

Labour Productivity, Economies of Scale and Opening Time in Large Retail Establishments

by

A. Roy Thurik*

Differences in labour productivity are dealt with for large French retail establishments. Influences of scale, weekly opening time, assortment composition, wage rate and share of counter service are considered. The relationship used is a result of analyses in the field of small retail establishments.

INTRODUCTION

The aim of this study is two-fold. First, to test whether economies of scale can be obtained with respect to labour productivity for large French retail establishments (*magasins populaires*,¹ hypermarkets and supermarkets). Second, to analyse the influence of weekly opening time on labour productivity. As far as we are informed, no detailed studies have been conducted yet on the explanation of differences in labour productivity of these shop types, which play an important role in French retailing.² The emphasis on the role of opening time is induced by the fact that recently the French press³ devoted much attention to the problem of establishing weekly opening time, and by a recent article on trading hours and economies of scale in retailing.⁴ In addition, the roles of assortment composition, wage rate and share of counter service are studied. The data used for our exercises stem from the French weekly *Libre Service Actualités*.

LABOUR PRODUCTIVITY IN RETAILING

In this study we shall use a relationship between volume of labour and value of annual sales for retail establishments which offer essentially the same product mix and service level. Such a group of establishments will be called shop type. This relationship was developed by Nootboom

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[1982: 163-86] for small retail establishments. The basic elements of his analysis are:

- (a) There is a linear non-homogeneous relationship between volume of labour and value of annual sales for establishments belonging to a certain shop type.
- (b) The intercept of this relationship is associated with threshold labour, i.e. a *minimum capacity of labour which must be present during opening hours*. The amount of this labour is assumed to be equal to the sum of opening times of all independently staffed departments in the shop. Per department the minimum capacity of one attendant must always be present.
- (c) Theoretically, this relationship can be derived noting that there are two types of labour: labour to serve customers and labour for other activities (administration, stock-keeping etc.), and using a very narrow definition of a shop type.⁵
- (d) Empirically, however, promising results are obtained for shop types having the practical definition given above.
- (e) The precise theoretical definition of a shop type does not leave room for a significant possibility for substitution of capital for labour. Consequently, the relation between volume of labour and value of annual sales can be studied disregarding the use of capital.

In mathematical form, the relationship reads for a certain shop type:

$$(1) \quad L_i = \alpha_0 + \alpha_{1i}Q_i \quad \text{with } \alpha_0 > 0 \text{ and } \alpha_{1i} > 0 \text{ for all } i,$$

where L_i : volume of labour in establishment i ;

Q_i : value of annual sales in establishment i ;

α_0 : threshold coefficient. Its value is independent of i , if it is assumed that the number of independently staffed departments and annual opening time are equal for all i ;

α_{1i} : scale adjusted labour intensity. This terminology becomes clear after rewriting equation (1): $L_i/Q_i = \alpha_{1i} + \alpha_0/Q_i$. The variable L_i/Q_i , volume of labour per value unit of annual sales, contains two parts: scale independent α_{1i} and scale dependent α_0/Q_i . L_i/Q_i decreases and approximates α_{1i} with increasing scale, if $\alpha_0 > 0$. The value of α_{1i} depends on specific properties of establishment i within the shop type. We shall return to these properties in the next section.

FRENCH SUPERMARKET-LIKE ESTABLISHMENTS

In applying relationship (1) to French *magasins populaires*, hypermarkets and supermarkets, we have to bear in mind that these establishments are sometimes very large. In Table A2 of the Appendix to this paper, an indication of the range of some variables is given. Also, there is considerable variation in the assortment composition per shop type. For instance, the non-food sales share usually increases with increasing scale. There-

fore, the establishments are assumed to consist of two smaller establishments: a food and a non-food establishment. This is done to facilitate our analysis of differences in labour intensities, because they depend largely on the type of products. Two relationships result from this approach:

$$(2) \quad L_{ki} = \alpha_{0k} + \alpha_{1ki}Q_{ki} \quad \text{with } k = 1, 2,$$

where $k = 1$ refers to food sales and $k = 2$ to non-food sales;
Clearly,

$$(3) \quad L_{1i} + L_{2i} \triangleq L_i \text{ and } Q_{1i} + Q_{2i} \triangleq Q_i,$$

where L_i : total volume of labour in establishment i ;
 Q_i : total value of annual sales in establishment i .

Summation of equation (2) gives:

$$(4) \quad L_i = \alpha_0 + \alpha_{11i}Q_{1i} + \alpha_{12i}Q_{2i},$$

where

$$(5) \quad \alpha_0 \triangleq \alpha_{01} + \alpha_{02}.$$

We are forced to confront equation (4) instead of equation (3) with the data because L_{1i} and L_{2i} are not available separately and because α_{01} and α_{02} cannot be estimated separately.

SPECIFIC PROPERTIES

We shall now introduce hypotheses on the influence of specific properties per establishment on the relationship between volume of labour and value of annual sales:

Opening Time

The intercept of the relation between volume of labour and value of annual sales increases, if opening time increases. In addition, opening time may influence scale adjusted labour intensity. If opening time increases:

- (a) intensity of competition decreases, because an increasing number of competing establishments is assumed to be closed. This may imply that customers have to accept longer waiting time. Then labour intensity decreases;
- (b) fluctuations in the requirement of labour increase, because an increasing number of opening hours comprises more 'odd hours'. The average discrepancy between required and available labour increases and labour intensity increases.

We have no a priori hypothesis about the resulting 'sign' of the influences of opening time on scale adjusted labour intensity.

Wage Rate

Firstly, it is assumed that the average wage rate per establishment is an

indicator of the quality of labour. Secondly, it is assumed that the motivation to use available labour efficiently is induced by the height of the wage rate. Thus, we assume that scale adjusted labour intensity decreases if the wage rate of the establishment increases.

Mode of Service

The mode of service depends on whether counter service or self-service is used to sell the products. Obviously, there is a difference in labour intensity between these types of service. We assume that scale adjusted labour intensity increases if the percentage of shop space used for counter service increases.

TEST SPECIFICATION

Combining equation (4) with the hypothesis of the previous section, we propose the following test specification:

$$(6) \quad L_i = \alpha_0 \left(\frac{DO_i}{\bar{DO}} \right) + (\alpha_{11} Q_{1i} + \alpha_{12} Q_{2i}) \left(\frac{DO_i}{\bar{DO}} \right)^{\alpha_2} \left(\frac{FL_i}{\bar{FL}} \right)^{\alpha_3} \exp \alpha_4 (CS_i - \bar{CS}),$$

where L_i : volume of labour in establishment i (in full-time equivalents);

DO_i : weekly opening time (in hours);

Q_{1i} : value of annual food sales (in 10^6 French francs of 1976);

Q_{2i} : value of annual non-food sales (in 10^6 French francs of 1976);

FL_i : wage rate per man-year (in 10^3 French francs of 1976);

CS_i : share of counter service area in total selling area;

\bar{DO} , \bar{FL} , \bar{CS} : sample averages.

Equation (6) needs some explanation:

- We restrict ourselves to a multiplicative specification of the influences (DO_i , FL_i and CS_i) on the scale adjusted labour intensities. This is done because it accounts for interaction between variables. An exponential specification is chosen for CS_i , because this variable can take zero value.
- The effect of these influences is taken to be symmetric regarding both assortment groups. This is assumed for the sake of convenience.
- α_{11} and α_{12} are called partial 'average' scale adjusted labour intensities, because they refer to one assortment group (partial) and to an establishment with $DO_i = \bar{DO}$, $FL_i = \bar{FL}$ and $CS_i = \bar{CS}$ ('average').
- α_0 is called 'average' threshold coefficient, because it expresses the threshold labour of an establishment with $DO_i = \bar{DO}$. Strictly, $\alpha_0 = \bar{ND} \times \bar{DO} \div \bar{DT}$, where \bar{ND} is sample average number of independently staffed departments and \bar{DT} is sample average working time per full-time employee.
- the hypotheses of the previous section say that $\alpha_3 < 0$, $\alpha_4 > 0$, whereas no a priori sign for α_2 is given.

TESTS

The coefficients of equation (6) are estimated for French *magasins populaires* of 1975–79 (MP), French hypermarkets of 1975–77 (HYP) and French supermarkets of 1975–79 (SUP).⁷ This estimation is performed by minimising the sum of squares of a disturbance variable which is added to the right hand side of equation (6) and which is assumed to have zero expectation and constant variance. Marquandt's algorithm [1963: 431–41] is used for this numerical minimisation. The results are given in Table 1.

TABLE 1
ESTIMATES OF THE COEFFICIENTS OF EQUATION (6) FOR FRENCH
SUPERMARKET-LIKE ESTABLISHMENTS

Shop type		MP	HYP	SUP
Threshold	$\hat{\alpha}_0$	2.76 (1.63)*	39.12 (8.89)	3.65 (1.12)
Foods	$\hat{\alpha}_{11}$	1.64 (.14)	.89 (.25)	1.85 (.10)
Non-foods	$\hat{\alpha}_{12}$	3.70 (.20)	2.15 (.26)	.98 (.20)
Opening time	$\hat{\alpha}_2$	-.20 (.09)	.33 (.19)*	-.14 (.07)
Wage rate	$\hat{\alpha}_3$	-.87 (.07)	-.86 (.11)	-.65 (.06)
Counter service	$\hat{\alpha}_4$.30 (.05)		
Number of observations	I	86	82	131
Goodness of fit	q^2	.975	.938	.929

Note: Estimated standard errors ($\hat{\sigma}$) are printed beneath the estimated coefficient. They are assumed to be asymptotically normally distributed. An asterisk (*) is printed next to the standard error of coefficient η if $(\hat{\eta}) < 2 \hat{\sigma}(\hat{\eta})$, i.e. if $\hat{\eta}$ is significantly different from zero at a 5 per cent level of significance. The square of the correlation coefficient between the vectors of L , and its estimation is taken as a measure of goodness of fit.

The following conclusions can be drawn from Table 1:

- (a) As expected $\hat{\alpha}_0 > 0$ and significantly in case of hypermarkets and supermarkets: economies of scale can be obtained with respect to labour productivity for large French supermarket-like establishments. 'Average' threshold labour is approximately 2.8 full-time equivalents for *magasins populaires*, 39 for hypermarkets and 3.7 for supermarkets. Sample average weekly opening times of these three shop types are 47, 70.4 and 49.2 hours, respectively. Under the assumption that average weekly working time per full-time employee is 36 hours and that one full-time equivalent is needed per independently staffed department, the calculated number of independently staffed departments becomes approximately 2 ($\approx 2.8 \times 36 \div 47$), 20 ($\approx 39.12 \times 36 \div 70.4$) and 3 ($\approx 3.7 \times 36 \div 49.2$), respectively.

- (b) As expected $\hat{\alpha}_{11} > 0$ and $\hat{\alpha}_{12} > 0$ and significantly. Foods are less labour intensive than non-foods for *magasins populaires* and hypermarkets, whereas they are more labour intensive than non-foods for supermarkets.
- (c) Weekly opening time has a negative influence on scale adjusted labour intensity for *magasins populaires* and supermarkets. It has a positive influence for hypermarkets, though here $\hat{\alpha}_2 > 0$ and significantly only at a 10 per cent level of significance.
- (d) As expected $\hat{\alpha}_3 < 0$ and significantly.
- (e) As expected $\hat{\alpha}_4 > 0$ and significantly. Unfortunately, the variable CS_i is not available for hypermarkets and supermarkets.

Finally, we see that the explanation obtained with relationship (6) is extremely high for cross-section samples. Examination of residual values computed with equation (6) does not reveal any structure. There is no reason at all to be suspicious about the use of equation (6) to explain differences in labour productivity.

INTERPRETATION

In the previous section, the results are discussed from a statistical point of view. In this section, these results will be interpreted from an economic point of view:

- (a) The calculated number of independently staffed departments seems realistic for *magasins populaires* and supermarkets: one department consists of a series of cash desks and the second and third consist of service counters for specialised goods (for example, fresh foods). The calculated number of cash desks for hypermarkets seems rather large. However, one has to bear in mind that most hypermarkets have a cafeteria, petrol station, garden centre or hobby centre, which are undoubtedly independently staffed.
- (b) Probably, *magasins populaires* and hypermarkets have a high degree of specialisation (deep assortment composition) in non-foods, whereas supermarkets specialise in foods. This may cause the differences in labour intensities between the assortment groups per shop type. On the whole, *magasins populaires* are more labour intensive than hypermarkets and supermarkets, which may explain the decrease of the market share of *magasins populaires* in the *grand commerce* in France.⁸
- (c) Specification (6) assumes that threshold labour increases with increasing opening time. We learn from the results in Table 1 that this effect is partially offset by a negative influence of opening time on scale adjusted labour intensity for *magasins populaires* and supermarkets. This counterforce is scale dependent; the elasticity of L_i with respect to $\frac{DO_i}{DO}$, E, reads:

$$(7) \quad E = \frac{d \log L_i}{d \log \frac{DO_i}{\bar{DO}}} = \left[\alpha_0 \frac{DO_i}{\bar{DO}} [1 - \alpha_2] + \alpha_2 L_i \right] / L_i.$$

Now, $E > 0$ if $L_i < L^*$ with $L^* = (1 - \frac{1}{\alpha_2}) \alpha_0 \frac{DO_i}{\bar{DO}}$. For *magasins populaires* and supermarkets $L^*(DO_i = \bar{DO}) = 17$ and 30, respectively. The sample minimum volumes of labour for *magasins populaires* and supermarkets are 20 and 12 respectively. See Table A2 of the Appendix to this article. From this we conclude that only for very small establishments $E > 0$ and that for the major part of the sales range an increase of relative weekly opening time appears to favour labour productivity.

For hypermarkets, however, there is a positive influence of relative opening time on scale adjusted labour intensity: $E > 0$ for all values of L . Our hypothesis concerning the difference between *magasins populaires* and supermarkets on the one hand and hypermarkets on the other is the following: generally, hypermarkets have a stronger competitive position than *magasins populaires* and supermarkets. They cannot improve this position by increasing relative weekly opening time, whereas *magasins populaires* and supermarkets can, motivating customers to accept longer waiting time and hence, decreasing labour intensity. Another hypothesis is based on the fact that, generally, hypermarkets have longer opening times than *magasins populaires* and supermarkets, and are not in a position to improve their competitive position by varying their already long opening time.

We refer to Nootboom [1983: 57-62] for a discussion of the influence of opening time under the assumption that DO_i/\bar{DO} is constant, in other words, there is a structural shift in opening time. Then

$$(8) \quad \frac{d \log L_i}{d \log DO_i} = \left[\alpha_0 \frac{DO_i}{\bar{DO}} \right] / L_i > 0$$

- (d) The influence of the wage rate is approximately equal for all three shop types. The values found for $\hat{\alpha}_3$ are comparable to, or somewhat higher than those found in earlier studies concerning small retail establishments.⁹
- (e) Labour productivity decreases if the share of counter service increases at the expense of the share of self-service. It would be interesting to study its influence on floorspace productivity and margin.

CONCLUSIONS

The main conclusions of the exercises with large French supermarket (-like) establishments are:¹⁰

- (a) The relationship between volume of labour and value of annual sales, discussed in the section on labour productivity in retailing, serves its

- purpose very well in the case of large retail establishments, because:
- (i) according to what is expected, a positive threshold coefficient is found, implying economies of scale regarding the use of labour;
 - (ii) the value of the threshold coefficient can quite well be explained in terms of expected number of independently staffed departments;
 - (iii) differences in labour productivity can very well be explained using variables such as assortment composition, wage rate, weekly opening time and share of counter service;
 - (iv) the explanation of the relationship used is extremely high for a cross-section sample.
- (b) Assuming that weekly opening time has a positive influence on threshold labour (labour which is independent of scale), we find that it has a negative influence on scale dependent labour in the case of *magasins populaires* and supermarkets. The latter influence offsets the former up from a certain (rather small) scale. Consequently, for the major part of the sales range, an increase of relative weekly opening time appears to favour labour productivity. This is not the case for hypermarkets.

NOTES

1. *Magasins populaires* can be associated with English variety stores, but they have an integrated supermarket.
2. The market share of *magasins populaires*, hypermarkets and supermarkets in total retailing sales grew from 17.9% in 1975 to 21.7% in 1979. See Marengo and Quin [1981:23].
3. See Laresse [1980:30-3], 'Libre Service Actualités' [1980a:22], [1980b:21-2], [1980c:17-19], and [1981:32-5], and Vié [1980].
4. Nootboom [1983], who analyses the influence of average opening time on average labour productivity per shop type. This article deals with the influence of different opening times on labour productivity per shop.
5. See Nootboom [1982:163-86].
6. See Nootboom [1981].
7. In the Appendix to this article, definitions of the shop types are given as well as the sources of the data used.
8. See Marengo and Quin [1981:23].
9. See Nootboom [1982] and Thurik and Van der Wijst [1982].
10. Further results concerning influences on labour productivity for these establishments are reported by Thurik [1982]. Differences in floorspace efficiency are discussed in Thurik and Koerts [1982].

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APPENDIX

The source of the data and the partitioning of our samples over the years of observation is given in Table A1. A further description of the data is given in Table A2. The definitions of the shop types are:

Supermarché: magasin d'alimentation (autonome) atteignant 400 m² de surface de vente (ne dépassant pas 2500 m²) en libre service ou réalisant au moins 7.5 millions de francs de chiffre d'affaires annuel, grâce à un assortiment de 2500 à 5000 références, comprenant 500 à 1500 références non alimentaires.

Hypermarché: libre-service de 2500 m² de surface de vente minimale, présentant un assortiment complet (20000 à 35000 références), avec des rayons alimentaires (3500 à 5000 références) et non alimentaires (16000 à 30000 références) et offrant un parking à sa clientèle.

Magasin populaire: point de vente limitant son assortiment (7000 à 10000 références) aux articles de grande vente et offrant généralement, en plus des secteurs nouveauté et bazar, des rayons alimentaires (1500 à 4000 références). Le plus souvent exploités en libre-service, ces derniers peuvent constituer, selon la surface qui leur est consacrée et leur propre chiffre d'affaires, un supermarché intégré au magasin populaire.

TABLE A1
SOURCE OF DATA AND PARTITIONING OVER THE YEARS OF OBSERVATION

Code	Year of observation	Number of establishments	Average sales (in 10 ⁶ French francs of the current year)	Average volume of labour (in full-time equivalents)	Source of the data
MP	1975	18	25.1	70.6	P. d. R., 1975, Magasins Populaires, L.S.A., No. 595 (7-10-1976)
	1976	24	23.1	65.7	P. d. R., 1976, Magasins Populaires, L.S.A., No. 631 (24-6-1977)
	1978	19	30.2	70.1	P. d. R., 1978, Magasins Populaires, L.S.A., No. 722 (13-7-1979)
	1979	25	30.5	60.1	P. d. R., 1979, Magasins Populaires, L.S.A., No. 757 (9-5-1980)
HYP	1975	86			
	1975	22	132.7	257.6	P. d. R., 1975, Hypermarchés, L.S.A., No. 593 (15-9-1976)
	1976	36	120.8	214.2	P. d. R., 1976, Hypermarchés, L.S.A., No. 629 (10-6-1977)
SUP	1977	24	180.8	276.7	P. d. R., 1977, Hypermarchés, L.S.A., No. 676 (30-6-1978)
	1975	82			
	1975	42	17.8	36.8	P. d. R., 1975, Supermarchés, L.S.A., No. 593 (19-6-1976)
SUP	1976	56	20.8	37.4	P. d. R., 1976, Supermarchés, L.S.A., No. 629 (10-6-1977)
	1978	23	22.0	36.4	P. d. R., 1978, Supermarchés, L.S.A., No. 720 (29-6-1979)
	1979	10	26.3	34.0	P. d. R., 1979, Supermarchés, L.S.A., No. 764 (27-6-1980)
		131			

Note: P. d. R. = 'Points de Repère', L.S.A. = 'Libre Service Actualités'.

TABLE A2
FURTHER DESCRIPTION OF THE DATA

<i>Code</i>	$\min L_i$ \bar{L} $\max L_i$	$\min Q_{1i}$ \bar{Q}_1 $\max Q_{1i}$	$\min Q_{2i}$ \bar{Q}_2 $\max Q_{2i}$	$\min DO_i$ $\bar{D}\bar{O}$ $\max DO_i$	$\min FL_i$ $\bar{F}\bar{L}$ $\max FL_i$
MP	20.0	5.87	2.41	40.0	25.2
	66.1	14.57	10.12	47.0	40.5
	207.0	69.06	38.67	65.0	53.4
HYP	65.0	24.27	11.95	52.0	28.3
	244.1	78.48	62.26	70.4	40.2
	517.0	162.66	154.72	79.0	56.9
SUP	12.0	4.31	.51	40.0	20.2
	36.8	15.40	4.56	49.2	38.6
	105.0	51.17	21.62	78.0	70.0

Note: L_i is volume of labour (in full-time equivalents), Q_{1i} and Q_{2i} are value of annual sales of foods and non-foods, respectively (in 10^6 French francs of 1976), DO_i is weekly opening time (in hours) and FL_i is wage rate per man year (in 10^3 French francs of 1976).

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