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4 Productivity in the Distributive Trades: The Shopper and the Economies of Massed Reserves

Walter Y. Oi

Goods are of little use unless they can be put in the hands of the ultimate consumers. Some direct sales are still observed, but the vast majority of consumable goods are channeled through middlemen specialists who facilitate the movement of goods in time and space, consummate mutually advantageous exchanges by matching buyers and sellers, and supply product information and ancillary services that reduce transaction costs. Retailers rarely charge explicit prices for their services that are demanded by both producers and consumers. They earn their remuneration by introducing a spread between retail prices and wholesale costs.

Wholesale and retail trade, which accounted for only 6.1 percent of total employment in 1880, provided fully 20.6 percent of all jobs in 1980. The size of the distribution sector is considerably smaller when size is measured not by employment but by man-hours, labor costs, or value added. Whatever metric we use, the share of the economy's resources allocated to distribution is steadily growing. Wallis and North (1986) defined a broader concept of a transaction sector that dealt with both the exchange of goods and the protection and enforcement of property rights. They estimated that in 1970 over half of the nation's resources were allocated to the transaction sector.

Economic theory has largely neglected the distributive trades. Henry Smith (1948), W. Arthur Lewis (1970), and Bob R. Holdren (1960) represent some notable exceptions who mainly examined the place of the retail establishment. Stores in these models are differentiated by location and behave like firms in a monopolistically competitive industry. Bucklin (1972) and Ingene and Lusch (1981) directed attention to the consumer who has to devote time and resources to shopping. As individuals acquired more cars and bigger houses, they changed their shopping behavior, which, in turn, affected the derived

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demand for retail services. Average transaction sizes got larger, and so, in combination with the economies of massed reserves, provided an environment that encouraged the development of large supermarkets. National advertising of standardized brands lowered search costs for customers who now had less incentive to inspect goods. They had less to gain by relying on the reputation of the Broadway to stock good underwear. They could simply buy Jockey. Some retail functions that were previously performed by retailers were shifted forward to consumers and others backward to producers. Stores are open longer, and retail clerks have less store-specific human capital. The product lines of supermarkets have been greatly expanded; those of gasoline service stations have been narrowed. The changing structure of the service bundle supplied by retail firms and the economies of massed reserves complicate the problem of measuring productivity for the distribution sector. The received theory of production has to be augmented by including the inputs of consumers and producers in measuring the rate of technical progress.

4.1 Growth of the Distributive Trades

When each household was largely self-sufficient, there was little need for the services of middlemen. Technological advances in transportation, agriculture, and manufacturing were responsible for the division of labor and the growth of large-scale enterprises. The propensities to truck, barter, and exchange expanded as resources were specialized. More transactions were required to move goods to their highest valued uses, and these could be more efficiently performed by specialists and institutions that make up the sector called the distributive trades.

The growth of this sector was documented by Harold Barger (1955) in *Distribution's Place in the American Economy.* In 1900, 62.0 percent of the 29.1 million persons in the labor force were in the goods-producing industries (agriculture, forestry, and fisheries, construction, mining, and manufacturing); only 8.2 percent were engaged in distributing goods. By 1980, only 26.5 percent were producing goods, and 25.5 percent were employed in wholesale and retail trade; confer table 4.1.[1] For every 100 persons who were producing goods in 1880, 8.6 workers were employed in distributing those goods. This figure climbed to 13.2 in 1900, 46.4 in 1950, and 77.1 in 1980. This dramatic shift in the industrial affiliation of the labor force overstates the sectoral reallocation of labor. Head counts ignore differences in the length of the work week and the skill mix of the work force. Over the period, 1900–1980, average weekly hours in the goods-producing industries fell from 51 hours to 40.9 hours, compared to a drop from 65 hours to 32.3 hours in trade. The ratio of

1. The first two columns, which were taken from Barger, refer to the labor force; the last two columns are census data on employed persons. The two series are not strictly comparable. To the extent that unemployment rates by industry vary, they could result in slightly different percentage distributions.

Table 4.1 **Employment, Hours, and Earnings by Major Industry, 1900–1980**

	1900	1940	1950	1980
Employees (thousands):				
All industries	29,070	53,300	55,813	97,639
Goods producing	18,020	22,190	22,368	25,857
Manufacturing	6,340	11,940	14,469	21,915
Transportation & utilities	2,100	4,150	4,346	7,087
Trade	2,391	7,180	10,385	19,934
Other*	6,559	19,780	18,714	44,761
Ratio, 100 (trade/goods)†	13.27	32.26	46.43	77.09
Average weekly hours:				
Goods producing	51	43	43.8	40.9
Manufacturing	52	38	40.5	39.7
Trade	65	48	40.5	32.3
Wholesale	N.A.	41.3	40.7	38.5
Retail	N.A.	43.2	40.4	30.2
Ratio, 100 (trade/goods)	127	112	92	79
Work hours per week (millions):				
Goods producing	919	954	980	1,058
Trade	155	345	421	644
Ratio, 100 (trade/goods)	17	36	43	61
Average hourly earnings ($):				
Goods producing	0.128	0.454	1.39	7.16
Manufacturing	0.175	0.633	1.44	7.27
Agriculture	0.087	0.253	0.75	3.90
Trade	0.175	0.536	1.26	5.34
Wholesale	N.A.	N.A.	1.48	6.96
Retail	N.A.	N.A.	0.98	4.88
Ratio, 100 (trade/goods)	136.7	118.1	90.6	74.6
Ratio, 100 (trade/manufacturing)	100.0	84.7	87.5	73.5

Sources: Employees, hours, and earnings 1900–1940 are taken from Harold Barger (1955); tables 1 and 5, and A1. Data for 1950 and 1980 obtained from *Historical Statistics and Statistical Abstract of the U.S.* (selected issues).

Note: n.a. = not available.

*Other industries include services, construction, government, and so forth.

†Ratio is defined as employment in trade divided by employment in goods producing industries.

the labor inputs in trade and the goods-producing industries measured by employment counts, (E_T/E_G) rose from .136 in 1900 to .771 in 1980, but when this ratio is measured in man-hours, (M_T/M_G), it climbed from .11 to .61.[2] The quality of labor has improved over time, but these improvements have

2. The data shown in table 4.1 pertain to hours paid rather than hours actually worked. Employees in retail trade receive fewer paid holidays and vacations. K. Kunze reported that in 1985 the ratio of hours actually worked to hours paid (H_A/H_P) was 0.914 in manufacturing and 0.964 in retail trade. The secular decline in this ratio was surely steeper in the goods-producing industries. If we could have measured man-hours actually worked, the labor input ratio would have been less than 0.61 in 1980.

been uneven across sectors. Three bits of evidence suggest that there has been a decline in the relative quality of the retail work force. First, the percentage of women in the work force increased for the economy as a whole, but the increase was even greater in retail trade. Many of the retail jobs that were created in the postwar period were filled by women and teenagers who were new entrants with little work experience. Second, part-time employees accounted for 13.0 percent of all employed persons in 1950 and 20.9 percent in 1980. In manufacturing, the reliance on part-timers changed little, from 8.5 to 9.6 percent. However, it nearly doubled in retail trade, climbing from 12.5 to 24.5 percent.[3] The rapid growth in the use of part-timers can, I believe, be explained by the changing nature of retail transactions. Third, the greater use of less skilled employees is corroborated by the data on relative wages. In 1900, the wage index shown at "ratio, 100 (trade/goods)" under "average hourly earnings" in table 4.1 was 136.7, meaning that retail employees earned hourly wages that were 36.7 percent above the wages of employees in the goods-producing industries. This wage index fell to 90.6 in 1950, and by 1980 wages in retail trade were 25.4 percent below the wages in the goods-producing industries. This decline is even sharper when manufacturing is the comparison group, as shown in the next row of table 4.1. At least three factors contributed to this drop in relative wages: (*a*) employment within retail trade shifted toward the low-wage three-digit industries; (*b*) the relative demands for part-timers and females who are paid lower wages climbed faster in retail trade; and (c) retail trade unions lost much of their market power. Adjusting the labor input for these quality changes would bring down the estimate of the growth of distribution.

Another measure of the resource reallocation can be gleaned from the value-added data. From 1950 to 1980, the share of total GNP generated by the goods-producing industries fell from 41.1 percent to 31.9 percent. The ratio of value added in trade to that in manufacturing, ($\mathrm{VA}_{trade}/\mathrm{VA}_{mfg}$) climbed from .725 in 1970 to .786 in 1987.[4] These data still indicate a relative growth of the distribution sector, but the size of the growth is far smaller than that indicated by employment counts.

Greater specialization was accompanied by a rise in the fraction of goods handled by middlemen. The proportion of consumable goods passing through retail outlets increased from 72 percent in 1869 to 87 percent in 1929. A faster rate of technical progress in producing goods also contributed to a movement of resources away from the goods-producing sector. The Bureau of Labor Statistics (BLS) has assembled data on output measured by value added X, em-

3. The three-digit industries within retail trade exhibited considerable dispersion in the percentage of employees on part-time work schedules. Over the 1950–80 period, it climbed from 11.4 percent to 39.1 percent in general merchandise stores, 26.6 percent to 45.3 percent in food and dairy stores, and 8.9 percent to 26.9 percent in gasoline service stations.

4. The value-added data were taken from table B.12 in the *Economic Report of the President, 1988*.

ployment E, and total hours H. These data shown in panel A of table 4.2 allow us to measure the relative importance of four sectors: goods G, manufacturing M, wholesale trade WT, and retail trade RT. The patterns are slightly different from those indicated by table 4.1, but they confirm the relative growth of the distributive trades. Labor productivity measured by output per hour in panel B, increased at an annual rate of 2.60 percent in goods, 2.69 for manufacturing, 2.45 for wholesale trade, and only 1.76 percent for retail trade. The time path of labor productivity for the entire period, 1947–87, is presented in figure 4.1. At the three-digit level, the BLS embraces a sales measure of output. These data are shown in table 4.3 for food stores F, department stores D, and gasoline service stations G.[5] Between 1967 and 1987, total output in constant dollar sales increased by 35.0 percent for food stores, 124.5 percent for department stores, and 50.3 percent for gas stations. Labor productivity (output per hour) grew at annual rates of 0.72 percent for food stores, 3.09 for department stores, and 4.00 for gas stations.[6]

Using a sales measure of output, Ratchford and Brown (1985) estimated that for the period 1959–79 total factor productivity (TFP) increased at a rate of 0.47 percent a year for food stores, and at 2.07 percent for manufacturing.[7] The slower growth rate of TFP in food stores in relation to manufacturing led these authors to conclude that in the years ahead an increasing share of the economy's resources will have to be devoted to distribution. I shall argue that not all the productivity changes are the results of exogenous technical progress, but they can, in part, be traced to changes in the organization of production.

4.2 The Output of a Retail Firm

Firms engaged in producing goods—extruding aluminum, fermenting grapes, or growing catfish—must establish channels through which their goods can reach the ultimate consumer. Direct sales by farmers and manufacturers were not uncommon at the turn of the century. In such an economy of vertically integrated firms, there is little need for a distribution sector. How-

5. Hall, Knapp, and Winsten (1961) used a sales measure of output that assumes a fixed proportions technology. Changes in the gross margin are attributed to changes in input prices. A margins or value-added measure of output assumes that changes in the gross margin are due to changes in the services supplied by the store. Input prices are presumed to move in proportion to changes in retail prices.

6. These growth rates are the regression coefficients of log-linear trend equations using all of the available data. The t-statistics are reported in parentheses in table 4.3.

7. TFP based on a margins measure of output led to a rate of technical progress of 0.34 percent a year. The TFP based on a sales measure of output fluctuated over the two decades. It grew at a rate of 1.20 percent a year for the first seven years 1959–66, slowed to 0.91 percent for the next six years 1966–72, and actually declined at a rate of -0.62 percent for the 1972–79 period. The BLS estimates of output per hour in food stores also fell during the decade of the 1970s. Ratchford and Brown controlled for changes in the sales mix by constructing weighted averages of the annual rates of change in sales for three departments—groceries, meats, and produce.

Table 4.2 BLS Measures of Productivity by Major Industry

	Goods	Manufacturing	Wholesale	Retail
A. Percentage distribution by industry:				
Output:				
1950	50.1	27.1	6.5	12.6
1970	46.0	27.2	8.2	11.6
1987	39.0	27.1	9.4	11.9
Employment:				
1950	52.5	30.1	5.6	16.6
1970	43.3	30.5	6.6	19.8
1987	31.9	21.4	6.8	22.2
Hours:				
1950	53.1	28.2	5.5	17.4
1970	44.7	30.6	6.8	18.9
1987	35.3	23.4	7.2	19.0
B. Index of output per hour (1977 = 100):				
1950	46.8	49.8	48.1	59.3
1970	88.7	80.3	84.3	87.0
1987	120.8	132.9	117.6	113.0
C. Annual growth rate, 1950–87:				
Output	2.55	3.24	4.28	3.07
Employment	0.17	0.59	2.05	2.32
Hours	−0.05	0.54	1.79	1.30
Output per hour	2.60	2.69	2.45	1.76

Table 4.3 Index of Output per Hour (selected retail industries)

	Food Stores	Department Stores	Gas Stations
Index of output:			
1958	66.8	N.A.	N.A.
1967	85.2	64.6	75.4
1979	103.5	107.7	94.5
1987	115.0	145.0	111.3
Index of output per hour:			
1958	72.0		
1967	95.5	77.2	63.2
1979	98.3	104.4	107.4
1987	92.8	137.2	145.7
Regression of log output per hour:			
Slope	.0072	.0309	.0400
t-value	4.10	27.60	49.63
Period	1958–1987	1967–1987	1963–1987

Note: n.a. = not available.

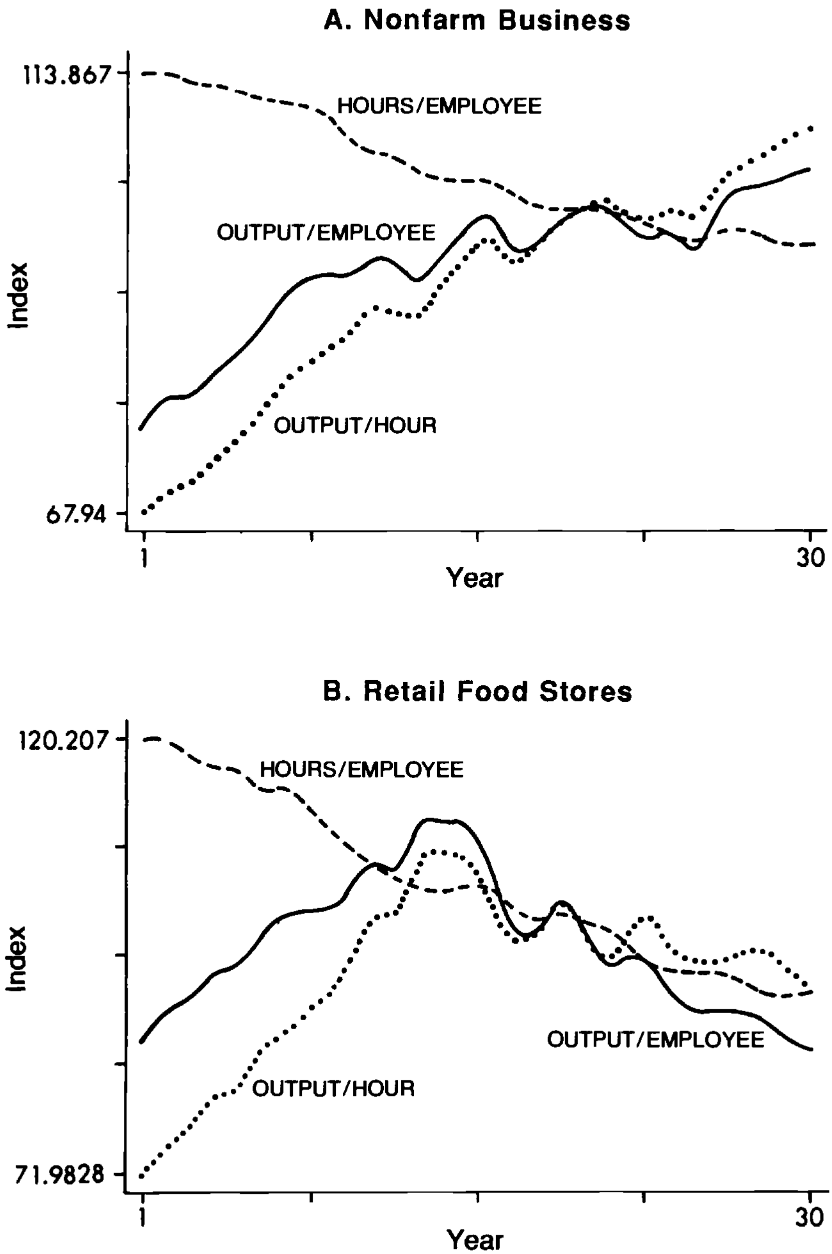

Fig. 4.1 Productivity index

ever, as specialization developed, the number of transactions increased at an exponential rate. The emergence of a distribution sector was a logical step toward the goal articulated by O. E. Williamson (1979), namely, to minimize the *sum* of production and transaction costs. Retail firms today supply composite bundles of services that may include some or all of the following: (1) exchange—they consummate transactions that transfer property rights to the goods that they handle; (2) a product line—they assemble and display an array of goods that are made available to customers, and they jointly supply product information; (3) convenience—they offer this product line at a location and time (store hours) that have the effect of reducing transaction costs; (4) ancillary services—they sometimes provide delivery, credit, and implicit warranties; and (5) production—they may engage in packaging and processing goods to put them in a more suitable form for the customer.[8] The derived demand for retail services depends not only on the consumer demands for final goods but also on the mix of services that are jointly supplied by the retailer. If a store buys local advertising or sets aside shelf space for displays, it may obtain price concessions from the manufacturer. Self-service establishments, especially cafeterias, realize lower gross margins because they are supplying fewer point-of-sale services. Variations in the quantity and quality of services can result in a dispersion of retail prices across stores and over time.

4.3 Technology and the Economies of Massed Reserves

A production function usually refers to a technical relation describing how inputs of labor and capital can be transformed into an output, $f(L,K) = X$. However, the production of retail services shares many of the properties that characterize the production of education and transport services. It differs from manufacturing in at least two important respects: First, the consumer-customer supplies an essential input that has to appear as an argument alongside labor and capital, yielding a function, $f(L, K, N) = X$. Second, demands are random, and delays are costly and result in a stochastic output. Producing a person trip from Oblong to Normal calls for the inputs of both the trip taker as well as the transport mode. The duke of Buccleuch and one moral philosopher constituted the inputs that produced one qualified student who could matriculate at Oxford. Without a customer, a retail firm could not produce a transaction which is the raison d'être for its existence. Time and resources have to be allocated to shopping, to search for the right product or the proper price, and to arrange to get the goods home. We usually carry our fresh fish home but ask to have our firewood delivered. Local advertising can obviously reduce search costs. The particular functions that are performed by the retailer

8. A retailer who jointly supplies delivery and credit is engaging in downstream vertical integration into transportation and finance. Making baked goods, prepared salads, and canned goods under private labels exemplifies upstream vertical integration. Lunch counters at variety stores and baby nurseries at department stores are other examples mentioned by Barger.

and those that are left to the customer or manufacturer jointly determine the output of the retail trade sector.

A retail firm ordinarily acquires the property rights to the goods it sells. (Exceptions are goods sold on consignment and sometimes catalog sales.) Stores maintain inventories, hire clerks, and stay open even when they have no customers. On the other side of the exchange, customers may have to wait to be served. Someone or something is almost always waiting. Idle resources are, however, productive when they are in a state of what W. H. Hutt (1939) called "pseudo-idleness." All idleness could, in principle, be eliminated, but, to accomplish this, the synchronization of the arrival rates of customers, clerks, and just-in-time inventories would be prohibitively expensive. We can find idle resources in the goods-producing industries, but neglecting this idleness appears to pose no serious analytic or empirical difficulties. This is not so for the distributive trades.

The cost functions of retail firms exhibit increasing returns that can, in part, be traced to the economies of massed reserves. E. A. G. Robinson (1958) pointed out that these economies are a consequence of the coordination and synchronization of activities that can be achieved only by large firms. They do not result from the law of large numbers. A clearer exposition of this distinction was provided by J. G. Mulligan (1983) and A. S. DeVaney (1976). These economies of massed reserves characterize the production function applicable to a retail firm.

Retailing is, in some respects, similar to the repairman's problem.[9] In this problem, a firm has M machines. The probability of a breakdown follows a Poisson distribution with a mean arrival rate of λ. The time required to repair a machine is exponentially distributed with a mean service time μ. If the firm employs only one repairman, there is some probability p_0 that none of the machines will need servicing. In this event, the repairman is idle. If two or more machines breakdown, a queue develops, and unproductive, idle machines have to wait to be repaired. The addition of a second repairman raises labor costs but reduces the opportunity costs of idle machines. If λ and μ are technically fixed, one can solve for the optimum ratio of machines to repairmen (M/R), which minimizes the sum of idle times of machines waiting to be repaired and of repairmen waiting for the arrival of a broken machine.

$$\frac{M}{R} = 1 + \left(\frac{\lambda}{\mu}\right)^{-1} \tag{1}$$

This problem is isomorphic to one where a hospital serves a population of M potential patients who arrive to be treated. A Poisson distribution describes the probability of the number of patient arrivals. If the mean duration of a hospital stay is μ, the sum of waiting times (empty beds waiting for patients

9. This is one of the queuing models analyzed by Gross and Harris (1974). Economic applications can be found in DeVaney (1976), Arrow, Levhari, and Sheshinski (1972), Syrquin (1972), and Levhari and Sheshinski (1970).

and sick patients lining up for a vacancy) is a minimum when the population to beds ratio satisfies equation (1). If M and R are both doubled, the mean length of the patient queue falls, and the occupancy rate of hospital beds rises.[10] These economies of massed reserves generate a cost function that exhibits increasing returns; unit costs are inversely related to firm size. The cost advantage enjoyed by the largest store has to be set against any cost disadvantages incurred by customers who have to travel longer distances or who have to wait in longer customer lines.

4.4 A Full-Price Model of Consumer Demand

Goods are not acquired in continuous flows. They are purchased in discrete lots or batches. Time and resources are allocated to the complementary activities of buying, carting, and storing consumable goods. The costs of these activities are incurred by both the consumer and the retailer. In this section, attention is first directed to an inventory model that determines the size of each transaction and hence trip frequency. Next, this model is extended to analyze how a customer chooses a store. Finally, I examine the way in which the full price is affected by selling efforts and search costs.

4.4.1 An Inventory Model and the Optimum Basket Size

Following T. M. Whitin (1952), the total cost of consuming Q units of a single good is the sum of three components: (1) expenditures for the good, PQ; (2) shopping or setup costs, $C_S = ST$, where S is the implicit cost of a trip, and T is the trip frequency per month; and (3) home-inventory costs, $C_H = h\left(\frac{q}{2}\right)$, where h is the unit cost of holding a home inventory whose average size is $\left(\frac{q}{2}\right)$. When (P, Q, S, h) are all exogenous, total cost is a function of only one decision variable, the basket or transaction size q.

$$C = C(q) = PQ + C_S + C_H = PQ + S\left(\frac{Q}{q}\right) + h\left(\frac{q}{2}\right) \tag{2}$$

A larger basket reduces total cost if it reduces C_S by more than it raises C_H. The optimum basket size balances these two opposing effects and is attained when $-C_S' = C_H'$.

$$q^* = \sqrt{\frac{2SQ}{h}} \tag{3}$$

10. Consider a community with several hospitals. Patient arrivals are proportional to bed capacities. If the largest hospital has 60 percent of all beds in this community, it gets 60 percent of all patient arrivals. If all of the beds in a particular hospital are filled, the patient has to wait for a vacancy or balk and move to another hospital. The likelihood of this situation is inversely related to hospital size. The queuing model implies that the largest hospital realizes the highest bed occupancy rate. This principle is equally applicable to airlines. George Douglas and James Miller (1974) found that on a given route, the carrier supplying the largest number of available seats enjoyed the highest seat occupancy rate or load factor.

Substitute for q^* in c, and divide by Q to obtain the full price P^*:

$$P^* = P + \gamma = P + \sqrt{\frac{2Sh}{Q}}. \tag{4}$$

The full price is the sum of the retail price P set by the store plus an implicit buyer cost γ, which is incurred by the shopper. Everyone who patronizes a given store pays the same price P, but γ can vary across customers resulting in a distribution of full prices. The implicit buyer cost is lower for those who confront lower cost parameters $\{S, h\}$ and who demand larger total volumes per month Q. The square-root formula assumes that $\{S, h\}$ are constants. Spoilage and limited storage capacity K' ought to produce a rising marginal holding cost function (MHC) like the curve depicted in figure 4.2. The optimum for this case results in a smaller basket q^{**}, which is to the left of q^*. A bigger refrigerator and more cupboard space shifts the capacity constraint K' to the right, meaning a larger basket q^{**} and fewer shopping trips per month.

4.4.2 Location and Store Choice

The implicit trip cost S depends on, among other things, the distance D between home and store. Assume that this relation is linear, $S = s_0 + s_1 D$.[11] Each customer is presumed to choose that store that provides him or her with the lowest full price. Consider a set of consumers who reside along a line of length L connecting stores A and B. If both stores charge the same price P, store choice is determined by proximity. Store A captures everyone who resides to the left of the midpoint D_m. If store A cuts its price, some customers located to the right of D_m find that they can obtain a lower full price by going to the more distant store A, even though this means a higher implicit buyer cost. Because the implicit buyer cost is an increasing function of the distance to store A, $(d\gamma_a/dD_a) > 0$, there is a critical distance D^* at which the full price at store A is the same as that at store B. This critical watershed distance is located further from store A for those customers who demand more per month Q, face a lower unit inventory cost h, or incur a lower incremental trip cost s_1. If $Q_1 > Q_2$, individual 1 may patronize the more distant store A; person 2 finds that for him or her, the full price is lower by shopping at the closer store B. We could thus observe two individuals who live across the street from one another but who choose to shop at different stores. The number N_a who choose to shop at store A will depend on the size of the retail price saving $(P_b - P_a)$ and the distribution of customers, $g(Z)$, which is the frequency of customers who face a cost penalty of traveling to store A of $Z = (\gamma_a - \gamma_b)$. It is obvious that Z is negative for everyone who lives to the left of the midpoint D_m. The customer traffic attracted by store A is thus

11. The value of the shopper's time, the basket size q, the number of checkout lanes, and the travel mode could all affect the shopping cost parameters. The fixed component, s_0, will be larger for those who demand larger baskets; the incremental cost per mile, s_1, is lower for those who drive rather than walk to the store. Although S is specific to the customer-store match, I shall assume that the trip cost parameters are the same for a given customer.

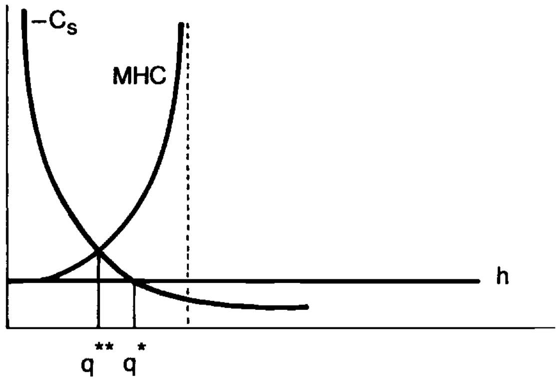

Fig. 4.2 Optimum basket size

(5) $$N_a = \int_{-\infty}^{P_b - P_a} g(Z)dZ$$

The incremental traffic due to a price change on the part of store A is simply the negative of the height of the frequency density evaluated at the size of the price saving, $\Delta = (P_b - P_a)$; that is, $dN_a/dP_a = -g(\Delta)$.[12] The profitability of price competition will be greater, the larger is the elasticity of N_a with respect to P_a.

4.4.3 Retail Services and the Full Price

Isaac Ehrlich and Lawrence Fisher (1982) developed a similar model in which the full price, $P^* = P + Vt$, is the sum of the retail price P plus an implicit shopper cost that depends on the value of the shopper's time, V, and the time required to purchase *one* unit of the good, t. This unit time requirement is inversely related to advertising A, in-store selling effort E, and the customer's total purchase volume Q. If A and E are aggregated into a composite retail service input R, and if Q is held constant, the time requirement function simplifies to $t = t(R)$ with $t'(R) < 0$. Ehrlich and Fisher argue that, if retailing is competitive, customers must confront the *same full price*, P^*, at all stores.[13] Stores can still compete by cutting prices or supplying more retail services but are always subject to the constraint that P^* is a constant. If

12. Total sales at store A depends on the conditional distribution of purchases Q given the size of the cost penalty Z.

$$X_a = \int\int f(Q \mid Z)g(Z)dQdZ$$

13. This differs from my model of spatially differentiated stores where it is only the marginal customer located at D^* in figure 4.3 who faces the same full prices at two competing stores. Those customers located nearer to a store enjoy an inframarginal rent.

$-Vt'(R) > P_R$, (where P_R is the price of the retail service input R), it pays to expand services because part of the added costs of more services can be passed on to customers via a higher price P. In response to an exogenous rise in V, stores will increase R by taking out more local ads that reduce customer search costs and supplying more in-store services that reduce the time needed to complete a shopping trip. Notice that in the Ehrlich-Fisher model the consumer is passive, but in an inventory model the shopper modifies his or her behavior to minimize the sum of shopping and inventory costs.[14] In a complete model, the implicit buyer cost, γ, is jointly determined by actions taken by both the customer and the retail firm.

4.5 Pricing by a Monopolistically Competitive Store

Each retail firm with its unique location has a limited amount of market power. The sales realized by a store depends on the price it sets P, its service level R, and a vector of exogenous variables Z, whose elements describe the socioeconomic characteristics of the neighborhood constituting its market area as well as the prices and service levels of competing stores. A price cut can expand sales by increasing either the number of customer transactions N or the average basket size q. If ε is the price elasticity of the firm's sales demand function, the store sets price P so that the marginal revenue is equal to the full marginal cost (FMC) which is the sum of (1) the wholesale cost P_W; (2) the direct marginal handling or operating cost C_X; and (3) the marginal transaction cost τ_N.[15]

$$MR_X = P\left(1 + \frac{1}{\varepsilon}\right) = \text{FMC} = P_W + C_X + \tau_N \tag{6}$$

14. The retailer is passive in the inventory model. The two models could be combined to allow for the joint minimization of the full price. The fixed component of my shopping-trip cost function could be expressed in a form analogous to Ehrlich and Fisher, namely, $s_0 = Vt_0$, where t_0 is the time input needed to search for the right store and to assemble goods at the store. The customer decides on the basket size and the choice of a store; the retail firm sets the price P and the service level R.

15. Profits for the retail firm are given by

$$\pi = (P - P_W)X - C(X, N) - P_R R$$

Holding the service level R constant, the first-order condition for a maximum is

$$(d\pi/dP) = X + (P - P_W)X_P - C_X X_P - C_N N_P = 0.$$

Divide by the demand response, $(dX/dP) = X_p < 0$, and define the marginal transaction cost as follows:

$$\tau_N = C_N(N_P/X_P),$$

If a price cut attracts no new traffic, $N_p = 0$ and hence $\tau_N = 0$. Alternatively, if the basket size is unaffected by a price reduction,

$$\tau_N = (C_N/q).$$

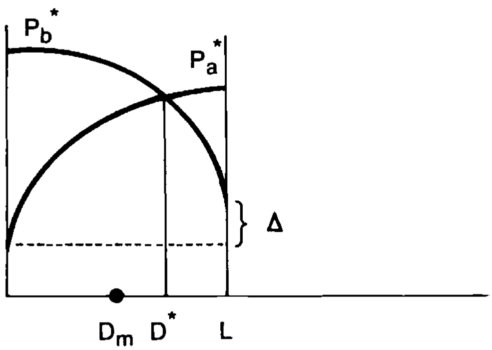

Fig. 4.3 Full price as a function of distance

Although this expression assumes that the store handles only one product, it is useful because it directs attention to the concept of the FMC, which exhibits increasing returns.

Nearly all stores handle a product line and have to set prices for many related products. The pricing problem is formally identical to that analyzed by R. H. Coase (1946) and M. J. Bailey (1954). The utility of shopping at store *A* is reduced whenever the price of a product purchased in positive quantity is increased. A decrease in the price of a good that makes up a larger share of the budget has a greater effect on utility and thus attracts more customers, resulting in spillover demands for other goods in the product line. The markup of price over FMC is likely to be smaller for goods that are traffic generators with spillover effects.

C. Bliss (1988) treated the retail firm as a multiproduct monopoly whose market power is limited by competition. The optimal spread between price and wholesale cost (operating costs were assumed to be fixed and invariant to sales volume) satisfies the Ramsey rule with smaller spreads for goods with more elastic demands. The surplus is just sufficient to cover the fixed operating cost. The price elasticities that determine the Ramsey prices are obtained from an indirect utility function applicable to a representative consumer who engages in one-stop shopping. To the extent that the same product is sold in several shops (which violates the one-stop shopping assumption but squares with the real world where cigarettes, shampoo, and aspirin can be purchased at a drugstore or supermarket), the pertinent price elasticities must be taken from the residual demand function facing a single spatially differentiated store. The store's pricing problem is very different from that analyzed in the Bliss model.

Setting prices for thousands of items poses a formidable problem. Some supermarket managers allegedly solve this problem by mimicking the price structure of a dominant firm such as the great A&P. The price data collected by Bob R. Holdren (1960) roundly rejects this allegation. For pricing purposes, Holdren claims that goods are placed into four categories: (1) items with externally fixed prices because of consignment selling or resale price maintenance; (2) goods whose prices are unnoticed; (3) goods with wide pricing latitudes because of ignorance, small budget shares, or diversity in product quality; and (4) highly competitive goods which make up his *k* class and whose prices are important in choosing a store.[16] The goods in the *k* class are strong traffic generators with spillover externalities. This latter point is nicely illustrated by Holdren who wrote: "The low margin on cornmeal was a surprise to this writer, but according to the supermarket operators, people who buy cornmeal, buy it relatively frequently and tend to be 'careful shoppers' and 'big eaters'. Thus to attract and hold them, lowering the price of cornmeal is relatively efficacious" (p. 80). Location and distance pose a higher barrier to switching when consumers do not have cars. Additionally, price cuts yield greater returns when customers are like the cornmeal addicts who demand larger baskets on each trip. There is, thus, a strong interaction between a store's pricing policy and the shopping behavior of consumers.

4.6 Price Competition and the Concentration of Food Stores

In 1940 there was one food store for every 78 households, but by 1980 each food store served, on average, 481 households. Expenditures for food per household (in constant dollars) increased by 38 percent, and cars per household nearly doubled. The share of sales captured by chain stores rose from 35.2 percent to 46.7 percent. Sales per store in constant dollars doubled in the decade of the 1940s, doubled again in the 1950s, but remained stable from 1960 to 1970; confer table 4.4. R. Parker (1986) estimated that the average of the four-firm concentration ratios for a sample of 196 cities increased from 45.3 percent in 1954 to 65.8 percent in 1977. Data from the census of retail trade also conform this trend toward increasing concentration. Supermarkets with 50 or more employees accounted for 19.20 percent of all food sales in 1967, which increased to 45.67 percent in 1982. This pattern is also evident in the employment data. The percentage of industrywide employment rose from 19.8 percent to 40.4 percent. This section explores the reasons for these changes in average store size and market concentration.

4.6.1 Scale Economies in Retailing

The empirical studies by Hall, Knapp, and Winsten (1961), Douglas (1962), and Bucklin (1972) revealed a positive relation between labor produc-

16. The preferred store is the one that provides the customer with the highest utility that depends on the vector of full prices and full income. The prices of goods in the *k* class allegedly have a greater effect on utility and are hence more important in choosing a store. According to Holdren, goods in the *k* class possess the following characteristics: (1) buyers are aware of the price; (2) price differences across stores are perceptible; (3) the good has a large budget share; (4) demand is predictable; (5) demand is relatively inelastic; and (6) a price difference will not be confused with a quality difference.

Table 4.4 Food Stores: Sales and Related Variables, 1940–1980

	1940	1950	1960	1970	1975	1980
No. of stores (in thousands):*						
Independent	405.0	375.0	240.0	174.1	142.73	112.6
Chain	41.35	24.70	20.05	34.20	23.08	18.70
Convenience	. . .	. . .	. . .	. . .	25.0	35.0
Total	446.35	400.70	260.05	209.30	191.80	167.10
Sales (in millions of constant 1967 dollars):*						
Independent	16,563	22,752	36,534	40,331	40,080	41,353
Chain	9,034	13,611	22,316	36,619	38,056	40,501
Convenience	. . .	. . .	. . .	. . .	3,124	4,870
Total	25,597	36,362	58,750	76,950	81,260	86,724
Sales per store (in thousands of constant 1967 dollars):						
Independent	41	61	152	232	281	367
Chain	218	530	1108	1071	1649	2166
Convenience	. . .	. . .	. . .	. . .	125	136
Total	57	91	226	369	424	519
No. of households (in thousands)	34,949	42,867	53,021	63,450	71,920	80,390
No. of registered autos:†						
Privately owned (in thousands)	27,372	40,191	61,420	88,775	106,077	120,866
Per household	0.78	0.94	1.16	1.40	1.47	1.50
Disposable income (in constant 1967 dollars):‡						
In billions of 1967 dollars	183.6	273.9	377.4	577.0	668.2	765.9
Per household	5,253	6,390	7,118	9,094	9,291	9,527

Sources: **Progressive Grocer* (April 1983, 48, 66); †MVMA *Facts and Figures;* ‡*Economic Report of the President* (1986, table B.26).

tivity and store size, a relation implying that there are increasing returns to scale. B. Nooteboom (1983) assembled data for Dutch supermarkets with similar service levels in terms of the width of the product line, types of departments, and annual store hours. He initially assumed that the labor input measured in man-hours M was a linear function of annual sales X.

$$M_i = \beta_0 + \beta_1 X_i + e_i,$$

where β_0 is the fixed labor input, and $\beta_1 = (\gamma_1 + \gamma_2)$ is the marginal labor requirement that is the sum of the labor time needed to handle another customer plus the time spent in stocking goods. Given a stochastic arrival rate of customers, the ratio of queuing to serving times is kept within narrow limits. Hence, $\gamma_1 = g_1/q$ is a constant, where g_1 is the mean waiting time, and the basket size q is a proxy for the mean serving time. Because $X = Nq$, man-hours is a linear function of the number of transactions or customer trips N and annual sales X.

$$M_i = \beta_0 + g_1 N_i + \gamma_2 X_i + e_i.$$

The fixed labor input β_0 is responsible for the increasing returns. This linear labor requirements function implies that the scale economies with respect to the average basket size q are greater than those with respect to the number of transactions N.[17] Other inputs such as floor space, equipment, parking, utilities, and advertising appear to be related to N and X in a similar manner.

Increasing returns are evident in the U.S. data for food stores, which are shown in table 4.5. Labor productivity measured by sales per employee hour (X/H) is higher in larger supermarkets where size is determined by selling area. The effect of size is somewhat weaker for chain stores. Average transaction size, inventory turns, and the capital utilization rate measured by store hours are all positively related to store size. A given relative increase in sales volume X or in the number of weekly transactions N is accompanied by a less than proportionate increase in operating costs. Supermarkets that achieve larger size thus enjoy lower unit operating costs.

4.6.2 Implicit Shopper Costs and Price Competition

According to D. Appel (1972), the *supermarket* was the institutional innovation that was responsible for the increased efficiency of food distribution. The idea for a self-service, cash-and-carry store was evidently conceived in 1916 when Charles Saunders opened his Piggly Wiggly store in Memphis. The supermarket movement in the east was launched by Michael Cullen who opened his King Kong store at Jamaica, New York, in 1930 and the Big Bear in Elizabeth, New Jersey. These stores followed the Piggly Wiggly model. By locating outside of densely populated areas, they could obtain low rents, which enabled them to acquire large selling areas and parking space. Large sales volumes were generated by cutting prices of nationally advertised brands, and customers were attracted by heavy local advertising. The supermarket offered low prices, but it eliminated free delivery and credit. All transactions were on a cash-and-carry basis. Part of the store's responsibility for assuring product quality was shifted to the manufacturers of branded goods.[18] The success of a low-price strategy obviously depends on high-price elasticities of demand.

The emergence of price competition in the 1930s can be explained by a model in which stores compete for customers who reside on a line connecting them. Customers who shop at store A realize a lower full price, $P^*_a < P^*_b$

17. Let $\delta M = (dM/M)$ denote a logarithmic derivative. The linear function implies that $0 < (\delta M/\delta q) < (\delta M/\delta N) < 1$. D. Schwartzman (1968) recognized this fact and argued that much of the upward trend in labor productivity (through 1963) could be explained by the growth in the average size of transactions.

18. The rapid growth of trademarks in the 1970s has accelerated this shift; confer Landes and Posner (1983) and Pashigian and Bowen (1989). The historical development of the supermarket is more fully discussed by Appel (1972, 42–44) and by Blozan (1986, 16).

Table 4.5 Selected Statistics for Supermarkets by Size and Ownership, 1988

	Independents			Chains		
Item	10–15	20–25	35+	10–15	20–25	35+
Weekly sales ($)	82,968	190,471	371,655	112,365	176,778	340,229
Sales per employee hour ($)	76.46	90.47	91.74	89.51	87.82	92.87
Store sales per hour ($)	852.00	1,619.00	2,676.00	937.00	1,422.00	2,357.00
Average transaction size ($)	12.16	17.02	21.28	12.39	15.38	19.34
Inventory turns	14.2	20.7	17.9	15.0	15.1	14.3
Item stocked	12,190	17,775	25,932	11,408	18,024	27,151
Inventory value (in thousands of dollars)	250	403	894	340	504	1,038
Weekly transactions	6,823	11,191	17,465	9,069	11,494	17,592
No. of checkouts	5.0	7.7	13.2	6.2	7.9	11.6
Employees						
Employees full-time	16.2	31.1	46.1	14.7	27.3	47.3
Employees part-time	21.2	46.2	108.9	33.9	44.0	87.2
Ratio part-time/full-time	1.31	1.49	2.36	2.31	1.61	1.84
Store hours (mean)	96	117	138	122	123	144
Open 24 hours, 7 days (%)	7	26	50	27	17	52
Scanning (%)	42	77	100	52	68	96

Source: Progressive Grocer, selected annual statistical supplements.
Note: Store size is measured in thousands of square feet of selling area.

meaning that the implicit shopping cost penalty is less than the price differential; that is, they satisfy the inequality,

$$Z = (\gamma_a - \gamma_b) < (P_b - P_a) = \Delta.$$

Let $S = s_0 + s_1 D = V(t_0 + t_1 D)$ denote the implicit cost of a shopping trip, where V is the value of the shopper's time, t_0 is the time spent at the store, and $t_1 D$ is the time required to travel to and from the store. Recall that D is the distance to store A; $(L - D)$ is the distance to B. The cost penalty of shopping at A is thus given by,

$$Z = \gamma_a - \gamma_b = k[\sqrt{t_0 + t_1 D} - \sqrt{t_0 + t_1(L - D)}], \tag{7}$$

where

$$k = \sqrt{\frac{2hV}{Q}}. \tag{8}$$

Equation (7) describes a nonlinear transformation from D to Z, which depends on the parameter vector $\{k, t_0, t_1\}$. If N consumers with the same value of k are uniformly distributed along the line, then $f(D) = N/L$, but their distribution as a function of the cost penalty Z is described by a dome-shaped curve like $g(Z)$ shown in figure 4.4. The maximum cost penalty of traveling to store A is incurred by the person residing next to store B:

$$(9) \qquad Z_{max} = Z(L) = k[\sqrt{t_0 + t_1 L} - \sqrt{t_0}].$$

Because Z is negative for those living to the left of the midpoint D_m, $g(Z)$ is symmetrical with a mode at $Z = 0$ and a lower bound of $Z(0) = -Z(L)$. The traffic attracted by a price cut on the part of store A depends on the height of the frequency distribution evaluated at the size of the price differential, $dN_a/dP_a) = -g(\Delta)$. Appel identified three factors that raised the price elasticity of demand and hence increased the returns to price cutting: First, the migration from rural to urban places resulted in higher population densities, which translate into proportional upward shifts in $g(Z)$. Second, rising real incomes and larger families increased the demand for food. A higher demand Q reduces k, which pulls in the bounds, $-Z(L) < Z < +Z(L)$ of $g(Z)$. If A's price advantage remains constant, more customers will shift to A unambiguously increasing its sales, X_A. Although the high-price store B loses customers due to a rise in Q, the net effect on its sales is indeterminate.[19] Third, higher car ownership rates lower the cost of going to more distant stores. As t_1 falls, the bounds for $g(Z)$ again move in toward the origin. In the limit as t_1 approaches zero, $g(Z)$ degenerates to a spike at $Z = 0$, and any price reduction below the competing store means that the price-cutter captures the entire contested market. Some high-priced stores disappear, and the market areas of the remaining stores expand.

In addition to urbanization, higher incomes, and car ownership rates, the returns to price competition were affected by home inventory costs and the value of time. A decrease in unit home-inventory costs h reduces k thereby increasing the demand facing the low-price store A. However, a higher value of time raises the costs of shopping at both stores. Because $(dk/dV) > 0$, a rise in V flattens $g(Z)$ and hence reduces N_a. In an inventory model, a higher cost of time discourages price competition, but this model ignores other responses available to consumers and retailers. A store could broaden its product line so that a shopper can economize on shopping time by purchasing food, drugs, and sundries at one place. These responses are examined in section 4.7.3, below.

To sum up, food stores and nearly all retail establishments are getting larger. Reference to table 4.6 reveals that, aside from apparel and eating/drinking places, we have experienced an absolute decline in the number of retail establishments in every two-digit industry. The decline has taken place in the smaller employment size classes. The number of large retail establishments with 20 or more employees has increased in every two-digit industry.

19. If the elasticity of N_b with respect to Q lies in the interval, $-1 < (\delta N_b/\delta Q) < 0$, an increase in demand per household Q will lead to larger sales, $X_b = N_bQ$. The loss of customers is more than offset by higher demands on the part of the remaining customers.

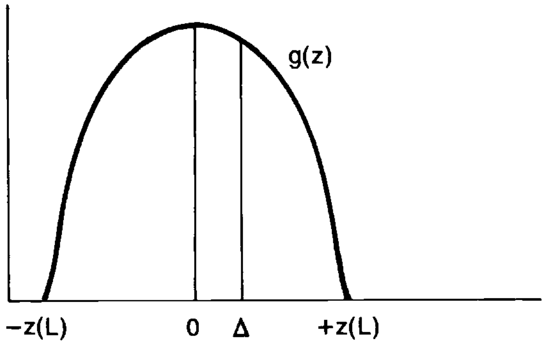

Fig. 4.4 Distribution of customers by implicit cost penalty

Technological advances outside of the distribution sector are mainly responsible for these trends. The relative prices of cars, refrigerators, and advertising messages have declined. Consumers are prepared to incur higher implicit cost penalties to patronize stores that offer lower prices. By cutting prices and altering the service mix, supermarkets have succeeded in attracting more customers and generating larger sales volumes that can be supplied at lower unit costs because of the economies of large scale and of massed reserves. These developments were responsible for the improvements in labor productivity that were observed through the mid-1970s.

4.7 On the Organization of Production and the Product Line

The corner grocer and the giant super belong to the same three-digit industry, SIC 541, but they differ in important respects that affect the relation of outputs to inputs. Attention is directed here to three aspects of this diversity. First, the capital to labor ratio and the rate of capital utilization surely affect labor productivity. Second, the composition of the retail work force has been influenced by the reallocation of distributive functions among the three participants—manufacturers, retailers, and consumers. Finally, I explore the reasons for changes in the output mix over time, and the effect of these changes on labor productivity.

4.7.1 Capital Intensity and Utilization Rate

The measurement of the capital to labor ratio is confounded by variations in the output mix and the quality of capital. The ratio of the book value of assets to employment is higher for larger supers, but selling areas and inventories per full-time equivalent employee are lower. Larger supers are more likely to have delicatessens, bakeries, and fresh fish, which call for less floor space but more capital equipment. Buildings and equipment are newer in big-

Table 4.6 Number of Retail Establishments and Consuming Units, 1963 and 1982

	No. of Establishments		
Industry	1963	1982	1982/1963
No. of consuming units (millions):			
Families	47.5	61.4	1.293
Households	55.2	83.5	1.514
Population, total	189.2	232.3	1.228
Population, 20 and older	115.3	161	1.396
Establishments operated entire year (SIC code):			
Retail trade, total	1,532,291	1,731,055	1.130
Building Materials (52)	87,499	63,449	0.725
General Merchandise (53)	58,264	32,584	0.559
Food stores (54)	289,073	164,595	0.569
Auto dealers (55x)	89,651	86,271	0.962
Gas stations (554)	180,879	109,506	0.605
Apparel (56)	109,392	126,194	1.154
Furniture (57)	86,832	88,918	1.024
Eating/drinking (58)	288,384	288,315	1.000
Drugstores (591)	52,063	47,423	0.911
Other (59x)	224,396	232,686	1.037
Selected 3-digit industries:			
Groceries (541)	222,442	121,039	0.544
Meat (542)	14,910	10,168	0.682
Retail bakeries (546)	16,935	16,199	0.957
Liquor stores (592)	37,093	32,802	0.884
Large establishments with 20 or more employees (SIC code):			
Retail trade, total	70,000	158,064	2.258
Building materials (52)	2,475	4,935	1.994
General merchandise (53)	10,383	13,948	1.343
Food stores (54)	16,644	29,041	1.745
Auto dealers (55x)	10,193	13,537	1.328
Gas stations (554)	514	2,175	4.232
Apparel (56)	5,058	6,765	1.337
Furniture (57)	2,059	3,291	1.598
Eating/drinking (58)	15,784	70,221	4.449
Drugstores (591)	2,702	5,288	1.957
Other (59x)	2,450	8,863	3.618
Selected 3-digit industries:			
Groceries (541)	15,874	26,561	1.673
Meat (542)	67	393	5.866
Retail bakeries (546)	493	1,681	3.410
Liquor stores (592)	108	615	5.694

ger stores that make more use of scanners.[20] Inventory turnover rates are positively related to size resulting in a lower inventory to labor ratio in large supers. If we adjust for differences in the output mix and equipment quality, the ratio of capital to labor is positively related to firm size.

The fixed overhead costs of capital account for a larger share of total costs in larger firms, which thus have a stronger incentive to utilize capital more intensively by operating more shifts in manufacturing or establishing longer store hours in retailing. In 1988, the largest supers were open for an average of 138 hours a week, and half of them were always open. The small independents reported an average of 96 hours a week, and only 7 percent were open 24 hours a day, 7 days a week. Size had a weaker effect on store hours for chain stores. The outlets in a given chain evidently adopt similar operating practices, including store hours. Over the last two decades, average store hours have steadily increased—possibly a response to a rise in the ratio of fixed to total costs or to an increase in consumer demands for longer store hours.[21] It could be argued that an expansion of store hours could induce a reduction in the price-cost margin if weekday and Sunday sales are viewed as related services. Alternatively, if sales volumes and store hours are positively related, the economies of scale could explain the decline in price-cost margins. Increases in the capital to labor ratio and longer store hours both contribute to improvements in labor productivity measured by the sales to employee hours ratio.

4.7.2 Standardization and the Skill Mix of the Retail Work Force

In 1950, one could still be served by a retail clerk or butcher, but self-service is now the rule, even at convenience stores. Cashiers make change, and stock clerks replenish shelves. We have to punch a computer to find the dog food. National advertising and brand names have replaced trained clerks who used to inform us about products. Store-specific human capital might have been a valuable asset when customers asked for particular clerks whose advice was sought and who would honor implicit warranties in the event that we got a defective or spoiled product. When transactions become impersonal and standardized, there is less to be gained by establishing durable, ongoing relations between customers and clerks who know one another. Barry Blue-

20. Nearly all of the giant supermarkets defined as those with 35,000 or more square feet of selling area were using scanners in 1986, but only around a third of the small supers with selling areas of 10,000–15,000 square feet had acquired this technology; see *Progressive Grocer,* pt. 2 (April 1987, 22). In 1981, the average age of the buildings owned by giant supers was 9.8 years compared to 16.6 years for small supers; see *Progressive Grocer* (April 1982, 23). The percentage of capital equipment acquired in the used market was inversely related to firm size for Japanese manufacturing firms; see Oi (1983).

21. Pashigian and Bowen (1989) favor the latter explanation. They find that trademarks and store hours are positively related to female wages but unrelated to male wages. A higher labor force participation rate and a high opportunity cost of female time are, in their view, responsible for longer store hours.

stone (1981) concluded that we have witnessed a retail revolution. Retail services have become impersonal resulting in a deskilling of the work force.

The reliance on part-timers is one indicator of the skill mix. In 1975, full-time employees outnumbered part-time workers in the supermarkets that responded to the *Progressive Grocer* survey, but by 1988, they made up only 41 percent of all employees at independent supers and 36 percent at the chains. The ratio of part-time to full-time employees (PT/FT) is positively related to size and rose from 1.04 in 1981 to 1.79 in 1988: see table 4.7. Part of the secular trend is due to a shift toward larger supermarkets. Even if size is held constant, the ratio exhibits a positive trend. By 1988, 70.3 percent and 64.8 percent of all employees at the giant independents and chains were on part-time work schedules. If the production function was homothetic, the larger supers should have faced a lower relative wage for part-time employees. The wage ratios shown in table 4.8 exhibit a contrary pattern, being somewhat higher at larger stores. The elasticity of hourly wages with respect to sales was +.081 and +.079 for part and full-time clerks.[22] Larger supermarkets have to pay higher wages because their employees have to supply more work effort. The wages reflect the effect of higher customer-arrival rates on labor productivity. More clerks have to be hired at the bigger supers, and the queuing model predicts that these employees are more productive because a smaller fraction of labor time is wasted in idly waiting for customers. More productive employees do indeed command higher wages, and the data indicate that the productivity gains associated with weekly sales volume are relatively greater for part-time employees. In addition to this relation with weekly sales, labor productivity is positively related to sales fluctuations over the diurnal and day-of-the-week cycles. Some 55 percent of all supermarket shopping trips and 60 percent of trips made by employed persons take place in the three days, from Thursday to Saturday. Unemployed individuals make few shopping trips on Sundays. The diurnal cycle of customer arrivals varies with the day of the week and shopper characteristics. Nonworking mothers prefer to shop on weekday mornings; Friday evenings are popular for working individuals.[23] Part-time employees are analogous to the standby generators that are activated only during the peak load period. The higher is the fraction of total demand produced during the peak period; the larger is the ratio of standby to fully utilized on-line generators that are operated in both peak and off-peak periods. Although we cannot cleanly identify the peak and off-peak hours at a super-

22. The log of the hourly wage was regressed on the log of weekly sales for the eight observations in 1984 and 1985. These elasticities imply that a fivefold increase in sales volume (roughly the differential between the giant and small supers) would be accompanied by a 13.9 percent higher wage for a part-time clerk and 13.6 percent for a full-time clerk. The wage-sales elasticities for the chain stores were +.161 and +.110 for part- and full-time clerks. The wage premiums associated with a fivefold increase in sales were 29.5 and 19.5 percent for part- and full-time clerks. These results are consistent with the firm-size effect on wages, which were reported by Lester (1967), Mellow (1981), Oi (1983), and Brown and Medoff (1989).

23. These data are reported in *Progressive Grocer* (April 1989, 42).

Table 4.7 **Ratio of Part-Time to Full-Time Employees by Store Size, 1981–1988**

Year	< 10	10–15	15–20	20–25	25–30	30–35	35+	All Stores
1981	0.98	1.04	1.12	1.20	1.14	. . .	. . .	. . .
1982	0.97	1.11	1.03	1.15	1.21	1.00	1.11	1.06
1984	0.92	1.13	1.27	1.38	1.36	1.27	1.43	1.17
1985	1.06	1.23	1.24	1.22	1.38	1.22	1.82	1.23
1986	1.08	1.22	1.32	1.40	1.58	1.96	2.26	1.33
1987	1.11	1.17	1.41	1.49	1.29	2.09	1.78	1.36
1988	1.19	1.31	1.42	1.49	1.34	1.70	2.36	1.43
Mean	1.04	1.17	1.26	1.33	1.33	1.54	1.79	1.26

Table 4.8 **Hourly Wages of Part-Time and Full-Time Clerks: 1985**

Sales Volume (in millions of dollars)	Part-Time Clerks	Full-Time Clerks	Ratio, Part-Time/ Full-Time
Independents:			
2–4	\$3.98	\$4.84	0.822
4–8	\$4.31	\$5.11	0.843
8–12	\$4.64	\$5.35	0.867
> 12	\$4.71	\$5.63	0.837
Average	\$4.18	\$5.01	0.834
Chains:			
2–4	\$4.15	\$5.45	0.761
4–8	\$5.07	\$6.23	0.814
8–12	\$5.49	\$6.45	0.851
> 12	\$5.72	\$6.69	0.855
Average	\$5.10	\$6.23	0.819
Regression of log wage on /a:			
Log sales X^*	0.0810	0.0791	0.0019
1985 dummy	0.0150	−0.0136	0.0286
R^2	0.8976	0.9778	0.4059
Regression of log wage on /a:			
log sales X^*	0.1605	0.1099	0.0506
1985 dummy	−0.0594	−0.0196	−0.0398
R^2	0.8347	0.8486	0.7576

Note: Let Y_{pt} = the log of the hourly wage of part-time clerks, Y_{ft} = the log of the hourly wage of full-time clerks, and $R = (Y_{pt} - Y_{ft})$ denote the log of the wage ratio that is equal to the difference in logs. I estimated three equations:

$$Y_{pt} = a_1 + b_1X^* + c_1D + e_1$$
$$Y_{ft} = a_2 + b_2X^* + c_2D + e_2$$
$$R = a_3 + b_3X^* + c_3D + e_3$$

where X^* is the logarithm of weekly sales, and D is a dummy variable equal to unity for the 1985 observations. Only the b_j and c_j parameter estimates are reported. We have the identities, $b_3 = (b_1 - b_2)$ and $c_3 = (c_1 - c_2)$. The coefficient of determination for the third regression is not equal to the difference in R^2 for the other two columns.

market, two generalizations seem to be warranted: First, working persons tend to shop on Friday evenings and weekends, which are usually the heavy peak hours. A rising labor force participation rate should have increased the ratio of sales in the high peak hours to sales in the low off-peak hours (X_H/X_L). Second, working individuals are more likely to shop at the larger supers whose longer store hours reduce their implicit shopping costs. The analogy to the generation of electric power implies that a rise in (X_H/X_L) increases the ratio of part to full-time employees (PT/FT). The available evidence suggests that the ratio of peak to off-peak sales (X_H/X_L) is positively related to store size and has increased over time in response to the increase in labor force participation rates. This increase in the within-week variability of food sales is responsible for part of the upward trend in the relative demand for part-time employees.

Retail trade which once provided full-time, stable jobs for most of its employees has become an industry characterized by low wages and high labor turnover rates. The introduction of scanners, organizational innovations in monitoring and warehousing, and the substitution of advertising for point-of-sale services have reduced the relative demand for stable, full-time, store-specific workers. But this is only part of the story. Shifts by consumers in the allocation of time to market and nonmarket activities and changes in shopping patterns have affected the derived demands for full-time and part-time employees. The productivity of part-time workers with little training has increased in relation to the productivity of full-timers. In order to survive, supermarkets have been obliged to alter the skill mix of the work force and the bundle of services which they provide to customers.

4.7.3 The Product Line and Labor Productivity

The supermarket consolidated the sales of groceries, meat, and produce under one roof. As the size of the establishment grew, it expanded the product line. It handled more brands of breakfast cereals and introduced new departments—bakeries, delicatessens, fresh fish, drugs, hardware, fresh flowers, video rentals, and so on. The size distribution of establishments has shifted to the right in nearly all of the two-digit retail trade industries; see table 4.6. In most instances, the pattern is similar to that in groceries; growth is accompanied by an expansion in the breadth of the product line. However, in a few cases, such as gasoline service stations, outlets have narrowed their product lines as they got larger. What are the reasons for these divergent trends? How do changes in the breadth of the product line affect productivity?

The implicit cost of a trip to a supermarket is a common cost for all the items in the basket. It is akin to the capital cost in the peak load pricing problem. The trip frequency that minimizes the sum of trip and home-inventory costs is determined by certain critical items just as the capital capacity is determined by demand in the peak period. An increase in the demand for napkins has no effect on the optimum number of shopping trips per month.[24] If the marginal trip cost is zero for most items, the supermarket would seem to have an advantage over specialty shops. Inventory costs and floor space place limits on the breadth of the product line. A typical supermarket in 1960 did not sell fresh salmon, presumably because it could not supply it at a sufficiently low *full price.* If the arrival rate of calls for fresh salmon was small, inventory and handling costs would have sharply increased the break-even price. As consumer demands climbed and selling areas expanded, the supermarket could supply salmon at a *full price* (adjusted for quality and a zero marginal trip cost), below that of a specialty fish market. Rising real incomes expand the range of items that are demanded in sufficient volumes to warrant the inventory and handling costs. The economies of one-stop shopping may prompt a consumer to buy his or her chocolates and fresh fish at the same store.[25] The product line has moved in the opposite direction in SIC 554, gasoline service stations. In the early 1970s, three-fourths of all stations had service bays for repairs and oil changes compared to fewer than half today. The use of self-service pumps increased from 31 percent of all motorists in 1976 to 78 percent in 1986. Stations are larger and more specialized. They are earning more revenues from pumping gas and fewer from repairs, lube jobs, and sales of tires, batteries, and accessories.[26] From the viewpoint of shopping trip costs, gasoline and lube jobs are not like soap and bagels. They are more like dry cleaning and haircuts. An optimum trip frequency is not determined by an inventory model. Shopping times are additive and do not exhibit the increasing returns applicable to acquiring more items at a supermarket. Design changes have lengthened the interval between filling tanks and changing oil. Nonprice competition and warranties have shifted part of the repair business to auto dealers. As the arrival rates for repairs and lube jobs fell, gas stations experienced a fall in the utilization rate of mechanics. Those stations that eliminated service bays found that the mechanics who previously pumped gas and repaired cars could be replaced by less skilled employees. Fewer stations offered a full product line (gas and repairs), and roughly half of all drivers chose to produce oil changes at home. In the 1980s, specialists emerged.

24. In the model analyzed by P. O. Steiner (1957), the case of a firm peak meant that there was excess capacity in the low, off-peak period. Optimum prices in peak and off-peak periods are $P_H = (\alpha + \beta)$ and $P_L = \alpha$, where α is the unit operating cost and β is the unit capital cost. Capital is a common input for both periods. Variations in the off-peak demand for electricity have no effect on the choice of the capital input unless the demands in both periods are equal to the capital capacity.

25. If the item is a delicacy that is infrequently purchased, the customer may prefer to go to a specialty shop where the expected *full price* (possibly including a component for assurance of quality), is lower than that at a supermarket. Stand-alone retail bakeries and delicatessens have declined as a consequence of a rising implicit cost of a shopper's time.

26. There were 426 cars per station in 1972 and 1,129 in 1986. The figures on average establishment size measured by gallons sold per month are a bit misleading because gasoline sales at convenience stores, whose market share is climbing, are excluded from SIC 554. The data reported in this section were obtained from chap. 3 of the study sponsored by the American Petroleum Institute (1988).

Franchise dealers found that they could attract enough arrivals to supply lube jobs at a *full price* below that attainable via home production. A division of labor was thus achieved by self-service stations and Jiffy Lube dealers who separately pumped gas and changed oil.

Variations in the output mix and tied services complicate the problem of measuring productivity. In the case of retailing, Robert Steiner (1978) proposed a vertical measure of productivity wherein inputs at both the manufacturing and retailing levels are aggregated and compared to final outputs at the retail level. This principle can obviously be extended to include the inputs supplied by consumers. A gas station that introduces self-service is substituting the labor services of the customer for hired labor. The consequence is an increase in the BLS measure of labor productivity. The annual growth rates of sales per employee hour reported in table 4.3 were 4.0 percent for gas stations and 0.7 percent for food stores. For stations of comparable size, the output per gas pump is higher at self-service stations. When the customer supplies the labor input, it takes less time to complete a transaction—filling the tank and paying the cashier.[27] The adoption of self-service has clearly led to real efficiency gains.

The difference in the rates of technical progress in distributing gasoline versus food can, in part, be explained by the fact that supermarkets have expanded their product lines and introduced new departments that call for larger inputs of labor per dollar of sales. In the context of the Becker (1965) model, the substitution of prepared baked goods for homemade cakes can be interpreted as the outcome of a search for the lowest *full price*. It is the obverse of the self-service gas station. The product in the vertical measure proposed by Robert Steiner is a cheesecake on a plate or gasoline in the tank. The inputs supplied by both retailer and consumer have to be related to these final products in calculating full prices and in determining labor or TFP. Fewer resources are needed to transform the ingredients into a cake at a supermarket bakery, but the costs of moving this cake onto a dinner plate are higher. The costs of acquiring a prepared cake or salad are higher than the costs of buying packages of flour and cream cheese. A rise in the implicit cost of home labor increases the relative full price of a homemade cake, where the full price is the sum of the transformation and transaction costs.

The rate of technical progress for a multiproduct firm as we ordinarily measure it is a weighted average of the rates of technical progress for the component goods in the firm's product line. Supermarkets in pursuit of higher profits have broadened their product lines into more labor-intensive departments with slower rates of productivity growth. Increases in the implicit costs of shopping

27. A correct production function has to include the input of the customer's time. In New Jersey and Oregon where self-service is illegal, the customer's time input entails an implicit cost of waiting while he or she receives full service. In the majority of transactions, the customer incurs the implicit cost of pumping one's own gasoline, which is probably quite low except in adverse weather. I wish to thank Dr. T. F. Hogarty of the American Petroleum Institute for discussions about the relative efficiency of the two types of gas stations.

and of household labor have enhanced the economies of one-stop shopping and increased the demands for prepared foods. These developments are responsible for the decline in sales per employee hour at food stores that took place in the mid-1970s. Gas stations, on the other hand, are allocating a larger fraction of resources into transferring goods (pumping gas), and moving out of the labor-intensive activities of auto repairs and servicing. Consumers are obtaining the distribution of gasoline and the production of repair services more cheaply by a division of labor between specialized institutions, even when we include the implicit costs of labor provided by customers.

4.8 Concluding Remarks

A production function that relates output to inputs lies at the heart of the received theory of productivity change, which is summarized by Jorgenson (1987) and Griliches (1987). In applying this theory to the distributive trades, one has to recognize at least three differences: First, the consumer supplies an essential input which has to be included as an explicit argument of the production function. Ignoring this fact constitutes a specification error that could bias the measured rate of growth in productivity. Second, producing transactions is similar to repairing machines. Both are characterized by the economies of massed reserves wherein a twofold increase in both the customer-arrival rate and the number of clerks leads to more than a twofold increase in the number of completed transactions. If the frictions resulting from transport and home-inventory costs can be reduced by technical advances outside of the distribution sector, retail firms can achieve larger sizes with their lower unit operating costs. Third, the output of a retail firm is a composite bundle whose composition varies across firms and over time. The relation between an aggregate measure of output (such as sales or value added) and purchased inputs depends on the makeup of this bundle. The output of a supermarket has changed over time, moving toward more embodied labor services in the goods that they handle.

Progress in the goods-producing industries is frequently associated with technological innovations. The development of the mechanical cotton picker, of the cranberry paddler, and of the chain saw was responsible for increases in TFP. However, institutional and organizational innovations as well as regulatory changes can have equally strong effects. The tax on chain stores, analyzed by Tom Ross (1986), impeded the spread of an important institutional innovation called the supermarket, which brought together the sales of groceries, meat, and produce under one roof. It mimicked the department store, which assembled a wide variety of goods and provided customers with the economy of one-stop shopping, trained clerks, and a reputation for stocking quality goods. The reputational value of the department store has been eroded by nationally advertised branded goods and specialty franchises that shifted the responsibility for product quality from the retail establishment to the manufacturer. Steiner contends that the fall in the gross margin on toys from 40 percent to 20 percent was largely due to national advertising and mass merchandising by discount outlets.[28] The establishment of shopping malls has reduced the value of one firm handling a wide variety of goods. The viability of the traditional department store is threatened by the shopping mall, specialty franchises, and national advertising. I fully expect to observe a leftward shift in the size distribution of general merchandise, apparel, and variety stores.

Gasoline service stations are, on average, smaller in those states that have divorcement laws preventing refiners from establishing dual distribution systems. The legislated inefficiency is reflected in higher retail prices and lower labor productivity.[29] If these divorcement laws were repealed, the rise in labor productivity could be confused with technical progress rather than to the elimination of a regulatory constraint.

The allocation of productive and distributive functions among the manufacturer, retailer, and consumer raises questions about the merits of trying to measure productivity at each level. There are compelling reasons to argue for a measure of final outputs—a cake on a dinner plate or gas in the tank. The division of labor is surely determined by comparative advantage. Technological innovations and changes in factor prices can alter the optimal allocation of resources across sectors. These reallocations are often endogenous and should be incorporated in an overall measure of technical progress in the combined production and distribution of ultimate consumer goods.

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28. The spread of television reduced the price of advertising messages which translated into a lower cost of informing consumers about particular goods identified by brand names and trademarks. The cost savings were passed on to consumers via lower retail prices that could not have been achieved if resale price maintenance laws had been strictly enforced.

29. Dual distribution is the practice where a refiner simultaneously distributes its product through vertically integrated outlets operated by salaried managers and independent outlets whose prices and operating practices are not controlled by the refiner. The price effects of divorcement laws have been studied by Barron and Umbeck (1984) and Hogarty (1986).

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Comment Sherwin Rosen

The empirical economist Colin Clark was among the first to track how the share of service-sector employment and output expand as economies grow and develop. Yet economists, by and large, have ignored services. Not only is there a remarkably small literature on the positive aspects of their analysis,

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but the accounting expedient of measuring output by inputs hardly has been addressed. The wealthier we become, the more we are doomed to suffer the sham of smaller measured productivity growth compared to more goods-intensive economies—this, in spite of the obvious and important innovations in service sector technology and economic organization that continue to occur over time. Walter Y. Oi's paper outlines a systematic way of thinking about the economics of services that is essential to research in this field. He presents a superb minicourse on the economics of retail trade. The essential element of the models reviewed is that distributional services are jointly produced by stores and customers. The economics of the retail service sector cannot be understood without recognizing that shoppers' time is a key input in the production of distributional services.

This point is established in the model showing how a customer divides annual purchases into basket sizes and number of trips to the store. The solution balances the costs of an additional trip against the incremental home-inventory costs of goods. By analogy to the economics of the household, Oi shows that the *full price* of an item is its retail price plus a term that reflects the consumer's time and money costs of shopping, and the cost of holding goods at home rather than in the store. An extension allows retailing services to be produced more intensively by varying advertising and brand recognition embodied in goods and salespersons' efforts to provide customer services as substitutes for customers' time and effort.

The economies of scale implicit in inventory holdings are bounded by spatial monopolistic competition among retail establishments. Nevertheless, they imply systematic changes in distributional service productivity as these bounds are changed over time. The full-price formula organizes these elements as consisting of changes in the value of time, transportation costs, residential density, urbanization, and inventory holding costs. I would emphasize the changing composition of families in this, particularly the increasing labor force participation of women. The substitution of market for home production and the resulting increase in the value of women's time has markedly changed the production of retail services.

The paper stresses an unfamiliar "economy of massed reserves," as the key ingredient in retailing. This concept comes from queueing theory, where it is shown that an increase in the number of clerks and customers, although holding their ratio constant, reduces queueing time in a multi-server facility. Yet that experiment is partial equilibrium because a customer would consider expected crowding and queue length in choosing a store: those things are another aspect of price. The equalization of full prices at the margin would cause queue lengths to adjust to use up any economies of massed reserves in a market equilibrium. In any event Rothschild, Arrow, Levhari and others have shown that these economies are not very large to begin with.

It is the simpler point that there are scale economies of inventory holdings that are key to understanding this sector. A store and its sales force are an inventory of goods waiting for customers. One can think of alternative arrangements in which customers wait for goods rather than the other way around. Ready examples are the queues for consumer goods observed in the former Soviet Union. A more interesting example for measurement is how to treat store hours. When gasoline service stations were open for only a few hours per day during the energy crisis in the 1970s, long lines of autos queueing for service were substituted for the waiting services of station operators and their employees. Measured productivity of service stations would have registered enormous gains over that period, in spite of the fact that the amount of services rendered fell dramatically. Only a scheme in which customer queueing time is subtracted from the value of output would recognize this point. Similarly, increased grocery and convenience store hours in recent years results in a drop in measured productivity, though the change in the value of customers' time and consumption patterns that provoked these changes no doubt has increased true productivity.

Services in general are subject to the problem that as the wage rate increases with economic growth the provision of service-intensive distribution becomes very expensive. This causes substitution to less service-intensive methods at the distribution point, such as self-service, and to more service-intensive methods at the production point, such as advertising and packaging. To that extent what we observe is a movement along some grand production function that should not be confused with productivity change. But to some other extent these observed substitutions are due to technical changes that should be properly counted as productivity improvements. For instance, the rising price of women's time and the smaller size of families increased the extent of preparedness in grocery stores, which range from old-fashioned raw ingredients for home-cooked meals to frozen, precooked items and to completely prepared gourmet meals. Microwave technology and the like are important in this. The paper stops short of discussing how to parcel these things out between productivity and (full-) price adjustments. Only a little thought is required to show that this will be a very hard problem to solve.

How should the increasing range of goods available through the distribution system be treated in all of this? Should the presence of kiwifruit and plantains in grocery stores today be attributed to improvements in food production or to improvements in retail services? How about the Colombian cut-flower business or the availability of Chilean fresh fruit and strawberries in the winter months? Do these things get counted as productivity improvements in the transportation sector rather than the distributional sector? Before initiating a debate about how to allocate them in our accounting schemes, it must give one greater pause to learn that they hardly count at all in our statistics today.

My guess is that the most workable general approach to measuring distributional services is to treat them as intermediate products in the consumer production of utility through the economics of home production. To be sure, problems abound in this approach, and it is obvious that many of them will not have easy answers. Yet in setting up the essential nature of the problem, Walter Oi's paper will serve as an important element in solving it.