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Nooteboom, B.

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Productivity growth in the grocery trade

B. NOOTEBOOM *

Research Institute for Small and Medium-Sized Business, The Hague, Netherlands

This paper presents a model of the growth of the average efficiency of labour, per type of shop, as a function of the wage rate, use of part-time labour, labour supply and demand, and economies of scale (shop size). The model is estimated on the basis of data for the grocery trade prior to 1975. This yields a forecast beyond 1975, which is compared with more recent observations. A re-estimate of the model on the basis of data for the grocery trade in the period 1975–78 is found to be in agreement with the original estimate. Some implications of the model are indicated.

I. INTRODUCTION

Before considering the growth of average productivity, this paper turns to the relation between labour volume and shop size, within a shop type, as a basis for determining later to what extent productivity growth is due to an increase of scale (shop size).

A shop type is defined as a class of shops which are homogeneous with respect to assortment composition (width and depth of the range of products sold), service (average service time and average queuing time per customer, number of service points per shop), own production (breadbaking, sausage production, repairs, etc.) and type of enterprise (independent, cooperative, voluntary chain, chain store, etc.).

In cross-sectional studies of individual shops (establishments), per shop type, we consistently find non-homogeneous linear curves of labour costs, as follows:

$$a_j = \alpha_0 + \alpha_1 Q_j; \qquad \alpha_0, \alpha_1 > 0, \qquad j \text{ index of the individual shop} \tag{1}$$

where: a = annual labour volume per shop (expressed in hours worked, or persons engaged, in full-time equivalents), Q = annual sales per shop (in guilders), α_0 = so-called 'threshold costs'.

For the present paper, we take this result as given. For the empirical evidence and theoretical justification (based on queuing theory) we refer to Nooteboom (1982).

According to our theory, the threshold costs (α_0) are equal to the annual opening time of the shop, for the shop type considered, multiplied by the number of independently staffed service points or departments per shop.

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The justification of studying labour costs independently from other costs (such as, notably, occupancy costs), is based on the consideration, supported by empirical evidence, that there is little opportunity for substituting shop space, inventory or other capital for labour without altering the product/service mix which is the 'output' of retailing, i.e., without making the transition to a different shop type. This lack of opportunities for substitution was reported and discussed before by McClelland (1966) and Holdren (1960). Thus the customary production functions used in neoclassical models, which are characterized by the properties of elasticities of substitution, are of little relevance in studies of retailing, if one makes the assumptions of homogeneity associated with the notion of a shop type. More relevant in this study is the matter of capacity utilization, in relation to the stochastic nature and the varying levels of customer arrivals. We found queuing theory to yield a fruitful theoretical tool for analysing these characteristic aspects of store operation.

The linear cost curve implies a hyperbolic economy of scale:

$$\frac{a_j}{Q_j} = \alpha_1 + \frac{\alpha_0}{Q_j}. \tag{2}$$

We see that for a decreasing shop size (in the cross-sectional sense), the labour intensity a/Q increases at an increasing rate.

The linear cost curve has two very convenient properties:

The economy of scale is entirely due to the threshold costs α_0. Once we know α_0, for a given shop type, we can calculate, for each shop, what we call the 'scale-adjusted efficiency' of labour PA_j, as follows:

$$PA_j = \frac{Q_j}{a_j - \alpha_0}. \tag{3}$$

The expected value of scale-adjusted efficiency PA_j is independent of the sales size Q_j. As a result, we can estimate the average scale-adjusted efficiency, for a given type of shop, on the basis of a sample which is not representative with respect to the distribution of sales size per shop. This is fortunate, since samples that are representative in that sense tend to be extremely scarce.

II. SPECIFICATION

PA_t indicates the average scale-adjusted labour efficiency per shop, for a given shop type in a given year t:

$$PA_t = \frac{1}{n} \sum_{j=1}^{n} PA_{tj}; \qquad n \text{ number of shops in the sample.} \tag{4}$$

For a study of productivity growth this measure is deflated by means of a sales price index associated with the average assortment of products sold by the shop type in question:

$$pa_t = \frac{PA_t}{\pi_t} \tag{5}$$

where: pa = deflated average scale-adjusted labour efficiency, π = sales price index of the average assortment (constructed from consumer price indices per product group, provided by the Central Bureau of Statistics, weighted with the average shares of those product groups in the assortment of the shop type considered).

We define the percentage increase of pa, as follows:

$$\dot{p}a_t = \frac{pa_t - pa_{t-1}}{pa_{t-1}} \tag{6}$$

where: $\dot{p}a$ = 'real' (in the sense of 'deflated') percentage increase of average labour efficiency *excluding* the effect of scale.

We can also study the growth of efficiency including the effect of scale, for which we define:

$$P_t = \frac{1}{n}\sum_{j=1}^{n}\frac{Q_j}{a_j}; \qquad p_t = \frac{P_t}{\pi_t}; \qquad \dot{p}_t = \frac{p_t - p_{t-1}}{p_{t-1}} \tag{7}$$

where: P = average efficiency without any adjustment (and thus including the effect of scale), $\dot{p}$ = 'real' percentage increase of average labour efficiency *including* the effect of scale.

In Appendix I it is proved that the relation between the growth including the effect of scale $\dot{p}$ and the growth of efficiency excluding it $\dot{p}a$ is as follows:

$$\dot{p}_t = \left(1 - \frac{\alpha_0}{a_t}\right)\dot{p}a_t + \frac{\alpha_0}{a_t}\dot{q}_t \tag{8}$$

where: a = average labour volume per shop, $\dot{q}$ = percentage increase of the average sales per shop (deflated).

For a given sample, a forecast of the growth of efficiency including the effect of scale ($\dot{p}$) depends on the average shop size in the sample. Thus the most generally applicable forecast is that of the growth of efficiency excluding the effect of scale ($\dot{p}a$), which does not depend on the average shop size in the sample observed.

Our model for the explanation of $\dot{p}a$ is as follows:

$$\dot{p}a_t = \beta_1 \dot{l}_t + \beta_2 \Delta pl_t + \beta_3 \Delta vu_t + \beta_0 \tag{9}$$

where: $\dot{l}_t$ = percentage increase of the wage rate of retailing personnel in the shop type studied, relative to the sales price of the assortment of products sold, Δpl = increase of the average percentage share of part-time labour in the total number of persons engaged (in percentage points), Δvu = increase of the balance of vacancies minus unemployed personnel in the trade in question, divided by the total national working population (in percentage points × 10).

In a neoclassical approach, the coefficient of the relative wage rate (β_1) might, on the basis of a constant elasticity of substitution (CES) production function, be interpreted as an elasticity of substitution (cf. Cramer, 1971). In our view, there are no significant opportunities for replacing labour (within a shop type), and the effect of the wage rate is due to nonhomogeneities in labour and service.

Nonhomogeneity of labour: to some limited extent, the effect is probably due to a change of the quality of labour, that is related to a change of the relative wage rate.

Nonhomogeneity of service: an increase of the cost of labour is to some extent absorbed by an increase of labour efficiency due to a reduction of service (shorter service times, longer queuing times, fewer deliveries and other ancillary services, etc.).

In retailing, the increasing use of part-time labour (Δpl) has been an important cause of increasing efficiency, in the attempt to achieve an adjustment of labour capacity to reflect the different intensities of demand during different hours of the day, days of the week, and seasons in the year. Clearly, there is some optimum level of the share of part-time labour. On the basis of our earlier studies of the linear cost curve, based on queuing theory (Nooteboom, 1980), we propose that this optimum level depends, among other things, on the shop size, with higher levels for larger shops. Thus, in a study of average productivity for a sample of shops it depends on the distribution of shop sizes in the sample. But in our present study of the growth of productivity we are concerned only with changes of the average share of part-time labour. Regardless of what the optimum level of the share is, as long as the share is increasing, it will yield a better adjustment of capacity to sales and hence an improvement of productivity[1]. Thus we do not need to know the optimum share for the specification and estimation of our model. We will need to know it when we apply the model for the purpose of forecasting; the question then is how long the share of part-time labour will continue to increase before it reaches its optimum level.

The labour market variable (Δvu) was used before, in explanations of retailing efficiency, by George (1966) and George and Ward (1973). Here also, there can be a two-fold explanation.

Refuge hypothesis: in times of recession, the unemployed seek refuge in self-employment as shopkeepers, thereby increasing the number of marginal and unsuccessful shops and reducing the average level of efficiency. With contemporary social security benefits for the unemployed, however, this explanation has lost much of its plausibility.

Availability of labour: retailing has to compete with employers who offer higher wages and better career opportunities, so that in times of labour scarcity there may be a forced increase of efficiency, because retailers simply have to make do with a shortage of labour, yielding not only a genuine increase of efficiency, but also a reduction of service. Conversely, in times of an abundant labour supply, the service level may rise, yielding a lower sales to labour ratio.

One could also propose an alternative hypothesis with an opposite effect, as follows: when labour markets are tight, the quality of labour entering low paid occupations in retailing is low, yielding a lower efficiency. However, this consideration would seem to carry most weight with respect to skilled and specialized labour, which one finds in industry but is less common in retailing. Nevertheless, a tight labour market could in principle have opposite effects: higher efficiency through forced labour saving; lower efficiency through a lower quality of labour. We will leave it up to the empirical results to decide which hypothesis is in agreement with the facts.

In the above we have turned to changes in service level for an explanation of changes in the deflated sales to labour ratio, which thereby cannot be interpreted as a measure of 'real', i.e., 'genuine' productivity. As has been noted by others, it is not at all clear what measure could be

[1] Provided that part-time labour does not represent full-time labour broken up in parcels, but does in fact represent a labour capacity which is present only during some part of opening time. We also note that the increase of the average share of part-time labour, for a given sample, is associated with the increase of average shop size in the sample. But the effect of an increasing share of part-time labour is in addition to (is not included in) the effect of increasing scale. This consideration also is based on our earlier studies in Nooteboom (1980).

used to express productivity in a 'real' sense (Hall *et al.*, 1961; Arndt and Olsen, 1975). It would, for example, be too much to assume that there is a reliable correspondence between changes of sale price or trading margin and changes in the 'quality' of the retailing service (Palamountain, 1955). Prices and margins also depend on competitive position as expressed, for example, by the development of market share (Nooteboom, 1980; chapter 8). In view of the absence of an ideal measure, we employ the deflated sales to labour ratio, but in doing so we prefer to speak of 'efficiency' rather than 'productivity', as a reminder that we are not measuring productivity in the usual 'real' sense.

III. DATA

Independent superettes and independent small supermarkets are the only two shop types in the Netherlands for which we had anything like a time series of average efficiency. The source of the data are the inter-firm comparisons of the Research Institute for Small and Medium-Sized Business in the Netherlands (EIM, The Hague). For the superettes (defined as grocery stores selling the majority of sales by self-service, and including either fresh vegetables/fruit or fresh meats in the assortment, but not both) we have observations for 1957, 58, and alternate years from 1959 to 1975 inclusive. For the small supermarkets (defined as grocery stores with the majority of sales by self-service and including both 'fresh groups' in the assortment; for the majority of the shops the sales area is less than 400 m^2) we have observations for alternate years from 1965 to 1975 inclusive. Pooling the data we thus have 15 observations of the percentage increase of efficiency. For the two-year periods we take the average percentage increase per year:

$$\dot{p}a_{73\text{-}75} = ([pa_{75}/pa_{73}]^{1/2} - 1)100. \tag{10}$$

For the superettes the number of individual shops included in the averages per year varies between 38 (1957) and 107 (1971). For the small supermarkets the number varies between 23 (1965) and 123 (1973).

The samples in successive years are not representative for the shop type as a whole. The observed shops were selected to maintain the greatest possible homogeneity with respect to: independent entrepreneurs (no chain stores or voluntary chains), service and assortment composition. Extremes of size (both the smallest and the largest) were excluded, so as to obtain a cluster of observations around the modal size.

During the observation period the sample sizes increased considerably: for the superettes it almost tripled in 14 years; for the supermarkets it increased more than fivefold in 8 years. One of the reasons for this was to compensate for an increasing nonhomogeneity as the differentiation in service and assortment increased (particularly in supermarkets). In view of this compensatory effect we did not attach different weights to averages in different years. Over the years about 60% of the shops included in one observation were also included in the next, so that there was sufficient overlap to yield meaningful growth figures between successive observations.

For the growth of the wage rate (variable $\dot{l}$ in Equation 9) we take the value calculated from the overall gross wage rate for retailing personnel (for a fixed composition of different labour categories) from the national statistics, including the shopkeepers' contribution to social security. The wage rate for the grocery/food trade was not available for the entire observation period. For the years that it is available, the differences in wage growth between different types of trade are slight. This was to be expected, since wages are centrally negotiated. The labour market variable (Δvu) is based on the national statistics, as it should be.

One serious problem remains, concerning the share of part-time labour (the variable Δpl in Equation 9). We should employ observations that apply to the particular samples used, but they are not available. We therefore use the overall average for the trade in foods (averaged across all food trades). The problem is that we have no way of telling whether this differs from the values for the observed samples of shops. This would be particularly serious if one were to use the level of the share of part-time labour (pl), which may very well vary between different types and sizes of shops within the food trade. In fact, we employ the *change* in the share of part-time labour (Δpl), which is expected to vary less between different types of shop, and we hope that this yields a sufficiently reliable indicator of the changing share in the observed samples.

Summing up: there are several minor data problems and one which is more serious. In view of this, our approach will be as follows: we estimate our model with the available data for the period 1957–75, subsequently we re-estimate the model with data from a different source for the period 1975–78. If in spite of the data deficiencies the results are the same for the different periods, with data from different sources, we will accept the result for the purpose of prediction. The argument then is that although there may be a problem in principle, apparently it is not serious in practice, or the model is sufficiently robust.

IV. FIRST ESTIMATE

With the data described above, with 15 observations in the period 1957–75, the estimate of the model (based on an ordinary least squares procedure) is as follows:

$$\dot{p}a = \underset{(0.15)}{0.70}\ \dot{l} + \underset{(0.47)}{1.71}\ \Delta pl + \underset{(1.77)}{1.94}\ \Delta vu - \underset{(1.1)}{2.0}; \qquad R^2 = 0.82. \tag{11}$$

The figures in parentheses are standard errors.

According to this result, the effect of the labour market variable (Δvu) is not significant. An analysis of the residuals showed one exceedingly large deviation for the superettes in the period 1963–65 (the development of superettes over this two-year period was one of the 15 observations).

In Appendix II we show the paths along which supermarkets emerged in the Netherlands, divided between independents, cooperatives and supermarkets. The analysis shows that the innovative trend towards supermarkets was started by the independents in 1954 (followed by the chain stores in 1955 and the cooperatives in 1958). Up to 1958 the independents led the trend, but then their growth declined, and they were overtaken by the chain stores in 1960. From 1961/1962 the growth of independent supermarkets accelerated again to a high rate, and the independents again overtook the chain stores in 1965. This pattern shows a marked difference from the findings of Fulop (1961) for the UK, according to which self-service was begun by the cooperatives, followed by the multiples and then the independents.

Between 1961 and 1963 the number of independent supermarkets increased from 20 to 67, and between 1963 and 1965 it increased from 67 to 230 (see Appendix II).

In view of the way in which the supermarkets emerged, our hypothesis now is as follows:

The trend towards the new shop type of supermarkets was started by a few daring independents.

The multiples rapidly caught on, while the remaining independents waited for the new shop type to prove itself.

As the new shop type proved to be consistently successful, more and more independents started to join the trend from 1961 onwards.

This step was made primarily by the more efficient independents running a superette.

As a result the average efficiency of the remaining independent superettes declined, particularly in the period 1963–1965.

If the hypothesis is correct, it might explain the large residual for the period 1963–65 which we found from the first estimate of our model. This is a hypothesis which we have not been able to test independently, but which we maintain for its plausibility. On the basis of this hypothesis, we introduce a dummy variable d for the one observation of the superettes for the period 1963–65.

The estimate of the model (based on an ordinary least squares procedure) then is as follows:

$$\underset{}{\dot{p}a} = \underset{(0.08)}{0.74\dot{l}} + \underset{(0.26)}{1.85\ \Delta pl} + \underset{(1.02)}{3.76\ \Delta vu} - \underset{(0.6)}{1.9} - \underset{(0.9)}{4.9d}; \qquad R^2 = 0.95 \tag{12}$$

The figures in parentheses are standard errors.

With the dummy variable for one of the observations, we now find a significant positive effect also of the labour market variable (Δvu), in accordance with our hypothesis.

With this result we calculated forecasts for the period 1975–77. The results, which were calculated in 1979, are given in Table 1.

Table 1. *Explanatory variables and estimates of the increase of efficiency* ($\dot{p}a$) *excluding the effect of scale* (%)

Period	$\dot{l}$	Δpl	Δvu	estimate of $\dot{p}a$
1975–76	2.3	1.0	−0.26	0.7
1976–77	−3.9	−0.08	−0.3[a]	−7.4

[a]Based on extrapolation not observation.

As illustrated in Fig. 1, the forecasts for the period 1975–77 are quite striking, in that they indicate a radical collapse of the growth of efficiency, after a reasonably steady growth of around 6% per annum in the period 1960–73. According to the model and its underlying theory, this is due to:

A more or less constant level of the share of part-time labour ($\Delta pl \approx 0$) since 1973, after a period of steady and substantial increase in the period 1963–73, during which the average share, in the food trade, increased from about 10% to about 30%.

A slow increase, or even a decline, of the wage rate relative to prices ($\dot{l}$), after a period of wage explosion up to the early seventies.

A continuing increase of unemployment ($\Delta vu < 0$), after the high employment levels during the sixties.

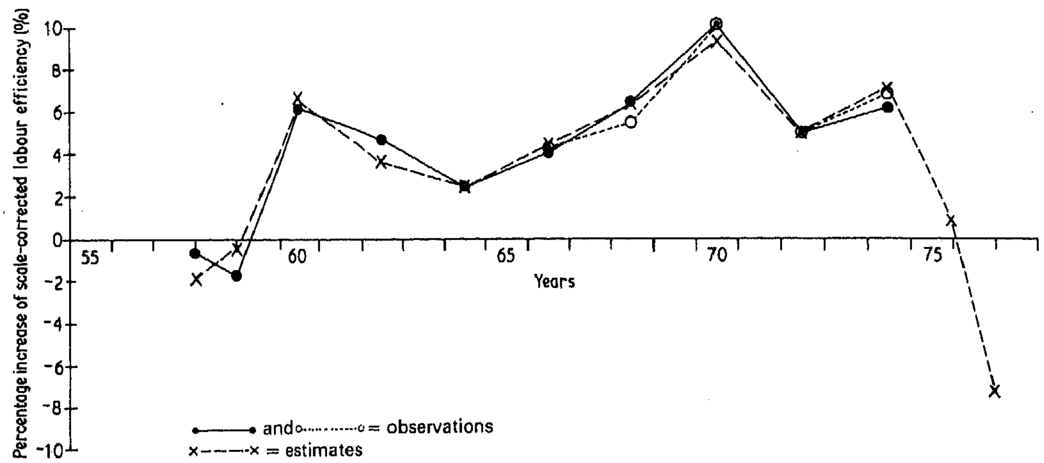

Fig. 1. Observations and estimates for self-service grocery trade.

In other words: the forecasts for 1975–77 were based on data showing trend breaks with respect to the data on which the model was estimated. Furthermore, there were deficiencies in the data on which the model was estimated. In view of this, together with the importance of the implications of the forecast, a test of the forecast and a re-estimation of the model under more recent economic conditions were desirable.

V. SECOND ESTIMATE

For a test of our forecasts we obtained observations on the growth of average efficiency for approximately 3000 establishments in the grocery trade, belonging to enterprises with no less than 10 persons engaged, in the period 1975–78, from the 'Production Statistics' of the Dutch Central Bureau of Statistics (CBS). The disadvantages of this sample were that it included shops of different types and did not include the smaller enterprises. But the advantage, which we considered to be of overriding importance, was the fact that the statistic covered 90% of the population of shops belonging to enterprises with no less than 10 persons engaged, which substantially reduces the risk of deviation from the increase of the share of part-time labour from the overall average used.

We also used averages from the Nielsen annual surveys *Distribution in the Netherlands* for 15 000 grocery and other food stores in the period 1976–78. Apart from complications due to differences in statistical classifications, the survey can be said to give an approximate representation of the entire grocery trade. According to the CBS classification the total number of shops in 1978 was about 10 000. The Nielsen survey exceeds this because it also included food shops for which groceries do not constitute the biggest sales item, but which offer an assortment comparable to grocery stores that do fall within the CBS classification. But because of this similarity with respect to assortment, and hence operating structure and costs, it is acceptable to use the survey along with the CBS statistics in a study of productivity. The Nielsen survey includes the shops of small enterprises that are not included in the CBS statistic. This category

Table 2. *Observed growth of average efficiency excluding the effect of scale, 1975–78* (%)

Sample	1975–76	1976–77	1977–78
CBS	−2.8	−6.3	8.7
Nielsen		−8.8	6.3
Forecasts from Table 1	0.7	−7.4	

consists largely of the independents that were studied in the first estimate of the model. Table 2 gives a confrontation between the growth of average efficiency observed from the CBS and Nielsen data, and the forecasts derived from the first estimation of the model.

Table 2 shows that the forecast of a drastic collapse of efficiency in the period 1975–77 is confirmed by the observations, especially in the year 1976–77. For the year 1977–78, however, the observations indicate considerable increases of efficiency. This militates against any hasty notion, which we had been tempted to consider, that from 1975 onwards there would no longer be any growth of efficiency.

Further analysis showed that our model could well be in agreement with the new facts: in spite of earlier indications, the share of part-time labour did again start to increase in 1977–78 ($\Delta pl > 0$), in 1977–78 the relative wage rate did increase ($\dot{l} > 0$). This was not due to any large increase of the wage rate, but to the fact that there was no increase in the price of grocery goods.

On the basis of the overall averages for the increase of the relative wage rate ($\dot{l} = 10.0\%$) and for the increase of the share of part-time labour ($\Delta pl = 0.9\%$), our forecast for 1977–78 would have been 5.5%, to be compared with the observations of 8.7 and 6.3% in Table 2.

For a test of our model, we re-estimated it on data after 1975. Previously, we conducted our estimates and forecasts on the basis of overall averages for the increase of the wage rate and for the increase of the share of part-time labour. For a specific sample, however, these variables may deviate from their overall averages, and it would be better to use observations on the wage rate and the share of part-time labour corresponding to the sample. Neither was available for the Nielsen data; both were available for the CBS data. The CBS source could be divided into 5 size classes of enterprise (each with its own wage rate and share of part-time labour), yielding a total of 15 observations in the period 1975–78. The source still suffers from the fact that it yields averages across different types of shop within the grocery trade. We also had panel data on 100 independent superettes and 40 independent supermarkets for the period 1976–78, from the Research Institute for Small and Medium-Sized Business in the Netherlands (EIM). These had the advantage of referring to fixed sets of shops of a more narrowly circumscribed type, while yielding the average wage rates corresponding to each sample. However, these data yielded no corresponding observations of the share of part-time labour, for which we had to fall back on the overall average for the food trade as a whole. The CBS data together with the panel data yielded a total of 20 observations.

We had direct observations only on the growth of efficiency including the effect of scale $\dot{p}$. Our earlier model (Equation 12) was estimated in terms of the growth of efficiency excluding the effect of scale ($\dot{p}a$). For a comparison, it thus had to be transformed, according to Equation 8. For the transformation we required an estimate of the ratio α_0/a. This ratio varies from one sample to another, but according to the available information, the average value was about 0.3.

Applying Equation 8 to our earlier model (Equation 12) we then obtain:

$$\dot{p} = 0.52\,\dot{l} + 1.30\,\Delta pl + 2.7\,\Delta vu + 0.3\,\dot{q} - 1.3. \tag{13}$$

The re-estimation of the model on the basis of the 20 observations after 1975 was complicated by a strong correlation between the vector Δpl and the unit vector associated with the constant term, due to a fairly steady increase of unemployment in the period concerned. To avoid multicollinearity, we moved the original estimate of the constant term (-1.3) to the other side of the equation. In other words: we increased all observations of $\dot{p}$ by 1.3 percentage points and regressed the result on the remaining variables.

The result was as follows:

$$\underset{}{\dot{p} + 1.3} = \underset{(0.09)}{0.60\,\dot{l}} + \underset{(0.58)}{1.71\,\Delta pl} + \underset{(2.3)}{3.3\,\Delta vu} + \underset{(0.10)}{0.36\,\dot{q}}; \qquad R^2 = 0.92. \tag{14}$$

The figures in parentheses are standard errors.

This is a fairly remarkable result:

The coefficients of $\dot{l}$, Δpl and Δvu all differ less than one standard error from the coefficients from the earlier estimate (on a different source of data for a different period of time);

The coefficient of $\dot{q}$ differs about half a standard error from the *a priori* value based on the estimate of the ratio α_0/a (0.3);

The result is not only consistent with the earlier estimate of the model for the efficiency excluding the effect of scale (Equation 12), but also with the transformation to the model for the efficiency including the effect of scale, according to Equation 8, which had not been tested empirically in this way before.

However, the re-estimate is less accurate (larger standard errors) than the original estimate. Thus the coefficient of Δvu is not statistically significant. Probably, this is partly due to a fairly strong intercorrelation between Δvu and Δpl, neither of which varied much in the observation period (correlation coefficient of -0.83). Also, we suspect that in the recent data we are confronted with a problem of heterogeneity in the CBS production statistics (aggregation of different shop types); in the estimation of the model including the effect of scale we implicitly assume that the ratio α_0/a is constant, while in fact it varies from one observation to the other. This also will contribute to a lower accuracy of the re-estimation.

In view of the above we choose to maintain the original estimate, derived from Equation 12, and we treat the re-estimation as a corroboration of the model under more recent economic conditions.

VI. CONCLUSIONS

The study of productivity growth in the grocery trade suffers from data deficiencies due to fragmentary and insufficiently differentiated statistics. However, our model yields estimates which are the same, within one standard error, for each of the coefficients, for data derived from different sources and referring to two different nonoverlapping time periods (1957–75 and 1975–78). Between these two periods there are large differences in the values of the variables involved (growth of productivity, wage rate and unemployment), yet the model performs reasonably well for both periods.

In view of this we consider it justified to use the estimate for the purpose of forecasting, in spite of the data deficiencies involved. Apparently the data deficiencies are not serious in practice, or the model is sufficiently robust to stand up to them.

There is considerable evidence to support the hypothesis that, apart from the effect of scale, average labour efficiency per type of shop depends on the (relative) wage rate, the share of part-time labour and the labour market. The evidence suggests that under the changed economic conditions after 1975, approximately the same model applies as during the sixties and early seventies. The model indicates that under present conditions of increasing unemployment and no real increase of the wage rate, the increase of efficiency will be relatively low. If in addition the share of part-time labour reaches its ceiling or optimum, which clearly lies somewhere below 100 %, as is bound to happen sooner or later, then the average efficiency per type of shop will actually decline. In Table 3 we give our forecast under three scenarios.

Table 3. *Expected growth of efficiency*

Scenario	Expected annual growth of efficiency excluding the effect of scale (%)
1 No real increase of the wage rate, no further increase of unemployment, a one percentage point annual increase of the share of part-time labour	0
2 No real increase of the wage rate, an increase of unemployment at the current rate, stationary share of part-time labour	$-3\frac{1}{2}$
3 Real decline of the wage rate of 2 %, an increase of unemployment at the current rate, stationary share of part-time labour	−5

We note that the results apply per shop type in the self-service grocery trade. We propose that theoretically a similar model, but possibly with different coefficients, applies to shop types in other trades. Our attempts to confirm this are seriously hampered by the lack of data in the Netherlands.

APPENDIX I PROOF OF THE TRANSFORMATION FORMULA (EQUATION 8)

In terms of differentials we have:

$$\dot{p} = \frac{\partial \log q/a}{\partial t} = \frac{a}{q}\frac{\partial q/a}{\partial t} \qquad \text{(A1)}$$

where: t refers to time, q = average deflated sales size per shop, a = average labour volume per shop, and:

$$\dot{p}a = \frac{\partial \log q/(a-\alpha_0)}{\partial t} = \frac{a-\alpha_0}{q}\frac{\partial q/(a-\alpha_0)}{\partial t} \tag{A2}$$

and:

$$\dot{q} = \frac{\partial \log q}{\partial t} = \frac{1}{q}\frac{\partial q}{\partial t} \tag{A3}$$

while according to the linear cost curve:

$$a = \alpha_0 + \alpha_1 q. \tag{A4}$$

Equation A4 yields:

$$\frac{\partial q/(a-\alpha_0)}{\partial t} = \frac{\partial 1/\alpha_1}{\partial q} = -\frac{1}{\alpha_1^2}\frac{\partial \alpha_1}{\partial t} \quad \text{and} \quad \frac{a-\alpha_0}{q} = \alpha_1 \tag{A5}$$

together with Equation A2, this yields:

$$\dot{p}a = -\frac{1}{\alpha_1}\frac{\partial \alpha_1}{\partial t}. \tag{A6}$$

Next, we have:

$$\frac{\partial q/a}{\partial t} = \frac{1}{a}\frac{\partial q}{\partial t} - \frac{q}{a^2}\frac{\partial a}{\partial t}. \tag{A7}$$

Since we are considering a given shop type, the number of departments per shop is fixed. We assume that the average opening time per shop is constant as well. Under this assumption, threshold labour is constant:

$$\frac{\partial \alpha_0}{\partial t} = 0 \tag{A8}$$

Equation A4 then yields:

$$\frac{\partial a}{\partial t} = \alpha_1 \frac{\partial q}{\partial t} + q\frac{\partial \alpha_1}{\partial t}. \tag{A9}$$

Substitution of Equation A9 in Equation A7 yields:

$$\frac{\partial q/a}{\partial t} = \frac{1}{a}\frac{\partial q}{\partial t} - \frac{q}{a^2}\alpha_1\frac{\partial q}{\partial t} - \frac{q^2}{a^2}\frac{\partial \alpha_1}{\partial t}. \tag{A10}$$

Substituting Equation A10 in Equation A1 we find:

$$\dot{p} = \frac{1}{q}\frac{\partial q}{\partial t} - \frac{\alpha_1}{a}\frac{\partial q}{\partial t} - \frac{q}{a}\frac{\partial \alpha_1}{\partial t}. \tag{A11}$$

Substituting Equation A6 we find:

$$\dot{p} = \left(1 - \frac{\alpha_1 q}{a}\right)\frac{1}{q}\frac{\partial q}{\partial t} + \alpha_1\frac{q}{a}\dot{p}a. \tag{A12}$$

On the basis of Equation A4 we have

$$1-\frac{\alpha_1 q}{a}=\frac{\alpha_0}{a};\quad \frac{\alpha_1 q}{a}=1-\frac{\alpha_0}{a} \tag{A13}$$

Substitution of Equation A13 and Equation A3 in Equation A12 yields:

$$\dot{p}=\left(1-\frac{\alpha_0}{a}\right)\dot{p}a+\frac{\alpha_0}{a}\dot{q} \qquad \text{Q.E.D.} \tag{A14}$$

APPENDIX II THE EMERGENCE OF SUPERETTES, SUPERMARKETS AND FOOD DISCOUNT STORES IN THE NETHERLANDS

Figures A1, A2 and A3 give plots of the growth of the number of superettes (small self-service grocery stores), supermarkets and discount stores (foods), split up between independents, cooperatives and chain stores. To facilitate visual inspection, the plots are construed on a

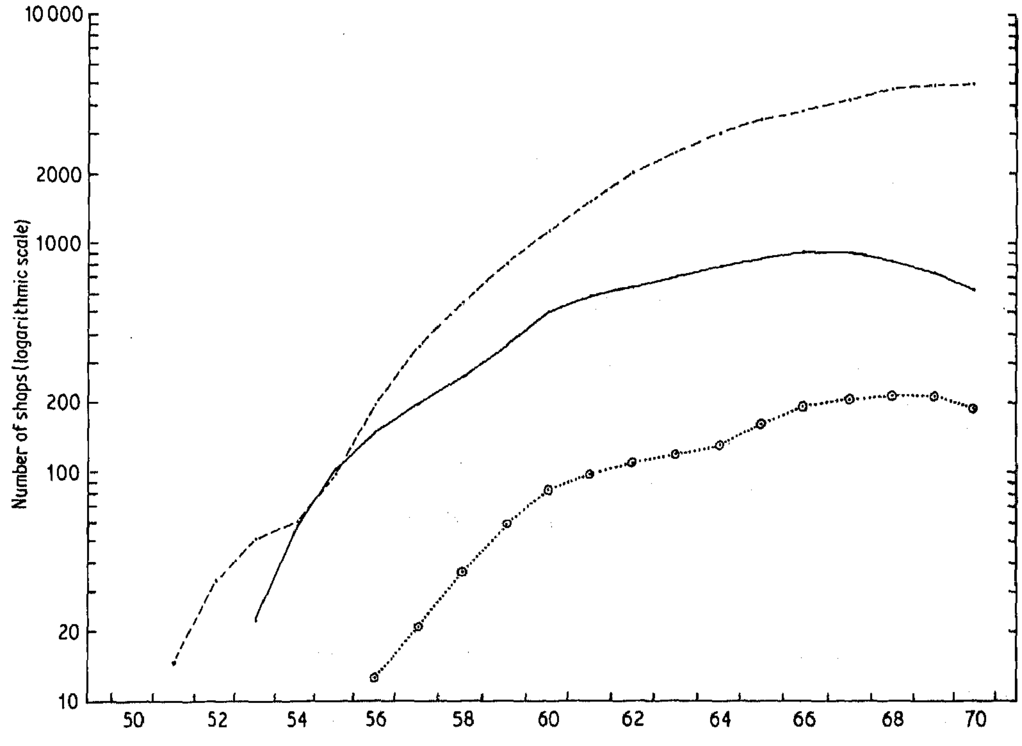

Fig. A1. Number of superettes (small self-service grocery stores), over the years 1951–1970. --. --, independents; . . ⊙ . ., cooperatives; —.—, chain stores.

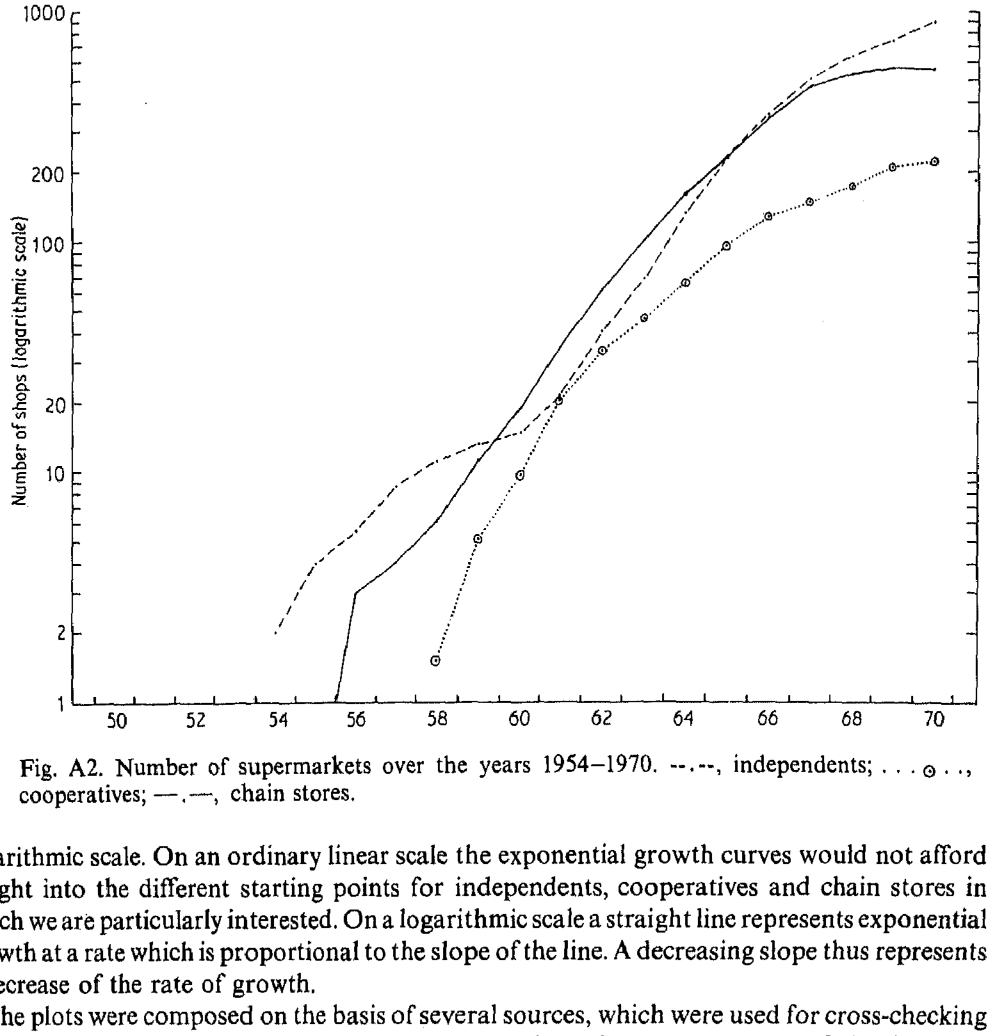

Fig. A2. Number of supermarkets over the years 1954–1970. --.--, independents; . . . ⊙ . ., cooperatives; —.—, chain stores.

logarithmic scale. On an ordinary linear scale the exponential growth curves would not afford insight into the different starting points for independents, cooperatives and chain stores in which we are particularly interested. On a logarithmic scale a straight line represents exponential growth at a rate which is proportional to the slope of the line. A decreasing slope thus represents a decrease of the rate of growth.

The plots were composed on the basis of several sources, which were used for cross-checking and mutual supplementation. These sources were: inter-firm comparisons of the Research Institute for Small and Medium-Sized Business in The Hague, Nielsen, statistics from cooperative societies, national statistics from the Central Bureau of Statistics, the Stichting voor Rationele Distributie (Foundation for Rational Distribution) and annual reports of chain store corporations.

The plots show that for all three types of general food store:

The development was initiated by the independents, followed by the chain stores and then the cooperatives.

Over a period of 4–6 years the growth of the independents declined, and they were overtaken by the chain stores.

Subsequently, in the case of the superettes and supermarkets, the growth of independents accelerated to a point where they again overtook the chain stores. In the case of the discount

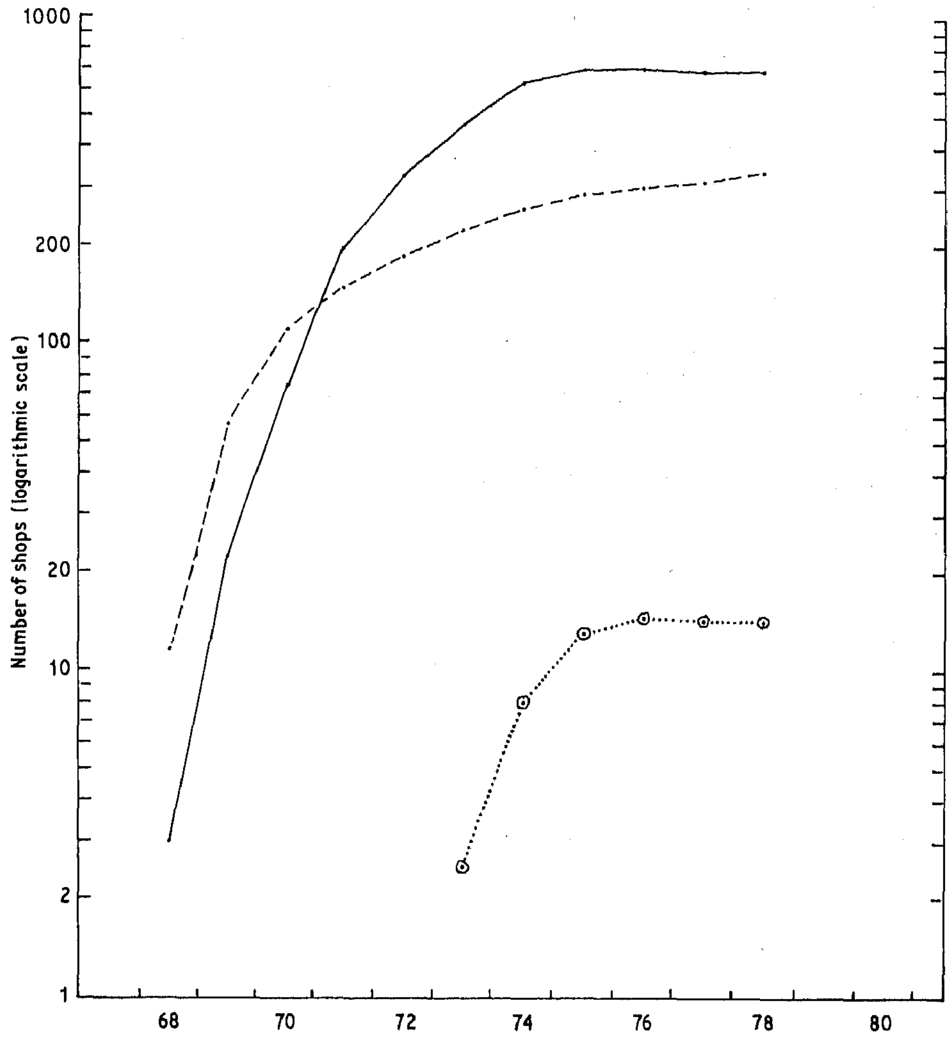

Fig. A3. Number of discount stores over the years 1968–1978. --.--, independents; . . ⊙ . ., cooperatives; —.—, chain stores.

stores the independents kept lagging behind the chain stores.

The cooperatives kept lagging behind both the independents and the chain stores throughout the life cycle of the shop type.

The plots also show that the penetration of supermarkets was faster, and was thus accomplished in a shorter period of time, than the penetration of the superettes. The penetration of discount stores was yet faster than that of the supermarkets: for all three categories (independents, supermarkets, cooperatives) the greatest upsurge only lasted about 4 years, before the decline of growth began. The next phase in the evolution is the development of superstores, but in the Netherlands this development has been limited by government intervention.

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