Productivity growth of Dutch agriculture, 1949-1989

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ABSTRACT

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Productivity measurement has become an important tool for assessing the productive achievements of a nation's agricultural sector. This study presents the results of such an assessment for Dutch agriculture since World War II. Contrary to most other studies in this field, agricultural education, extension and research have been included as inputs to agriculture. The data show that - for the whole period - the growth of gross total productivity was 3.0% per annum. Fastest growth occurred in the Sixties, when the annual growth rate was 3.7%. In an attempt to assess the benefits of (governmental) investments in education, extension and research - the so-called non-traditional inputs - the internal rate of return was calculated at between 25 and 40%.

A particular feature of productivity growth in the Netherlands is that it has come about through a very high growth of output, combined with a rather large use of inputs. This at least becomes apparent when comparing Dutch agricultural productivity performance with that of other western countries. In other countries, productivity growth resulted foremost from a relatively modest growth of inputs.

Productivity/Productivity growth/Index numbers/Agricultural Economics/Human capital/The Netherlands

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CONTENTS

PREFACE

This booklet presents the results of a research after productivity growth in Dutch agriculture since 1949. This research was part of a much broader study on the Dutch technology policy in agriculture that was undertaken by the LEI-DLO and the National Council of Agricultural Research (NRLO) at the request of the Dutch Council of Scientific Advice to the Government (WRR). This study is published in Dutch language only (Van der Meer, Rutten and Dijkveld Stol, 1991). Only a part of the quantitative results of the productivity research has been published in the final WRR- study. In order to make all relevant data available, the LEI-DLO decided to publish these separately. It should be noted, however, that after the manuscript for the WRR was finished, the construction of the productivity series has been improved and the series themselves have been updated. Consequently, the final data as published in the WRR-study are not fully similar to those in this study.

The director,

L.C. Zachariasse

The Hague, September, 1992

1. INTRODUCTION

To each producer, the quantity of inputs needed to produce a certain quantity of output is an important indicator of his productive performance. Whatever the type of business one is engaged in, knowledge of the development of physical productivity stands at the core of individual enterprises. At the more aggregate level, however, data on productivity are often outdated or even completely lacking. This also is the case for the Dutch agricultural sector (i.e., animal and arable production and horticulture). In fact, Stolwijk (1976) represents the first and thus far only comprehensive productivity study on Dutch agriculture which encompasses all production factors. Beside this study, some research had been done after the land or labour productivity of Dutch agriculture, e.g. Van den Noort (1970), Van der Meer (1989), and Van der Meer and Yamada (1986).

This report presents and discusses a quantitative analysis of productivity growth of Dutch agriculture in the period 1949-1989. The underlying study focused on the agricultural sector as a whole. As a consequence, structural adjustments within the agricultural sector (e.g., the growth of glasshouse horticulture and intensive livestock-breeding) are only touched upon. The same applies to (the evolution of) the relationship between agriculture and related enterprises (supplying and processing firms). A further restriction is that, analogous to the National Accounts approach, the empirical analysis only deals with inputs and goods which can be valued directly into monetary terms. The production (or sacrifice) of other goods - partly connected with external effects - is not taken into consideration.

The structure of this report is as follows. First the concept of productivity is examined (chapter 2). Here, we briefly discuss concepts of output and input, productivity ratios and measurement problems. In chapter 3 the results of a productivity analysis of Dutch agriculture (1949-1989) will be presented, whereas the next chapter deals with the impact of investment in 'human capital' (research and development, education and extension) on productivity growth. Chapter 5 goes somewhat deeper into the sources of productivity growth, as it presents a test of two hypotheses from the well-known Induced Innovation theory. In chapter 6 the results from chapter 3 as well as those of other productivity studies on Dutch agriculture are compared with international productivity data. In the final chapter some conclusions are drawn.

Annexes A, B and C contain the time-series that have been constructed for this study, including a description of the data variables and data sources.

2. THE CONCEPT AND MEASUREMENT OF AGRICULTURAL PRODUCTIVITY

There are a number of productivity ratios available to express the quantity of inputs needed for obtaining a certain output. These ratios differ from one another in how input and output are being defined. In case the definition of 'input' is restricted to a single factor of production, the ratio represents partial productivity. A popular example is labour productivity. The ratio that relates all inputs or all factor inputs to output represents total productivity. Next, 'output' can be defined in a number of ways, e.g. as total gross or net value added. Figure 2.1 summarizes some concepts of productivity. What type of productivity ratio should be used depends primarily on the goals of the research. Thus, when one is interested in factor allocation, partial productivity ratios should be calculated. When the productivity performance - or the technical efficiency of the production process - is the object of analysis, a total productivity ratio is required. In each case, however the concepts of output and input need to be well defined. Annex B gives detailed information about how these concepts have been defined in this study.

Coverage of input	Coverage of output	
	Total production	Net value added
Single factor (e.g. labour)	Gross factor productivity	Net factor productivity
All factors	Gross multifactor productivity	Net multifactor productivity
Total input 1)	Gross total productivity	

1) Factor plus non-factor input; see Annex B for a more detailed description.

Figure 2.1 A schematic review of concepts of productivity

In this study 'human capital' has been added as a fourth factor of production, representing public expenditures on agricultural research and development, education and extension. For these so-called non-traditional inputs the agricultural sector pays only to a very limited degree. The incorporation of these inputs serves as a second-best solution to the problem of how to deal with changes in the quality of factors of production. For quality changes are only partly reflected by prices. This can be seen most clearly in the case of agricultural labour: its price is to a very limited extent determined by the level of skills. Consequently, without correction, the measurement of the volume of labour by means of hours worked underestimates the actual labour input and overestimates labour productivity. It is however very difficult and time-consuming to construct acceptable quality-adjusted series for labour inputs, and the same holds for the other traditional factors of production (capital and land). The addition of human capital, for which measurement was more feasible, can therefore be regarded as a sort of artificial catch-all for quality changes.

Once the output and input concepts have been defined, a number of steps have to be taken before a productivity ratio can be computed. The first step involves the problem of adding heterogenous inputs and goods: how to add the physical output of apples to the physical output of pears? This can be done by adding values instead of quantities. But this creates another problem, since the sum of values needs to be made 'physical' again. The second step is to construct series of value in constant prices, which can be considered as an approximation of quantity series. But in order to enable aggregation of individual 'pseudo physical' series, they must somehow be weighted over time. In other words: which base year should be chosen? Especially when the analysis covers several decades, the choice of the base year may have a strong impact on the outcomes of productivity measurements. For when base year X is chosen, it is implicitly assumed that the shares of individual inputs or outputs remain constant during the period for which series are being computed. But in reality, these proportions change over time. This problem, commonly known as the index number problem, cannot fully be solved, so some degree of distortion must be accepted. To draw the sting somewhat, several base-years can be chosen. Subsequently, the resulting series can be smoothed by means of the chain-linking procedure. (Annex C gives an example of how these chain-linked series have been constructed.) Furthermore, most aggregated series have been constructed by means of a Tornqvist-index (see Annex B).

3. TRENDS IN INPUT, OUTPUT AND PRODUCTIVITY

3.1 Input and output

During the period 1949-1989 enormous changes have taken place within Dutch agriculture. The number of farms (of more than 1 hectare) has decreased from 250,000 to 115,000, and the agricultural labour force has shrunk from 530,000 to 230,000 full-time labour units. On the other hand the development of the productive capacity of agriculture was even more marked. These few facts alone indicate that a far-reaching process of substitution and technical change must have taken place. Indeed, aggregate data on this period show that whereas factor input has declined at an average rate of almost two per cent per year, the use of non-factor inputs has on average increased by more than four per cent each year (table 3.1). Total input increased slightly, whereas total production increased rapidly (see figures 3.1a and 3.1b). The average growth rate 1) of total production and gross value added, for example, was three per cent or more.

Table 3.1 Growth rates (%) of the volume of output and input, 1949-1989

Item	Period a)				
	1950/ 1960	1960/ 1970	1970/ 1980	1980/ 1988	1950/ 1988
Total production	3.61	3.79	4.39	2.42	3.61
Intermediate consumption	7.10	4.61	4.34	1.16	4.45
Gross value added b)	1.41	3.11	3.59	4.21	3.02
Depreciation	2.12	4.16	4.76	2.77	3.48
Net value added b)	1.34	3.00	3.33	4.41	2.94
Non-factor input c)	6.51	4.52	4.33	1.25	4.29
Factor input d)	-1.79	-3.04	-1.05	-1.47	-1.86
Total input	1.42	-0.09	1.07	-0.47	0.58

a) 1950 = average of 1949-1951, etc.; b) At market prices; c) Intermediate consumption plus depreciation; d) Including non-traditional inputs (see text).

1) Unless stated otherwise, growth rates refer to *annual* growth rates.

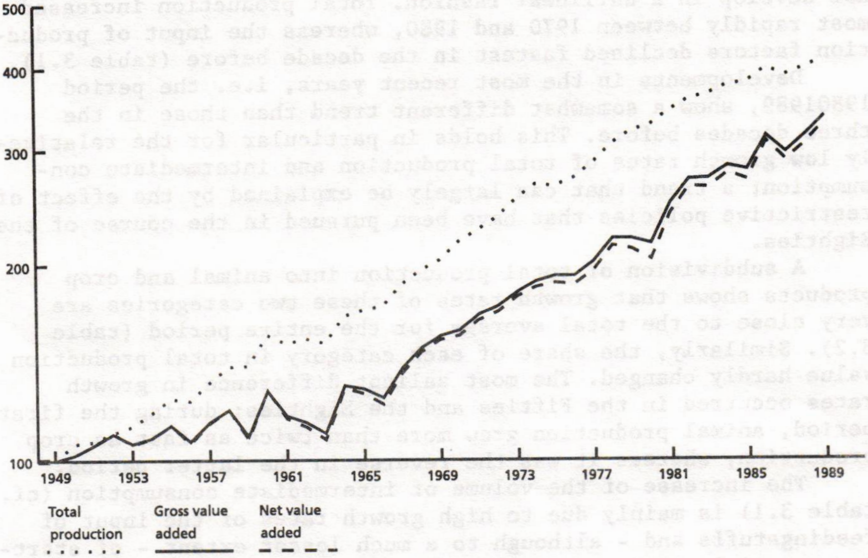

Figure 3.1a The development of three output categories, 1949-1989 (volume index, 1949=100; log scale)

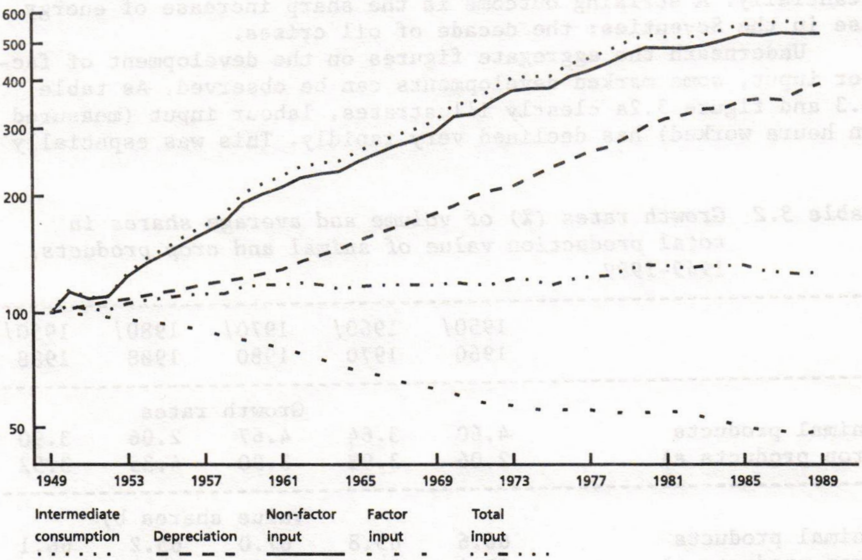

Figure 3.1b The development of five input categories, 1949-1989 (volume index, 1949=100; log scale)

A break-down in sub-periods shows that output and input did not develop in a unilinear fashion. Total production increased most rapidly between 1970 and 1980, whereas the input of production factors declined fastest in the decade before (table 3.1).

Developments in the most recent years, i.e. the period 19801989, show a somewhat different trend than those in the three decades before. This holds in particular for the relatively low growth rates of total production and intermediate consumption; a trend that can largely be explained by the effect of restrictive policies that have been pursued in the course of the Eighties.

A subdivision of total production into animal and crop products shows that growth rates of these two categories are very close to the total average for the entire period (table 3.2). Similarly, the share of each category in total production value hardly changed. The most salient difference in growth rates occurred in the Fifties and the Eighties: during the first period, animal production grew more than twice as fast as crop production, whereas it was the reverse in the latter period.

The increase of the volume of intermediate consumption (cf. table 3.1) is mainly due to high growth rates of the input of feedingstuffs and - although to a much lesser extent - of starting material (seeds, livestock) (table 3.4). Between 1980 and 1989, most non-factor inputs had much lower growth rates than before. The input of energy products even declined, although their value share in total intermediate consumption rose substantially. A striking outcome is the sharp increase of energy use in the Seventies; the decade of oil crises.

Underneath the aggregate figures on the development of factor input, some marked developments can be observed. As table 3.3 and figure 3.2a clearly illustrates, labour input (measured in hours worked) has declined very rapidly. This was especially

Table 3.2 Growth rates (%) of volume and average shares in total production value of animal and crop products, 1949-1989

	1950/ 1960	1960/ 1970	1970/ 1980	1980/ 1988	1950/ 1988
			Growth rates		
Animal products	4.60	3.64	4.67	2.06	3.90
Crop products a)	2.06	3.98	3.90	4.35	3.52
			Value shares b)		
Animal products	66.6	65.8	67.0	65.2	66.1
Crop products a)	33.4	34.2	33.0	34.8	33.9

a) Including products from horticulture; b) Average shares over entire sub-period, i.e. over 1949-1960, 1960-1970, etc.

Table 3.3 Growth rates (%) of volume and average shares in factor input value of labour, capital, land and 'human capital, 1949-1989

	1950/ 1960	1960/ 1970	1970/ 1980	1980/ 1988	1950/ 1988
			Growth rates		
Labour	-2.48	-4.79	-2.96	-1.32	-2.98
Capital	0.40	2.12	3.32	1.03	1.75
Land	-0.04	-0.42	-0.51	-0.34	-0.33
Human capital a)	11.47	6.39	0.31	0.75	4.84
			Value shares b)		
Labour	82.15	77.81	68.10	65.70	73.96
Capital	10.95	13.70	22.93	24.90	17.70
Land	5.03	4.65	4.44	4.86	4.73
Human capital a)	1.87	3.85	4.53	4.53	3.62

a) Human capital here implies public expenditure on research and development, extension and education (See Annex B); b) Average value shares over entire sub-period, i.e. over 1949-1960, 1960-1970, etc.

Table 3.4 Growth rates (%) of volume and average shares in intermediate consumption value of several items, 1949-1989

	1950/ 1960	1960/ 1970	1970/ 1980	1980 1988	1950/ 1988
			Growth rates		
Starting material	8.75	12.30	10.14	9.27	10.24
Feedingstuffs	12.01	5.74	5.81	2.02	6.68
Fertilizers	2.41	1.84	2.16	0.16	1.79
Energy/lubricants	4.53	3.33	7.69	-2.38	3.85
Other	2.24	2.39	1.13	1.53	1.84
			Value shares *)		
Starting material	1.08	1.24	2.76	3.76	2.92
Feedingstuffs	55.64	64.76	65.09	60.97	62.55
Fertilizers	17.43	11.51	8.55	8.26	9.42
Energy/lubricants	4.34	3.54	6.32	9.85	7.34
Other	21.51	18.96	17.28	17.16	17.77

*) Average value shares over entire sub-period, i.e. over 1949-1960, 1960-1970, etc.

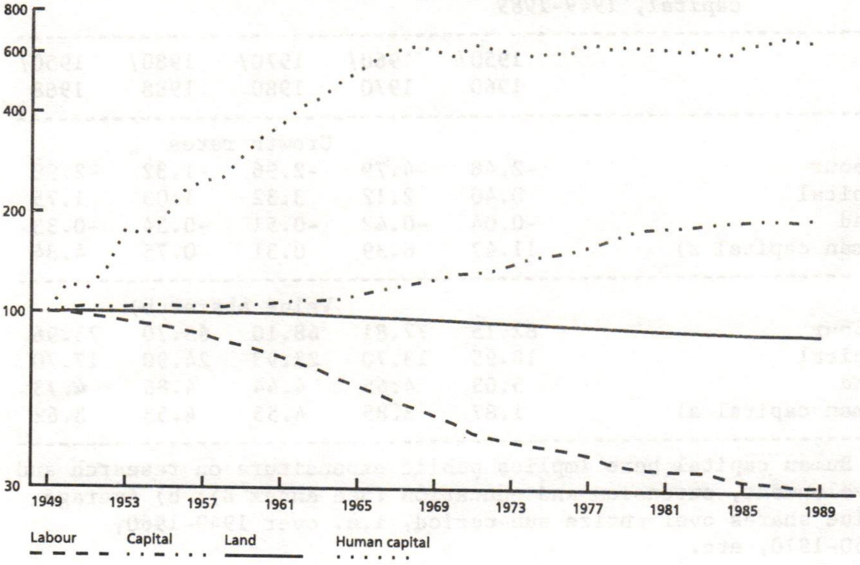

Figure 3.2a The development of factor input, 1949-1989 (volume index, 1949=100; log scale)

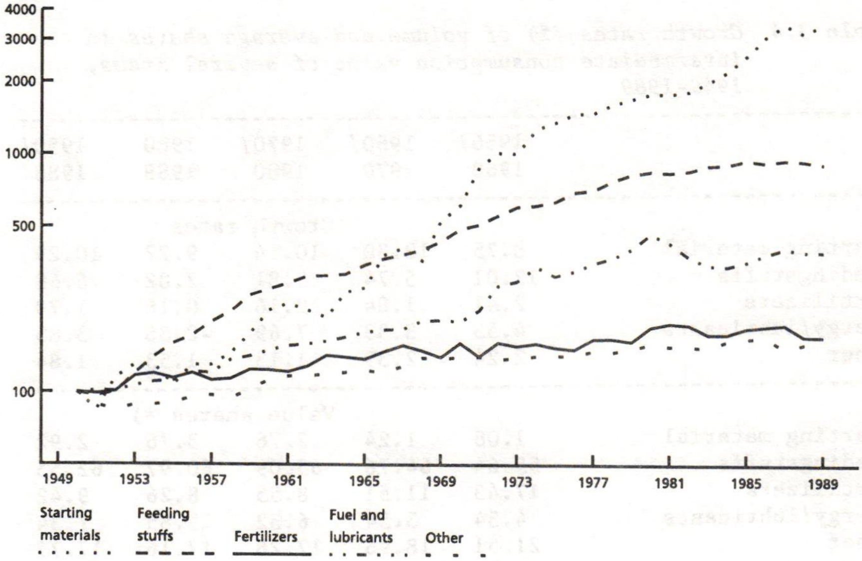

Figure 3.2b The development of non-factor input, 1949-1989 (volume index, 1949=100; log scale)

the case between 1960 and 1970, as a result of the fast growth of non-agricultural sectors. Capital input, on the other hand, has increased, with highest average growth rates between 1970 and 1980. Apparently, the actual replacement of labour by capital took some time to materialize. During the Eighties, the growth pattern of factor inputs has become relatively moderate, i.e. the observed changes in labour and capital input were much smaller than during the three decades before 1980. Because of a relatively sharp increase of the price of labour, the share of labour in the total value of factor input declined only from four fifths to two thirds, whereas the value share of capital more than doubled.

Mainly due to the decline of the dairy livestock after the implementation of the superlevy (1984), the volume input of feedstuffs increased at a relatively low rate (see table 3.4 and figure 3.2b). Since prices fell as well, the value share of feedingstuffs declined somewhat. The volume growth of energy use shows a remarkable trend, since it increased relatively sharp in the Seventies - the decade of the oil crisis and sky-rocketing energy prices!

3.2 Productivity growth

The input and output developments dealt with above, can be combined and summarized by means of productivity indicators. As table 3.5 shows, gross total and net multifactor productivity increased at an annual growth rate of three, respectively (almost) five per cent. Whereas in each sub-period the growth rate of gross total productivity comes close to the average rate for the entire period, net multifactor productivity shows a more erratic growth pattern. The relatively high growth rate between 1980 and 1989 of the latter indicator was due to the high growth rate of net value added (which on its turn was the result of a moderate growth of depreciation; see also table 3.1).

*Table 3.5 Growth rates of gross total and net multifactor productivity and terms of trade, 1949-1989 *)*

	1950/ 1960	1960/ 1970	1970/ 1980	1980/ 1988	1950/ 1988
Gross total productivity	2.16	3.70	3.28	2.91	3.01
(Terms of trade)	(-2.30)	(-3.51)	(-5.28)	(-1.79)	(-3.30)
Net multifactor prod'ty	3.20	6.24	4.40	5.97	4.89
(Terms of trade)	(-3.59)	(-5.83)	(-8.89)	(-3.05)	(-5.49)

*) See figure 3.1.

Whereas productivity is a measurement of physical output-input relations, the terms of trade measure the price-ratio of output and input. Data on both productivity and terms of trade give an indication of how the aggregate income position of the sector has developed over time. Table 3.5 makes clear that throughout the period 1949-1989 productivity growth was almost enough to fully compensate for the deterioration of the terms of trade (3.0 versus -3.3 per cent per annum). Especially in the Eighties a real improvement of the sectoral income occurred, for then the price-ratio of gross output and total inputs declined less than the physical ratio increased (-1.8 versus 2.9 per cent per annum). This decade was however preceded by one in which a significant worsening of the sectoral income took place.

The growth patterns of gross total and net multifactor productivity, as well as of gross labour, land and capital productivity are displayed in figure 3.3. Since the vertical axis is expressed in a logarithmic scale, it can easily be seen that the growth pattern of these productivity indicators is quite monotonous. Only in the case of gross total and net labour productivity, a slight acceleration of growth can be observed in the period 1963-1973. As table 3.3 shows, this was the result of the relatively fast decline of labour input during this period.

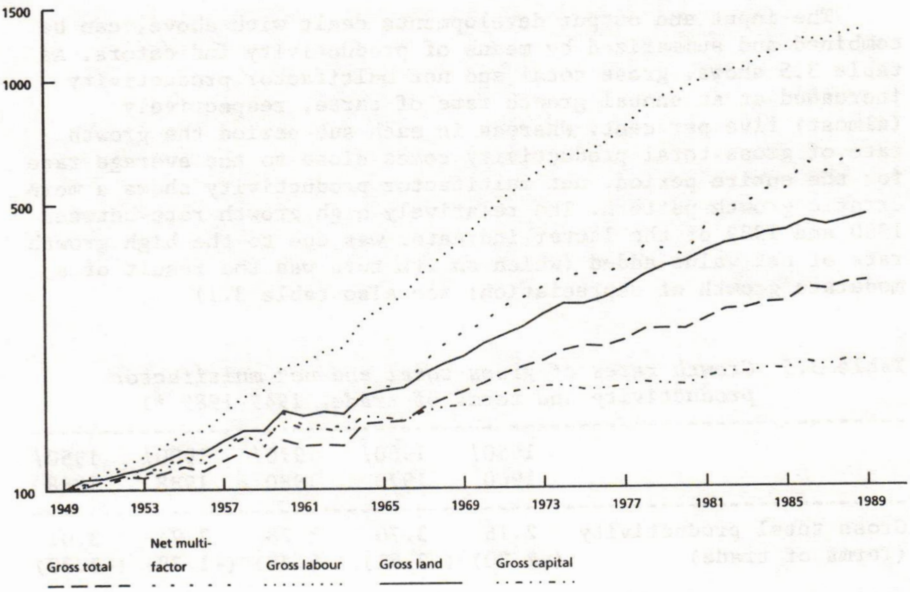

Figure 3.3 The development of five productivity indicators, 1949-1989 (1949=100; log scale)

A sligthly different way of quantifying output-input relations, is to compute to which degree an increase in production can be accounted for by a change in total input. Obviously, when output and input increase at the same rate, productivity change must be zero. In that case there is no 'unexplained residual', simply because there is nothing to be explained! In practice, however, the residual can be significant, resulting in productivity change. Table 3.6 presents the results of such a calculation.

This table clearly shows that throughout the entire period, the main part of production growth was to be accounted for by other things than input growth. Between 1980 and 1989, this unaccounted percentage was even more than 100.

Table 3.6 Total annual output and input growth and the 'unexplained' residual

	1950/ 1960	1960/ 1970	1970/ 1980	1980/ 1988	1950/ 1988
Growth rate of gross output	3.61	3.79	4.39	2.42	3.61
Growth rate of total input	1.42	0.09	1.07	-0.47	0.58
Unaccounted percentage *)	61	98	76	>100	84

) Calculated as: 100-100(Input growth/Output growth).

Whatever technique is used for productivity measurement (be it the output-input ratio or the residual), the results might only indicate that the list of inputs that are believed to be 'responsible' for output is not be exhaustive and/or that the inputs have not been measured properly. After all, one would like to know where the observed residual comes from. The mere fact that most productivity measurements do yield rather high 'unexplained residuals' has lead Solow (1957) to label this residual simply as 'technical change'. Others have - later - criticized this approach by pointing at the possibility that traditional measurements of both output and input quantities do not adequately account for quality improvements.

4. THE CONTRIBUTION OF PUBLIC INVESTMENT IN HUMAN CAPITAL TO PRODUCTIVITY GROWTH

4.1 Introduction

Public investment in human capital is often thought to play a significant role in productivity growth in agriculture. Not surprisingly, many attempts have been made to determine both the effectiveness and profitability of this investment. The general impression these attempts leave is that the rate of return to (public) investment in human capital is very high. Thus, Evenson (1979, 1989) estimated the contribution of expenditure on agricultural research to economic growth in the United States to be approximately 40 per cent. And Thirtle and Bottomley calculated the rate of return to be about 70 per cent for the United Kingdom between 1965 and the beginning of the Eighties.

In this chapter, such an attempt for Dutch agriculture will be presented. Contrary to most other studies, human capital here refers to research and development, as well as extension and education.

4.2 Basic assumptions and methods of estimation

4.2.1 Introduction

The productivity series discussed in earlier chapters enable an assessment of the benefits of investments in knowledge in Dutch agriculture. The first problem to be tackled is: how should both benefits and costs in this case be defined?

4.2.2 Benefits of investment in knowledge

When increases in knowledge result in productivity growth, it seems appropriate to assume that the benefits of investment in knowledge can be expressed as that part of productivity growth that cannot be explained by the increase of the volume of (traditional) inputs. This is the so-called residual (see 3.2). The benefits thus consist of realised productivity gains.

4.2.3 The costs of knowledge augmentation

The volume of knowledge that is available to agricultural producers on the one hand increases as a result of efforts in the field of research, extension and education, and - on the other hand - decreases because this knowledge is subject to economic obsolescence and forgetfulness. In this respect, the similarity between knowledge and capital goods is evident. The really available volume of knowledge, however, can never be determined fully, since an objective means of depreciation is lacking. Thus, while gross investment in knowledge can be calculated, net investment cannot. This gives an over-estimation of real costs. Moreover, the gross investment in knowledge have a bearing on activities that go beyond the field of productivity and technology in primary agriculture. E.g., it includes research and education for agriculture in developing countries and for forestry and fisheries.

The expenditures for extension are less biased: only a small part is directed towards fields other than productivity and technology in agriculture. On the other hand however, the contribution by the agricultural trade and industry to socio-economic extension has not been included in the expenditure data.

Finally, a large part of the capacity of academic research and of all types of education is not only directed towards other branches than primary agriculture, but also - even if they are aimed at primary agriculture - to other fields than productivity and technology. Unfortunately, figures on the share of primary agriculture in these activities are not readily available. Information from annual reports of the National Agricultural Research Council (NRLO) an the Agricultural University of Wageningen indicates this share to be roughly fifty per cent. As to education, the share will be somewhat higher.

In short, as far as the direct costs are concerned, a substantial (downwards) correction would give a better approximation of the real level of gross investments in research, extension and education for primary agriculture. But there are indirect costs as well. Thus, no account has been taken of the expenditures that are induced by the (increased) negative external effects of agricultural production; external effects that are somehow related to public investments into productivity and technology.

Although the general opinion of society is that these negative external effects should be subtracted from the value of production - an thus from productivity gains - there is great uncertainty as to the weighting of these costs and as to how far the principle should be applied to agriculture. In other words, although the financial burden of efforts to increase knowledge in agriculture (efforts that originate from public goals among which the advancement of income, productivity and employment) largely lies with the state, the social costs of negative external effects are passed through to non-agricultural producers and to consumers.

Nevertheless, all these pros and cons taken together, the direct costs are expected to produce a reasonable image of gross investments in knowledge augmentation. At the same time, they make clear that the final figures are of a very indicative nature.

4.2.4 Time lag

Investments in knowledge do not give immediate results. There will mostly be a period of 'ripening' before they produce economic benefits. Since the length of the ripening period will probably differ from case to case - if known at all - one can only roughly approximate it by supposing a certain time-lag for categories of knowledge investment. The time-lags for the effect of investments in research, extension and education on productivity gains have been set at five, one, and three years respectively.

Furthermore, it has been assumed that the efficiency of the utilization of knowledge has remained constant during the entire period; an assumption that leaves out the possibility that there is a back-log in the utilization of knowledge. I.e., a constant relationship is assumed to exist between what is technologically possible and the average utilization of technological possibilities. In reality this relationship will vary over time.

4.3 Results

In order to estimate - and properly interpret - the ratio of benefits and costs, it is always necessary to make assumptions about the accountability of the benefits. According to one method all investments in knowledge are summarized and related to the residual of traditional productivity analysis. This is the method Yamada (1967) followed. Another method takes the annual investments in knowledge as costs, and the annual residual as benefits and subsequently calculates the internal rate of return which is the rate of interest that equals the net present value of the benefits and that of the costs. The results of both methods are given in table 4.1 1).

An advantage of Yamada's method is its simplicity and transparency, which cannot be said of the method that uses the internal rate of return. A disadvantage however is that time-lags cannot be implemented since this method only allows for calculations on relatively short periods. A further problem is that the Yamada method is very sensitive to the choice of the price base that is needed to sum up investments. However, as table 4.1 shows, this problem is not present when we compare periods: the development of the residue is more telling than it's absolute value.

The calculations based on Yamada's method show surprisingly small differences between periods. Only in the Fifties the return seem to have been quite low. Considering the large dif-

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1) These calculations are based on the data of 1949-1987. Due to lack of time, the most recent years (1988 and 1989) have not been incorporated.

Table 4.1 Returns to expenditures on knowledge (%) as calculated by different methods, 1950-1988

Method and productivity basis a)	1949/ 1959	1960/ 1969	1970/ 1979	1980/ 1987	1949/ 1987
Internal rate of return method b)					
- gross basis	-	-	-	-	40.0
- net basis	-	-	-	-	25.0
Yamada's method c)					
- gross basis	125.0	168.9	199.5	132.1	156.4
- net basis	89.2	120.0	84.2	101.3	98.7

a) The residual is the difference between total input and total production (method 'gross') or the difference between factor input and net value added (method 'net'); b) Price basis: current prices; c) Price basis: prices of 1970. For each period, the cumulated benefits (the residue) are divided by the cumulated costs (the expenditures). The ratio is multiplied by 100.

ference between the gross and net residuals, it cannot be said with certainty that there is a slow-down of the returns in the Eighties.

The internal rate of return method gives satisfying results. Although a rate of return of 25 to 40 per cent comes close to results from other studies - for other countries - an important difference is that in this study expenditures on extension and education are included.

5. INTERMEZZO: A TEST OF TWO INDUCED-INNOVATION-HYPOTHESES

The series of output and input enable a test of a number of Induced-Innovation-hypotheses made by Hayami and Ruttan (1985) and Yamada and Ruttan (1980). It is for example possible to test the hypothesis which states that a negative relationship can be expected between the price of fertilizer relative to the price of land and the use of fertilizer per hectare. In other words, when fertilizer becomes cheap relative to land, its use per hectare will increase. This will not only occur in the short run (i.e., with given techniques), but in the long run as well since this price movement will induce a search for more fertilizer-responsive crops. Furthermore, when labour becomes more expensive relative to land, farmers will be induced to substitute 'fertilizers and other chemical inputs such as herbicides and insecticides for more labour-intensive husbandry practices' (Yamada and Ruttan: 522). Thus, fertilizer use per hectare can be expected to be positively related to the price of labour relative to land. These two hypotheses can be combined into the following equation:

$$LN(\frac{Q_c}{Q_a}) = C + \alpha LN(\frac{P_c}{P_a}) + \beta LN(\frac{P_l}{P_a})$$

where, Qc= quantity of fertilizer and pesticides;
Qa= quantity of land;
Pc= price of fertilizer and pesticides;
Pl= price of labour;
Pa= price of land.
C = constant

All variables are measured as indexes of quantities and prices respectively. The results of a test of both hypotheses combined into one equation are given in table 5.1.

Over the entire period (1950-1989), more than 80 per cent of the variance of the use of chemicals per hectare can indeed be explained by the movement of two price ratios, namely the price of chemicals relative to land (Pc/Pa), and the price of labour relative to land (Pl/Pa). The signs of the coefficients are as expected and both the T-test and the Durbin-Watson-test yield fairly good results. Only when the period is split into two parts, does the degree of determination become very low (31% for the second half). Although significantly greater than zero, the level of the coefficient of the labour-land price ratio is low compared to that of the chemicals-land price ratio, although it cannot pass the test in the second period (cf. the high level of T-significance). The relatively high (negative) coefficient of the chemicals-land price ratio in the first half of the period (i.e. relative to the second half) is rather surprising; it indicates that the inducement effect was relatively great then.

Table 5.1 Relationship between the use of chemicals (fertilizers and pesticides) and relative factor prices in the Netherlands, 1950-1989

Period	Coefficient of prices ratios		T-significance		R2	Stand. error	DFE	Durbin-Watson-test
	Pc/Pa	Pl/Pa	Pc/Pa	Pl/Pa				
1950-'69	-0.45	0.26	0.001	0.006	0.85	0.05	16	1.50
1970-'89	-0.29	0.20	0.018	0.235	0.31	0.07	16	1.76
1950-'89	-0.34	0.25	0.000	0.000	0.84	0.06	36	1.68

An identical test has been done for a very similar hypothesis, based on the perception that concentrate feeds 'occupy a role in livestock production similar to fertilizer in crop production. As the price of concentrate feeds has declined over time they have been increasingly substituted for forages, hay, and other roughages.' (idem: 523). Here, the use of feed concentrates per hectare is expected to be negatively related with the price ratio of concentrates and land, and positively with that of labour and land. As to the latter price ratio, the reasoning is that labour-intensive practices (like roughage and hay production) will be substituted for by concentrates when labour becomes expensive relative to land. Again, this substitution is not confined to the short run, since this relative price movement will induce the development of husbandry practices that allow for such substitutions to take place (idem: 523). The corresponding equation is:

$$LN\left(\frac{Q_f}{Q_a}\right)=C+\alpha LN\left(\frac{P_f}{P_a}\right)+\beta LN\left(\frac{P_l}{P_a}\right)$$

where, Qf= quantity of feedconcentrates
Pf= price of feedconcentrates.

This second hypothesis, which is also part of the 'model of biological technology' as Yamada and Ruttan called it, is confirmed by the data for the Netherlands (table 5.2).

All the coefficients have the expected signs, and the degree of determination is surprisingly high. In fact, the only worrisome outcome is the rather low score on the Durbin-Watson test although it remains just within the one per cent level of significance.

Table 5.2 Relationship between the use of feed concentrates and relative factor prices in the Netherlands, 1950-1989

Period	Coefficient of prices ratios		T-significance		R2	Stand. error	DFE	Durbin-Watson-test
	Pc/Pa	Pl/Pa	Pc/Pa	Pl/Pa				
1950-'69	-1.48	0.97	0.000	0.000	0.98	0.08	16	1.45
1970-'89	-0.55	0.54	0.000	0.001	0.79	0.05	16	1.80
1950-'89	-0.81	0.84	0.000	0.000	0.85	0.07	36	1.69

The analysis thus clearly supports the induced innovation theory: factor use has been influenced by changes in relative factor prices. One of the mechanisms through which such an effect takes place is that techniques are being introduced that enable producers to continue substituting the relatively cheap factor of production for the relatively expensive factor of production. These price-induced changes in techniques are therefore of crucial importance to a better understanding of productivity growth.

6. INTERNATIONAL COMPARISON OF DATA ON TOTAL PRODUCTIVITY

How does agricultural productivity in the Netherlands perform in comparison with agricultural sectors abroad? Answering this question meets two major problems : the first and relatively innocent one is that studies in which the Netherlands is one of the countries compared rarely use the same period. The second problem is far more serious, namely differences in research methodology. We have already mentioned the problem of how to choose the 'right' productivity indicator, how to choose the 'right' index number technique and how to measure all inputs and outputs concerned. In these three fields, there is such a variety of approaches, that even when the studies cover the same period, it is merely coincidence when results are identical. Therefore, comparisons such as those summarized in table 6.1 should be interpreted carefully for they only give an impression of how the global magnitude (and sign) of the final productivity data compare to each other.

Table 6.1 Growth rates of total agricultural productivity a) for several countries and periods according to different studies

Studies and periods	LEI-DLO study Netherlands b)	Countries according to several studies: Netherlands	German federal	United Kingdom	France	Denmark	EC-9
(1) Van den Noort							
1950-1962	*3.2*	3.8	2.6	-	-	-	-
(2) Behrens/ De Haan							
1963-1970	*4.6*	2.5	1.6	1.5	1.7	1.1	1.7
1963-1976	*4.2*	2.5	2.0	1.4	1.6	1.5	1.8
(3) Henrichsmeyer							
1965-1985	*3.6*	1.5	1.4	2.2	1.6	1.6	1.7
(4) Hochmann c.s.							
1975-1984	*2.7*	2.1	1.9	2.7	2.3	3.3	2.2
(5) Bureau c.s. c)							
1974-1987	*2.8*	2.2	1.5	2.1	2.3	1.9	2.1

a) Study 1 refers to net multifactor productivity, whereas the studies 2-5 refer to gross total productity; b) Non-traditional inputs have been excluded in the productivity data from the LEI-DLO study; c) EC here refers to EC-10.

This table deserves some further explanation. It actually gives four types of comparisons:

- net multi-factor productivity vis-à-vis gross total productivity (all studies taken together, including this study);
- productivity performance of country X vis-à-vis that of country Y (within each study);
- productivity performance for the Netherlands as measured by this study vis-à-vis results for the Netherlands from other studies;
- differences between periods.

The figures for the Netherlands from our study (given in italics) are only added to illustrate that although the trend they show corresponds with that from other studies, their magnitude is incomparable. The causes of the sometimes rather large difference between the productivity figures from this study and those from the other studies mentioned in the table, are manifold. A major cause, however lies in the way labour input has been measured: in this study, labour has been measured in hours worked, whereas in the other studies the measurement unit is number of people, man-years, or full-time labour-units.

This being said, these figures do give a slight impression of the relative performance of Dutch agriculture. Thus, they clearly indicate that some of the countries mentioned in the table have experienced a higher growth of total (agricultural) productivity than the Netherlands.

Especially during the second half of the Seventies, and the first half of the Eighties, Dutch agriculture seems to have lost its leading position in the top of the best performing countries. Compare for example the figures given by Behrens and De Haen for 1963-1976 with those given by Hockmann and Bureau et al. (1991).

An important finding by Behrens and De Haen, as well as by Hockmann is that their decomposition of productivity growth shows that the relatively high growth rate of productivity of Dutch agriculture between 1963 and 1976 (table 6.1) is predominantly caused by a high growth of gross output, since that of gross input was much higher in the Netherlands than elsewhere. The latter on its turn was caused by a relatively slow decline of the labour volume in agriculture and a relatively high growth of the use of machinery.

7. RETROSPECT AND PROSPECT

By definition, productivity growth is nothing more than the occurrence of a divergence between measured output and input growth. From a stringent theoretic point of view, the existence of productivity growth is rather puzzling. For how can it be possible for output to grow faster than input, when both are measured in identical units? This can in fact only take place when starting from a situation in which factors and means of production lay idle, i.e., are actually not being used fully. Stated this way, productivity growth can only be a catching-up of a state of inefficiency, or else it must be the result of erroneous measurement!

The way productivity growth is being conceived nowadays is much less strict in that it allows for measurable but unexplainable progress in the combination of inputs and output. Such an approach has been followed in this study, in the sense that an effort was made to construct quasi-physical time-series for several categories of input and output. Without other frames of reference, these series only show that:

a) a substantial part of the growth of production can indeed not be accounted for by the growth of inputs;
b) productivity growth of Dutch agriculture has had its ups and downs since 1949. E.g., in the Sixties productivity increased at a higher rate than in the other decades;
c) the components of productivity growth (categories of output and input) evolved in a specific way. To illustrate this, consider the rate of productivity growth in the Eighties as compared to the Seventies: although gross total productivity increased at an almost similar rate, total production increased much less in the Eighties than in the Seventies, while total input even decreased.

The latter finding is of particular interest, for it may indicate that the technological path followed by Dutch agriculture differs from the one followed earlier: more directed towards an overall strategy of input-saving and less toward output-increasing (Cf. Hutten and Rutten, 1990).

In spite of all shortcomings to productivity analysis, it would therefore be worth-while to repeat an exercise as this study each five years. Not only do these analyses give a somewhat better understanding of the magnitude and components of productivity growth, they also help set the contours of quantitative research after technological change. Especially in the light of the new challenges and threats the agricultural sector nowadays is confronted with, monitoring the productive performance of the sector remains an important task.

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ANNEXES

ANNEX A DATA ON OUTPUT, INPUT AND PRODUCTIVITY IN DUTCH AGRICULTURE

Mark:

Of each category of input and output, two tables are presented in this annex:

a) the development of value in current prices, and of cumulated volume and price indexes;
b) the growth rates (in % per annum) of these three variables for four subperiods and for the period as a whole. Of each (sub)period the beginning and the ending year are three-year averages. E.g. "1950" = the average of 1949-1951.

The following categories are tabled:

1. Animal output
2. Crop output
3. Total output (1+2)
4. Starting material
5. Fertilizers, pesticides, etc.
6. Fuel and lubricants
7. Feedstuffs
8. Other intermediate inputs
9. Total intermediate consumption (4+5+6+7+8)
10. Gross value added (3-9)
11. Depreciation
12. Total non-factor input (9+11)
13. Net value added (10-11)
14. Land input
15. Labour input
16. Capital input
17. Research & Development expenditure
18. Extension expenditure
19. Education expenditure
20. Total non-traditional inputs (17+18+19)
21. Total factor input (14+15+16+20)
22. Total input (12+21)
23. Four productivity indicators (cumulated quantity indexes only)

Table A.1a Animal production

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	1675	100	100
1950	2368	115	123
1951	2542	117	130
1952	2828	116	146
1953	2729	122	134
1954	2942	131	134
1955	3064	135	135
1956	3308	140	141
1957	3532	149	141
1958	3427	153	133
1959	3811	164	139
1960	3889	178	130
1961	4065	180	135
1962	4135	190	130
1963	4357	180	144
1964	4952	187	158
1965	5621	200	168
1966	5810	202	172
1967	6207	211	176
1968	6979	227	184
1969	7570	235	192
1970	7967	253	188
1971	8380	258	194
1972	9642	273	211
1973	11484	290	236
1974	11216	309	217
1975	12459	310	240
1976	13787	324	254
1977	14889	341	261
1978	15655	363	258
1979	16390	382	256
1980	17072	389	262
1981	19800	406	291
1982	21521	419	307
1983	21822	433	301
1984	22201	438	303
1985	22702	440	308
1986	21837	453	288
1987	19933	437	273
1988	20302	442	274
1989	22359	442	302

Table A.2a Crop production

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	1098	100	100
1950	1105	91	110
1951	1307	91	131
1952	1431	101	129
1953	1311	98	122
1954	1454	98	135
1955	1607	108	136
1956	1561	98	146
1957	1667	105	145
1958	1820	117	141
1959	1712	104	150
1960	2293	125	167
1961	2085	111	170
1962	2349	108	197
1963	2488	113	200
1964	2819	137	187
1965	2870	128	204
1966	3070	132	212
1967	3331	152	200
1968	3243	151	196
1969	3566	157	207
1970	3920	166	215
1971	4239	180	215
1972	4519	183	225
1973	5241	196	243
1974	5538	204	247
1975	6092	199	279
1976	7705	204	344
1977	7393	211	318
1978	7362	227	295
1979	7555	234	294
1980	8746	243	327
1981	9934	260	348
1982	10194	272	341
1983	10886	271	366
1984	12397	293	385
1985	11835	297	363
1986	12263	324	344
1987	12694	328	353
1988	13007	344	344
1989	14244	370	351

Table A.1a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	6.0	4.6	1.4
1960-1970	7.4	3.6	3.6
1970-1980	8.3	4.7	3.5
1980-1988	2.0	1.4	0.6
1950-1988	6.1	3.7	2.3

Table A.2a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	5.7	1.9	3.6
1960-1970	6.8	4.0	2.7
1970-1980	8.4	3.9	4.3
1980-1988	5.4	4.4	1.0
1950-1988	6.6	3.5	3.0

Table A.3a Total output

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	2773	100	100
1950	3473	106	118
1951	3849	107	130
1952	4259	110	140
1953	4040	113	129
1954	4396	118	134
1955	4671	124	136
1956	4869	123	143
1957	5199	131	143
1958	5247	139	136
1959	5523	139	143
1960	6182	156	143
1961	6150	151	147
1962	6484	154	152
1963	6845	151	163
1964	7771	166	168
1965	8491	170	180
1966	8880	172	186
1967	9538	186	185
1968	10222	196	188
1969	11135	203	198
1970	11887	217	198
1971	12619	226	201
1972	14161	237	216
1973	16725	253	239
1974	16754	266	227
1975	18551	264	253
1976	21492	272	285
1977	22282	287	280
1978	23017	307	271
1979	23945	321	269
1980	25818	328	284
1981	29734	345	311
1982	31715	359	319
1983	32708	365	323
1984	34598	377	331
1985	34537	381	327
1986	34100	399	308
1987	32627	390	302
1988	33309	401	300
1989	36603	412	320

Table A.4a Starting material

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	-	-	-
1950	14	100	100
1951	11	85	91
1952	13	115	80
1953	17	131	94
1954	23	131	124
1955	20	108	129
1956	21	131	112
1957	21	131	112
1958	21	146	100
1959	24	177	96
1960	27	223	86
1961	28	238	84
1962	26	223	83
1963	30	208	100
1964	41	266	110
1965	42	279	107
1966	47	383	86
1967	55	409	95
1968	50	363	96
1969	77	532	102
1970	92	617	105
1971	140	888	111
1972	184	1024	126
1973	190	1017	131
1974	210	1283	115
1975	250	1371	128
1976	310	1491	146
1977	340	1504	159
1978	370	1637	159
1979	380	1725	155
1980	407	1814	158
1981	450	1813	175
1982	480	1858	182
1983	534	2035	185
1984	596	2256	186
1985	712	2636	190
1986	842	3164	187
1987	939	3567	185
1988	907	3264	196
1989	1020	3607	199

Table A.3a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	5.9	3.6	2.2
1960-1970	7.2	3.8	3.2
1970-1980	8.4	4.4	3.8
1980-1988	3.2	2.4	0.8
1950-1988	6.3	3.6	2.6

Table A.4a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1951-1960	8.5	8.8	-0.2
1960-1970	14.5	12.3	1.8
1970-1980	14.8	10.1	4.3
1980-1988	11.7	9.3	2.2
1951-1988	12.4	10.1	2.1

Table A.5a Feedstuffs

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	-	-	-
1950	506	100	100
1951	621	97	127
1952	710	100	140
1953	745	120	123
1954	835	141	117
1955	960	161	118
1956	1073	174	122
1957	1151	199	114
1958	1275	220	115
1959	1518	257	117
1960	1544	275	111
1961	1648	292	112
1962	1882	313	119
1963	1959	314	123
1964	2084	319	129
1965	2446	348	139
1966	2732	369	146
1967	2889	385	148
1968	3000	403	147
1969	3159	437	143
1970	3710	492	149
1971	3921	512	151
1972	4273	560	151
1973	5520	607	180
1974	5790	617	185
1975	5770	639	178
1976	6880	702	194
1977	7240	715	200
1978	7340	784	185
1979	8380	834	199
1980	8965	854	207
1981	9540	846	223
1982	9860	863	226
1983	10791	909	235
1984	11146	920	239
1985	10836	960	223
1986	9815	937	207
1987	9401	961	193
1988	9655	952	200
1989	9800	926	209

Table A.5a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1951-1960	11.0	12.0	-0.9
1960-1970	8.6	5.7	2.7
1970-1980	9.6	5.8	3.6
1980-1988	1.0	1.7	-0.7
1951-1988	7.7	6.3	1.4

Table A.6a Fertilizers, pesticides

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	-	-	-
1950	245	100	100
1951	271	99	112
1952	294	101	119
1953	309	117	108
1954	317	120	108
1955	313	115	111
1956	325	121	110
1957	313	113	114
1958	326	114	116
1959	353	125	115
1960	361	124	118
1961	346	122	115
1962	373	129	118
1963	408	144	116
1964	428	141	124
1965	444	139	131
1966	475	149	130
1967	510	158	131
1968	486	151	132
1969	458	141	132
1970	519	162	131
1971	577	142	165
1972	590	163	148
1973	630	158	163
1974	740	162	187
1975	820	155	216
1976	820	152	220
1977	970	169	234
1978	1000	170	241
1979	990	165	245
1980	1247	190	269
1981	1430	197	296
1982	1540	194	324
1983	1323	177	304
1984	1328	177	306
1985	1479	188	322
1986	1331	191	285
1987	1203	195	252
1988	1080	174	254
1989	1108	173	261

Table A.6a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1951-1960	3.0	2.4	0.6
1960-1970	3.9	1.8	2.1
1970-1980	9.0	2.2	6.6
1980-1988	-0.2	0.2	-0.3
1951-1988	3.9	1.6	2.3

Table A.7a Fuel and lubricants

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	-	-	-
1950	50	100	100
1951	60	102	117
1952	64	102	125
1953	67	107	126
1954	69	111	125
1955	71	113	126
1956	80	122	131
1957	90	121	148
1958	98	137	143
1959	99	143	139
1960	104	151	138
1961	107	158	135
1962	111	161	138
1963	116	165	140
1964	125	172	146
1965	134	180	149
1966	144	184	156
1967	155	185	167
1968	162	202	160
1969	157	203	154
1970	164	200	163
1971	194	223	174
1972	237	285	166
1973	290	298	194
1974	480	343	279
1975	510	314	324
1976	630	329	382
1977	730	355	410
1978	860	375	458
1979	1040	407	510
1980	1446	473	610
1981	1670	434	768
1982	1730	378	913
1983	1720	349	983
1984	1878	346	1084
1985	1957	362	1079
1986	1312	389	674
1987	1270	411	617
1988	1160	399	581
1989	1151	397	578

Table A.8a Other Intermed. inputs

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	-	-	-
1950	315	100	100
1951	326	89	117
1952	320	84	121
1953	322	89	115
1954	338	89	121
1955	363	91	127
1956	403	96	133
1957	434	98	141
1958	421	95	140
1959	459	103	142
1960	525	113	147
1961	554	117	150
1962	570	118	153
1963	588	119	157
1964	659	122	172
1965	705	124	180
1966	743	122	194
1967	807	130	198
1968	886	140	201
1969	912	140	207
1970	973	140	220
1971	1056	142	236
1972	1145	138	263
1973	1310	141	294
1974	1510	143	335
1975	1650	143	365
1976	1800	144	397
1977	1910	151	402
1978	2020	149	430
1979	2190	154	450
1980	2438	161	481
1981	2500	157	504
1982	2590	157	522
1983	3023	155	620
1984	2894	166	553
1985	3027	170	565
1986	3087	173	566
1987	2802	154	576
1988	2967	161	583
1989	3087	165	592

Table A.7a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1951-1960	6.7	4.5	2.1
1960-1970	5.2	3.3	1.8
1970-1980	23.2	7.7	14.4
1980-1988	-1.5	-1.3	-0.1
1951-1988	8.5	3.8	4.5

Table A.8a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1951-1960	5.4	2.2	3.0
1960-1970	6.7	2.4	4.2
1970-1980	9.3	1.1	8.0
1980-1988	3.1	0.5	2.7
1951-1988	6.2	1.5	4.6

Table A.9a Total intermed. inputs

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	928	100	100
1950	1131	115	106
1951	1289	109	127
1952	1401	111	136
1953	1462	127	124
1954	1583	139	123
1955	1728	147	126
1956	1902	158	130
1957	2009	168	129
1958	2141	179	129
1959	2454	204	130
1960	2562	215	128
1961	2684	225	128
1962	2963	238	134
1963	3101	243	137
1964	3339	247	146
1965	3772	262	155
1966	4140	276	162
1967	4416	289	165
1968	4583	299	165
1969	4762	314	164
1970	5457	347	170
1971	5887	351	181
1972	6428	381	182
1973	7940	406	211
1974	8730	410	229
1975	9000	410	236
1976	10440	440	256
1977	11190	455	265
1978	11590	478	262
1979	12980	504	278
1980	14502	524	298
1981	15590	519	324
1982	16200	517	338
1983	17390	524	358
1984	17842	541	355
1985	18011	561	346
1986	16387	558	317
1987	15616	572	294
1988	15769	563	302
1989	16166	561	311

Table A.10a Gross Value Added

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	1845	100	100
1950	2343	102	125
1951	2560	106	131
1952	2858	110	141
1953	2578	106	132
1954	2813	108	141
1955	2943	113	141
1956	2968	107	151
1957	3189	114	151
1958	3106	119	141
1959	3070	109	153
1960	3620	128	154
1961	3466	117	161
1962	3521	114	167
1963	3744	110	184
1964	4432	130	185
1965	4720	128	199
1966	4740	125	206
1967	5123	138	201
1968	5639	148	206
1969	6373	155	223
1970	6430	158	220
1971	6732	167	218
1972	7733	172	243
1973	8785	181	263
1974	8024	188	231
1975	9551	192	270
1976	11052	192	312
1977	11092	202	298
1978	11427	219	282
1979	10965	219	271
1980	11316	215	285
1981	14144	248	308
1982	15515	270	311
1983	15318	271	306
1984	16756	283	320
1985	16526	280	320
1986	17713	315	305
1987	17011	297	310
1988	17540	316	301
1989	20437	337	328

Table A.9a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	8.7	7.1	1.5
1960-1970	7.7	4.6	2.9
1970-1980	10.3	4.3	5.8
1980-1988	1.2	1.2	0.1
1950-1988	7.2	4.4	2.7

Table A.10a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	4.2	1.4	2.8
1960-1970	6.8	3.1	3.5
1970-1980	6.4	3.6	2.7
1980-1988	5.3	4.2	1.0
1950-1988	5.7	3.0	2.6

Table A.11a Depreciation

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	151	100	100
1950	162	102	105
1951	183	105	115
1952	194	107	120
1953	197	109	120
1954	206	111	123
1955	221	113	129
1956	235	115	135
1957	252	119	141
1958	255	121	140
1959	258	123	139
1960	268	126	141
1961	285	129	146
1962	313	136	153
1963	334	141	157
1964	363	146	164
1965	396	154	170
1966	429	160	177
1967	458	167	182
1968	498	173	190
1969	563	180	207
1970	636	189	223
1971	750	200	248
1972	831	207	265
1973	888	212	277
1974	1035	224	306
1975	1213	237	339
1976	1382	248	369
1977	1519	260	387
1978	1647	268	407
1979	1848	285	430
1980	2124	304	463
1981	2367	318	493
1982	2534	325	516
1983	2651	337	521
1984	2737	339	535
1985	2898	353	540
1986	2997	359	556
1987	3183	356	593
1988	3393	376	597
1989	3641	392	615

Table A.12a Total non-factor input

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	1079	100	100
1950	1293	113	106
1951	1472	109	125
1952	1595	110	134
1953	1659	124	124
1954	1789	135	123
1955	1949	143	127
1956	2137	152	130
1957	2262	161	130
1958	2396	171	130
1959	2711	192	131
1960	2830	202	130
1961	2969	211	130
1962	3276	223	136
1963	3435	228	140
1964	3702	232	148
1965	4168	246	157
1966	4570	259	164
1967	4873	271	167
1968	5081	280	168
1969	5326	293	168
1970	6093	322	175
1971	6637	327	188
1972	7259	353	191
1973	8828	375	218
1974	9765	381	238
1975	10213	382	248
1976	11821	409	268
1977	12709	423	278
1978	13237	442	277
1979	14828	467	294
1980	16626	487	316
1981	17957	486	343
1982	18734	485	358
1983	20042	493	377
1984	20579	508	376
1985	20909	526	369
1986	19384	523	344
1987	18798	531	328
1988	19163	528	336
1989	19807	529	347

Table A.11a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	5.0	2.1	2.9
1960-1970	9.2	4.2	4.8
1970-1980	12.5	4.8	7.4
1980-1988	6.2	2.7	3.4
1950-1988	8.3	3.5	4.7

Table A.12a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	8.3	6.5	1.7
1960-1970	7.8	4.5	3.1
1970-1980	10.6	4.3	6.0
1980-1988	2.0	1.2	0.7
1950-1988	7.4	4.3	3.0

Table A.13a Net Value Added 1)

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	1694	100	100
1950	2181	102	126
1951	2377	106	133
1952	2664	110	143
1953	2381	106	133
1954	2607	108	142
1955	2722	113	142
1956	2732	106	152
1957	2937	114	152
1958	2852	119	141
1959	2812	108	154
1960	3352	128	155
1961	3181	116	162
1962	3208	112	168
1963	3410	107	187
1964	4069	129	187
1965	4324	126	202
1966	4310	122	209
1967	4665	136	203
1968	5141	146	208
1969	5810	153	224
1970	5794	155	220
1971	5982	164	215
1972	6902	169	241
1973	7897	178	262
1974	6989	184	224
1975	8338	187	263
1976	9671	186	306
1977	9573	196	289
1978	9780	214	270
1979	9117	211	255
1980	9192	204	266
1981	11777	240	290
1982	12981	263	291
1983	12666	263	285
1984	14019	276	299
1985	13628	270	298
1986	14716	309	281
1987	13829	289	282
1988	14146	307	272
1989	16796	330	301

Table A.13a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	4.1	1.3	2.7
1960-1970	6.5	3.0	3.4
1970-1980	5.5	3.3	2.1
1980-1988	5.1	4.4	0.7
1950-1988	5.3	2.9	2.3

1) At market prices.

Table A.14a Land

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	113	100	100
1950	107	100	94
1951	110	100	97
1952	118	100	104
1953	130	100	115
1954	141	100	124
1955	154	100	136
1956	162	100	143
1957	168	100	149
1958	171	100	152
1959	163	100	144
1960	176	100	156
1961	186	100	165
1962	192	99	171
1963	192	99	172
1964	202	98	182
1965	205	98	185
1966	218	97	198
1967	222	97	202
1968	236	97	216
1969	231	96	212
1970	398	96	368
1971	417	95	388
1972	429	95	401
1973	446	94	418
1974	480	94	453
1975	468	93	444
1976	508	93	484
1977	567	92	544
1978	660	92	636
1979	725	91	702
1980	819	91	797
1981	894	90	874
1982	925	90	909
1983	938	90	925
1984	997	89	988
1985	1098	89	1093
1986	1116	89	1115
1987	1169	89	1166
1988	1256	89	1255
1989	1312	88	1316

Table A.14a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	4.8	-0.0	4.8
1960-1970	7.1	-0.4	7.6
1970-1980	8.8	-0.5	9.4
1980-1988	5.5	-0.3	5.8
1950-1988	6.6	-0.3	6.9

Table A.15a Labour

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	1737	100	100
1950	1869	100	108
1951	1962	97	116
1952	2054	96	123
1953	2103	94	129
1954	2256	92	141
1955	2399	91	152
1956	2465	88	161
1957	2609	86	175
1958	2756	82	193
1959	2827	80	204
1960	2875	77	215
1961	2960	74	230
1962	3016	71	246
1963	3192	68	271
1964	3568	64	322
1965	3758	61	356
1966	3992	58	397
1967	4096	55	431
1968	4200	52	462
1969	4373	50	505
1970	4913	47	597
1971	5192	44	677
1972	6017	43	807
1973	6802	42	940
1974	7742	41	1092
1975	9206	40	1321
1976	10027	39	1469
1977	10382	38	1567
1978	10546	36	1669
1979	10818	35	1758
1980	11589	35	1919
1981	12536	35	2091
1982	13723	34	2297
1983	14401	34	2414
1984	14426	33	2501
1985	14677	32	2614
1986	14794	32	2660
1987	15097	32	2744
1988	15198	31	2813
1989	15482	31	2844

Table A.16a Capital

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	209	100	100
1950	233	103	109
1951	288	104	133
1952	306	103	142
1953	274	104	126
1954	268	105	122
1955	281	105	128
1956	334	104	154
1957	401	104	184
1958	384	104	177
1959	369	106	167
1960	386	106	174
1961	397	108	177
1962	420	109	184
1963	436	109	191
1964	551	111	238
1965	630	114	265
1966	773	118	315
1967	768	121	305
1968	866	124	334
1969	1073	127	403
1970	1256	133	453
1971	1421	133	510
1972	1755	136	618
1973	2221	142	748
1974	2240	149	720
1975	2800	152	882
1976	3483	155	1072
1977	3860	161	1146
1978	4149	169	1175
1979	4574	178	1230
1980	5281	183	1381
1981	6235	185	1615
1982	6678	186	1717
1983	5703	190	1439
1984	5587	192	1392
1985	5088	194	1252
1986	4555	196	1110
1987	4615	196	1143
1988	4608	195	1132
1989	5170	201	1229

Table A.15a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	4.5	-2.5	7.2
1960-1970	5.3	-4.8	10.6
1970-1980	9.2	-3.0	12.5
1980-1988	3.4	-1.3	4.8
1950-1988	5.7	-3.0	8.9

Table A.16a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	4.7	0.4	4.3
1960-1970	12.5	2.1	10.2
1970-1980	15.7	3.3	12.0
1980-1988	-1.4	1.0	-2.3
1950-1988	8.2	1.7	6.3

Table A.17a Research

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	8	100	100
1950	11	120	104
1951	12	118	119
1952	13	127	122
1953	16	161	115
1954	18	169	126
1955	22	205	125
1956	25	231	128
1957	28	246	137
1958	34	283	144
1959	39	321	144
1960	43	345	150
1961	50	371	159
1962	55	407	161
1963	61	435	168
1964	68	449	179
1965	76	480	189
1966	88	519	202
1967	99	554	213
1968	112	592	224
1969	124	624	237
1970	128	605	252
1971	160	680	281
1972	182	712	304
1973	200	710	335
1974	229	710	384
1975	277	767	431
1976	299	724	492
1977	308	779	471
1978	341	762	533
1979	379	825	547
1980	409	844	576
1981	420	849	589
1982	421	816	614
1983	408	800	607
1984	396	772	610
1985	426	826	614
1986	443	849	621
1987	480	925	617
1988	473	906	621
1989	519	969	638

Table A.18a Extension

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	9	100	100
1950	10	104	106
1951	11	106	122
1952	11	109	121
1953	12	123	116
1954	13	116	127
1955	15	130	128
1956	19	169	128
1957	20	164	139
1958	20	158	144
1959	19	148	144
1960	20	153	150
1961	21	155	157
1962	24	173	162
1963	28	192	167
1964	32	206	179
1965	37	225	190
1966	41	231	202
1967	45	242	214
1968	46	232	226
1969	44	213	237
1970	46	207	254
1971	51	209	277
1972	56	213	300
1973	63	214	335
1974	70	209	381
1975	79	207	434
1976	83	203	468
1977	88	202	497
1978	95	208	525
1979	99	206	548
1980	103	203	578
1981	102	197	590
1982	103	193	612
1983	102	193	606
1984	85	161	606
1985	95	176	613
1986	95	176	618
1987	94	174	618
1988	92	170	618
1989	90	162	636

Table A.17a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	15.7	11.8	3.4
1960-1970	12.1	6.3	5.4
1970-1980	11.3	2.8	8.3
1980-1988	2.5	1.3	1.1
1950-1988	10.7	5.7	4.7

Table A.18a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	7.3	3.9	3.3
1960-1970	8.9	3.3	5.5
1970-1980	8.0	-0.4	8.4
1980-1988	-1.2	-2.2	1.1
1950-1988	6.0	1.3	4.7

Table A.19a Education

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	8	100	100
1950	9	120	106
1951	11	115	122
1952	12	133	121
1953	15	173	116
1954	15	163	127
1955	17	177	128
1956	20	209	128
1957	24	225	139
1958	24	222	144
1959	28	258	144
1960	34	302	150
1961	39	332	157
1962	46	379	162
1963	49	395	167
1964	62	461	179
1965	72	504	190
1966	86	567	202
1967	96	599	214
1968	107	631	226
1969	108	605	237
1970	114	599	254
1971	140	674	277
1972	143	635	300
1973	159	634	335
1974	187	652	381
1975	223	684	434
1976	265	755	468
1977	329	882	497
1978	323	821	525
1979	343	834	548
1980	353	816	578
1981	367	830	590
1982	387	844	612
1983	424	933	606
1984	421	925	606
1985	473	1027	613
1986	494	1064	618
1987	510	1100	618
1988	497	1073	618
1989	496	1040	636

Table A.20a Total non-tradit.input

Year	Value in mln. NLG	Cumulated indexes quantity	price
1949	25	100	100
1950	30	121	99
1951	34	117	116
1952	37	134	111
1953	43	178	98
1954	46	171	110
1955	53	193	112
1956	64	232	111
1957	72	249	117
1958	78	256	124
1959	85	296	117
1960	98	338	117
1961	110	368	121
1962	126	418	122
1963	139	443	127
1964	162	495	133
1965	186	538	140
1966	215	588	148
1967	240	619	157
1968	265	639	168
1969	276	618	181
1970	288	597	196
1971	351	647	220
1972	381	630	245
1973	421	615	278
1974	485	603	326
1975	578	613	383
1976	647	616	427
1977	725	658	447
1978	760	635	486
1979	821	647	515
1980	865	637	551
1981	889	636	568
1982	911	623	594
1983	934	643	590
1984	902	605	605
1985	993	653	617
1986	1031	665	629
1987	1084	689	638
1988	1062	675	638
1989	1105	673	666

Table A.19a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	13.9	10.3	3.3
1960-1970	13.6	7.7	5.5
1970-1980	11.4	2.8	8.4
1980-1988	4.4	3.3	1.1
1950-1988	11.1	6.1	4.7

Table A.20a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	price
1950-1960	12.8	11.5	1.2
1960-1970	12.1	6.4	5.3
1970-1980	10.9	0.3	10.6
1980-1988	3.0	0.7	2.2
1950-1988	10.0	4.8	4.9

Table A.21a Total factor input

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	2084	100	100
1950	2239	100	107
1951	2394	98	117
1952	2514	97	124
1953	2550	96	127
1954	2711	95	137
1955	2887	94	148
1956	3025	92	158
1957	3249	90	173
1958	3389	87	187
1959	3444	85	194
1960	3535	83	204
1961	3653	81	217
1962	3753	78	230
1963	3959	76	250
1964	4482	73	295
1965	4779	71	324
1966	5198	69	362
1967	5326	66	385
1968	5567	65	412
1969	5953	63	452
1970	6855	61	538
1971	7382	59	603
1972	8582	58	716
1973	9890	57	832
1974	10948	56	939
1975	13052	56	1128
1976	14666	56	1264
1977	15533	56	1341
1978	16115	55	1418
1979	16937	55	1485
1980	18553	55	1626
1981	20554	55	1789
1982	22237	55	1952
1983	21975	53	1986
1984	21912	52	2039
1985	21857	50	2090
1986	21497	49	2096
1987	21965	49	2155
1988	22125	48	2209
1989	23069	49	2246

Table A.22a Total input

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1949	3162	100	100
1950	3532	105	107
1951	3866	102	120
1952	4110	102	128
1953	4208	106	126
1954	4500	108	132
1955	4835	109	140
1956	5162	111	147
1957	5511	112	156
1958	5784	112	163
1959	6156	117	166
1960	6365	118	171
1961	6621	118	177
1962	7029	120	186
1963	7395	118	198
1964	8184	115	224
1965	8946	117	242
1966	9768	118	262
1967	10199	118	273
1968	10648	118	285
1969	11279	118	303
1970	12948	120	341
1971	14019	118	375
1972	15841	119	422
1973	18719	123	482
1974	20713	122	537
1975	23266	118	624
1976	26487	122	686
1977	28242	124	720
1978	29352	125	743
1979	31765	130	772
1980	35179	133	835
1981	38510	133	918
1982	40971	131	991
1983	42017	132	1005
1984	42491	133	1014
1985	42765	133	1017
1986	40880	129	1003
1987	40763	127	1012
1988	41288	126	1035
1989	42876	128	1060

Table A.21a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	4.7	-1.8	6.6
1960-1970	6.6	-3.0	10.0
1970-1980	10.7	-1.1	11.9
1980-1988	2.3	-1.5	3.8
1950-1988	6.2	-1.9	8.3

Table A.22a Idem, growth rates

Year	Value in mln. NLG	Cumulated indexes quantity	Cumulated indexes price
1950-1960	6.1	1.4	4.6
1960-1970	7.2	0.1	7.1
1970-1980	10.7	1.1	9.5
1980-1988	2.1	-0.5	2.6
1950-1988	6.7	0.6	6.1

Table A.23a Productivity indicators (cumulated quantity indexes)

Year	Gross total prod'ty	Net multifactor prod'ty	Gross labour prod'ty	Gross land prod'ty
1949	100	100	100	100
1950	101	102	107	106
1951	105	107	110	106
1952	108	113	115	110
1953	107	110	120	112
1954	109	114	128	118
1955	113	121	137	124
1956	111	115	139	123
1957	117	127	153	132
1958	124	137	169	139
1959	119	126	175	139
1960	132	154	202	156
1961	128	143	204	151
1962	128	143	217	155
1963	128	142	223	153
1964	144	177	261	169
1965	145	179	280	174
1966	146	176	297	177
1967	158	205	340	192
1968	166	225	374	203
1969	172	242	408	211
1970	181	254	458	227
1971	191	279	512	238
1972	199	293	551	250
1973	206	312	606	268
1974	218	330	651	283
1975	224	337	658	283
1976	223	335	692	293
1977	231	352	751	310
1978	245	392	844	334
1979	247	386	906	351
1980	246	372	942	360
1981	260	435	999	381
1982	275	482	1043	398
1983	276	495	1062	407
1984	284	536	1134	422
1985	286	538	1178	428
1986	310	628	1248	451
1987	306	591	1232	440
1988	318	638	1288	452
1989	322	669	1314	467

Table A.23b Idem, growth rates

Period	Gross total prod'ty	Net multifactor prod'ty	Gross labour prod'ty	Gross land prod'ty
1950-1960	2.2	3.2	6.3	3.6
1960-1970	3.7	6.2	9.0	4.2
1970-1980	3.3	4.4	7.5	4.9
1980-1988	2.9	6.0	3.8	2.8
1950-1988	3.0	4.9	6.8	3.9

ANNEX B DESCRIPTION OF DATA AND DATA SOURCES

1. Total production (Tables A1, A2 and A3)

Aggregate output has been calculated in a number of steps. First a subdivision was made between animal and crop production (including horticultural products). For each of these, yearly totals for value in current and in constant prices were obtained from various issues of EUROSTAT, 'Economic Accounts for agriculture' 1). Next, these figures were linked in order to get smooth, i.e. uninterrupted and consistent, current and constant price series. The constant price series were used as proxies for the quantity indexes. By taking the ratio of the current and constant price series, implicit price indexes were calculated subsequently. These (chain) price indexes were then considered to represent 'actual' prices for the two 'goods' and were used for the calculation of the compound price index for total production (see Annex III for more details about the techniques of smoothing and index numbering used in this study).

2. Total intermediate consumption (Tables A4, A5, A6, A7, A8 and A9)

Data on intermediate consumption include starting material (seeds, plants, livestock and animal products), lubricants, fertilizers and soil improvers, plant protection products (pesticides, herbicides, etc.), feedingstuffs, materials and small tools, and other services. Consequently, these series are a mixture of both internal and external deliveries to agriculture. The volume and price indexes of total intermediate consumption were estimated through aggregation of series on these items in a way similar as for total production. Sources are also the same. Total non-factor input (Table A12) consists of total intermediate consumption plus depreciation.

3. Depreciation (Table A11)

Constant and current price series for depreciation are jointly calculated with the capital stock as indicated below (§7) by Oskam (1986 and an unpublished update for recent years). The calculation by Oskam assumes a shorter life time of capital goods than the Central Bureau of Statistics (CBS) does. Consequently, the estimated annual depreciation is higher. In the 1960s the difference was only about eight per cent, but it increased to almost twenty per cent in the 1980s. Oskam's assumptions appear to be close to the assumptions used by the LEI in its annual survey of farm accounts ('Bedrijfsuitkomsten

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1) Until 1975 these data were published by Eurostat in 'Agricultural Statistics'.

in de landbouw'). Data for 1987-1989 have been estimated on the basis of Eurostat, Economic Accounts for Agriculture.

4. Gross and net value added (Table A10 and A13)

Gross and net value added were calculated as usual:
Gross output *minus* Intermediate consumption *gives* Gross value added *minus* Depreciation *gives* Net value added. Calculated price and volume indexes are aggregated indexes.

5. Stock of agricultural land (Table A14)

Official series on the cultivable land area show various discontinuities. Van der Meer (1986) estimated adjusted series for the years up till 1985. Data for recent years were partly corrected and estimates for 1986 and 1987 were added. In particular for the 1970s the official estimates strongly underestimated the actual area. The adjustment was made on the base of special information compiled by the CBS for some selected years. Data on changes in quality of land, e.g. because of investment in land consolidation and drainage, are not available.

For the calculation of land input, costs of land per hectare are required. Unfortunately, there are several statistical series on land prices and land rent for different categories of land. Part of the land is rented. For this land a weighted average net rent is available, but it actually underestimates the cost of all land since there is strict land rent control at levels undoubtedly below the market equilibrium. Because of this the share of land rented has continuously been declining from more than fifty percent in the 1950s to about one third in recent years. For land cultivated by owners, statistics are available on average sales prices. However, before 1963 there was also tight control on land sales prices and since that time there is still price control for sale of rented land. In other cases average reported prices may not be representative for all land. If farms are sold no separate prices for land and buildings are given. Sales for non-agricultural use are likely to be for higher prices than for agricultural use. In recent years sales prices are also affected by various types of rents related to quota rights (milk, sugar, starch potatoes, deposit rights for manure) and contracts or regulations for protection of land scape and nature. Even if it would be possible to construct a representative price statistic, then the choice of an interest rate would be arbitrary. Obviously the rate of return to capital invested in land is not the same as for government bonds, since the expected value for the principal will not be the same.

Given all these problems, the choice was made to adopt net paid rent per hectare as the indicator for land input prices. The volume of total land input was calculeted as net rent per hectare multiplied by the area of agricultural land.

Charges for investment and maintenance of public infrastructure such as public drainage systems, are considered as taxes and therefore not included as a cost.

Data for 1988 and 1989 have been estimated on the basis of CBS/LEI, Landbouwcijfers.

6. Labour input (Table A15)

The volume of labour input is measured in hours worked. Estimates of hours worked and cost of labour per hour worked for the period 1949 - 1986 were obtained from Van der Meer (1987) and slightly adjusted and extended for recent years. The estimates of hours worked are based on Full-Time Labour Units (FTLU or 'arbeidsjaareenheden (aje)' in Dutch), formerly called man years ('manjaren') as published by the Central Bureau of Statistics (CBS). By this concept the CBS expresses part-time labour in full-time units by taking into account working hours or working days, of part-time workers in relation to a norm for full-time labour. This norm was about 3000 hours per year in the 1950s and declined to 2250 hours in 1969 and 1975 and to 2000 hours in 1979 and 1983. However, the actual number of hours worked per full-time worker did not follow these norms closely. In particular working hours of full-time family workers exceed the norm. By using the actual number of hours worked as reported in farm account surveys of the LEI, corrections were made for male full-time family workers. Hours worked in agriculture by employees of contractor services and machine co-operatives are included. All hours worked are unweighted, i.e. no corrections were made for skill, age or sex.

In all previous productivity studies the uncorrected FTLU figures were used. Over the period 1950 - 1956 there is hardly any difference in both measures, but over the period 1956 - 1970 labour input in hours declined more rapidly, namely by 0.88 per cent point annually, whereas from 1970 - 1983 the difference was even 1.3 per cent point per year. As a consequence this study finds a more rapid decline of labour input and a more rapid increase in productivity.

The average cost per hour worked was derived from LEI statistics for various groups of paid workers. This cost figure is higher than the paid wage cost per contact hour. It includes all wage costs, allowances and social security payments, and the total amount is expressed per hour actually worked. The average cost per hour of paid workers will in general be higher than the shadow wage rate for family labour, but since there is no unambiguous way to estimate the shadow wage rate, the cost for paid labour was assumed to apply for all labour.

Data for 1988 and 1989 have been estimated on the basis of CBS/LEI, Landbouwcijfers, and LEI, Landbouw-Economisch Bericht 1992.

7. Investment and capital stock (Table A16)

The CBS does not publish figures on capital stock for agriculture. Based on data provided by the CBS, Oskam estimated series of capital stock data in constant and current prices for the period 1949 - 1985 (Oskam 1986, and an unpublished update). Tentative estimates for 1986 and 1987 were added.

The data cover the capital value of modern buildings, machines and equipment, and cattle. Traditional buildings are included in the cost of land. The accumulated value of investment in land and drainage is not included in the series of capital stock.

A normative estimate of capital factor input is derived by multiplying the capital stock by the interest rate used by the LEI in its farm accounts survey. This interest rate is slightly lower than the rate of return on government bonds.

8. Expenditure on Education, Extension, and Research and Development (Table A17 to A20)

8.1 General remarks

'Non-traditional' inputs like education, extension and research and development (R&D) are more difficult to calculate than traditional inputs. As an approximation, the costs of producing and distributing knowledge have been calculated. This approach has the disadvantage that the production and distribution of knowledge is not only directed towards Dutch agriculture. E.g., a substantial number of people - educated from Dutch agricultural vocational schools, colleges and the veterinary and agricultural faculties in universities - find employment in other sectors and/or in other countries. On the other hand, however, part of the knowledge available to Dutch agriculture comes from other sectors (i.e. non-agricultural schools and research institutes) or from abroad. One can easily imagine more of these trade-offs. In this study it is assumed that these positive and negative flows of knowledge are in balance, so that properly deflated registered expenditures in principle form a reasonable indication of the quantity of knowledge-related inputs.

Data on expenditure on non-traditional inputs are restricted to expenditures that are aimed at productivity and technology in primary agriculture. Cost of education for subjects of forestry and fisheries are included in agriculture. Expenditure on education and extension refers only to (gross) government expenditure, whereas expenditure on R&D consists of expenditure by enterprises as well as of government expenditure.

The estimates of expenditures on education and R&D are derived in seven steps. First, estimates of total expenditure for education and research have been derived for the Agricultural University at Wageningen. Second, similar estimates were made for the Faculty of Veterinary Science of the University at Utrecht. The third step was to present estimates of expenditure for education at agricultural vocational schools including agricultural colleges. The fourth step was to derive estimates of expenditure on agricultural research by government research institutes. In the fifth step the same was done for private enterprises. In the sixth place estimates were made about the share of education which is oriented to productivity and technology in primary agriculture; the successive estimates were added and presented as the total expenditure on education. Finally, data on total expenditure on research and development by government and private enterprises have been summarized 1).

8.2 The Agricultural University at Wageningen

Data on total expenditure of the Agricultural University at Wageningen is available for all years from 1949 onwards (CBS, 'Uitgaven voor wetenschappelijk onderzoek', various issues). These data have to be split into a component education and a component research. Official estimates of the share of research is available for the sub-periods 1969 - 1981 and 1982 - 1987. These shares are based on estimated shares of time spent on research by academic staff members (CBS, 'Tijdsbesteding van het wetenschappelijk personeel van universiteiten, hogescholen en academische ziekenhuizen', 1972/73 and 1982/83) for current expenditure and a 50/50 share for investment. As a consequence of the allocation of current expenses, the cost of university administration is comprised under education. Since the shares of time allocation differed significantly between both sub-periods the discontinuity was smoothed over an intermittent six-year period.

For the years before 1969 no official data are available about the share for research. Estimates were made by assuming that the 1972/73 share was applicable for current expenses, whereas investment was allocated on a 50/50 share similar as for the period from 1969 onwards. However, such an estimate could not be made for the years 1949, 1951, 1953, 1955, 1957, 1959 because no details on investment and current expenditure are available in the statistics. Therefore, total expenditure was split on the base of the share in the preceding and subsequent years.

8.3 The Veterinary Faculty of the University of Utrecht

Data for the Veterinary Faculty of the National University of Utrecht consist not only of components for research and education but also for health care. From 1969 onwards the components are estimated on the base of time allocation by academic staff for the sub-periods 1969 - 1981 and 1982 - 1987 as found for the years 1972/73 and 1982/83 (CBS, 'Tijdsbesteding van het wetenschappelijk personeel van universi-

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1) Mr. Höbaus, from the Dutch Council of Agricultural Research (NRLO), has gathered most of the data on agricultural research and education.

teiten, hogescholen en academische ziekenhuizen', 1972/73 and 1982/83). The shares, 58/31/11 for 1972/73 and 53/36/11 for 1982/83, were applied to both investment and current expenditure. The discontinuity between the two sub-periods was removed by smoothing over six intermittent years.

For the years 1962-1969 the 1972/73 shares were applied. For the years 1949 - 1961 no data are available for the veterinary faculty. An estimate of total expenses was derived on the base of the share of veterinary students in the total student population of Utrecht University. For this an average relative cost of 145 per cent was calculated for veterinary students for the years 1964 - 1968 from the University financial report.

8.4 Agricultural vocational schools and agricultural colleges

Available data cover all direct expenditure for education, not investment. Sources are from CBS ('Statistiek van de uitgaven der overheid voor onderwijs', various issues, and 'De ontwikkelingen van het onderwijs in Nederland', 1966 edition).

8.5 Research and Development by enterprises

For the year 1969 onwards statistics are published about the expenditure on research and development by private enterprise according to the Netherlands Standard Industrial Classification (CBS, 'Speur- en ontwikkelingswerk in Nederland', various issues). There are actually two series. The first and longest series shows the research expenditure of all enterprises belonging to an industrial classification group regardless of the functional orientation of the research. The second series, which is only available from 1977 onwards, classifies research expenditure of all enterprises by the industrial classification groups towards which it is functionally oriented. The difference between both series is that basic research can not be functionally classified by industrial group. In other respects it is obvious that a chemical industry can devote some of its research to agriculture, while an agricultural enterprise may do some research and development work on packing and improvement of machinery. In this study the first type of classification is used since it is available for a much longer period.

8.6 Extension

Expenditures on extension were obtained from the annual budgets of the Ministry of Agriculture. Only those items have been used that deal with technical (or agronomic) extension. Thus, all PR-like extension activities have been left out, as well as extension in the field of food consumption and food quality, and of fisheries. As much as possible, actual rather than estimated expenditures have been taken from the annual budgets. For the final series in current prices, the same deflator has been applied that was used for R&D expenditures.

9. Aggregate productivity series (Table A23)

Several productivity ratios have been calculated (see also figure 2.1, chapter 2):

$$\textit{Gross total productivity} = \frac{\textit{Total production}}{\textit{Factor + non-factor input}}$$

$$\textit{Net multifactor productivity} = \frac{\textit{Net value added}}{\textit{Factor input}}$$

$$\textit{Gross labour productivity} = \frac{\textit{Total production}}{\textit{Labour input}}$$

$$\textit{Gross land productivity} = \frac{\textit{Total production}}{\textit{Land input}}$$

ANNEX C THE CONSTRUCTION OF VOLUME AND PRICE INDEXES

1. The approach in general

There are several techniques for constructing compound indexes. The series of output, input and productivity have been calculated by means of two types of chain-linked index numbers, namely:
- Fisher Index (combining Laspeyres and Paasche Indexes),
- a Divisia Index 1),

The Fisher Index number was used for a number of single series, namely depreciation, land, labour and capital. Of all other (aggregate) series volume indexes were constructed by means of a Divisia-like index number. For these series, price indexes are derived from value and volume series.

Of each technique, we will first present the general formula. Next, an example is given of the chain-linking procedure.

2. Index formulas

2.1 Fisher Ideal Index

The general formula is the square root of the Laspeyres index multiplied by the Paasche index:

$$\overset{F}{\underset{01}{Q}}=\sqrt{\overset{L}{\underset{01}{Q}}*\overset{P}{\underset{01}{Q}}} \tag{1}$$

where

$$\overset{L}{\underset{01}{Q}}=\frac{\sum_{i=1}^{n} p_{0,i}*q_{1,i}}{\sum_{i=1}^{n} p_{0,i}*q_{0,i}}*100 \tag{2}$$

and

$$\overset{P}{\underset{01}{Q}}=\frac{\sum_{i=1}^{n} p_{1,i}*q_{1,i}}{\sum_{i=1}^{n} p_{1,i}*q_{0,i}}*100 \tag{3}$$

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1) Adopted from L.R. Christensen, 'Concepts and measurement of agricultural productivity', American Journal of Agricultural Economics, 57(1975)5, 911.

2.2 Divisia

The formula used here is::

$$\ln \overset{D}{\underset{01}{Q}} = \sum_{i}^{n} [0,5*(\frac{p_{i,1}*q_{i,1}}{\sum p_{i,1}*q_{i,1}} + \frac{p_{i,0}*q_{i,0}}{\sum p_{i,0}*q_{i,0}})]*\ln(\frac{q_{i,1}}{q_{i,0}}) \qquad (4)$$

3. Chain-linking

In order to reduce distortions that result from the use of one single base year (see chapter 2), the original series of value in constant prices consisted of subseries with different base years with one year overlap between each subseries. The resulting discontinuous series were smoothed by means of the chain-linking procedure. As an example of this procedure the original discontinuous and smoothed series of fertilizer input are presented below.

Example of chain-linking: the construction of a part of the series of feedstuffs

Year	Row	Value in current prices a) (A)	Value in constant prices b)			
			original series 1 (B)	original series 2 (C)	linked series (D)	formula
1965	1	2446		2168	3139	C1*D6/C6
1966	2	2732		2300	3330	C2*D6/C6
1967	3	2889		2398	3472	C3*D6/C6
1968	4	3000		2513	3638	C4*D6/C6
1969	5	3159		2725	3945	C5*D6/C6
1970	6	3710	3709	3070	4445	B6*D9/B9
1971	7	3921	3855		4619	B7*D9/B9
1972	8	4273	4219		5056	B8*D9/B9
1973	9	5520	4572	2310	5479	C9*D11/C11
1974	10	5790		2349	5571	C10*D11/C11
1975	11	5770		2432	5770	A11

a) In NLG; b) For 1965-1970: in constant prices of 1963 (NLG); for 1970-1973: in constant prices of 1970 (NLG); for 1973-1975: in constant prices of 1980 (ECU). The linked series are at the price level of 1975.

Productivity measurement has become an important tool for assessing the productive achievements of a nation's agricultural sector. This study presents the results of such an assessment for Dutch agriculture since World War II. Contrary to most other studies in this field, agricultural education, extension and research have been included as inputs to agriculture. The data show that - for the whole period - the growth of gross total productivity was 3.0% per annum. Fastest growth occurred in the Sixties, when the annual growth rate was 3.7%. In an attempt to assess the benefits of (governmental) investments in education, extension and research - the so-called non-traditional inputs - the internal rate of return was calculated at between 25 and 40%.

A particular feature of productivity growth in the Netherlands is that it has come about through a very high growth of output, combined with a rather large use of inputs. This at least becomes apparent when comparing Dutch agricultural productivity performance with that of other western countries. In other countries, productivity growth resulted foremost from a relatively modest growth of inputs.

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