index for the manufacturing sector as a whole may be considered as the national average, so that individual deviations from this average reflect the growth of individual industries, in the same way as the changing percentage structure.

Table 7 shows the percentage share structure at a broad level of aggregation in 1950, 1960, 1970, and 1980, taken from IIASA computer printouts of the *net volume of production*. These data were compiled for only 20 groups. In order to provide more detail, and to enable us to update the analysis through the early 1980s, we supplemented the indexes of the net volume of production, starting with 1970, with nearly 60 more indexes representing net production (*Nettoproduktionsindex*), gross production (*Bruttoproduktionsindex*), or other measures of the physical quantities of production (see Tables 8 and 9).

The industries shown in Tables 7 and 8 are grouped into three categories: slow growth, fast growth, and former fast growth. The grouping is based on year-by-year observations of whether the percentage shares in total manufacturing output of each of the 20 SYPRO groups were continuously falling or continuously rising since 1950 or only since the 1970s.

2.3. Slow-Growth and No-Growth Industries

These are the groups whose growth has continuously lagged behind the national average for manufacturing as a whole. Their share in total output decreased from 43% in 1950 to 29% in 1980. These "underperformers" or "losers" include all of the basic, heavy industries, all the older industries using established technologies, as well as a few others for which demand changed significantly during the period studied.

2.3.1. Metal Producing and Processing Industries

The most prominent "losers" are the metal producing and processing industries, from primary metals through to metal fabrications and the construction of nonelectrical machinery. The share of these seven SYPRO groups in total manufacturing eroded from 35% in 1950 to 25% in 1980.

At first, the drop was only slight. During the 1950s, when the growth of German industry was very strong, and with reconstruction still continuing in many sectors of the economy, the *total* share of the metal and metal processing industries did not change very much, namely from 35.38% in 1950 to 34.34% in 1960. This small decrease can be mainly ascribed to iron and steel producing, ferrous foundries, and constructional steel (including shipbuilding and rolling stock), which started early on their relative decline, while nonferrous metals and nonelectrical machinery construction were still expanding their shares in total manufacturing output.

However, after 1960, with the *Wirtschaftswunder* slowly petering out, almost all of the basic metal and metal processing industries started in earnest on a path of relative decline. Their combined share in total manufacturing output decreased from 34.34% in 1960 to 28.78% in 1970, and to 25.25% in 1980.

Table 7. The changing structure of manufacturing output in the FRG, 1950–80; percentage shares calculated using constant 1970 prices.

Industry or sector	1950	1960	1970	1980
1. Slow-growth industries				
Iron and steel production	6.23	5.65	4.60	3.77
Steel foundries	2.67	1.88	1.24	0.78
Steel drawing	0.90	0.94	0.89	0.78
Non-ferrous metals	1.50	1.53	1.32	1.39
(Subtotal)	(11.30)	(10.00)	(8.05)	(6.72)
Constructional steel, shipbuilding	4.68	4.03	2.98	2.48
Fabricated metal products, hardware	7.19	7.07	6.30	6.17
Nonelectrical machinery construction	12.21	13.24	11.45	9.88
(Subtotal)	(24.08)	(24.34)	(20.73)	(18.53)
Stone, sand, clay (incl. cement)	4.48	3.72	3.46	3.02
Lumber, sawmills	2.11	1.05	0.84	0.84
Cellulose, pulp, raw paper, cardboard	1.40	1.06	0.97	1.05
Textiles, excl. clothing	7.74	5.49	4.26	3.69
Food, beverages, tobacco	13.22	11.31	10.31	10.99
Misc. consumer goods	14.37	12.30	10.58	9.49
(Subtotal)	(43.32)	(34.93)	(30.42)	(29.08)
Total slow-growth industries	78.70	69.27	59.20	54.33
2. Fast-growth industries				
Electric, electronic equipment; optical, precision instruments	6.53	10.03	12.67	14.35
Chemicals	6.68	7.59	10.92	12.44
Synthetic and plastic goods	0.22	0.78	1.79	2.81
Fine ceramics, glass	2.13	1.95	1.81	2.24
Total fast-growth industries	15.56	20.35	27.19	31.84
3. Former fast-growth industries				
Mineral oil refining	1.12	2.38	3.95	3.61
Rubber and asbestos goods	1.30	1.34	1.42	1.27
Vehicles and repair, incl. automobiles, aircraft, and space ships	3.26	6.63	8.25	8.88
Total former fast-growth industries	5.68	10.35	13.62	13.76
Total manufacturing (%)	100.00	100.00	100.00	100.00
Total manufacturing (10^9 DM at 1970 prices)	65.5	175.4	299.5	370.2

Source: Net Volume of Production at 1970 prices for 20 SYPRO groups at 2-digit level compiled by *Deutsches Institut für Wirtschaftsforschung* (DIW) See IIASA computer printouts for annual data.

Table 8. The growth of individual manufacturing industries in the FRG,

	Industry or sector	1950	1960	1970	1971	1972	1973
1	*1. Slow-growth industries*						
2	Iron and steel production	29.6	71.9	100.0	90.2	96.7	111.8
3	Steel foundries	47.1	89.2	100.0	88.6	82.8	90.1
4	Steel drawing	22.2	62.0	100.0	98.0	104.2	112.4
5	Crude steel ingots index, IQ	.	.	100.0	89.5	97.4	110.4
6	Non-ferrous metals	25.6	68.0	100.0	99.1	101.1	113.9
7	Copper, refined, unwrought, IQ	.	.	100.0	98.6	98.2	100.2
8	Aluminum, unwrought, primary, IQ	.	.	100.0	138.3	143.9	172.4
9	Constructional steel, shipbuilding	34.4	79.3	100.0	106.6	106.2	111.0
10	Shipbuilding, NP	.	78.1	100.0	.	99.4	.
11	Locomotives, IQ	.	.	100.0	91.7	89.0	20.7
12	Fabricated metal products, hardware	25.0	65.8	100.0	97.8	99.5	107.9
13	Nonelectrical machinery	23.3	67.7	100.0	98.4	97.5	100.6
14	Nonelectrical machinery, BP	.	.	100.0	.	98.4	.
15	Food processing, BP	.	.	100.0	.	101.3	.
16	Agricultural machinery, BP			100.0		83.7	.
17	Metalworking machinery, BP	.	.	100.0	.	91.8	.
18	Textile machinery, sewing						
19	machinery, leather, shoes, BP	.	.	100.0	.	109.8	.
20	Stone, sand, clay (incl. cement)	28.3	62.9	100.0	107.2	113.9	110.9
21	Cement, IQ			100.0	107.0	112.6	107.0
22	Lumber, sawmills	55.4	73.4	100.0	104.6	107.2	116.0
23	Cellulose, pulp, raw paper, cardboard	31.6	64.3	100.0	100.5	105.5	113.8
24	Paper, raw, IQ			100.0	101.7	108.3	118.1
25	Textiles, excl. clothing	39.7	75.4	100.0	105.4	108.3	108.1
26	Cotton woven fabrics, IQ	.	130.1[a]	100.0	98.3	101.1	99.8
27	Woollen woven fabrics, IQ	.	133.6[a]	100.0	103.9	111.5	98.3
28	Cellulose fiber woven fabrics, IQ	.	92.1[a]	100.0	95.1	90.9	86.7
29	Food, beverages, tobacco	28.1	64.3	100.0	105.8	107.4	111.8
30	Food, beverages, tobacco, NP	.	64.3	100.0	.	105.8	.
31	Food, NP	.	65.3	100.0	.	105.8	.
32	Tobacco processing, NP	.	62.0	100.0	.	105.5	.
33	Beer, IQ	.	.	100.0	103.6	105.3	107.2
34	Liquor, IQ	.	.	100.0	118.4	94.2	106.7
35	Cigarettes, IQ	.	.	100.0	104.9	104.8	108.4
36	Cigars, IQ	.	.	100.0	118.4	94.2	106.7
37	Sugar, IQ	.	.	100.0	113.4	110.7	118.8
38	Margarine, IQ	.	.	100.0	100.9	102.8	100.2
39	Sausage and meats, IQ	.	.	100.0	105.9	109.6	110.9
40	Fruit, canned, IQ	.	.	100.0	119.5	107.6	120.3
41	Fruit juices, IQ	.	.	100.0	115.8	129.6	152.0
42	Misc. consumer goods,						
43	excl. food	29.7	68.2	100.0	102.7	108.2	108.4
44	Paper and cardboard goods, NP	25.2	59.8	100.0		106.4	.
45	Printing, NP	24.9	60.0	100.0	.	104.3	.
46	Leather producing, total, NP	97.9	116.8	100.0	.	100.5	.
47	Leather goods excl. shoes, NP	30.3	86.1	100.0	.	98.3	
48	Shoes, BP	52.0	95.1	100.0	.	91.9	.
49	Clothing, NP	29.2	78.8	100.0	.	107.3	.
50	Wood processing incl.						
51	furniture, BP	24.9	58.6	100.0	.	121.8	.
52	Furniture, BP	13.5	41.4	100.0	.	121.2	.
53	Musical instruments, toys,						
54	jewellery, fountain pens,						
55	etc., NP	17.9	69.2	100.0	.	101.4	.

1950–83; index numbers, 1970 = 100. For footnotes see page 20.

1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	
										1
120.7	92.9	95.6	91.3	96.2	104.8	101.4	.	.	.	2
89.8	81.8	82.7	80.0	77.8	83.6	78.8	.	.	.	3
103.5	87.6	103.4	98.1	104.1	109.4	107.9	.	.	.	4
118.7	89.7	94.7	86.8	92.0	102.7	97.7	92.7	79.9	79.8	5
112.0	96.6	117.4	117.3	121.9	130.3	130.3	.	.	.	6
104.4	104.0	110.1	108.5	97.6	92.6	92.3	95.5	97.0	103.7	7
222.9	219.3	225.6	240.1	239.3	240.1	236.6	235.9	234.0	240.6	8
108.3	110.0	108.0	104.8	97.0	96.9	103.0	.	.	.	9
112.0	.	121.7	113.1	99.8	92.8	97.2	105.9	121.0	102.3	10
16.6	16.6	17.2	15.2	14.5	11.7	13.1	13.8	16.6	.	11
103.6	95.1	106.7	112.1	110.2	116.7	120.0	.	.	.	12
100.9	95.3	98.2	97.9	97.6	102.1	106.6	.	.	.	13
101.6	96.1	100.2	99.5	99.0	103.0	106.5	105.1	102.7	99.7	14
104.6	.	101.2	105.0	103.4	100.7	107.2	103.2	100.7	98.3	15
109.7	.	117.9	122.4	112.0	118.4	107.8	104.5	113.6	122.6	16
90.9	.	82.8	78.5	81.5	85.3	92.4	92.5	81.9	75.8	17
										18
105.5	.	85.5	76.3	73.7	78.0	81.8	77.5	69.7	69.9	19
100.2	92.2	95.5	97.3	102.0	110.0	108.0	.	.	.	20
93.9	87.4	89.1	83.9	89.4	93.0	90.2	82.2	78.3	81.3	21
113.6	105.3	118.4	120.1	120.9	125.9	124.7	.	.	.	22
119.1	98.2	116.3	121.1	125.7	135.4	137.4	.	.	.	23
122.8	100.6	121.0	129.7	134.1	145.2	147.1	151.5	150.0	.	24
101.8	98.6	108.6	106.3	104.6	108.0	107.1	.	.	.	25
95.3	84.0	97.4	87.0	80.2	80.4	85.0	75.8	82.4	88.0	26
78.3	78.8	82.7	76.1	77.0	76.9	86.5	74.4	60.9	58.9	27
81.7	73.0	75.7	68.9	72.7	77.4	71.2	.	.	.	28
113.1	113.5	119.8	120.2	123.8	127.8	131.8	.	.	.	29
109.0	.	114.0	113.5	116.1	118.6	121.2	123.3	119.6	120.6	30
108.4	.	113.5	107.9	115.0	118.7	120.8	122.7	122.6	121.4	31
110.6	.	115.3	109.7	116.8	120.6	122.7	125.0	112.1	119.0	32
107.5	108.3	112.0	110.3	107.7	107.6	109.8	111.0	111.8	.	33
111.1	112.0	100.9	99.7	116.4	114.9	113.5	106.7	95.9	.	34
110.4	111.2	114.9	108.9	117.0	120.5	124.1	126.4	113.1	.	35
111.1	112.0	100.9	99.7	116.4	114.9	113.5	106.7	95.9	.	36
120.7	121.3	129.5	175.3	145.9	148.1	142.6	168.1	176.2	.	37
97.2	93.9	98.2	96.5	95.8	93.9	94.3	95.6	95.2	.	38
116.5	127.2	134.1	135.1	197.3	204.2	212.8	215.6	219.5	.	39
122.0	110.2	134.7	93.2	112.7	116.1	110.2	98.3	130.5	.	40
137.1	159.6	168.4	161.6	178.7	217.3	261.2	328.7	347.1	.	41
										42
102.5	97.7	104.4	107.6	107.1	110.7	110.9	110.7	.	.	43
112.4	.	108.6	114.5	116.1	122.6	124.6	122.7	121.9	124.1	44
104.8	.	105.4	110.0	113.9	123.2	127.7	124.6	121.4	120.5	45
77.5	.	78.6	77.7	77.4	77.0	71.6	81.1	80.4	85.6	46
82.6	.	87.3	84.1	81.4	82.5	75.3	70.1	66.6	63.2	47
72.3	68.4	.	67.5	64.5	64.5	63.7	61.1	58.2	54.8	48
91.7	.	94.0	91.0	87.8	87.6	83.4	76.1	68.7	67.9	49
										50
119.3	.	122.7	131.8	129.8	130.9	131.8	114.5	105.0	107.7	51
121.2	.	129.4	139.7	138.6	134.9	134.8	122.7	108.2	110.5	52
										53
										54
91.6	.	96.9	109.6	111.9	108.3	93.7	91.2	89.4	87.0	55

Table 6. *Continued*

	Industry or sector	1950	1960	1970	1971	1972	1973
56	*2. Fast-growth industries*						
57	Electric, electronic equipment;						
58	optical, precision instruments	11.3	46.4	100.0	99.2	106.9	118.7
59	Precision, optical instruments						
60	and clocks, NP	17.7	49.8	100.0	.	90.8	.
61	Electric and electronic						
62	equipment, excl. precision						
63	and optical instruments, NP	11.5	49.6	190.0	.	107.4	.
64	Cables, IQ	.	.	100.0	99.8	98.1	98.5
65	Misc. electrical consumer						
66	goods, incl. household						
67	appliances and repair, BP	5.4	60.8	100.0	.	116.1	.
68	Radio, television, phono-						
69	graph, BP	6.9	53.9	100.0	.	106.1	.
70	Office machinery, electronic						
71	data processing equipment, NP	.	.	100.0	.	130.9	.
72	Chemicals	13.4	40.7	100.0	105.5	112.7	126.8
73	Chemical investment goods, NP	14.3	40.7	100.0	.	111.5	.
74	Primary						
75	Ammonia, IQ	.	.	100.0	100.0	98.2	105.6
76	Methanol, IQ	.	.	100.0	101.6	116.5	128.5
77	Intermediate						
78	Nitrogen fertilizers, IQ	.	.	100.0	88.3	87.9	93.0
79	Phosphate fertilizers, IQ	.	.	100.0	105.2	103.4	108.1
80	Dyestuffs, IQ	.	.	100.0	104.5	119.0	126.7
81	Synthetic fibres, IQ	.	.	100.0	122.3	147.3	187.3
82	Final consumer goods						
83	Pharmaceuticals, IQ	.	.	100.0	108.7	120.1	131.7
84	Cosmetics, IQ	.	.	100.0	106.0	107.8	124.8
85	Synthetic and plastic goods	2.7	25.5	100.0	111.9	126.0	144.9
86	Plastic goods, NP	2.0	25.5	100.0	.	126.0	.
87	Fine ceramics and glass	25.8	63.4	100.0	100.7	104.8	113.4
88	Fine ceramics, NP	40.7	90.0	100.0	.	98.7	.
89	Flat glass, NP	18.5	55.5	100.0	.	108.6	.
90	Hollow glass processing, NP	30.1	91.1	100.0	.	111.7	.
91	*3. Former fast-growth industries*						
92	Mineral oil refining	6.2	35.3	100.0	101.1	104.4	110.5
93	Motor gasoline, IQ	.	52.4[a]	100.0	102.9	105.3	120.9
94	Distillate fuel oils, IQ	.	32.4[a]	100.0	105.5	108.7	120.6
95	Residual fuel oils, IQ	.	40.1	100.0	96.3	99.7	105.2
96	Mineral oil refining, NP	6.8	35.3	100.0	.	104.5	.
97	Road vehicles and repair,						
98	air and space ships	8.7	47.0	100.0	102.2	103.3	112.0
99	Road vehicles and repair						
100	(investment goods), NP	10.0	48.7	100.0	.	102.6	.
101	Road vehicles and repair						
102	(consumer goods), BP	5.0	34.8	100.0	.	108.9	.
103	Motorcycles, bicycles, BP	0.6	32.1	100.0	.	133.2	.
104	Rubber and asbestos goods	20.1	55.4	100.0	97.5	98.4	104.5
105	Tires automobile, IQ	.	46.2[A]	100.0	99.7	109.8	110.1
106	Total Manufacturing NP	22.5	58.8	100.0	101.6	104.5	112.5
107	Total Manufacturing NPV	21.9	58.6	100.0	101.6	105.4	112.5
108	Total Manufacturing Output NPV						
109	(10^9 DM at 1970 prices)	65.5	175.4	299.5	304.2	315.5	370.2

1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	
										56
										57
119.3	109.9	121.3	130.6	131.9	134.7	140.1	.	.	.	58
										59
98.9	.	98.6	102.5	99.8	108.5	112.2	106.4	99.7	98.1	60
										61
										62
119.5	.	122.0	129.0	129.8	132.7	137.3	134.8	133.3	134.7	63
100.2	87.4	84.6	82.9	85.7	93.3	96.4	91.8	86.1	.	64
										65
										66
132.7	.	136.4	142.4	138.5	144.1	147.3	132.1	126.2	138.6	67
										68
147.2	.	168.6	191.7	198.5	175.0	173.4	166.3	181.7	189.4	69
										70
140.6	.	128.9	168.2	189.0	218.1	242.1	268.7	280.4	323.9	71
130.2	114.3	132.3	132.2	138.9	146.3	140.8	.	.	.	72
126.3	.	129.4	130.1	136.0	143.6	137.8	137.5	132.8	142.6	73
										74
113.3	119.2	102.3	109.2	107.4	118.7	112.2	107.7	86.2	93.5	75
135.6	89.3	121.9	102.8	91.9	100.9	95.3	80.3	82.2	77.4	76
										77
99.7	92.6	79.5	83.1	80.6	85.8	94.3	84.3	61.3	67.8	78
104.7	83.1	76.5	79.3	77.4	77.1	79.6	70.1	59.6	.	79
141.0	82.9	142.9	128.6	129.6	138.1	118.1	127.6	114.3	122.9	80
177.3	140.0	180.0	170.5	185.5	196.4	190.0	203.2	171.8	.	81
										82
141.8	146.3	152.0	152.8	163.9	164.2	168.6	171.9	173.3	.	83
120.5	120.8	133.5	139.5	147.1	143.8	150.0	147.3	152.5	.	84
144.4	132.3	152.4	169.4	180.4	198.7	193.4	.	.	.	85
144.4	.	159.2	169.4	181.5	200.8	196.5	191.2	190.2	204.0	86
109.6	103.8	118.1	150.1	150.9	154.3	153.5	.	.	.	87
104.8	.	98.7	97.9	93.5	94.1	96.2	95.1	87.5	88.3	88
104.2	.	128.7	144.5	144.0	154.6	166.4	146.8	140.8	151.8	89
120.8	.	120.5	123.4	122.4	123.4	124.7	122.7	118.2	117.3	90
										91
101.8	95.6	100.6	103.5	103.4	119.3	113.0	.	.	.	92
118.4	119.5	125.2	133.6	137.6	155.2	154.7	142.4	145.7	145.1	93
107.7	94.4	105.7	106.1	105.4	120.8	108.4	.	.	.	94
94.3	76.6	83.2	77.6	72.7	77.5	61.9	.	.	.	95
102.0	99.5	101.2	100.9	115.5	107.9	95.4	91.4	.	.	96
										97
97.8	99.9	113.7	122.0	125.1	135.4	133.1	.	.	.	98
										99
95.9	.	114.2	120.5	121.5	128.2	122.8	131.2	133.7	136.9	100
										101
90.3	.	93.5	95.1	105.8	109.5	105.9	108.0	113.8	121.5	102
129.5	.	146.9	166.4	144.2	139.9	157.4	150.8	129.7	132.8	103
99.7	92.2	103.8	108.3	106.7	111.3	110.8	.	.	.	104
92.2	85.3	100.4	101.0	99.9	103.5	100.7	94.3	95.7	.	105
108.0	102.8	109.4	111.8	113.1	118.8	119.0	116.4	112.9	113.5	106
110.2	102.8	112.0	115.3	117.0	123.0	123.6	.	.	.	107
										108
337.0	330.0	307.7	335.5	345.2	350.4	368.3	362.7	351.6[E]	353.0[E]	109

Footnotes for Table 8

[a] 1962 values.

Sources: If not otherwise stated, the indices are compiled from the Net Production Volume in prices of 1970 for 20 SYPRO groups at 2-digit level, see Table 5.

IQ	=	Index implicit in physical quantities of production; see Table 7.
NP	=	Net Production Index from *Statistisches Bundesamt Lange Reihen zur Wirtschaftsentwicklung 1982*, updated with *Wirtschaft und Statistik*, February 1984; *Statistische Nachrichten*.
BP	=	"Brutto" (Gross) Production Index from *Lange Reihen*, op. cit.
IP	=	Index implicit in value of output at *current* prices (*Produktion ausgewählter industrieller Erzeugnisse*) converted to constant prices of 1970 (*Index der Erzeugerpreise gewerblicher Produkte*) from FRG *Statistisches Bundesamt. Statistisches Jahrbuch*, 1983, and earlier issues.
NVP	=	Net production volume
E	=	Extrapolated with net production index

2.3.1.1. Primary Metals

For the production of crude steel ingots (*Stahlrohblöcke und -rammen*) there was not only a relative decline, but an actual cutback of production in physical terms. From 44.3 million metric tons in 1970 (and 52.6 million metric tons in 1974), output fell to 38.5 million metric tons in 1977. After a short-lived recovery that peaked at 45.4 million metric tons in 1979, output has since continuously dwindled to a level of 35.3 million metric tons in 1983. The result of these fluctuations, superimposed on the clear downward trend set in train by the first and second oil price shocks, was that the amounts of crude steel produced in 1982 and 1983 were 20% below their 1970 level and 33% below their 1979 peak. The reasons for the decline of the steel industry are discussed in Section 2.3.3 below in connection with the shrinking demand for constructional steel.

For copper, the cutback in production was less pronounced. The output of refined, unwrought copper fell from 405.8 thousand metric tons in 1970 to 374.4 thousand in 1980, before climbing slowly back to 393.6 thousand in 1982 and 420.7 thousand metric tons in 1983 (barely 4% above the 1970 level).

2.3.2. Aluminum – The Exception

For aluminum it was a different story. The production of unwrought primary aluminum increased from 309.0 thousand metric tons in 1970 to a peak of 741.8 thousand in 1977 and 1979. After that it fell steadily to a low of 723.0 thousand in 1982 followed by a timid recovery to 743.4 thousand in 1983. A few words of explanation for these developments are in order.

In the 1960s the FRG, like other European countries, aimed at expanding its aluminum capacity through the construction of smelters, in order to reduce dependence on imports from Canada and the United States in the face of an increasing domestic market. Factors favoring capacity expansion at that time were low construction costs, subsidized electricity prices (based on the expected availability of cheap nuclear power), high international prices for primary aluminum (when one US Dollar was approximately equal to four D-Marks), and proximity to industrial users. By the end of the 1960s a wave of expansion set in that lasted through 1974.

However, the unexpected revaluation of the dollar in August 1971 and the subsequent plummeting of the exchange rate relative to the D-Mark produced major difficulties for the industry, which were then exacerbated by the oil price shock of 1973. Energy costs were not so much of a problem, even though the

Table 9. Quantities of selected products produced in the FRG, 1970–83.

Industry	Quantity	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Crude steel ingots	1000 m.tons	44315	39665	43154	48924	52602	39746	41848	38473	40762	45496	43300	41096	35414	35345
Copper, refined, unwrought	"	405.8	400.0	398.5	406.7	423.6	422.2	446.6	440.2	396.0	375.6	374.4	387.6	393.6	420.7
Aluminum, unwrought, primary	"	309.0	427.5	444.7	523.7	588.9	577.6	597.1	741.8	739.5	741.9	731.0	729.0	723.0	743.4
Locomotives (all types)	1000 pieces	145	133	129	30	24	24	25	22	21	17	19	20	24	.
Cement	1000 m.tons	38324	41012	43146	41011	35977	33498	34152	32163	34258	36659	34651	31500	30000	31166
Paper, raw	"	4413	4490	4780	5213	5417	4439	5339	5723	5916	6409	6493	1684	6620	.
Cotton woven fabrics[a]	million sq.m.	930	914	940	928	886	781	906	809	746	748	791	705	766	818
Woollen woven fabrics[a]	"	126.2	131.1	140.7	124.0	98.8	99.4	104.4	96.0	97.2	97.1	109.2	93.9	76.8	74.3
Cellulose fiber woven fabrics[a]	"	592.4	563.4	536.4	513.4	484.1	432.2	448.4	408.2	430.7	456.3	422.0	.	.	.
Ammonia, synth. (N. content)	1000 m.tons	1821	1788	1923	2064	2170	1961	1863	1989	1955	2161	2044	1962	1570	1703
Nitrogen fertilizers (N content)	"	1568	1586	1378	1459	1564	1452	.	.	.	.	.	.	.	1063
Phosphate fertilizers (P_2O_5 content)	"	912	959	943	986	955	758	696	723	706	703	726	639	544	.
Methanol (100%)	1000 m.tons	863	877	1005	1109	1170	771	1052	887	793	871	823	693	709	666
Dyestuffs, synth. organic (tar)	"	105	110	125	133	148	87	150	135	136	145	124	134	120	129
Synthetic fibers	"	220	269	324	412	390	308	396	375	408	432	418	447	378	.
Motor gasoline	"	13660	14265	14598	16759	16407	16560	17346	18511	19066	21506	21447	19733	20188	20104
Distillate fuel oil	"	36348	40459	41687	46237	41310	36191	40523	40704	40431	46330	41571	.	.	.
Residual fuel oils	"	33591	32361	33476	36347	31692	25719	27938	26055	24411	26020	20803	.	.	.
Tires, automobile (cars and trucks)	1000 units	37548	37422	41242	41333	34607	32017	37699	37936	37519	38878	37799	35412	35952	.
Cables	1000 tons	475	474	466	468	476	415	402	394	407	443	458	436	409	.

[a] 1982 Production: Cotton woven farics 1210 = (million square meters); Woollen woven fabrics 186.6 = (million square meters); Cellulose fibers woven fabrics 549.0 = (million square meters); Motor gasoline 7262 = (1000 m. tons); Distillate fuel oil 12437 = (1000 m. tons); Residual fuel oil 19546 = (1000 m. tons); Tires, automobile (cars and trucks) 17349000 units.

Source: Series of "*Produktion Ausgewählter Erzeugnisse*" in FRG *Statistisches Jahrbuch* 1972 to 1983. Updated with oral communications from *Statistisches Bundesamt*, Wiesbaden.

For some of the production quantities see also the United Nations *The Growth of World Industry 1960–1971*, Vol. II, and *Yearbook of Industrial Statistics*, 1980 Edition, Vol. II., updated with *UN Monthly Bulletin of Statistics*.

cheap nuclear power did not materialize, because of the industry's long-term contracts with electric power plants and the implementation of various energy-saving techniques.*

The difficulties described above provide some explanation for the transition of aluminum from a fast-growth, new industry to one that is likely to stagnate over the next few years – a factor to be considered when examining the impact of structural changes on energy consumption discussed below in Section 3.

2.3.3. Constructional Steel, Metal Products, and Hardware

The lack of growth in constructional steel production, which includes shipbuilding and locomotives, is quite similar to that of iron and steel. The share of constructional steel in total manufacturing output decreased without interruption from 4.68% in 1950 to 2.48% in 1980. By 1980, the index implicit in the net volume of production was only 3% above the 1970 level and 11% below that for 1973.

To some extent the heavy decline in steel production and the fabrication of constructional steel are due to the displacement of steel by lighter materials, such as more concrete in highway bridges or more plastic in cars, and the replacement of steel by plastics or aluminum in the manufacture of refrigerators, washing machines, and cans, the displacement of canning itself by deep freezing, etc. Other industries producing investment goods such as the construction of nonelectrical machinery, have themselves become slow-growth industries, while some steel-using activities, such as shipbuilding, have ceased to grow or have gone out of style, as for example locomotive construction (see also Tables 8 and 9).

One very strong reason for the decline in the production of investment goods, for which iron and steel and constructional steel are important inputs, is that when the post-World War II reconstruction had run its course, infrastructure building was largely complete in the FRG and elsewhere, for example the United States. Consequently, the demand for steel dried up as the construction of highways, bridges, and tunnels, or the laying and expansion of urban underground railways gave way to mainly upkeep and maintenance operations. This tailing off of the infrastructure boom was also a major factor in the decline of the stone, sand, and clay industry, as discussed in Section 2.3.5 below.

In contrast to constructional steel, the relative decline of metal products and hardware was less severe: their share in total manufacturing fell from 7.19% in 1950 to 6.17% in 1980.

2.3.4. Nonelectrical Machinery Construction (Engineering)

In the 1950s, the construction of nonelectrical machinery was still a relatively fast-growing industry, whose share in total manufacturing output increased from 12.21% in 1950 to 13.24% in 1960 and to 13.66% in 1961. After that time, however, its share decreased continuously to 11.45% in 1970 and further to 9.88% in 1980. In terms of the index (1970 = 100), production in this industry reached only 106 in 1980 (considerably below the national average of 123.6); production continued to decline in the early 1980s, so that by 1983 it had fallen slightly below the levels of 1970 and 1973.

*For details of the structural change in the aluminum smelting industry in the United States, Western Europe, and Japan, see the papers submitted by M.J. Peck, C. Kirchner, A. Goto, and others to the Task Force Meeting on *Structural Change in the World Aluminum Industry* held at the International Institute for Applied Systems Analysis, Laxenburg, Austria, 2–4 May, 1984.

While the production of food processing machines followed very closely the growth trend for nonelectrical machinery as a whole, this was not the case for agricultural machinery, where output fared relatively rather better. On the other hand, metalworking and the textiles, sewing, and leatherworking machines group fared much worse, reflecting the plight of the industries they serve. For example, in 1983 the gross production index (1970 = 100) hit 75.8 for metalworking and 69.9 for the textiles, sewing, and leatherworking machines group.

2.3.5. Stone, Sand, and Clay (including Cement)

Cement, which is an important component of this industry, requires a high energy input. The industry also includes other traditional building materials such as bricks, whose production is energy intensive. The continuous *relative* decline of this industry can be seen in the decline of its share in manufacturing as a whole from 4.48% in 1950 to 3.46% in 1970, and further to 3.0% in 1980. The slow growth of the industry has already been discussed in Section 2.3.3 above in connection with the decline in the demand for steel for infrastructure activities.

Cement production, because of its energy-intensive nature, deserves some further analysis. From 1970 to 1972, the production indexes (1970 = 100) for the groups "stone, sand, and clay" and "cement" were identical. However, since 1973, the year of the first oil price explosion, cement production has fallen much faster than that of the group as a whole. Measured in physical quantities, the 1983 cement production of 32.2 million metric tons was 19% below the 1970 level (38.3 million metric tons) and 28% below the 1972 peak.

The explanation for the decline of the stone, sand, and clay industry (including cement) is similar to that for iron and steel and constructional steel, discussed above in Section 2.3.3.

2.3.6. Lumber and Sawmills, Cellulose, Pulp, and Paper

The group of industries including lumber and sawmills, cellulose, pulp, and "raw" (*unveredelt*) paper is worth examining, because its energy requirements are rather high, especially for raw paper.

Both industries' shares in total manufacturing output decreased between 1950 and 1970, from 2.11 to 0.84% for lumber and sawmills, and from 1.40 to 0.97% for the paper industry. However, in the 1970s the output from lumber and sawmills moved up in step with total manufacturing, while output from the cellulose, pulp, and paper industry rose faster than total manufacturing. In physical quantities, raw paper production rose from 4.4 million metric tons in 1970 to 6.6 million tons in 1982, or by 50%, which is far more than that for manufacturing as a whole.

2.3.7. Textiles, Excluding Clothing

The decline of textiles (excluding clothing) is quite characteristic of the developed countries. The *share* of this industry in total manufacturing in the FRG continuously decreased from 7.74% in 1950 to 3.69% in 1980; during the 1950s and 1960s *output* was still growing, though at a far slower rate than for manufacturing as a whole. In the 1970s growth became very weak. For some products there was an absolute decline. For instance, the production of cotton and woollen woven fabrics in 1970 were respectively 30% and 33.6% less than they had been in 1962. By 1983, the output of cotton fabrics had slumped to 12% below the level of 1970, and woollen fabrics to more than 40% below the 1970 level. Woven fabrics from cellulose fiber, which was still a growth industry

in the 1960s (though not as much as it had been in the 1950s), also slumped in the 1970s, but not as much as cotton and wool.

2.3.8. Food, Beverages, and Tobacco

The share of the food, beverages, and tobacco industry in total manufacturing output in the FRG decreased from 13.22% in 1950 to 10.31% in 1970. It later increased a little to 10.99% in 1980. Thus, in 1980 the percentage share of the food group was somewhat higher than that of nonelectrical machinery (9.88%), which was discussed above.

However, not all of the components of the food, beverages, and tobacco group moved at the same pace. Unfortunately, there is no easy way of disaggregating the food sector, for its component industries may well have followed very diverse growth paths. A breakdown at a fairly high level of aggregation may be gleaned from the net production index; this shows that in the 1970s and through 1981 food taken by itself moved at about the same pace as the food, beverages, and tobacco group. But in the recession years of 1982 and 1983, food expanded faster than did the group as a whole.

Within the food group, not all the constituent industries developed at the same rate. Based on the index numbers implicit in the physical production quantities shown in Table 9, the production of some commodities, such as sugar and especially sausage and meats, increased rather rapidly in the 1970s, with very little let-up in the growth rate through the recession of the 1980s. As a result, the 1970 = 100 based index for sugar rose to 176.2 in 1982, while that for sausage and meats climbed to 219.5. At the same time, the index for margarine production, which showed no growth during the 1970s, was down to 95.2 in 1982. These indicators somehow reflect the fact that by 1982 the recession (which came later to the FRG than to the United States) had not yet made much of an impact on household incomes.

Some of the changes within the FRG food industry were due to changes in technology and taste. For instance, the production of canned fruit – which is of course affected by good and bad harvests as well as taste – expanded very little in the 1970s; the expansion in 1982 was due mostly to the record harvest. At the same time, the fad for fruit juices shows in the index of production, which raced, without a pause for either the first or the second oil-price-induced recession, from 100 in 1970 to 347.1 in 1982.

The expansion of other beverage industries, such as beer and liquor, was less spectacular. Perhaps these beverages were adversely affected by the growing taste for fruit juices. In 1982, the output of beer was only 10% above that of 1970, while that of liquor (including wines) had slumped to 4% below the 1970 level. The liquor industry may also have suffered from the inroads made by foreign wines.

Tobacco processing generally grew faster than food in the 1974–1981 period. But in the recession years of 1982 and 1983, its growth lagged behind that of food. This could be an effect of the recession and/or due to heightened anti-smoking consciousness.

2.3.9. Miscellaneous Consumer Goods, Excluding Food

The share in total FRG manufacturing of miscellaneous consumer goods, excluding food, continuously decreased from 14.37% in 1950 to 9.49% in 1980. This group includes paper and cardboard goods, printing, leather making and leather goods (including shoes), clothing, wood processing and furniture, musical instruments, toys, and other miscellaneous light industries. These

industries are lumped together in the energy balances, because of their relatively modest energy requirements. They are, however, of considerable importance when we come to study the impact of foreign trade. For this reason, disaggregation of the group would be very useful. To make up for this shortcoming, attention is drawn to the production indexes (1970 = 100) in Table 8, which indicate differences in growth rates. It can be seen that paper and cardboard, and also printing, were growing through 1983 at a faster rate than both the miscellaneous group as a whole and total manufacturing industries. On the other hand, many of the miscellaneous industries suffered not only relative, but also absolute decline, particularly in the 1970s; these include leather producing, leather goods excluding shoes, shoes, and clothing. Hardest hit, possibly through foreign imports, was the shoe industry. Its 1983 output, as measured by the gross production index, had tumbled to 45% below the 1970 level – and almost back to the level of 1950.

Clothing, as measured by the net production index, fell by 1983 to 30% below its 1970 mark – which had still been about double that of 1950. For musical instruments and toys, etc., output declined after 1970. The net index of production (1970 = 100), after reaching a peak of 111.8 in 1978, subsequently tumbled to 87.0 in 1983.

The analysis presented above of the slow-growth industries has shown that there are a few whose growth only recently slowed down, for instance lumber and sawmills, cellulose, pulp, (raw) paper, and food, beverages, and tobacco. Whether this reflects a new trend in structural change – or whether it is merely a temporary occurrence related to the recession – only time will tell.

2.4. Fast-Growth Industries

The group of industries that grew faster than total manufacturing increased their share in total output from 15.56% in 1950 to 31.84% in 1980. This group is largely composed of the more "sophisticated" industries that utilize more recently developed technologies, such as electric and electronic equipment production, much of it directly based on innovation, the chemicals and allied industries, synthetic, plastic goods, and more recently the manufacture of fine ceramics. The behavior of this group has been in marked contrast to that of, for example, the comparatively "simple" nonelectrical machinery construction industry, which is mainly based on older, established technologies, and has relatively declined during the period studied.

2.4.1. Electric and Electronic Equipment, Optical and Precision Instruments

The group with the highest share in the net volume of production is electric and electronic equipment, including optical and precision instruments. The combined share of these industries in total manufacturing output has risen from 6.53% in 1950 to 14.35% in 1980. Both electric and electronic equipment and the optical and precision instruments industry require a relatively low energy input. For this reason they were combined in the energy balances that served as a model for the classification of the net production volume. However, for a broader analysis of structural change, and one that took into consideration foreign trade as well as energy, it would have been preferable not to combine the two industry groups. This is because, since 1970, the two industries have followed different growth paths, as can be seen from the indexes of net production shown in Table 6.

2.4.1.1. Optical and Precision Instruments

Optical and precision instruments have long played a traditional role in German exports. From 1950 to 1970, the growth in the production of optical and precision instruments was quite similar to that of the electric equipment industry. However in the 1970s and 1980s, production of optical and precision instruments showed generally negative growth. The 1970 = 100 based index of net production was either actually below or only slightly above 100 through 1977. In 1978 and 1979 it went up to 108.5 and 112.2, respectively, but it subsequently fell again to stand at 98.1 in 1983.

2.4.1.2. Electric and Electronic Equipment

The growth of the electric and electronic equipment industry, as measured by the net production index, was quite strong in the 1970s through 1977. This gave way to stagnation in 1978, followed again by renewed growth in 1979 and 1980. However, the recession years brought a small dip in 1981 and stagnation in 1982 and 1983. Despite the slackening of the industry's growth rate, 1983 production of electric and electronic equipment was still nearly 35% above the 1970 level – which was considerably more than the corresponding figure (13.5%) for manufacturing as a whole.

However, not all branches of the electric and electronic equipment industry experienced the same growth. Those that are closely tied to the provision of infrastructure expanded at a much slower rate, while some of them even experienced negative growth. For example, in the early and mid-1970s, cable manufacturing fell until in 1977 it hit a low of 20% below its 1970 level. Some of this fall may be explained by the fact that output is measured in tons, and since there may have been a shift from heavier to lighter materials during the period this could have introduced some bias. The industry started to grow again in 1978, but the expansion was short-lived: a new peak was reached in 1980 but this was still below the 1974 peak. With the subsequent decreases in 1981 and 1982, cable production eventually tumbled to 19% below its 1970 level.

In contrast to the behavior of cables and other infrastructure related to electrical equipment, the slackening in the growth of the production of household appliances seems to be of more recent date. The recent, relatively poor performance of this latter group may have contributed substantially to the recent weakening of the growth rate of electric and electronic equipment production as a whole. The production index for household appliances is available as part of the *gross* production of "other electrical consumer goods, including household appliances and repair". The output of this group, which excludes radios and TVs, peaked in 1980, when the 1970 = 100 based gross production index stood at 147.3. It subsequently fell to a low of 126.2 in 1982, followed by an increase to 138.0 in 1983.

The performance of the household appliances industry contrasts with the growth of the radio, television, and phonographic industry, for which the index of *gross* production (1970 = 100) climbed almost uninterruptedly, so that by 1983 output was nearly 90% above the 1970 level. This growth, of course, is still trivial in comparison with the spectacular development of "office machinery and electronic data processing," which is an example of the innovation industry *par excellence*. The 1970 = 100 based *net* production index shot up to a peak of 140.6 in 1974 (data for 1975 are presently not available). There was a mild slump in 1975/76 when the recession brought on by the first oil price explosion hit the FRG. However, since 1977 the spectacular growth of the office machinery and electronic equipment group has been resumed, with even more momentum gained through the recession of the early 1980s. As a result, the net production index stood at 323.9 in 1983.

2.4.2. Chemicals

The share of chemicals in total manufacturing in the FRG rose from 6.68% in 1950 to 12.44% in 1980. The chemicals group includes a variety of industries, some producing primary or basic chemicals, others intermediate products such as fertilizers, dyestuffs, and synthetic fibers, and others again final products like pharmaceuticals and cosmetics. Each of these subgroups differs in its energy requirements and in the proportion of value added it generates. A disaggregation of the chemicals group according to these or other subgroups is unfortunately not available in the German statistical literature. Yet this sort of disaggregation would be of great value in analyzing the impacts of structural changes on energy demand. In the absence of disaggregated data, these impacts can only be surmised from a study of production indexes calculated from the output (in physical terms) of a number of specific chemical industries and estimates of energy demand and value added for recent years reported in the German Statistical Office's monthly publications on turnover, energy, and labor input.*

In contrast to the expansion of the chemicals industry as a whole, the production of primary chemicals stagnated in the 1970s and fell with the recession of the 1980s. This can be seen from the 1970 = 100 based indexes (see Table 9), which show that by 1983 ammonia production was at 93.5 and methanol even further down at 77.4. Some of the intermediate chemicals did not do much better. The corresponding indexes for nitrogen fertilizers dropped to 61.3 in 1982, followed by a modest recovery to 67.8 in 1983. Phosphate fertilizer fell to 59.6 in 1982 (no data are as yet available for 1983). Organic dyestuffs made from tar were at one time the showpiece of German chemical production. However, from the production quantities shown in Table 9, it seems that this industry's growth over the period studied was no more than the national average (total manufacturing), which is itself less than that for chemicals as a whole. Dyestuff production peaked in 1976, when the 1970 = 100 based index rose to 142.9. It has since regressed with minor fluctuations, but has never again reached the 1976 level; in 1983 the index stood at 122.9.

While fertilizers and dyestuffs did not do well, synthetic fibers did very well indeed. The production index (1970 = 100) climbed to 171.8 in 1982, well above the levels for total manufacturing and for chemicals as a whole.

Unfortunately, there is no way of measuring the output in physical quantities of pharmaceuticals and cosmetics. There are also no indexes for either net or gross production volumes. For this reason a volume index was compiled from the gross production values at current prices, adjusted by the growth of prices appropriate for each particular industry. This admittedly crude device shows that the output of pharmaceuticals (like that of synthetic fibers) increased by more than the national average, and also by more than chemicals as a whole. The 1970 = 100 based index for pharmaceuticals stood at 173 in 1982; since then, growth has been almost continuous, with only minor stagnation in 1976/77.

For cosmetics, an index constructed along similar lines also shows almost uninterrupted growth, punctuated by only minor cutbacks, quickly overcome, in 1975/76, 1979, and 1981. As a result, the 1982 output of cosmetics is estimated to have topped the 1970 level by more than 50%.

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*Statistisches Bundesamt. *Produzierendes Gewerbe. Beschäftigung, Umsatz und Energieversorgung*, in *Fachserie 4 Reihe 4.1.1*, 1980.

2.4.3. Synthetic Plastic Goods and Fine Ceramics

The shares of synthetic and plastic goods and of fine ceramics (which includes micro-chips) increased, respectively, from 0.22 and 2.13% in 1950 to 2.81 and 2.24% in 1980. The strong growth of synthetic and plastic goods manufacturing is another example of the growth of innovation industries. The same is true to some extent for fine ceramics, including glass. Actually, this latter group was a relatively declining, slow-growth industry in the period 1950–1970, during which its share in total manufacturing decreased from 2.31 to 1.81%. However, its share then recovered to 2.29% by 1980. This comeback may have been due to the growth of components used in connection with electronic data processing.

2.5. Former Fast-Growth Industries

The mineral oil refining, vehicles and repair, and rubber and asbestos industries all experienced much faster growth than total manufacturing during the 1950s and 1960s. The combined share of these industries in total output rose from 5.68% in 1950 to 13.62% in 1970. This growth was nearly as fast as that experienced by the electric and electronic equipment industry, and certainly faster than the growth of chemicals. However, in the 1970s electric and electronics equipment enjoyed continuous, rapid growth (thanks in part to the innovation industries), and so did chemicals (mostly because of the growth of final consumer goods and a few intermediate products), but the growth of mineral oil refining, vehicles and repair, and rubber and asbestos markedly slowed down.

2.5.1. Mineral Oil Refining

Based on the net volume of production, the total output of the mineral oil refining industry peaked in 1973, when the 1970 = 100 based production index stood at 110.5. A subsequent fall to a low of 95.6 in 1975 was quickly overcome as output reached a new and higher peak of 119.3 in 1979, giving way thereafter to a prolonged slowdown consisting of an initial fall followed by stagnation. It is worth noting that the slowdown of *total* mineral oil refining did not materialize until after the second oil shock, when the output of motor gasoline finally stopped growing. Measured in physical quantities, 1983 gasoline production was still a good 20% above 1973, and 45% above the 1970 level. This development paralleled FRG consumption of motor gasoline, which also raced on through 1980, whereas in other developed countries such as the United States the recession came earlier and cut somewhat deeper into gasoline consumption.*

But not all of the output of mineral oil refineries expanded by as much as gasoline. The reaction of the fuel oils to the oil price explosions came earlier, and was more serious. The 1970 = 100 based index implicit in the quantities of distilled fuel oil produced peaked first at 120.6 in 1973 and a second time in 1979; but by 1980, production was down to 8% above the 1970 level (later data are not readily available). For residual fuel oils, production cutbacks were still more serious. Output peaked twice, in 1973 and 1979; but the second peak was considerably below the first, and by 1980 production had slumped to nearly 40% below the level of 1970 (for details see Tables 8 and 9).

*See also C. Doblin, *The Breaking of the Energy Coefficient*. Invited Paper for the Seventh International Scientific Forum on New Energy Realities, organized by the University of Miami, Center for Theoretical Studies. November 1983. The paper is in press as part of the conference proceedings.

The discrepancy between these developments for gasoline and fuel-oil production may also have been influenced by price policies. No substantial price increase for gasoline materialized until after the second oil price shock, while in the intershock period gasoline prices including taxes were not substantially raised. When adjusted for inflation, gasoline prices stagnated and at times actually decreased during the intershock period. This was quite similar to the observed development of gasoline prices in other developed countries, e.g. the United States. At the same time, in the FRG and elsewhere, fuel-oil prices increased much more, and much sooner, than did those for gasoline.

2.5.2. Rubber and Asbestos

The impact of the "energy crisis" on the production of tires was more direct than it had been on the production and consumption of motor gasoline. The index implicit in the physical output quantities shows that the production of tires, like that discussed above for fuel oils, peaked in 1973. After that year, production was cut back continuously, so that by 1982 the index was 4% below the level of 1970 and 13% below that of 1973.

2.5.3. Road Vehicles and Repair, Aircraft and Space Ships

The share of road vehicles and repair, aircraft and space ships in total manufacturing increased from 3.26% in 1950 to 8.25% in 1970, but reached only 8.88% by 1980. The growth of automobile production significantly slowed down in the 1970s; but was this because the industry had come of age or because it felt the impact of the oil crisis? Or were both factors at work?

The output of automobiles, including trucks and bicycles, is measured by two production indexes: the index of *net* production of road vehicles serving as investment goods, and the index of *gross* production of road vehicles regarded as private, consumer goods. The latter shows the tremendous expansion of the automobile industry. The gross production index moved from 5.0 in 1950 to 34.8 in 1960, with an even steeper growth to 100.0 in 1970. The fact that automobile production expanded more in the 1960s than in the 1950s is in marked contrast to the growth-rate behavior of total manufacturing (and GDP) discussed elsewhere in this report.

Automobile production slumped for the first time after the first oil price explosion, when the 1970 = 100 based gross production index fell to 90.3 in 1974. In the intershock period, output picked up again, reaching a second peak in 1979. However, the second peak only reached about the same level as the first in 1973. Output fell slightly in 1980, but despite the recession it subsequently picked up again, so much so that in 1983 a third peak was reached, which topped the twin peaks of 1973 and 1979 by about 10% and the 1970 level by more than 20%.

The recovery of road vehicles regarded as investment goods (mostly trucks and buses) was even stronger than that of private motor vehicles. Measured in terms of the net production index, output in the recession years of the early 1980s climbed steadily, reaching a 1983 level that was 37% above the 1970 figure.

This recent comeback for the German automobile industry is remarkable and somewhat counter-cyclical. It is, however, too early to tell whether the 1983 resurgence in automobile production was just a passing event or whether it has a more permanent character.

3. ENERGY FLOWS

3.1. Introduction

3.1.1. Final Energy Demand for Manufacturing and Total National Primary Energy Consumption

The manufacturing sector's demand for final energy comes from the section on manufacturing in the published Energy Balances of the FRG.* The crude oil input to refineries and petroleum used as feedstocks for the chemicals industry were added from the non-manufacturing section of the Balances. For this reason, the energy data, prepared for Part II of this study and used here as well, are 13–14% higher than the final energy demand of the manufacturing sector measured at the source. For details see Tables 10 and 11.

In 1950, the demand for final energy by the manufacturing sector was 41.4 million metric tons of hard coal equivalent (TCE), and the total primary energy consumption of the FRG amounted to 124.4 million TCE. Except for a minor cutback in 1966/67 the demand for energy rose steadily, till in 1973 it reached 106.6 million TCE for final demand by the manufacturing sector and 371.9 million TCE for total primary demand from all sectors.

The impact on the manufacturing sector's energy demand of the recession caused by the oil price explosion of November 1973 resulted first in stagnation (1974), followed by a severe cutback to 94.1 million TCE in 1975. Total primary energy demand fell immediately in 1974, and still further in 1975, when it reached a low of 243.2 million TCE. However, this decrease was quickly overcome, and with subsequent expansion – though at a slower growth rate than before – total primary energy demand reached a new peak in 1979 that surpassed the levels of 1973 and 1970. The resurgence was due to the fact that the consumption particularly of gasoline but also of total household energy resumed their growth at prerecession rates through 1979. However, for final energy demand from the manufacturing sector there was not much growth during the economic recovery that took place in the intershock period.**

The rather weak growth in the final energy demand for manufacturing in 1976 was followed by stagnation in 1977 and 1978. During the short-lived expansion of steel production, demand hit a new peak of 104.5 million TCE in 1979. This second peak, in contrast to the behavior of total primary demand, remained below the level of 1973 and was only slightly above that of 1970.

What was the effect of the second oil price explosion on energy demand? Gasoline consumption continued to move upward and peaked in 1980; it dropped only slightly in 1981 and 1982, and picked up again in 1983, by which time it had returned to the level of 1979.

Total household energy consumption peaked in 1979 and fell in 1980–1982, after which stagnation and a minor upturn in 1983 brought demand back to the level of 1974. But demand from the manufacturing sector was more seriously affected. From its peak in 1979 it fell continuously till it reached a low of 85.5 million TCE in 1982, which came close to the level already reached much

*Arbeitsgemeinschaft Energiebilanzen. *Energiebilanzen der Bundesrepublik Deutschland*, prepared annually by R. Gabel of the *Arbeitsgemeinschaft Energiebilanzen* in Essen, and published by *Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke* in Frankfurt, FRG.

**See also Claire Doblin, *The Growth of Energy Consumption and Prices in the USA, FRG, France, and the UK 1950–1980*. Research Report RR-82-18. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Table 10. The changing structure of demand for final energy in the manufacturing sector of the FRG, 1950–82; percentage shares.

Industry	1950	1960	1970	1973	1980	1982
Primary metals						
Iron and steel[a]	33.7	37.5	32.4	31.4	28.1	26.2
Nonferrous	2.9	2.7	2.5	3.1	4.0	4.2
Chemicals[b]	15.7	17.5	15.6	14.9	15.7	17.6
Mineral oil refining	3.3	4.7	10.5	10.9	12.2	10.8
Stone, sand and clay, incl. cement	13.5	11.6	10.3	10.8	8.9	8.1
Food, beverages, tobacco	7.5	5.8	5.7	5.7	6.4	6.7
Cellulose, pulp, paper	3.5	3.0	3.3	3.2	3.5	4.1
Textiles, excl. clothing	4.8	3.3	2.8	2.6	2.4	2.3
Nonelectrical machinery construction	2.4	2.1	2.6	2.6	2.7	2.8
Road vehicles, incl. repair, air and space ships	1.0	1.4	2.5	2.8	3.4	3.9
Fine ceramics, glass	3.8	3.2	3.1	3.1	3.0	3.1
Electric and electronic equipment, optical and precision instruments	1.5	1.5	2.0	2.1	2.3	2.5
Fabricated metal products, hardware	2.0	1.8	2.1	2.1	2.1	2.0
Constructional steel, shipbuilding	0.8	0.7	0.5	0.5	0.6	0.6
Rubber and asbestos goods	0.7	0.7	0.9	1.0	0.8	0.9
Synthetics and plastic goods	0.1	0.2	0.6	0.8	1.1	1.2
Lumber, sawmills	0.6	0.4	0.6	0.7	0.7	0.7
Miscellaneous: Paper and cardboard goods, Printing, Leather and leather goods, Clothing, Wood products, furniture, Musical instruments, toys	2.3	1.6	1.9	1.9	2.1	2.2
Total in percent	100.0	100.0	100.0	100.0	100.0	100.0
Total in 10^6 TCE	41.4	75.0	102.1	106.6	99.7	85.8
Total in 10^{15} Joule	1213	2197	2991	3122	2926	2514

Note: 10^6TCE = 29.29×10^{15} Joule

[a] Includes iron and steel, steel foundries and drawing.

[b] Includes crude oil used as a feedstock.

Source: compiled from *Arbeitsgemeinschaft Energiebilanzen. Energiebilanzen der Bundesrepublik Deutschland 1982* Table 3.2 and earlier issues. Annual data through 1980 are available on IIASA computer printouts.

Note: Feedstocks for chemicals and crude oil for refineries were added from the non-manufacturing sections of the *Energiebilanzen*.

Table 11. The growth of demand for final energy by the manufacturing industries in the FRG, 1950–83; index numbers, 1970 = 100.

Industry	1950	1960	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Iron and steel	41.3	84.9	100.0	88.9	91.3	102.0	108.8	87.9	89.5	82.3	81.9	88.9	84.6	78.4	68.2	
Steel foundries	81.1	113.8	100.0	91.9	86.1	89.0	108.2	72.9	79.0	79.0	91.0	96.3	92.0	83.0	71.1	
Steel drawing	47.8	56.5	100.0	94.5	85.5	87.9	81.1	74.5	82.0	82.1	71.1	70.5	68.1	51.7	53.7	
Nonferrous metals	45.8	77.5	100.0	106.7	111.4	128.7	137.6	130.4	137.7	146.5	146.6	152.1	152.5	146.9	138.0	
Chemicals (basic, fibers and others)[a]	40.7	82.6	100.0	100.7	97.1	99.4	103.1	89.8	100.0	102.2	104.9	108.3	98.1	103.5	94.5	
Mineral oil refining[b]	12.8	33.0	100.0	100.0	101.1	108.0	114.0	103.1	113.3	111.3	111.2	120.5	113.7	91.9	86.6	
Stone, sand, clay, incl. cement	53.1	82.4	100.0	104.5	108.2	109.1	93.4	83.0	84.2	84.8	82.1	85.6	84.1	86.4	83.2	
Cellulose, pulp, paper	42.8	68.5	100.0	99.1	98.9	101.7	99.8	85.9	98.7	106.5	104.7	103.9	104.9	107.7	103.7	
Lumber, sawmills	42.1	51.8	100.0	98.1	105.3	111.9	105.3	103.0	106.9	110.8	119.8	118.6	113.3	101.1	87.2	
Food, beverages, tobacco	53.8	75.5	100.0	103.0	102.7	105.0	109.1	107.7	110.8	111.8	111.1	111.9	110.4	106.4	101.1	
Textiles, excl. clothing	89.3	87.4	100.0	101.0	100.6	96.8	89.5	85.6	89.2	90.5	90.9	90.0	84.1	77.2	69.4	
Constructional steel	59.6	98.5	100.0	91.0	95.0	101.5	91.4	94.7	99.2	126.9	125.3	123.0	114.9	111.7	109.7	
Machinery, nonelectrical	29.2	53.6	100.0	100.8	104.8	108.3	101.3	99.5	106.3	107.5	111.1	110.0	108.6	104.4	96.8	
Road vehicles	15.4	41.9	100.0	104.3	111.0	114.2	100.0	100.2	112.1	123.9	131.1	135.7	130.9	129.9	128.3	
Electric and electronic equipment, etc.	29.2	53.6	100.0	100.8	104.8	108.3	101.3	99.5	106.3	107.5	111.1	110.0	108.6	106.3	102.7	
Metal fabricated products	38.6	64.8	100.0	98.2	100.9	104.8	99.4	96.5	102.5	97.6	104.9	106.1	99.9	90.9	82.3	
Fine ceramics, glass	49.7	77.4	100.0	101.2	103.9	104.6	101.1	93.0	93.6	106.0	95.5	95.7	95.7	91.2	84.7	
Rubber and asbestos	33.4	53.7	100.0	101.3	109.3	111.3	101.9	95.6	104.2	102.6	102.0	98.8	91.9	83.8	81.6	
Synthetic and plastic goods	8.9	27.3	100.0	114.9	127.1	136.8	131.7	129.0	148.7	159.4	167.9	184.6	168.7	166.0	163.3	
Miscellaneous	48.7	61.6	100.0	101.4	106.2	108.5	100.7	97.8	103.1	104.6	116.4	114.7	109.7	104.3	99.6	
Total	40.5	73.5	100.0	97.4	98.8	104.4	105.4	92.7	98.0	97.4	97.9	102.4	97.6	91.9	83.9	85.0[PE]
In 10^6 TCE	41.4	75.0	102.1	99.5	100.9	106.6	107.4	94.6	100.0	99.4	100.0	104.5	99.7	94.1	85.8	86.9[PE]
In 10^{15} J	1212.6	2196.7	2990.5	2914.4	2955.4	3122.3	3145.8	2770.8	2929.0	2911.4	2929.0	3060.8	2925.9	2756.3	2513.7	2546.6[PE]

PE = preliminary estimate.

Notes and sources see Table 10.

earlier in 1966/67. According to preliminary data, the downslide seemed later to have been arrested with a mild recovery in 1983.

The growth of total primary energy consumption, as well as that of final energy demand for the industry, household, and road transportation (gasoline) sectors, is shown as index numbers (1970 = 100) in Figure 3, for the period 1970–1983.

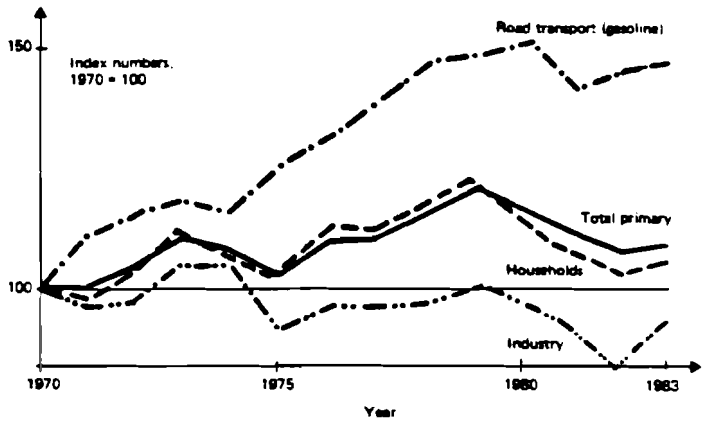

Figure 3. FRG Energy Consumption. Total Primary and by Sectors: Industry, Households and Road Transport (Gasoline), 1970–1983. Index Numbers, 1970 = 100.

Following the first oil price explosion in 1973, total primary energy consumption in the FRG and other Western developed countries expanded more slowly and contracted more quickly than GDP. In the FRG, as elsewhere, the "breaking of the energy coefficient" was hailed as a sign of energy savings, promoted by the unprecedented growth in energy prices.* The energy savings theory was further substantiated by the observation that total manufacturing output expanded faster and contracted less than total energy input. Examination of the flows of output from and final energy inputs to individual manufacturing industries is expected to throw some light on a number of questions. Is the cutback in energy demand the result of voluntary savings, such as those resulting from technologically more efficient fuel utilization? And/or is the cutback the result of structural changes in the manufacturing profile of the FRG or of the general slowdown in the rate of growth of manufacturing as a whole? Answers to these questions can only be surmised or inferred from the flows of energy and output at disaggregated levels. An effort to quantify the effects of technological and structural changes is made by Michael Kraus in the second part of this study.

3.1.2. Final Energy Demand for Manufacturing and Value Added

In the FRG, as in other industrialized countries such as the United States, the major part of the manufacturing sector's demand for final energy comes from just a few industries that are associated with relatively low value added. A

*See also Claire Doblin, *The Breaking of the Energy Coefficient*. Invited paper for the Seventh International Scientific Forum on New Energy Realities, organized by the University of Miami, Center for Theoretical Studies. November 1983. The paper is in press as part of the conference proceedings.

comparison of the percentage structure of final energy demand and of net production volume (which corresponds to the concept of *gross* value added) is summarized below for a few selected industries. The summary has been compiled from the tables on the structure of output (Table 7) and demand for final energy (Table 10). In those tables, the industries producing primary, intermediate, and final chemical goods were lumped together as one group. In view of the fact that primary chemicals are the most energy-intensive, we attempted to separate this group from the rest, on the basis of an FRG survey of employment, turnover, and energy consumption for the year 1980.* We estimated that primary chemicals (SYPRO 4031) account for 85% of the energy requirements and 50% of the value added for chemicals as a whole (SYPRO 40). The data on final energy and value added for selected industries in 1980, shown in Table 12, indicate that as much as 72.9% of final energy was used by industry groups whose combined value added amounted to only 30.5% of the total, while 48.9% of value added was generated by industries that used only 12.6% of total final energy.

Table 12. Final energy input and gross value added for selected industries in the FRG, 1980; percentage shares.

Industry	Final energy input (%)	Gross value added[a] (%)	Industry	Final energy input (%)	Gross value added[a] (%)
Primary metals			Electric and electronic		
Iron and steel	28.1	5.3	equipment	2.3	14.4
Nonferrous metals	4.0	1.4	Nonelectrical machinery	2.7	9.9
Primary chemicals	13.3[b]	6.2[c]	Road vehicles	3.4	8.9
Mineral oil refining	12.2	3.6	Fabricated metal,		
Stone, sand, and clay			hardware	2.1	6.2
(incl. cement)	8.9	3.0	Misc. consumer goods	2.1	9.5
Total	66.5	19.5	Total	12.6	48.9

[a] Net volume of production in 1980, but at 1970 prices.
[b] Estimated as 85% of energy requirements for chemicals as a whole.
[c] Estimated as 50% of value added for chemicals as a whole.

The discrepancy between energy input and value added would have been more drastic had it been possible to use *net* instead of *gross* value added data, since gross value added is inflated by production taxes, which are fairly high for liquor and tobacco, and especially for mineral oil refining (*Mineralölsteuer*).

3.2. The Impact of Structural Changes in Industry on Flows of Final Energy Demand from the Manufacturing Sector

A comparison of the indexes of production for manufacturing as a whole (Table 8) and total input of final energy (Table 11) shows clearly that the growth of energy demand has continuously lagged behind that of output, measured in terms of value added. One major explanatory factor has been the long-term structural changes discussed earlier in Section 2. In other words, the relative

*FRG Statistisches Bundesamt. *Beschäftigung, Umsatz und Energieversorgung der Unternehmen und Betriebe im Bergbau und im verarbeitenden Gewerbe*, 1980. *Fachserie 4, Reihe 4.1.1.*

decline of the energy-intensive industries since the 1950s and 1960s was exacerbated during the 1970s when a few of these industries experienced an absolute decline in quantities produced.

The most prominent examples here are the iron and steel producing industries, which alone commanded as much as 28.1% of the final energy that went into the entire manufacturing sector in 1980. It is obvious that any drop in either the relative or absolute growth of this industry will significantly affect the demand for energy of the manufacturing sector as a whole.

The second-largest users of final energy are the chemicals and allied industries. It is true that the group as a whole belongs to the fast-growth category; however, it covers the manufacture of a wide diversity of products, at the basic, intermediate, and final consumer goods stages. Although the latter, i.e. pharmaceuticals, toiletries, etc., grew rapidly, their energy requirements are relatively modest; the sluggish growth and in the 1970s the absolute decline of basic chemicals (see Table 10) predominated in terms of energy demand over the growth of final consumer goods so that, overall, chemicals contributed significantly to the slow growth in the total energy demand of manufacturing.

Other slow-growth industries that acted as depressants on final energy demand for manufacturing are stone, sand, and clay (including cement) and the food, beverages, and tobacco group, whose shares in total energy demand were 8.9 and 6.4%, respectively, in 1983. The slow-growth energy-intensive industries were joined by mineral oil refining during the latter part of the period studied. Its importance as a user of energy can be seen from the fact that in 1980 it absorbed as much as 12.2% of the total energy used in manufacturing. This is therefore a former fast-growth industry, whose output slowed down under the impact of the "oil crisis."

However, structural changes in the mix of industrial production, namely the slow growth of the energy-intensive industries, and the faster growth of industries with lower energy requirements (e.g. electrical equipment, especially computers, etc.) are not the only, though they may be the major reason for the decline in energy demand. Another factor that may have had some bearing on this matter will now be discussed.

3.3. Changes in the Efficiency of Energy Utilization

The flows of energy input in the FRG since 1950 are measured by means of index numbers (E), based on 1970 = 100. This is similar to the indexes of net volume of production (V) discussed earlier in Section 2. Division of the energy input by the output (E/V), both expressed as index numbers, indicates whether the energy input per unit of output has increased, decreased, or remained stationary over the years. A set of 1970 = 100 based indexes for production (V), energy input (E), and the energy coefficient (E/V) is presented in IIASA computer printouts, which are available from the author on request.

In the long period from 1950 to 1983, the growth in final energy input for *total* manufacturing has continuously lagged behind the growth in output. Over the same period, the energy used per unit of value added has continuously decreased; this is shown in Figures 4–11, which were compiled from Tables 8 and 11 and the computer printouts mentioned above. These show clearly that energy savings, or increased efficiency in the use of energy, did not start in 1973 when the price of energy sky-rocketed. Instead, energy savings by the manufacturing sector have followed a long-term trend: they were already evident in the 1950s (though this may not have been a very normal period); they continued in the 1960s, despite the fact that energy prices on the whole were

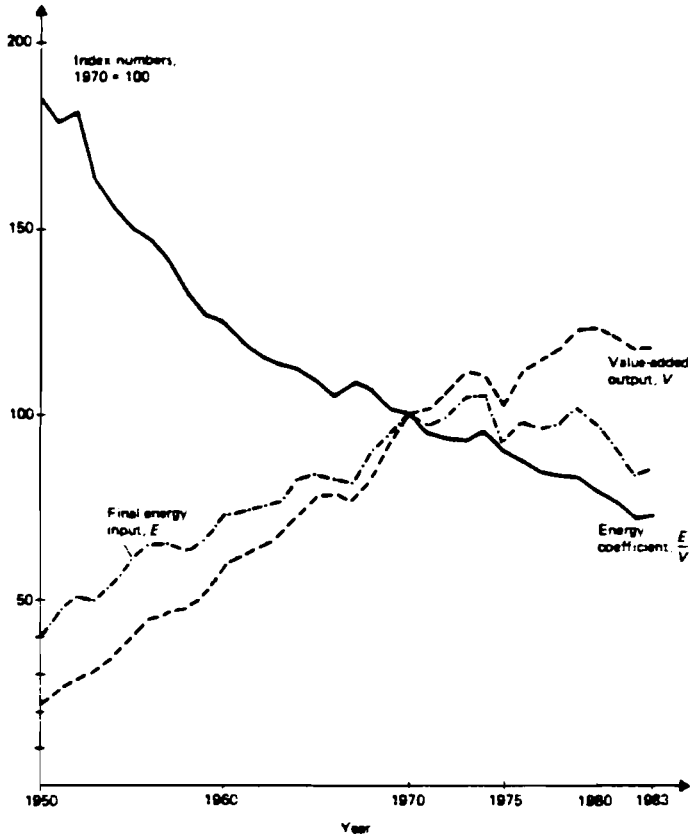

Figure 4. FRG Total Manufacturing. The Growth of Output, Final Energy Input, and the Energy Coefficient since 1950.

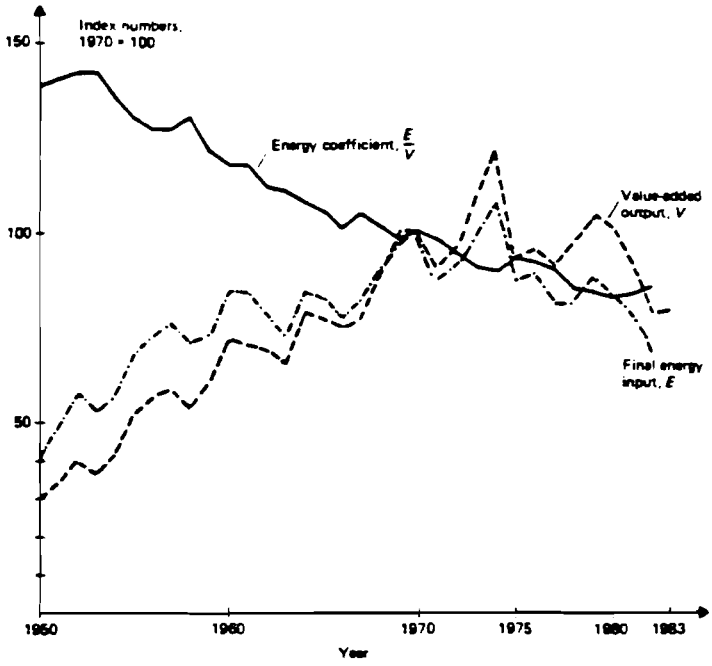

Figure 5. FRG Iron and Steel Producing Industries. The Growth of Output, Final Energy Input and the Energy Coefficient since 1950.

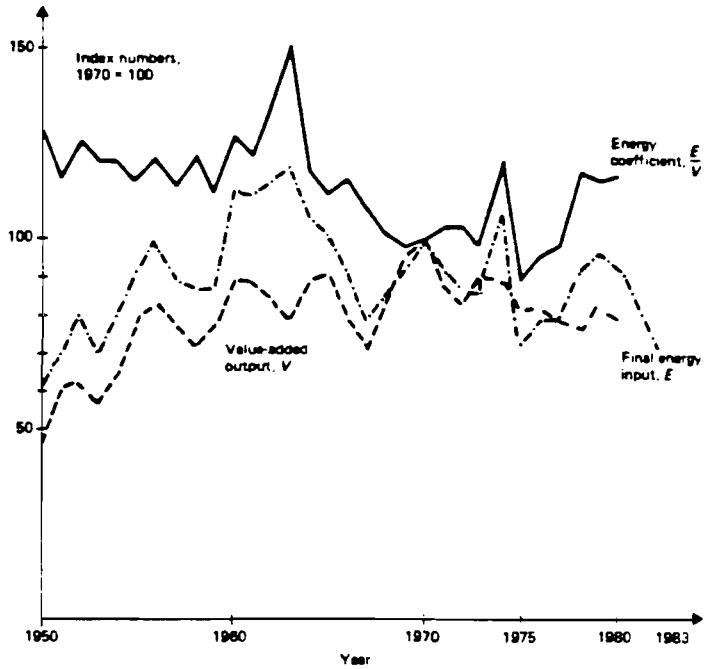

Figure 6. FRG Steel Foundries (castings). The Growth of Output, Final energy Input and the Energy Coefficient since 1950.

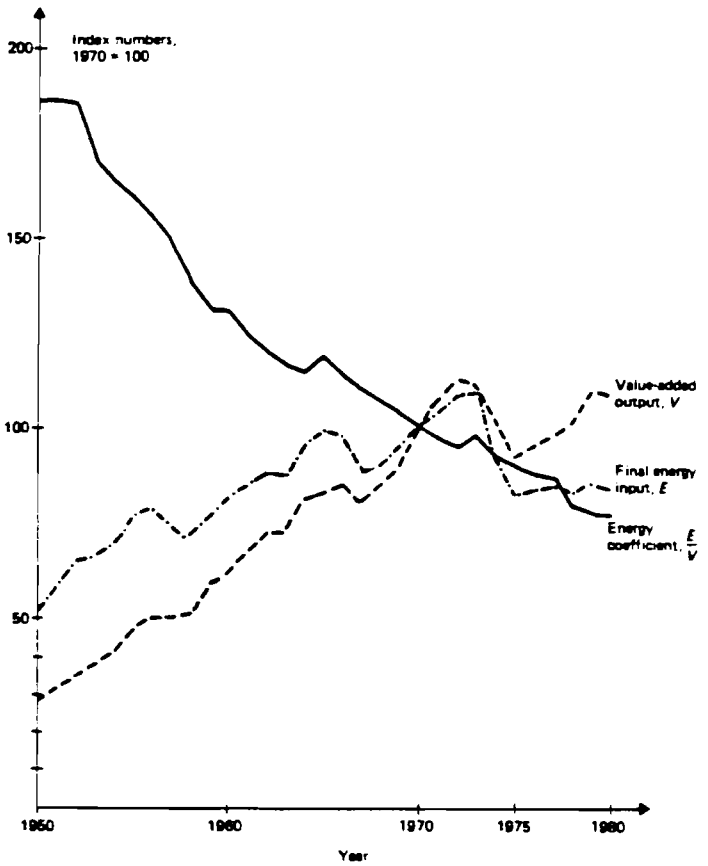

Figure 7. FRG Stone, Sand and Clay (incl. Cement) Industries. The Growth of Output, Final Energy Input and the Energy Coefficient since 1950.

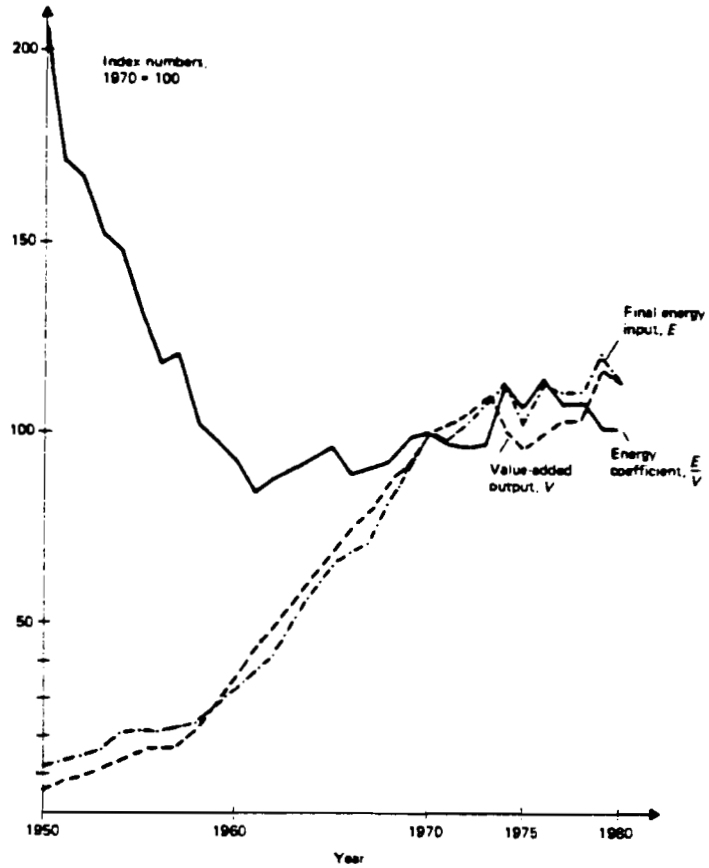

Figure 8. FRG Mineral Oil Refining. The Growth of Output, Energy Input and the Energy Coefficient since 1950.

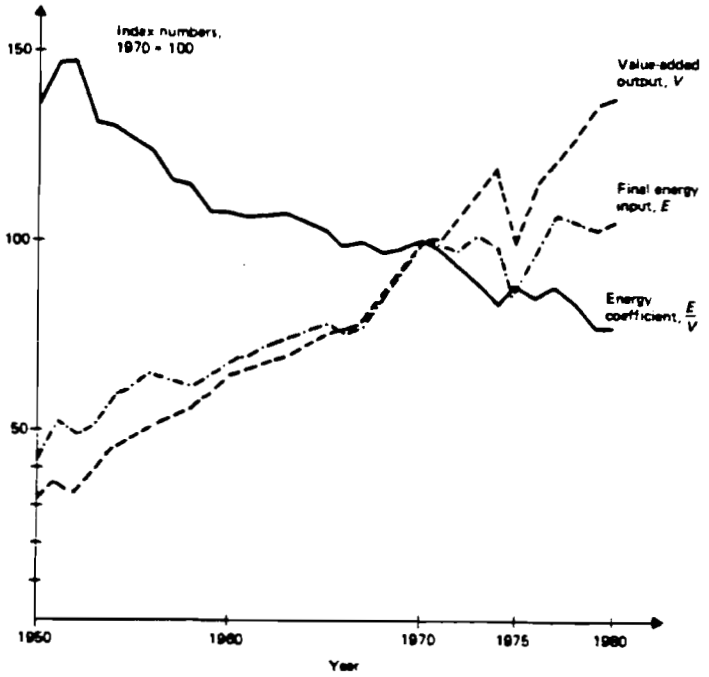

Figure 9. FRG Cellulose, Pulp and (raw) Paper Industry. The Growth of Output, Final Energy Input and the Energy Coefficient since 1950.

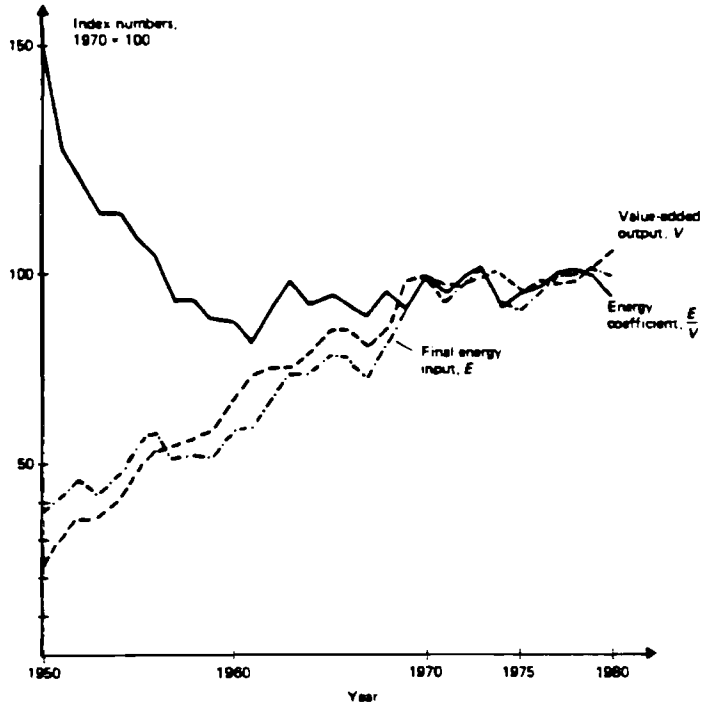

Figure 10. FRG Machinery Construction. The Growth of Output, Final Energy Input and the Energy Coefficient since 1950.

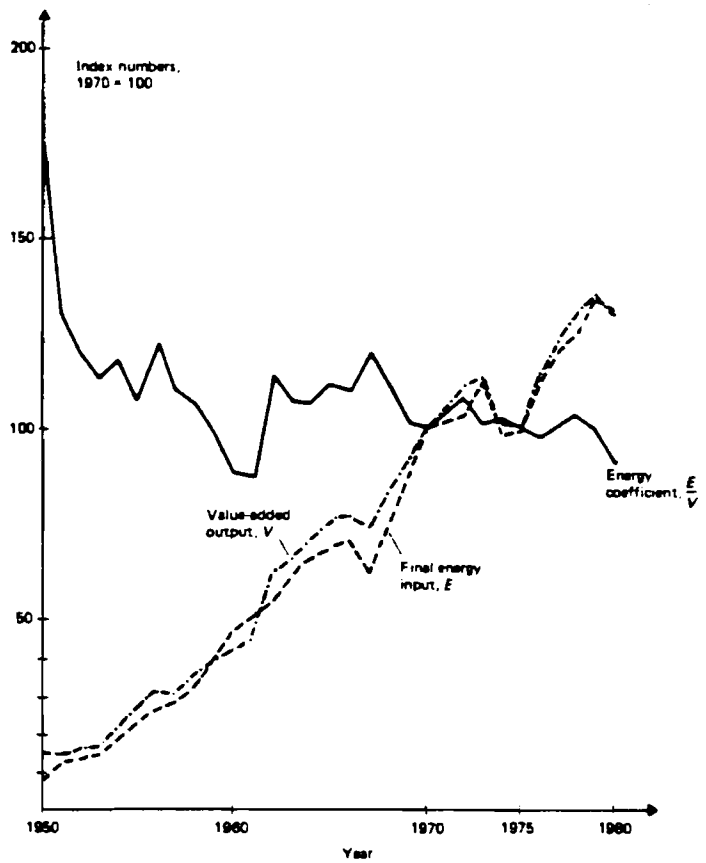

Figure 11. FRG Motor Vehicles Industry (incl. Airplanes). The Growth of Output, Final Energy Input and the Energy Coefficient since 1950.

not increasing at that time; they persisted through the 1970s when energy prices *were* rising sharply, and they continued in the early 1980s when this was no longer the case.

What brought about this long-term trend of technological improvements in the efficiency of fuel utilization? While we are not in a position to make any quantitative assessments, we can point to a few factors that may have been instrumental. First of all it must be borne in mind, and this goes for all industries, across the board, that there is a perpetual process of retiring old and usually fuel-inefficient equipment. In times of recession the equipment may not get replaced at all; an important example of this is the steel industry in the United States in the 1970s. But if and when the retired equipment is replaced or new equipment is installed, this will be more up-to-date and almost certainly more fuel efficient. Some of the improvement in the efficiency of fuel utilization in the manufacturing sector, both total and by individual industries, was also due to interfuel substitution, namely the replacement of coal by oil and gas, and the substitution of fossil fuels by electricity. In addition, there are special factors to be considered for each individual industry. For iron and steel this involved changes in the mix of input materials, from ores to the less energy-demanding recirculation of scrap metal, a switch that is most practical in times of low demand for the industry's output. Then there was the introduction of new technology during the 1970s, which led to massive savings of energy by aluminum smelting and paper manufacturing; both of these industries are energy intensive, but they play a relatively minor part in the industrial structure of the FRG. The growth of value added, final energy demand, and the energy coefficient is shown for total manufacturing and for selected industries in Figures 4–11.

3.4. Summary

The analysis presented above has shown that the major reason why energy requirements failed to grow as much as value added for the manufacturing sector as a whole is the pattern of structural changes in FRG industry. In other words, the slow growth of major, energy-intensive industries that are low in value added coincided with the fast growth of industries that are high in value added and relatively modest in energy requirements. A contributing factor was the general decline in energy input required per unit of value added across almost all manufacturing industries, due to the more efficient utilization of fuel. This is also a long-term trend, caused by the continuous retirement of older, less fuel-efficient equipment as well as interfuel substitution. There remains the question of why the decrease in the energy demand for manufacturing should have influenced the so-called "breaking of the energy coefficient." Here it seems that the long-term trends in energy "savings" caused by structural changes in industrial profile and technological efficiency improvements were accelerated by the slowdown in investments for infrastructure, particularly public-sector construction, that started in the late 1960s and early 1970s. After the oil price explosions of 1973 and 1979 came recessions that further slowed down the energy-intensive industries, particularly most of the primary metals, stone and earth, and basic chemicals. With the output of these industries falling below 1970 levels, and the output of industries that are lighter in energy requirements and higher in value added rising, the gap began to widen between the energy input and value added output for manufacturing as a whole.

4. THE CHANGING STRUCTURE OF MANUFACTURING CAPITAL STOCK

4.1. Sources and Definitions

The values of the manufacturing sector's capital stock at constant 1970 prices used here are estimates of the gross value of plant and equipment (*Anlagevermögen*) prepared by the statistical authorities of the FRG. The inclusion of plant construction means that the assets or capital stock have by definition a longer life than if the estimates related to equipment only. For this reason, the time lag between manufacturing output, energy input, and capital stock tends to be somewhat distorted. On the other hand, the distortions would be more serious if the capital stock related to equipment alone. This is because certain structures, e.g. blast furnaces, are included in some countries as plant (USA) and in other countries as equipment (USSR). For this reason it may be preferable to use total capital-stock data including both plant and equipment, so as to facilitate international comparisons. The disaggregation into 20 industry groups was made by the German statistical authorities to agree with the classification used for the net volume of production, which in turn follows the groupings of the Energy Balances discussed in Sections 2 and 3 above.

4.2. The Manufacturing Sector as a Whole

The value in constant 1970 prices of the entire capital stock used in the manufacturing sector as a whole rose uninterruptedly from D-Mark 100.1 billion in 1950 to 213.7 billion in 1960 and 417.9 billion in 1970. In the 1950s capital stock more than doubled and in the 1960s it nearly doubled. Both decades were characterized by high growth of manufacturing output.

During the 1970s, the growth rates of both GDP and manufacturing output slowed down, and the growth of the capital stock for total manufacturing, though nearly uninterrupted throughout the decade, amounted to no more than 37% overall. This slow growth of capital stock was consistent with the slowdown of investments as a function of the slackening growth of GDP.

4.3. Selected Industries

The relative decline of some of the slow-growth industries discussed earlier in Section 2 was reflected to some extent in the changing structure of capital stock (see Table 13). Thus the share in total capital stock of the iron and steel industries, after a small increase from 7.42% in 1950 to 8.73% in 1960, consistently fell thereafter to a low of 6.60% in 1980. The same was true for steel foundries and steel drawing, whose shares dropped, respectively, from 2.23 and 1.16% in 1950 to 1.04 and 0.82% in 1980. Similarly, the constructional steel industry, which includes shipbuilding and locomotives, experienced a long-term decrease in its share of total manufacturing capital stock from 2.84% in 1950 to 2.05% in 1980. Nonferrous metals saw its share in total manufacturing stock drop from 3.64% in 1950 to a low of 2.01% in 1970. Between 1971 and 1975/76 there was an increase, seemingly reflecting the investment in the aluminum industry. But with plans for the further expansion of aluminum smelters in limbo, the share of capital stock for nonferrous metals has been constant since 1975.

The relative decline in the capital stock of these energy-intensive, slow-growth industries, particularly during the 1970s, seems to have been due to the fact that little or no new capital stock was introduced, coinciding with the shutdown of older, obsolete equipment. This process of disinvestment rather than

Table 13. The changing structure of capital stock in the manufacturing sector of the FRG, 1950–80; percentage shares.

	1950	1960	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1. Slow Growth Industries													
Iron and steel production	7.42	6.73	7.70	7.61	7.61	7.54	7.38	7.27	7.23	7.11	7.01	6.80	6.60
Steel foundries	2.23	1.67	1.35	1.32	1.28	1.25	1.22	1.19	1.15	1.13	1.10	1.08	1.04
Steel drawing	1.16	1.29	1.00	0.98	0.97	0.95	0.93	0.91	0.89	0.87	0.86	0.84	0.82
Nonferrous metals	3.84	2.42	2.01	2.08	2.10	2.12	2.16	2.17	2.16	2.13	2.10	2.08	2.07
Constructional steel, shipbuilding	2.84	2.73	2.12	2.07	2.05	2.04	2.05	2.06	2.08	2.09	2.07	2.06	2.05
Fabricated metal products, hardware	2.86	3.85	4.31	4.33	4.35	4.37	4.37	4.36	4.38	4.42	4.45	4.47	4.49
Nonelectrical machinery	9.11	9.68	9.04	9.08	9.09	9.09	9.09	9.09	9.11	9.14	9.18	9.25	9.31
Stone, sand, clay	3.41	4.04	4.76	4.74	4.78	4.85	4.85	4.77	4.66	4.59	4.53	4.50	4.49
Lumber and sawmills	0.99	1.23	1.09	1.06	1.06	1.06	1.06	1.05	1.04	1.03	1.03	1.03	1.03
Cellulose, pulp, paper	1.77	2.13	2.00	1.98	1.93	1.89	1.86	1.84	1.82	1.81	1.80	1.81	1.87
Textiles, excl. clothing	7.31	6.67	7.27	7.24	7.23	7.26	7.25	7.21	7.19	7.23	7.29	7.37	7.39
Food, beverages, and tobacco	13.16	12.30	11.60	11.46	11.42	11.41	11.40	11.40	11.43	11.47	11.45	11.40	11.30
Misc. consumer goods	5.58	7.12	7.27	7.24	7.23	7.26	7.25	7.21	7.19	7.23	7.29	7.37	7.39
2. Fast Growth Industries													
Electric and electronic mach.	6.14	7.92	9.24	9.37	9.44	9.57	9.76	9.95	10.10	10.26	10.41	10.59	10.78
Chemicals	21.52	15.48	14.95	14.94	14.84	14.75	14.79	14.91	15.03	15.08	15.04	14.93	14.78
Synthetic and plastic goods	0.25	0.60	1.38	1.47	1.55	1.63	1.71	1.77	1.81	1.89	1.96	2.05	2.14
Fine ceramics and glass	1.13	1.41	1.55	1.55	1.55	1.56	1.58	1.58	1.58	1.58	1.60	1.60	1.59
3. Former Fast Growth Industries													
Mineral oil refining	3.02	2.72	2.86	2.82	2.82	2.83	2.84	2.86	2.85	2.80	2.77	2.70	2.60
Motor vehicles	5.03	6.61	8.96	9.15	9.25	9.26	9.28	9.30	9.29	9.30	9.42	9.69	10.07
Rubber and asbestos	1.38	1.18	1.34	1.39	1.43	1.44	1.44	1.44	1.44	1.43	1.41	1.38	1.35
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total manufacturing capital stock: in 10^9 DM at 1970 prices	100.1	213.7	417.9	444.8	466.9	489.9	508.3	523.1	535.7	544.6	554.0	563.7	575.7

Source: *Deutsches Institut für Wirtschaftsforschung* (DIW); see year-by-year data in IIASA computer printouts.

new investment appears to have been one of the major reasons for the increased efficiency in fuel utilization that followed the first oil price explosion.

Other so-called slow-growth industries whose shares in total manufacturing output receded markedly over the 30-year observation period maintained a fairly unchanged share in total manufacturing capital stock. This is true, for example, of the textile industry, whose fairly high share remained more or less at 7% of total manufacturing capital stock between 1950 and 1980. Likewise, nonelectrical machinery construction, which in contrast to electric and electronic equipment was only a slow-growth industry, maintained a fairly stable share of 9% in total manufacturing capital stock throughout the period 1950–1980. The food, beverage, and tobacco group saw its share in total capital manufacturing stock fall slightly from a high of 13.8% in 1950 to 12.30% in 1960, and after a few minor ups and downs in the 1970s it stood at 11.30% in 1980.

It may be assumed that, despite underutilization of capital stock, some of the relatively declining industries such as food, textiles, and nonelectrical machinery construction, which work with older and less sophisticated technologies, saw no need to shut down their old equipment.

The fast growth in the production of the chemical industry coincided with a decrease of the industry's share in total manufacturing stock from 21.52% in 1950 to 15.48% in 1960. This decrease may have been due to noneconomic circumstances. Throughout the 1960s and 1970s the share of chemicals in total manufacturing capital stock oscillated around 15% but never again reached the high of 1950. This lack of growth in the share of capital stock contrasts with the rapid growth in the industry's output. Unfortunately, the available data on output, energy input, and capital stock relating to chemicals are not sufficiently detailed to make a meaningful analysis. Based on selected output and energy consumption data we can only surmise that the reason for the relatively slow growth of the manufacturing capital stock for chemicals as compared to the very fast growth in the industry's output may be the structural shift within total chemicals production from energy- and capital-intensive basic and intermediate goods to final consumer goods that require less of both these factors.

As regards mineral oil refining, its share in capital stock dropped from 3.02% in 1950 to 2.72% in 1960, which was somewhat similar to what happened with the chemicals industry. After 1960 the share kept rising again to a high of 2.95% reached in 1968. Thereafter it decreased, reaching a low of 2.60% in 1980. This may indicate that mineral oil refining has ceased to be a fast-growing industry.

Now to the growth industries *par excellence*, electric and electronic equipment, and motor vehicles (including aircraft). The post-World War II automobile industry got its lift with the "*Wirtschaftswunder*"; so did the electric and electronic equipment industry, whose continued expansion is based on technological innovation. The growth of both these industries was reflected in the rapid growth of their capital stock. The share of motor vehicles (including automobiles, aircraft, and space ships) in total manufacturing capital stock moved from 5.03% in 1950 to 6.61% in 1960, and further upward to 10.07% in 1980. A similar process occurred for electric and electronic equipment, where the share increased from 6.14% in 1950 to 7.92% in 1960 and then without interruption to 10.78% in 1980.

Finally, the processing of plastics and synthetics into manufactured goods is a comparatively young and fast-growth industry, based on technical innovation. Its share in total manufacturing capital stock rose from 0.25% in 1950 to 2.14% in 1980.

This ends our admittedly very broad survey of the changes in the capital structure of the manufacturing sector of the FRG. For a look at a few other industries not explicitly mentioned above and for year-by-year data, the reader is referred to Table 13.