The Contribution of Growth in Total Factor Productivity to Growth in South Africa: 1970-97

Johannes Fedderke

ERSA, University of the Witwatersrand

ABSTRACT: This paper is concerned with revealing the changing patterns of growth in the South African economy. Output growth is decomposed into the contributions of growth in labour, capital and total factor productivity over the 1970-97 period, and on a sectoral level. Evidence reveals strong sectoral differences in the underlying stucture of output growth, and strong concentration in the source of efficiency gains in three digit manufacturing sectors.
JEL Classification: O3, O47

1 Introduction

Growth continues to elude the South African economy. More seriously, South Africa's growth performance has been on a steady downward trend since the early 1970's. This downward trend is present both when we consider the growth rate in real Gross Domestic Product (GDP), as well as when we consider the growth rate in real per capita GDP - see Figure 1. What is alarming about the evidence of Figure 1 is less the declining trend in the two growth rates depicted. Such evidence is available for a number of countries, and was central to the debate surrounding the long-term economic development of the USA for the last twenty years (until the most recent upsurge in US growth). Instead, what is alarming about the South African evidence is the *extent* of the decline in the two growth rates in GDP. By the 1990's the growth rates were frequently negative rather than positive. Note further that the growth rate of real per capita GDP lies consistently below that of level of real GDP, carrying the further implication that the average real resources available per individual resident of the country was growing at an ever slower rate, and during the 1990's actually began to decline consistently. Certainly the evidence is of a long term structural decline in growth rather than a sudden poor performance during the course of the 1990's.

The evidence on growth in real GDP for South Africa is thus not reassuring. But the evidence must be also viewed in context. The declining growth performance of the South African economy mirrors declining growth rates elsewhere in the world. On the other hand middle income countries as a whole grew at 2.7% per annum on average over the 1980-90 period, and at 3.9% per annum on average over the 1990-98 period. In the case of East Asia the acceleration was from 8.0 to 8.1% per annum over the same period. Thus South Africa as a middle income country has performed well below the average maintained by its peer economies.

Two further factors might give us reason to pause before accepting the evidence we have seen at face value. The first is that in the mid-1990's Figure 1 does show evidence of a recovery in growth performance, though it remains to be seen how sustainable the recovery will prove to be. The second is that one of the reasons that has been advanced for the sharp increase in the growth performance of the US economy is that GDP measurement has been improved in order to take better account of quality improvements in output in the economy, especially as concerns the contribution of information

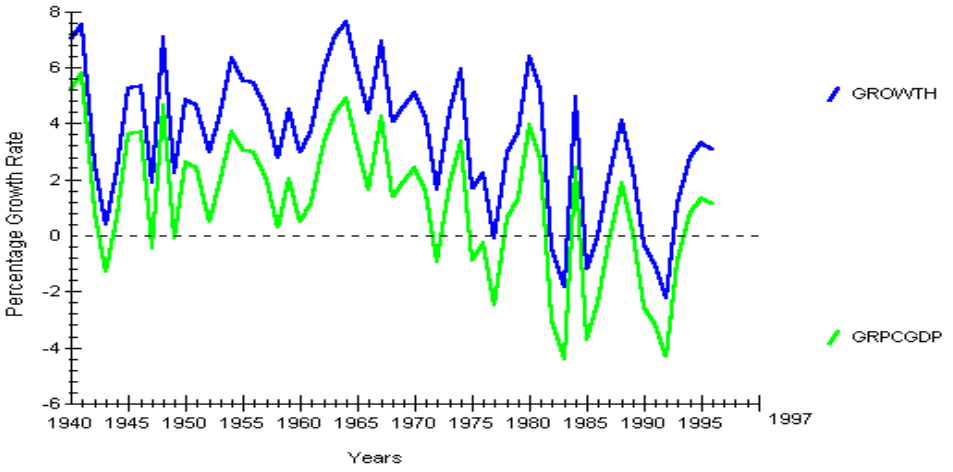

Figure 1: Growth Rates in Real Gross Domestic Product (GROWTH) and Per-Capita Real Gross Domestic Product (GRCGDP)

technology to production methods. The question that then arises is whether in the South African case a similar impact might not become evident if such revised GDP figures were to be considered.

The South African Reserve Bank has made some attempts to correct its measures of GDP in order to bring the measure in line with revised international best practice. In Figure 2 we report the implied growth rates on both the "old" and the "new" measure of GDP. While it is evident that the revision of the GDP figures has indeed had an impact, the impact is not such as to alay significantly growth concerns for the economy.

Concern with the apparent decline in the structural capacity of the South African economy to generate growth carries warning signals in a wider sense also.Durlauf and Quah (1998:2) point out that averaged over 1960-4, the poorest 10% of the world's economies each had per capita incomes less than 0.22 the world average (while containing 26% of the world's population); the richest 10% of the world's economies each had per capita incomes greater than 2.7 times the world average (while containing 12.5% of the world's population). By 1985-9 the 10th percentile had declined to 0.15 the world average, the 90th percentile had increase to 3.08 times the world average.

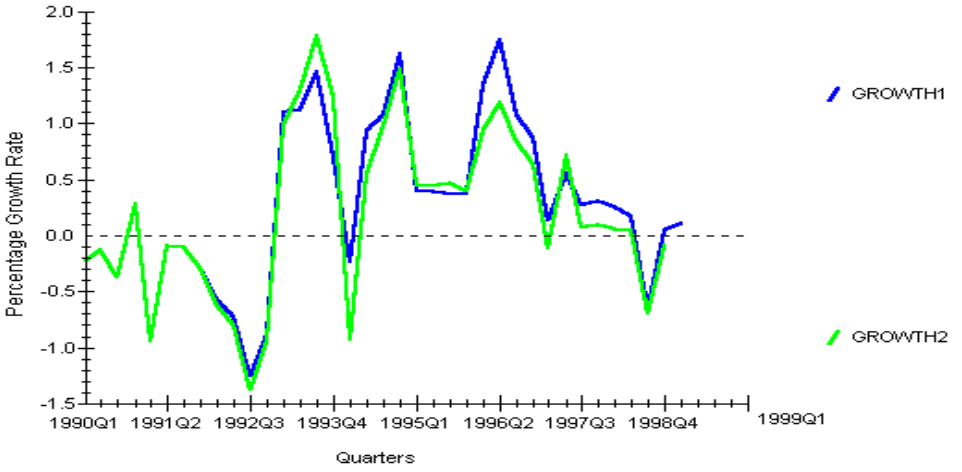

Figure 2: Growth Rate in Real GDP over the 1990's in terms of "old" (GROWTH1) and "new" (GROWTH2) GDP measures

The picture is again one of widening disparities. Yet on the other hand in 1960-4 the distance between the 15th and 25th percentiles in per capita income was 0.13 times world per capita income - by 1985-89 the distance had fallen to 0.06; similarly the distance between the 85th and 95th percentiles fell from 0.98 to 0.59 times the world per capita income (see Durlauf and Quah 1998:3). The implication is one of a widening of the overall spread of incomes over the post-1960 period, but of increased clustering amongst the relatively poor and rich.

Put another way, the last quarter of the twentieth century has seen the emergence of distinct growth "clubs". Belonging to one or the other (rich or poor) carries significant implications for the welfare prospects of the citizens of countries.

In this wider world-wide context therefore, the evidence we have already seen concerning the changing performance of the South African economy, above all the declining growth rate in real and per capita real GDP, carries serious implications. There is not much evidence to suggest that South Africa is on a growth path which is serving to improve the welfare of its citizens sufficiently to allow it to join the club of developed countries rapidly.

We face the serious policy concern of how we can ensure that the economic environment in South Africa can be altered sufficiently to enable the population in such a manner as to reverse this trend.

In the present paper the concern is to provide one building block toward a better understanding of the South African growth performance. The purpose is to undertake a decomposition of output growth into the contributions to growth provided by factor (capital and labour) inputs, in order to isolate the contribution of growth in total factor productivity. The decompositions are undertaken for the 1970-97 period, on a decade by decade basis. Moreover, the decomposition is undertaken not only on an aggregate level, but on a sector-by-sector basis, particularly for the manufacturing sectors of South Africa. Finally, the contribution of total factor productivity is weighted by the real output contribution of sectors, to arrive at an intimation of the real cost reduction implied for the economy.

An important result of the decompositions is an improved understanding of the underlying pattern of output growth for the South African economy across its constituent sectors.

2 A Brief Consideration of Some International Evidence

International evidence from developed countries has often pointed to the significant contribution of growth in total factor productivity rather than growth in factor inputs to output growth.[1] One illustration of this emerges when one considers the relative contribution of labour, capital and the remaining Solow residual or Total Factor Productivity (TFP) to growth in real output.[2] Considering the rapid and sustained period of economic growth that the developed world underwent in the period from 1950-62, it emerges that

[1] See for instance Abramovitz (1956, 1986, 1993). For continued and more recent discussion of this evidence see also Fagerberg (1994) and Maddison (1987).

[2] Computation of Total Factor Productivity growth is by means of the standard primal estimate given by:

$$TFP = \frac{\dot{Y}}{Y} - s_K \frac{\dot{K}}{K} - s_L \frac{\dot{L}}{L}$$

where s_K and s_L denote the shares of capital and labour in output respectively, Y denotes output, K capital, and L labour.

	Growth in Real GDP	Contribution by: Labour	Capital	Technology (TFP)
Japan	6.45	0.77	1.17	4.57
Italy	5.36	0.54	0.57	4.29
Germany	5.15	-0.12	0.93	4.43
France	4.80	0.37	0.76	3.67
Netherlands	3.65	0.09	0.78	2.79
Norway	3.27	0.02	0.85	2.41
Belgium	2.64	0.36	0.28	2.02
Denmark	2.56	-0.11	0.77	1.94
United States	2.15	0.22	0.60	1.36
United Kingdom	1.63	0.10	0.37	1.18

Table 1: Decomposition of growth in real GDP, Source Fagerberg (1994)

the contribution of factors of production (capital and labour) never matched that of technological advance at least in the sample of developed nations under consideration. We provide some summary evidence in Table 1. In effect, the growth in output in these countries is difficult to explain by reference to growth in factor inputs, and instead the weight of expectation for economic growth begins to fall on the contribution of technological advance.

Economists have thus well understood that growth in factor inputs has appeared to contribute a relatively small proportion of the total growth in per capita GDP in most developed economies. One response to this finding has been some degree of scepticism as to the apparent overwhelming preponderance of technological advance as an engine for growth. In work on developed nations the decomposition of output growth has been considerably refined over the years, reducing the explicit contribution of technological progress.[3]

A number of additional considerations have been proposed as candidates that might contribute to economic growth besides growth in factor inputs and growth in technology. Beginning with a seminal study, Denison (1967) decomposed the contribution of technology noted in Table 1 into t*echnological change* proper, *catch up* with the world's technological leader, *structural change* in ensuring more efficient resource allocation, and the realization of

[3]See Denison (1967), and also the discussion in Fagerberg (1994), Jorgenson (1988), Jorgenson and Grilliches (1967) and Maddison (1987).

	Technology (TFP)			
	Technological Advance	Catch Up	Structural Change	Economies of Scale
Japan	1.41		1.07	1.88
Italy	0.76	0.88	1.42	1.22
Germany	0.75	0.83	1.00	1.59
France	0.76	0.74	0.95	1.00
Netherlands	0.75	0.43	0.63	0.77
Norway	0.76	0.18	0.92	0.57
Belgium	0.76	0.07	0.51	0.51
Denmark	0.75	-0.27	0.67	0.64
United States	0.75	-	0.29	0.36
United Kingdom	0.75	0.04	0.12	0.36

Table 2: Decomposition of TFP growth into constituent components, Source Denison as cited in Fagerberg (1994)

economies of scale. One illustration of the net result is reported in Table 2.

What emerges is that the contribution of technology can indeed be pared down considerably once the additional factors brought into consideration are taken into account.[4] While the contribution of technological progress may now appear to be more "realistic", a few words of caution at this point are equally appropriate. If it is true that technology is a public good, then it becomes difficult to explain why it is that some countries struggle with catch-up in technology, and others do not.

The restriction of output growth due to technology to be constant across all countries is in itself therefore artificial. The distinction between genuinely "new" technology and the process of acquiring technology that was already in existence but a specific country did not have access to, does make sense at one level. These are two processes that are distinct both conceptually, and in terms of what renders them feasible. But at another level to the country doing the acquiring, the effect of the two acquisitions is much the same. In both instances production possibilities that did not exist before become accessible. Therefore the distinction between the two processes while useful,

[4]The essentially identical contribution of technology across developed countries reflects the assumed public goods character of technological change. The United States does not evidence any catch-up since it is viewed as the technology leader in the post-war period.

is also to some extent artificial. A similar argument can be made with respect to both economies of scale and structural change. Again these are innovations not in the sense of "new knowledge", but they do innovate, and they do open up new forms of production not previously in existence.

For all of these reasons, very detailed decomposition of the output growth attributed to technology may carry with it more ambiguity than insight, and we might be better advised to try to understand the factors in aggregate. TFP growth provides one with an indication of the magnitude of efforts to increase the efficiency with which factor inputs are used in production. While it may indeed be insightful to establish why efficiency gains are being realized, in the final instance it is the fact that they are being realized that matters. TFP growth is really technological change in its broadest sense. Considering the magnitude of its contribution is therefore a useful starting point. At least we know how much there is to explain, before we consider decomposing it into its constituent parts.

We conclude the brief review of international evidence by pointing to an important modulation relevant to developing countries. Evidence from developing countries has emphasized the possibility of a changing trajectory in output growth, in developing countries beginning with a heavy reliance on capital intensive output growth, shifting to total factor productivity growth with rising per capita GDP.[5] One illustration of this is reported in Table 3.

3 The Methodology and its Limitations

Computation of Total Factor Productivity (TFP) growth is by means of the standard primal estimate given by:

$$TFP = \frac{\dot{Y}}{Y} - s_K \frac{\dot{K}}{K} - s_L \frac{\dot{L}}{L} \tag{1}$$

where s_K and s_L denote the shares of capital and labour in output respectively, Y denotes output, K capital, and L labour.

However, it is vital to realize that evidence to emerge from this simple growth accounting decomposition can only be understood to be broadly indicative. The literature on growth accounting since the contributions of Denison (1962, 1967, 1974) has provided further sophistication to the decomposition (see the discussion above), and further extensions have emerged

[5] See for instance Lim (1994).

Region	Capital	Labour	Technical Progress
Developing Countries, 1960-87:	*65*	*23*	*14*
Africa	73	28	0
East Asia	57	16	28
Europe, Middle East & North Africa	58	14	28
Latin America	67	30	0
South Asia	67	20	14
Selected developed countries, 1960-85:			
France	27	-5	78
West Germany	23	-10	87
Japan	36	5	59
United Kingdom	27	-5	78
United States	23	27	50

Table 3: Decomposition of GDP growth. Figures are percentages of total output growth, Source Lim (1994)

due to developments in endogenous growth theory (for a useful overview of the developments see Barro 1998).[6]

The first crucial limitation of the simple decomposition approach outlined above is that it does not disaggregate factor inputs by quality classes. The work of Jorgenson and Grilliches (1967) and Jorgenson, Griliches and Fraumeni (1987) demonstrates the potentially substantial impact this carries for the conclusions to be drawn from the decomposition. Given the extent of segmentation in South African labour markets, the impact of factor input quality is potentially of considerable significance. Unfortunately data limitations preclude the possibility of pursuing this line of enquiry further.

A second limitation of the simple growth decomposition attaches to the assumption that factor social marginal products coincide with observable factor prices. One response to this difficulty is provided by recourse to a regression approach, in order to obtain direct evidence on factor elasticities. However, the regression approach is subject to its own, and severe limitations. Both factor input growth rates are unlikely to prove exogenous with respect to output growth rates, raising the prospect of bias and inconsis-

[6] An alternative methodology, combining the insights from new growth and new trade theory, is given by Anderton (1999). Unfortunately data limitations for South Africa preclude its use. Findings support the conclusion that relative R&D and patenting activity influence import penetration and hence long term growth prospects.

tency in parameter estimates due to simultaneity. Moreover, both factor input growth rates are likely to be subject to considerable measurement error, once again raising the prospect of inconsistent parameter estimates. The problem is of particular significance for the capital stock growth rate, for which capacity utilization carries important implications, and the likelihood of an *under*estimation of the contribution of growth in the capital stock to output growth. For these reasons, while regression approaches are not unheard of, the predominant approach in the literature remains rooted in growth accounting decomposition approaches. The present study follows suit.

But potentially the most significant limitation of the simple decomposition approach attaches to its assumption of constant returns to scale. Since endogenous growth theory directs its most fundamental challenge against traditional growth theory on this very assumption, this may constitute a fundamental limitation.

Since the potential limitations arising from the assumption of constant returns to scale are addressed in a separate study (see Fedderke 2001), in the current context we proceed on the assumption that homogeneity of degree one can be invoked. In this the study follows numerous others internationally. Nevertheless, readers should bear in mind the implicit assumptions that underlie the decompositions presented in the discussion that follows.

3.1 The Data

Data for the current study is drawn from the Trade and Industry Policy Secretariat data base. Variables include the output, capital stock, and labour force variables and their associated growth rates.

4 Aggregate Evidence for South Africa

South Africa's aggregate experience mirrors that of many developing countries. Table 4 illustrates that the contribution of growth in total factor productivity to South African growth in aggregate output has been steadily rising since the 1970's.[7] The 1970's and 1980's saw growth that was heavily

[7] The computations were by means of the standard primal estimate given by:

$$TFP = \frac{\dot{Y}}{Y} - s_K \frac{\dot{K}}{K} - s_L \frac{\dot{L}}{L}$$

	Growth in Real GDP	Of Which: Labour	Capital	Technology
1970's	3.21	1.17	2.54	-0.49
1980's	2.20	0.62	1.24	0.34
1990's	0.94	-0.58	0.44	1.07

Table 4: Decomposition of growth in real GDP into the contribution of factors of production and technological progress, Figures are in percent

led by growth in capital and labour inputs, with very little contribution by technology. In the 1990's the situation is reversed. In the 1990's growth in the labour force input contributed negatively, and growth in the capital input contributed relatively weakly to growth in GDP. Instead, the single strongest contributor to output growth during the course of the 1990's is a strong augmentation in technology.

Thus the evidence suggests the presence of a structural break in the SA economy. While in the 1970's and 1980's output growth in the economy as a whole was driven by growth in factor inputs, the 1990's have seen a growing reliance on technological improvements and efficiency gains in the economy. Part of the reason for this evidence is that the 1990's saw a decline in formal sector employment,[8] such that growth in labour inputs could not possibly have added to the growth in real output of the economy. The declining contribution of capital to the growth performance of the South African economy is due to the declining investment rate that South Africa has experienced.[9] We are thus left with a finding that the contribution of technological progress to South African growth in aggregate has been steadily rising since the 1970's - though admittedly it is assuming a rising proportion of a declining growth rate.

The aggregate evidence hides strong sectoral differences, however. We report the summary evidence in Table 5. The implication of the evidence is that the principal South African economic sectors show strong differences in terms of the decomposition of their output growth. The only consistent

where s_K and s_L denote the shares of capital and labour in output respectively. The factor shares are provided by data on Gross Operating Surplus and the Real Wage Bill respectively.

[8] See the more detailed discussion in Fedderke, Henderson, Mariotti and Vaze (2000).

[9] See the more detailed discussion in Fedderke (2000), and Fedderke, Henderson, Kayemba, Mariotti and Vaze (2000).

	Growth in Real GDP	Of Which: Labour	Capital	Technology
Agriculture, Forestry and Fishing				
1970's	4.27	-0.10	2.00	2.37
1980's	4.30	-0.24	-0.56	5.10
1990's	2.40	-0.20	-0.92	3.52
Mining				
1970's	-1.08	0.51	3.81	-5.40
1980's	-0.55	0.18	3.90	-4.63
1990's	-0.60	-2.32	0.10	1.62
Manufacturing				
1970's	4.94	1.67	2.78	0.49
1980's	1.48	0.78	1.21	-0.52
1990's	0.43	-0.47	1.69	-0.79
Service Industry				
1970's	3.41	1.49	2.80	-0.88
1980's	2.81	0.82	1.28	0.71
1990's	1.50	-0.59	0.44	1.65

Table 5: Decomposition of growth in real output into the contribution of factors of production and technological progress, Evidence by principal economic sectors, Figures are in percent

feature across all four principal sectors of the South African economy is that the contribution of the labour factor input toward output growth has been on a downward trend from the 1970's through to the 1990's. In terms of the contribution of growth in capital stock, we find that in the agricultural sectors, the mining industry and the service industries[10] capital has been of declining importance as a contributor toward output growth, while for manufacturing industry it has assumed increasing importance.[11]

Finally, in terms of the contribution of technological progress, the strongest efficiency improvements have consistently been evident in the agricultural

[10] Included in this sectoral grouping are: Electricity, gas & steam, Water supply, Building construction, Civil engineering & other construction, Wholesale & retail trade, Catering & accommodation services, Transport & storage, Communication, Finance & insurance, Business services, Medical, dental & other health & veterinary services, Other community, social & personal services: Profit seeking.

[11] See also the evidence in Fedderke, Henderson, Kayemba, Mariotti and Vaze (2000).

sectors, though the contribution declined during the 1990's. Mining by contrast, while coming off a low growth rate of technological progress, has been on an upward trend, as has service industry. Manufacturing industry has shown the weakest performance in terms of technological progress in the South African economy.

There is also an important sense in which the evidence contained in Table 5 is misleading, however. The evidence merely presents the decomposition of output growth in each sector into the contributions of capital, labour and technology. This does not provide us with a means of establishing the importance of the contribution of technological progress in each economic sector to aggregate economic growth in South Africa, since the contribution of each sector is not weighted by the magnitude of output the sector contributes to aggregate output. A sector experiencing relatively low levels of technological progress, but which is a large producer in the economy, may nevertheless be contributing more to the aggregate growth in output in the economy through technological process than a very small sector whose rapid technological advance generates a proportionately small augmentation of aggregate output.

In order to assess the point, we consider the contribution of the principal economic sectors in the South African economy to Harberger's (1998) computations of real cost reduction. The object is to weight the contribution of each economic sector's technological advance to aggregate growth in output, but weighting the contribution by the size of the sector's output. One means of doing so is by applying the average annual growth contribution of technology to output growth to the starting value of real value added in the period for which the TFP contribution has been computed. In Figures 3 through 6 we depict the outcome of this exercise on a decade by decade basis, after indexing the contributions of each sector.[12]

The diagrams illustrate that the total impact of technological progress in the economy to output growth was negative during the 1970's. While technological progress in agriculture and manufacturing contributed in about equal measure to output growth in the economy during the 1970's, both services and mining had negative contributions of technological progress that more than eliminated the contribution of technological progress to output growth in the economy as a whole. Note also that once the relative size of the sectors is taken into consideration the relative contributions of the agricultural and manufacturing sectors to output growth through technological progress

[12]For more details on this methodology see Harberger (1998).

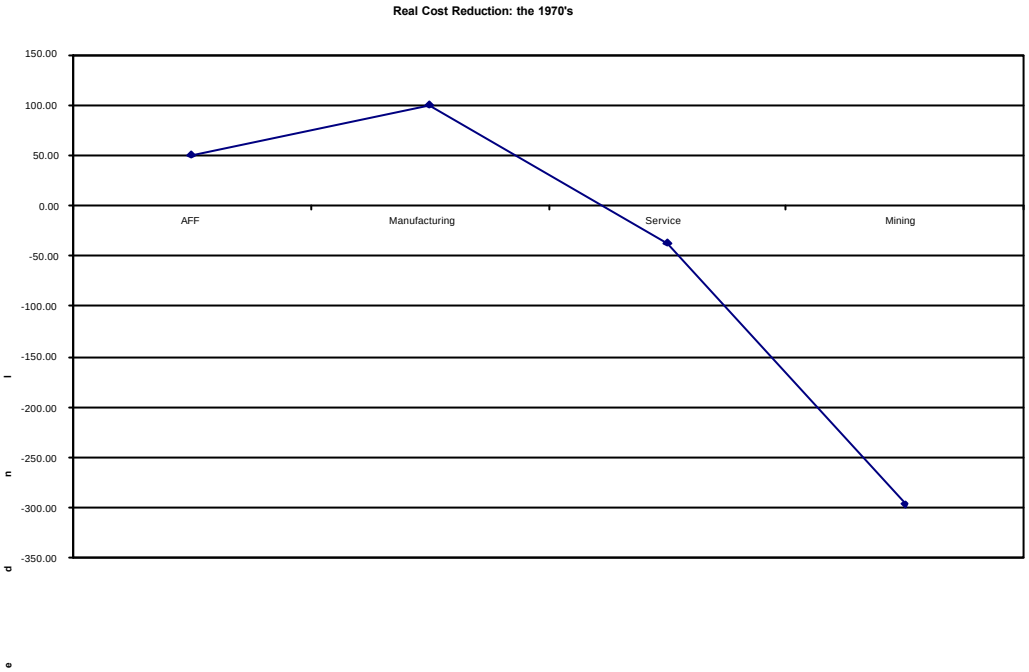

Figure 3: Real cost reduction: the 1970's.

is considerably more equal than suggested by the evidence of Table 5. By the 1980's, the total net impact of technological progress on output growth in the economy had turned positive, if only just. While technological advance in agriculture and services made positive contributions to output growth during the 1980's, in manufacturing and mining the contribution of efficiency improvements (TFP) was negative, though not sufficiently so to render the total impact of technology unfavourable on output growth. Finally, during the 1990's the contribution of technology had turned strongly positive. For all sectors but manufacturing technological progress contributed positively to real output growth, and the net impact was unambiguously positive.

5 The Evidence for South African Manufacturing Industries

The implication of the above evidence confirms our initial finding: that technology as a contributor to economic growth in the South African economy has become increasingly important, though sectoral differences cannot be

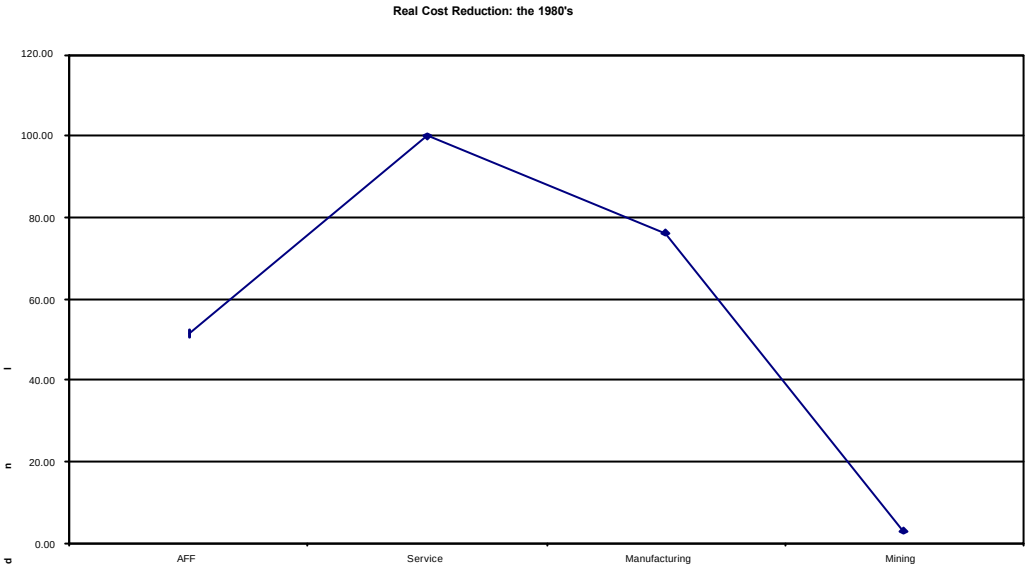

Figure 4: Real cost reduction: the 1980's.

neglected. In particular, the exception to this finding is that in the manufacturing sector specifically the 1990's have seen a process of restructuring, with a strong link between growth in capital stock and output growth, and a declining importance of technological innovation.

The exceptional behaviour of the manufacturing sector deserves a little closer comment. To begin with, we should note that the aggregate story about the manufacturing sector disguises evidence of an important structural break in the nature of growth in the manufacturing sector. In Table 6 we report the correlation between growth in labour, capital and total factor productivity and output growth for the 28 three digit manufacturing sectors of South Africa for the 1970's, 1980's and 1990's.[13] The correlation between output growth and the contribution to output growth by the three sources of output growth changes dramatically between the three decades. In the 1970's and 1980's, the strongest correlation is between output growth and the TFP measure. In the 1990's the strongest correlation is between output growth

[13] SIC version 5 three-digit classifications were employed. Appendix 1 contains the more detailed data on manufcturing sector TFP computations.

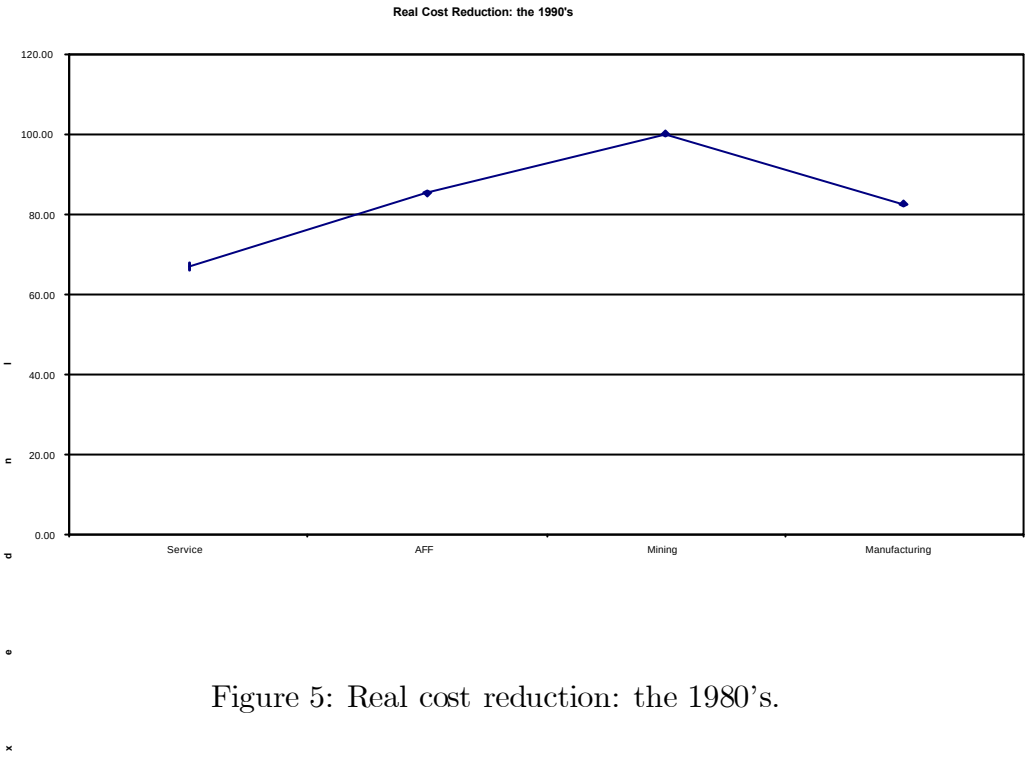

Figure 5: Real cost reduction: the 1980's.

and the growth rate of capital stock. The implication is that in the first two decades sectors that experienced high growth rates in output, were also likely to have a strong track record of technological innovation. In the 1990's, by contrast, this association has become less prevalent. Instead, strong output growth has become associated with a strong growth rate in physical capital stock.

A number of explanations are possible for this transformation. The first is the evidence now accumulating that capital markets in South Africa underwent restructuring during the course of the 1990's.[14] The suggestion is that the 1970's and 1980's saw, through state intervention in capital markets and due to the relative international isolation of this period, strong distortions in capital markets due to policy interventions. The liberalization of the policy environment saw changed incentives and rates of return to investment activity, such that capital came to be reallocated from sectors with strong state involvement, to manufacturing industry. Hence the strong burst in cap-

[14]See for instance the discussion in Fedderke, Henderson, Kayemba, Mariotti and Vaze (2000).

	1970's	1980's	1990's
Labour	0.4	0.54	0.08
Capital	-0.14	0.3	0.74
Technology	0.79	0.93	0.38

Table 6: Correlation between alternative sources of output growth and growth

ital creation in manufacturing sectors, including those with historically small capital stock during the course of the 1990's. It remains to be seen whether this will prove to be sustainable.

A further potential explanation for the changing profile in manufacturing sector output growth arises from the likely impact of the period of international isolation South Africa faced during the 1970's and 1980's. In general we might expect manufacturing sectors in developing countries to follow advances in technology generated in developed countries, rather than incurring the cost of generating new technology of their own accord. Such emulation presupposes the possibility of access, however. The period of isolation may have made access to international advances either impossible, or at the very least more costly. As a consequence it may well be that South African manufacturing industry was starved of access to international advances in technology and thus had little option but to engage in technological innovation of its own accord.

A second feature worth noting about technical change in the manufacturing sector is that the aggregate TFP growth for the manufacturing sector hides strong sectoral variation in technological progress. Thus in the 1970's Other Chemicals & Man-Made Fibres and Basic Non-Ferrous Metals both had a contribution from technology to output growth in excess of 10%. And in the case of Electrical Machinery and Plastic Products the technology contribution was between 5 and 10 %. In the 1980's Other Industries and the Coke & Refined Petroleum Products sectors again had technology contributions to output growth in excess of 10%, while TV, Radio & Communication Equipment and Professional & Scientific Equipment had contributions between 5 and 10%. The evidence for the 1990's conforms to the evidence we have already presented for the decade: the contribution of technology to output growth is considerably lower than in previous decades in all manufacturing sectors, with growth in capital stock being the main contributor to growth in manufacturing for all sectors.

Weighting the contributions of TFP by the magnitude of value added produced in each sector adds a further nuance to the manufacturing sector evidence. Again we employ the Harberger (1998) approach of applying the average annual growth contribution of technology to output growth to the starting value of real value added in the period for which the TFP contribution has been computed. In Figures 6 through 8 we depict the outcome of this exercise on a decade by decade basis. For ease of reference Table 7 provides the key for identification of sectors. What emerges from the real cost reduction evidence is that for all three decades under consideration, the positive contribution to output growth by technological progress is dominated by a small number of sectors. Six sectors contributed 80% of the real cost reduction due to technological progress in the manufacturing sector during the 1970's,[15] seven sectors did so during the 1980's,[16] while in the 1990's only three sectors did so.[17]

Thus in each of the three decades under consideration technological progress is highly concentrated in a few core sectors. Moreover, the sectors providing the strongest contribution of technological progress to output growth are highly volatile from decade to decade. This is evident not only from the diagrams, and the position of the economic sectors within them, but also from Spearman rank correlation coefficients computed on the rankings of the technology contributions of sectors in each decade. The rank correlation between the ranks of sectors in the 1970's and 1980's is -0.39, between the ranks in the 1970's and 1990's 0.19, and between the ranks in the 1980's and 1990's -0.50. The net implication is that the position of sectors relative to others in terms of their contribution to technological progress is volatile, with the relative contribution in one decade providing a poor predictor of subsequent performance.

This volatility of the technology contribution emerging from the manufacturing sectors carries with it a potential policy implication for the promotion of technological progress. The volatility of the technology contribution of

[15] In declining order of importance these are: Other Chemicals & Man-Made Fibres, Machinery & Equipment, Electrical Machinery, Metal Products excluding Machinery, Basic Non-Ferrous Metals, Paper & Paper Products.

[16] In declining order of importance these are: Motor Vehicles, Parts & Accessories, Coke & Refined Petroleum Products, Other Industries, Television, Radio & Communication Equipment, Printing, Publishing & Recorded Media, Plastic Products, Beverages.

[17] In declining order of importance these are: Machinery & Equipment, Basic Iron & Steel, Basic Chemicals.

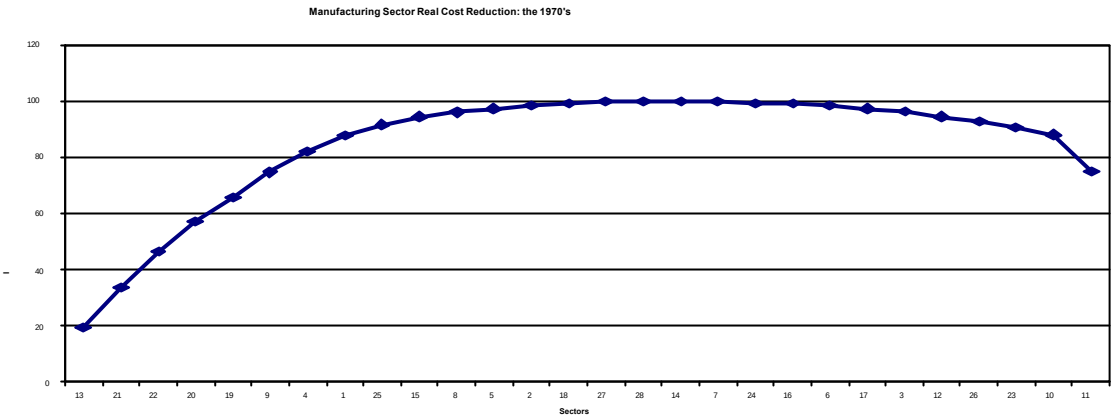

Figure 6: Real cost reduction: the 1970's.

the economic sectors, means that it may prove to be very difficult to forecast with any reliability sectors that are promising candidates in developing new technology. The difficulty of forecasting the location of technological progress by implication renders difficult the process of targeting incentives for technological advance to specific sectors. The likelihood is simply that the targeted incentives will be misplaced, and thus constitute wasted resources. What is far more likely to be successful as a policy for technological innovation is the creation of general "enabling conditions" for entrepreneurs who wish to innovate, and to allow entrepreneurs to take advantage of the enabling conditions wherever and whenever they may deem it to be appropriate. This allows the volatility in innovational location identified above to be accommodated, and would allow the economy to take advantage of all innovative opportunity rather than simply in those sectors which government happens to have targeted.

6 Conclusions and Evaluations

This paper has presented decompositions of output growth in South Africa over the 1970-97 period. Decompositions were presented for aggregate output growth, for South Africa's principal economic sectors, as well as for the SIC 3-digit manufacturing sectors.

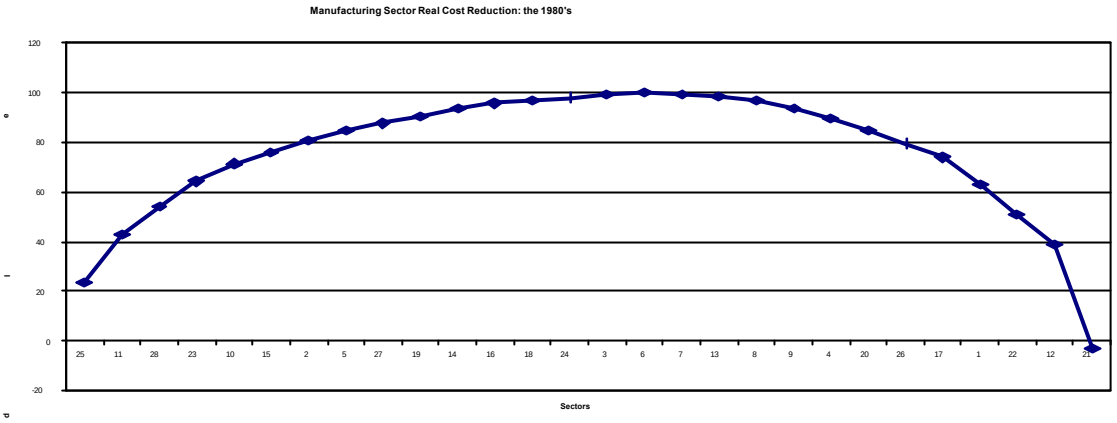

Figure 7: Real cost reduction: the 1980's.

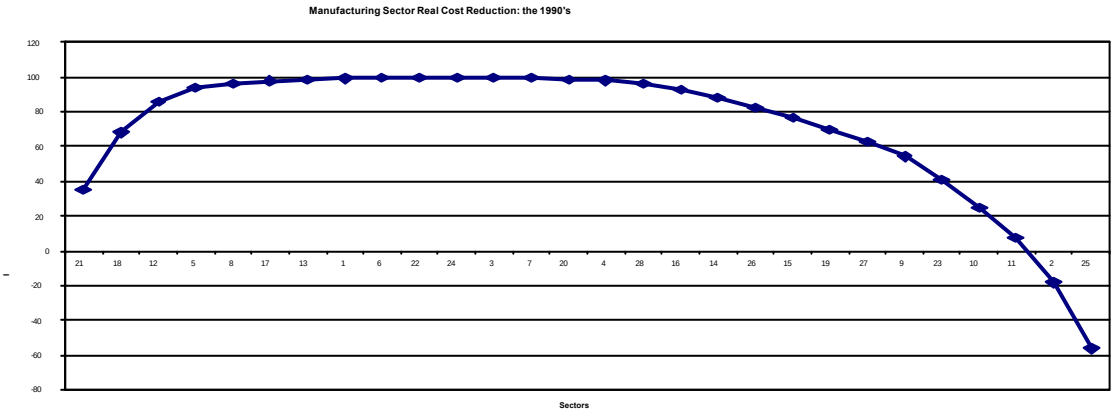

Figure 8: Real cost reduction: the 1990's.

1	Food
2	Beverages
3	Tobacco
4	Textiles
5	Wearing apparel
6	Leather & leather products
7	Footwear
8	Wood & wood products
9	Paper & paper products
10	Printing, publishing & recorded media
11	Coke & refined petroleum products
12	Basic chemicals
13	Other chemicals & man-made fibres
14	Rubber products
15	Plastic products
16	Glass & glass products
17	Non-metallic minerals
18	Basic iron & steel
19	Basic non-ferrous metals
20	Metal products excluding machinery
21	Machinery & equipment
22	Electrical machinery
23	Television, radio & communications equipment
24	Professional & scientific equipment
25	Motor vehicles, parts & accessories
26	Other transpor equipment
27	Furniture
28	Other industries

Table 7: Key to sectoral numbers

What emerges is that for aggregate output, as well as for the mining and service sectors South Africa's growth performance has come to rely increasingly on the efficiency gains associated with growth in total factor productivity. Agriculture, forestry and fishing by contrast has consistently relied on growth in total factor productivity since the 1970's.

The manufacturing sector by contrast shows evidence of a structural break during the course of the 1990's, with a switch from output growth that was relatively heavily reliant on total factor productivity growth, to growth driven by capital accumulation.

Further evidence presented in the paper demonstrates that where total factor productivity growth is weighted by the size of a sector's contribution to aggregate output, efficiency gains in South African manufacturing are highly concentrated in a very small number of sectors in any given time period. This mirrors the finding of Harberger (1998) for the economy of the United States, and suggests that technological progress is more likely to be "mushroom-" than "yeast-like" in Harberger's terminology.

What also emerges from the evidence on real cost reduction in the manufacturing sector, is the considerable degree of "churning" amongst sectors over time. High growth in total factor productivity in one time period proves to be a very poor predictor of future efficiency gains by the same sector. Thus sectors which experienced large total factor productivity gains in the 1970's by no means necessarily experienced such gains during the course of the 1980's or 1990's. This finding carries significant policy implications. In particular, the implication would appear to be that subsidies and incentives targeted at specific sectors chosen for perceived promise in terms of future technological advance, are likely to fail. Quite simply the predictability of future efficiency gains due to total factor productivity appears to be low.

The findings of this paper do rest on the standard computation of the Solow residual. In the preceding discussion the limitations of this approach were specified. One line of further research is therefore to consider whether the conclusions presented above are sensitive to the relaxation of the assumptions that underlie the decomposition. A further set of questions would relate to the extent to which efficiency gains are related to endogenous growth processes in South Africa. However, such questions are beyond the scope of the present paper, and are left for future research.[18]

[18] Fedderke (2001) represents one possible extension in this direction.

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Appendix1: TFP data for South African Manufacturing Sectors

	Growth in Real GDP	Of which: Labour	Capital	TFP	Rank TFP
Other chemicals & man-made fibres	16.12	1.02	4.00	11.10	1
Basic chemicals	15.13	2.36	2.35	10.42	2
Electrical machinery	13.26	3.20	1.55	8.51	3
Plastic products	12.01	3.13	2.10	6.78	4
Paper & paper products	7.44	0.31	2.02	5.10	5
Textiles	2.80	0.67	-0.77	2.90	6
Machinery & equipment	4.96	1.91	0.53	2.52	7
Metal products excluding machinery	4.89	1.81	0.78	2.30	8
Food	6.60	1.57	2.94	2.09	9
Wood & wood products	5.02	1.24	1.86	1.92	10
Furniture	2.15	0.46	-0.11	1.80	11
Motor vehicles, part & accesories	5.54	2.97	1.01	1.56	12
Wearing apparel	3.80	2.52	-0.04	1.33	13
Beverages	8.09	1.83	5.02	1.24	14
Basic iron & steel	6.29	2.63	3.42	0.24	15
Rubber products	3.36	1.41	2.02	-0.06	16
Other industries	3.82	2.94	0.95	-0.08	17
Non-metallic minerals	2.69	0.49	2.74	-0.54	18
Footwear	0.62	0.54	0.64	-0.56	19
Basic chemicals	4.87	3.29	2.51	-0.92	20
Glass & glass products	1.63	-0.13	2.72	-0.96	21
Printing, publishing & recorded media	0.87	1.99	0.73	-1.86	22
Other transport equipment	3.29	3.30	2.21	-2.22	23
Leather & leather products	-0.04	1.66	0.65	-2.35	24
Tobacco	0.26	0.28	2.60	-2.62	25
Professional & scientific equipment	-4.53	-0.12	0.34	-4.74	26
Television, radio & communication equipment	-1.48	2.65	1.91	-6.04	27
Coke & refined petroleum products	-3.11	0.65	21.46	-25.22	28

Table 8: Manufacturing Sector Output Growth Decomposition in the 1970's

	Growth in Real GDP	Of which: Labour	Capital	TFP	Rank TFP
Other industries	15.65	1.26	-0.22	14.62	1
Coke & refined petroleum products	17.63	1.51	4.10	12.02	2
Television, radio & communication equipment	12.47	2.39	0.09	9.99	3
Professional & scientific equipment	13.48	3.34	2.28	7.65	4
Plastic products	9.07	3.39	2.02	3.67	5
Motor vehicles, part & accesories	5.89	0.58	1.76	3.55	6
Furniture	8.11	3.93	1.08	3.10	7
Glass & glass products	4.34	-0.63	2.06	2.92	8
Printing, publishing & recorded media	4.99	1.50	0.64	2.86	9
Leather & leather products	3.80	1.27	-0.22	2.76	10
Rubber products	2.49	-0.07	0.09	2.47	11
Beverages	6.54	0.92	3.85	1.77	12
Tobacco	0.53	-0.05	-1.15	1.73	13
Wearing Apparel	3.26	1.34	0.20	1.72	14
Basic non-ferrous metals	3.28	0.17	1.70	1.41	15
Basic iron & steel	-0.67	-0.58	-0.26	0.17	16
Other chemicals & man-made fibres	2.44	1.95	0.68	-0.19	17
Metal products excluding machinery	-0.47	-0.04	0.21	-0.64	18
Wood & wood products	0.68	1.05	0.32	-0.70	19
Textiles	-0.71	-0.46	0.82	-1.07	20
Paper & paper products	4.28	1.47	3.89	-1.07	21
Footwear	1.82	2.40	0.53	-1.11	22
Non-metallic minerals	0.78	0.51	1.78	-1.52	23
Food	-0.05	0.79	1.13	-1.96	24
Other transport equipment	-3.04	0.73	-0.30	-3.47	25
Electrical equipment	-1.00	1.33	1.26	-3.60	26
Basic chemicals	2.04	0.77	5.38	-4.10	27
Machinery & equipment	-3.33	0.64	0.80	-4.77	28

Table 9: Manufacturing Sector Output Growth Decomposition in the 1980's

	Growth in Real GDP	Of which: Labour	Capital	TFP	Rank TFP
Basic iron & steel	3.73	-2.29	3.02	3.00	1
Basic chemicals	1.35	-1.38	0.02	2.72	2
Machinery & equipment	1.32	-1.11	-0.16	2.60	3
Wearing Apparel	1.84	0.67	-0.56	1.72	4
Wood & wood products	2.02	0.72	0.38	0.93	5
Leather & leather products	0.52	-2.61	2.56	0.57	6
Professional & scientific equipment	0.35	-0.12	0.02	0.45	7
Non-metallic minerals	-1.15	-1.49	-0.02	0.36	8
Other chemicals & man-made fibres	0.55	-0.77	1.22	0.10	9
Electrical machinery	1.71	1.83	-0.19	0.07	10
Food	1.28	-0.59	1.82	0.06	11
Tobacco	-3.68	-2.52	-1.14	-0.02	12
Metal products excluding machinery	-0.09	-0.45	0.43	-0.07	13
Textiles	-1.98	-1.65	-0.11	-0.22	14
Footwear	-3.57	-2.69	-0.48	-0.40	15
Other industries	7.45	-0.23	8.45	-0.76	16
Paper & paper products	0.11	0.01	1.46	-1.36	17
Basic non-ferrous metals	10.55	-1.16	13.58	-1.87	18
Plastic products	2.58	0.91	4.02	-2.35	19
Rubber products	-1.81	-0.88	1.86	-2.79	20
Glass & glass products	-0.27	-0.46	3.05	-2.87	21
Furniture	-1.13	0.79	2.00	-3.91	22
Printing, publishing & recorded media	-1.43	0.70	1.82	-3.95	23
Coke & refined petroleum products	-2.57	-0.31	1.90	-4.16	24
Other transport equipment	-5.43	-1.08	-0.15	-4.20	25
Motor vehicles, parts & accessories	-1.74	0.79	2.45	-4.98	26
Beverages	-2.76	-1.08	3.44	-5.12	27
Television, radio & communication equipment	-1.98	2.50	1.97	-6.45	28

Table 10: Manufacturing Sector Output Growth Decomposition in the 1990's