

# Evaluating Labor Productivity in Food Retailing

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Competition from new store formats including supercenters, warehouse clubs, and mass merchandisers has emerged as a major threat to traditional grocery chains. A primary objective of this paper is to understand how the store-level performance is related to the workforce composition of full-time and part-time employees chosen by the food retailer along with benefits and incentives provided to employees. The elasticity of complementarity for food retailers measures how changes in store size affect use of full-time and part-time employees. Larger store size increases the marginal value of labor, and firm hiring decisions shift to expanded use of part-time employees.

**Key Words:** elasticity of complementarity, employee compensation, food retailing, inverse price elasticities

The retail food industry has undergone significant changes since the 1980s as supermarkets have responded to increased competition from alternative retail formats and changes in consumer shopping habits. Supermarkets have evolved from small, independently owned, full-service establishments to large, administratively centralized, horizontally and sometimes even vertically integrated self-service chains. Competition from warehouse clubs, mass merchandisers, supercenters, and convenience stores has intensified, forcing supermarkets to reevaluate many of the ways in which they conduct their business operations. As the size of the typical supermarket grew, not only in the United States but also in Europe, economists began to focus attention on economies of size and scale in food retailing. Paul Miller, in a 1930 article in the *American Journal of Agricultural Economics*, was perhaps the first agricultural economist to examine the emergence of mass retailing by chain stores and the implications for growers and processors.

The importance of food retailing is also reflected in research initiatives highlighted on the Economic Research Service's webpage,<sup>1</sup> including public policy related to the structure of U.S. retail food markets and its impact on agricultural

suppliers, financial performance, competition, and food market prices. Li, Sexton, and Xia (2006) discuss the extent of market power by retailers, noting that "we know rather little about retailers' behavior in terms of choices of products and brands carried, pricing strategies promotions" (p. 236), and the authors conclude that the implications for consumers and producers are not clear.

Wal-Mart, the world's largest retailer, has perfected the supercenter format to become the leading firm in the grocery industry. From a base of only 10 in 1993, Wal-Mart now operates over 2,195 supercenters, with company plans indicating that this store format will expand by 200 new stores every year for the next five years. Target was operating 177 SuperTarget locations as of January 2007. The supercenter format is identified as the major threat to traditional grocery chains, as close to 80 percent of supermarket managers listed competition from this store format as their major concern (National Grocers Association 2005).

A clear gap in the current work on the food retail sector is an analysis of the retail labor force and how hiring decisions and employment opportunities are related to retail performance and store-level decisions. Davis et al. (2006) examined human resource practices across retail food establishments and found that these practices are quite persistent even in the face of new external competition, such as entry by a new supercenter.

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<sup>1</sup> [http://www.ers.usda.gov/Briefing/FoodMarketingSystem/foodre\[-\]tailing.htm](http://www.ers.usda.gov/Briefing/FoodMarketingSystem/foodre[-]tailing.htm) ("Briefing Rooms: Food Marketing Systems in the U.S.")

We extend this work by incorporating detailed store-level information on benefits and incentives that can be linked to store performance. Researchers have assessed the impacts of new store formats such as “big box” stores on rural economies and local food stores’ sales and on community social capital stocks (Goetz and Rupasingha 2006, Artz and Stone 2006).

Food retailing and marketing researchers have examined the impact of supercenter entry on pricing strategies and profitability of incumbent supermarkets. The effects of changing product market competition on retailing employment trends have been addressed by Basker (2005), who found that Wal-Mart entry has a positive short-run effect on county retail employment that diminishes over time. While recognizing that Wal-Mart supercenters compete directly with food retailers, Basker does not make an attempt to quantify their direct effects on grocers.

Retailers are increasingly concerned about the link between workforce decisions and store-level performance measures such as value-added. Industry publications comment on the “people gap” in food retailing that leads managers to “focus on today’s operating efficiencies at the expense of tomorrow’s front-line work force” (Major 2003, p. 245). Human resource managers have suggested that the industry is not attracting the right mix of workers and will have to face significant turnover rates and increasing pressure on margins in future years.

The retail food industry recognizes the key role that employee benefits and incentives play in retaining employees and encouraging entry by prospective workers. The 2003 Employee Benefits Study (Food Marketing Institute 2003) noted that a wide array of daily activities offered by successful supermarkets including cashiering, bagging, stocking, pricing, merchandising, and buying rely on performance by well-trained employees. Industry publications identify the scope and variety of benefits offered by food retailers and assess costs of benefits offered by food retail and distribution industries. Our broader objective is to understand how the workforce composition of full-time and part-time employees chosen by the food retailer along with employee benefits and incentives impact store-level performance.

A production function approach based on a performance measure for supermarket operations is integrated with workforce characteristics and

employee benefits and incentives offered by food retailers. The elasticity of complementarity measures the effect of a change in a relative input quantity (such as labor) on the relative input price, and flows directly from the estimation of a production function where input quantities are exogenous and input prices are endogenous. Substitution measures between inputs in food retailing are derived and the factors that influence relative factor prices are assessed. Data for the study are from the Supermarket Panel conducted by The Food Industry Center (TFIC) at the University of Minnesota. The Panel is an annual survey of supermarkets where store managers provide information on store characteristics, operations, and performance. An empirical model is specified, and data collection procedures, characteristics of the Panel, and results from the econometric model are presented. Discussion of the implications, along with directions for future research, conclude the paper.

The elasticity of complementarity is the appropriate measure used to assess key policy and competitive developments facing an industry such as food retailing. The impact of a tax incentive to encourage the supply of capital or hire specific types of workers depends on the Hicks elasticity. Seidman (1989) showed that a tax incentive to stimulate the use of capital benefits low-skilled labor if the two inputs are complements by the Hicks elasticity, highlighting the empirical relevance of this measure. Regulatory strategies to deal with large-scale retail facilities (“big box” retailers) typically include municipal zoning ordinances, which rely on size and height limitations on stores, conditional use restrictions, impact assessments and development fees, and design guidelines for buildings, landscaping, and road access. The effects of these ordinances on relative factor prices for store square footage and employees are appropriately analyzed using the production framework proposed here.

Most of the research on labor substitution patterns examines workers characterized by demographic groups such as age-race-sex groups. Grant and Hamermesh (1981) examined groups such as youths, adult blacks, white women, and white men. Berger (1983) differentiated workers by sex along with years of schooling and years of experience. The model we develop focuses on the use of full-time and part-time workers, an important characteristic of the retail workforce.

**Analysis of the Food Retailing Firm**

A key issue in the food retailing sector is understanding how the earnings of employees are influenced by store characteristics such as store size and the full-time and part-time workforce in the store. Hicks partial elasticities are designed to assess the response of relative factor prices to exogenous changes in relative factor quantities and to measure returns to factors of production such as earnings of employee groups.

The impacts of innovative store formats that have influenced food retailing can be measured using the elasticity of complementarity. Wal-Mart has introduced the Neighborhood Market as a new store format that “has the potential to revolutionize United States retailing in the coming decade just as powerfully as discount stores did in the 1980s and supercenters are doing in the 1990s” (Discount Store News 1999). Neighborhood Markets are about one-quarter the size of typical supercenters (or about 40,000 square feet), stocking about one-fifth of the items (between 20,000 to 23,000 items), and represent a modern version of the neighborhood grocery. The emphasis is on consumer convenience with ease of entry for quick shopping, and they feature fresh produce, dairy, and dry grocery departments, general merchandise, a one-hour photo center, and a drive-through pharmacy. Big-box retailers including Wal-Mart, Target, Costco, and Home Depot are developing multi-level store formats to penetrate urban areas while combating sprawl and complying with strict zoning guidelines.

Consider a firm operating in perfectly competitive product and factor markets with a production function based on a vector of inputs  $x$  which are transformed into a measure of store performance  $y$  (or output) described by the production function  $y = F(x)$ . Facing nonrandom input prices, the firm seeks to minimize costs for a given output level. The Hicks elasticity of complementarity measures the response of an input price to a change in the input quantity where the shift in factor price is chosen to keep marginal cost and quantities of other factors constant. The elasticity of complementarity,  $\rho_{ij}^H$ , is defined from the production function as

$$(1) \quad \rho_{ij}^H = \frac{F(x)F_{ij}(x)}{F_i(x)F_j(x)},$$

where  $F_i(x) = \partial F(x)/\partial x_i$  and  $F_{ij}(x) = \partial^2 F(x)/\partial x_i \partial x_j = F_{ji}$ . Inputs  $i$  and  $j$  are defined to be gross q-complements in the production of a variable output when  $\rho_{ij}^H > 0$ , or when an increase in the quantity of input  $j$  increases the price (or marginal valuation) of input  $i$ . When  $\rho_{ij}^H < 0$ , inputs  $i$  and  $j$  are gross q-substitutes. The Hicks elasticities measure the gross effects of changes in input quantities on input prices and include both substitution and output effects.

The translog production function for the food retailing establishment is specified as

$$(2) \quad \ln F = \alpha_0 + \sum_i \alpha_i \ln x_i + \sum_q \delta_q \ln x_q + \frac{1}{2} \sum_i \sum_j \beta_{ij} \ln x_i \ln x_j + \frac{1}{2} \sum_q \sum_s \rho_{qs} \ln z_q \ln z_s + \sum_i \sum_q \gamma_{iq} \ln x_i \ln z_q,$$

where  $z$  is a set of store-level organizational and operational factors that influence performance, and  $\beta_{ij} = \beta_{ji}$ . The production function is homogeneous of degree  $\theta$  in the set of variable inputs  $x$  if

$$\sum_i \alpha_i = \theta, \quad \sum_j \beta_{ij} = 0$$

for all  $j$ , and

$$\sum_i \gamma_{iq} = 0$$

for all  $q$ . Constant returns to scale for the set of variable inputs in the specification is obtained when  $\theta = 1$ . The partial production elasticity of output for the  $i$ th factor is defined as

$$(3) \quad \varepsilon_i = \frac{\partial \ln F}{\partial \ln x_i} = \alpha_i + \sum_j \beta_{ij} \ln x_j + \sum_q \gamma_{iq} \ln z_q,$$

and the elasticity of scale is the sum of the partial production elasticities for the variable inputs,

$$\varepsilon = \sum_i \varepsilon_i.$$

The Hicks elasticities can be computed from the translog production function as

$$(4) \quad \rho_{ii}^H = \frac{\beta_{ii} + \varepsilon_i^2 - \varepsilon_i}{\varepsilon_i^2}$$

$$\rho_{ij}^H = \frac{\beta_{ij} + \varepsilon_i \varepsilon_j}{\varepsilon_i \varepsilon_j}.$$

Uncompensated quantity elasticities,  $\eta_{ij}$ , or inverse price elasticities, are calculated along with the inverse output elasticities,  $\eta_{iy}$ , in the empirical results. The inverse price elasticities are

$$(5) \quad \eta_{ii} = \frac{\beta_{ii}}{\varepsilon_i} - \frac{\sum_j \beta_{ij}}{\varepsilon} - 1$$

$$\eta_{ij} = \frac{\beta_{ii}}{\varepsilon_i} - \frac{\sum_k \beta_{kj}}{\varepsilon}.$$

The inverse price elasticities measure the change in price of a factor (such as full-time labor) given a one percent change in the quantity of a factor (such as store size). The inverse output elasticities from the translog model are

$$(6) \quad \eta_{iy} = \frac{\sum_j \beta_{ii}}{\varepsilon \varepsilon_i} - \frac{\sum_k \sum_j \beta_{kj}}{\varepsilon^2} - \frac{1}{\varepsilon}.$$

Sato and Koizumi (1973) demonstrated that the elasticity of complementarity can be related to factor prices, quantities, and the output share of a given factor by

$$(7) \quad \rho_{ij}^H = \left[ \frac{\partial \ln p_i}{\partial \ln x_j} \right] \left[ \frac{1}{s_j} \right],$$

where  $p_i$  is the price of the  $i$ th factor and  $s_i$  is the share of output accruing to that factor. Major influences on changes in relative factor prices can be derived from equation (7) when all factor quantities are allowed to adjust, as

$$(8) \quad \partial \ln p_i - \partial \ln p_k = \sum_{i \neq j \neq k} s_j [\rho_{ij}^H - \rho_{ij}^H] \partial \ln x_j$$

$$+ s_i [\rho_{ii}^H - \rho_{ik}^H] \partial \ln x_i$$

$$s_k [\rho_{ik}^H - \rho_{kk}^H] \partial \ln x_k.$$

Shifts in the relative earnings of full-time and part-time employees can be predicted given spe-

cific scenarios or assumptions about changes in quantities of each factor.

### Empirical Model of Supermarket Operations

The Supermarket Panel is an annual, nationwide survey of supermarkets that collects data on store characteristics, operating practices, and performance. The Panel was established in 1998 by the Food Industry Center as a basis for ongoing study of the supermarket industry. Panel data booklets are mailed directly to store managers each January. Each respondent receives a customized benchmark report comparing his/her store to a peer group of stores similar in size and format. The Panel is unique because the unit of analysis is the individual store, and stores are tracked over time. In contrast, findings presented in the *Annual Report of the Grocery Industry* published by *Progressive Grocer* and the Food Marketing Institute's annual *SPEAKS* report are based on company-level responses for representative stores. Data collection procedures for the 2002 Supermarket Panel, selected at random from the nearly 32,000 supermarkets in the United States, are described in detail by King, Jacobson, and Seltzer (2002), and the variables for the model are presented in Table 1.

The translog production function for the food retail establishment is based on value-added as the output measure along with measures of the operational and environmental constraints facing the supermarket. Store performance depends on variable inputs for store size (*SSize*), the hiring of full-time labor (*FTHrs*), and part-time labor hours (*PTHrs*). The store-level organizational and operational factors ( $z_q$ ) that influence performance are discussed below. A stochastic error term, assumed to reflect errors in optimizing behavior, is added to the production function in equation (2). Estimation proceeds by maximum likelihood, assuming that the error term is an independently and identically distributed normal random variable.

The output measure for the retail store is weekly gross margin or value-added, defined as weekly sales minus the cost of goods sold. Baily and Solow (2001) suggest that value-added generated by retailers is the best measure of retailing output. They note that the value-added measure

**Table 1. Variable Descriptions and Summary Statistics**

Variable	Description	Mean	Std. Dev.	Survey Question <sup>a</sup>
<i>ValAdd</i>	Value-added (\$/week)	\$56,556	\$53,810	Q52, Q54
<i>SSize</i>	Store selling area (square feet)	28,100	22,747	Q8
<i>FTHrs</i>	Full-time labor (hours per week)	1032.9	909.7	Q20
<i>PTHrs</i>	Part-time labor (hours per week)	896.7	785.9	Q20
<i>GSize</i>	Ownership group size (number of stores)	199.3	536.9	Q14
<i>SelfDist</i>	Membership in a self-distributing group, 1 if yes, 0 if no	0.37	0.48	Q15
<i>Union</i>	At least 25 percent of employees covered by a collective bargaining agreement, 1 if yes, 0 if no	0.23	0.42	Q25
<i>FTBen</i>	Benefits offered to full-time employees	3.09	1.59	Q26
<i>FTIncen</i>	Incentives offered to full-time employees	0.59	0.81	Q26
<i>PTBen</i>	Benefits offered to part-time employees	1.5	1.74	Q26
<i>PTIncen</i>	Incentives offered to part-time employees	0.44	0.71	Q26
<i>Convl</i>	Conventional format, 1 if yes, 0 if no	0.64	0.48	Q30
<i>FoodDrug</i>	Food/drug combination format, 1 if yes, 0 if no	0.23	0.42	Q30
<i>SCenter</i>	Warehouse, Supercenter, Super Warehouse format, 1 if yes, 0 if no	0.09	0.29	Q30
<i>Superstore</i>	Superstore format, 1 if yes, 0 if no	0.04	0.2	Q30

<sup>a</sup> The question number for each variable in the 2002 Supermarket Panel Annual Report conducted by The Food Industry Center (TFIC) at the University of Minnesota.

of output reflects the amount of retail services that are provided, such as the variety of merchandise provided, convenience of store location, and availability of checkout and food department personnel, along with the availability of in-store services.

Results from summary income statements of conventional supermarkets confirm a close relationship between value-added measures and labor productivity at the store level. The Food Marketing Institute (2002) reported that the most profitable food retailers invested a higher percentage of expenses in personnel than did lower performing supermarkets, even though overall expenses for the top performers were lower than those for the least profitable stores. Payroll as a percentage of total expenses was at 47.5 percent for the most profitable stores and 41.9 percent for the least profitable stores. High performing stores use managerial skills and operational methods to control overall expenses more effectively and to maintain high gross margins.

The two inputs considered in this analysis are store selling area and weekly labor hours. Store

selling area is a rough measure of the capital used in a retail operation. Store energy costs and other major capital inputs, such as refrigeration equipment and lighting, shelving and display cases, and front-end checkout equipment, are highly correlated with store selling area.

The impact of workforce quality and composition on retail performance is measured by the store's use of full-time and part-time workers. The labor inputs are full-time labor hours (*FTHrs*) and part-time labor hours (*PTHrs*). Oi (1992) noted that reliance on part-time workers is an indicator of the skill mix of the retail work force. Increases in the ratio of part-time to full-time employees are driven partly by larger store sizes. But larger stores also pay higher wages than smaller stores because their employees supply more work effort. The result is that wages of part-time workers are higher at larger supermarkets than at smaller stores.

Larger stores must hire more clerks, and these employees are more productive because they waste less time in waiting on customers. Full-time workers also benefit from higher wages at larger

supermarkets. The key relationship to note is the size-wage premium: as stores get bigger, wages of part-time workers rise faster than wages of full-time workers. Oi (1992) concluded that productivity gains associated with sales volume in food retailing are relatively greater for part-time employees. The empirical model allows us to evaluate the relative impact of full-time and part-time employees on store performance as measured by value-added.

To test whether the benefits and the incentive packages offered to employees influence value-added at the store level, a variable for these measures was formed. The Supermarket Panel recorded information on the typical compensation package for full-time and part-time workers where the category of full-time workers excluded department heads and store managers. Benefits included individual health insurance, family health insurance, disability insurance, company-funded pension, and a 401(k) plan. The menu of incentives offered by the firm indicated whether the firm offers an annual bonus, whether it uses individual performance incentive pay or incentive pay based on product or category performance, and the presence of an employee stock ownership plan. The benefits and incentives offered by food retailers are listed in Table 2.

The benefits variable for full-time (*FTBen*) and part-time (*PTBen*) employees was constructed as the number of benefits provided by the establishment (from 1 to 5). The incentives measure for full-time (*FTIncen*) and part-time (*PTIncen*) employees was a count of the incentives offered (from 1 to 4). Our measures here are consistent with yet also more comprehensive than research (Decressin et al. 2004, Brown and Medoff 2003) on benefit offerings by firms that utilizes dichotomous indicators for whether firms provide benefits such as pensions, welfare plans (health, life, supplemental employment, and disability insurance), or fringe benefit plans.

On average, full-time employees received 3 of the 5 listed benefits and 0.59 of the 4 incentives, with part-time employees recording lower scores on both indicators. Four benefit measures were received by over 50 percent of full-time employees: individual health insurance, family health insurance, disability insurance, and the 401(k) plan. There were no incentives provided to more than half of the full-time employees, and none of

the benefits or incentives were available to more than 50 percent of the part-time employees. The difference between benefits offered to full-time and part-time employees is dramatic and reinforces the importance of examining how these workers influence store performance. A large proportion (45 percent) of part-time employees receive no benefits, matched by a similar proportion (46 percent) of full-time employees who receive four or more (maximum of 5) of the benefits.

The data confirm a clear correlation between store size and the provision of benefits and incentives for both full-time and part-time employees. Offerings of benefits and incentives tend to increase for both types of employees as store size increases. Stores with floorspace between 45,000 and 60,000 square feet offer the most benefits and incentives for full-time workers, and the largest stores (over 60,000 square feet) provide the most extensive benefit set for part-time workers.

Characteristics of the organizations that own and operate stores may also impact gross margin, and four characteristics are featured in the model. First, membership in a larger group (*Gsize*) may boost productivity through multistore economies in procurement and advertising and through centralization of some managerial functions. Hoppe (2002) commented on established empirical findings that large firms tend to adopt new technology sooner than small firms, as the larger firms expect a greater rate of return from adoption.

The role of multiplant economies in the adoption and diffusion of technological innovations in food retailing chains also influences technology adoption decisions. Multiplant firms may attain savings in nonproduction costs such as transportation, distribution, and inventory control while taking advantage of the economies of massed reserves along with information-sharing between plants. Jensen (2004) demonstrated how economies of multiplant operations influence the relationship between firm size and technology adoption. If learning costs of new technology are greater for a large firm, the small firm can lead in adoption. However, if the profit increase accruing to the large firm with multiplant operations is large enough, the learning cost effect is overcome and the large firm is more likely to lead in technology adoption. Food retailing chains may benefit from multiplant economies in the adoption and diffusion of technological innovations.

**Table 2. Summary of Benefits and Incentives Offered by Food Retailers**

Abbreviation	Benefit or Incentive	Full-Time	Part-Time
<i>IHINS</i>	Individual health insurance	84.8	35.4
<i>FHINS</i>	Family health insurance	73.0	25.8
<i>DINS</i>	Disability insurance	55.4	25.5
<i>CFPEN</i>	Pension	37.8	25.2
<i>401K</i>	401(k) plan	57.8	38.1
<i>ANBON</i>	Annual bonus	19.3	12.0
<i>IPIP</i>	Individual performance incentive pay	16.7	15.2
<i>IPCP</i>	Incentive pay linked to product / category performance	5.6	3.2
<i>ESOP</i>	Employee stock ownership program	17.0	13.5
<i>Ben</i>	IHINS + FHINS + DINS + CFPEN + 401K		
<i>Incen</i>	ANBON + IPIP + IPCP + ESOP		

<sup>a</sup> Data from the 2002 Supermarket Panel Annual Report conducted by The Food Industry Center (TFIC) at the University of Minnesota. The proportion of employees receiving the benefit or incentive is recorded in the table.

A second organizational descriptor is a binary variable equal to zero if the store is wholesaler-supplied and equal to one if the store is part of a self-distributing group (*SelfDist*). Stores and distribution centers are under common ownership in self-distributing chains, facilitating coordination between these two segments of the retail supply chain and enhancing productivity gains. Stores in self-distributing groups, which account for about 37 percent of the sampled stores, report a value-added figure that is over 2.5 times higher than that recorded by wholesaler-supplied stores. Sales per square foot measures are about 25 percent higher (\$8.92 vs. \$7.19). Stores in self-distributing groups provide higher levels of benefits and incentives for both full-time and part-time workers.

Unionization is a third organizational factor that may affect productivity if having a unionized workforce is associated with significant differences in worker skills and/or workforce stability. A binary variable equal to one if at least a quarter of the workforce is covered by a collective bargaining agreement (*Union*) and zero otherwise is also included in the empirical model, resulting in about 23 percent of the stores being identified as unionized. Unionized stores register high performance for the value-added measure, with a dollar amount that is over 2 times higher than non-unionized stores. The sales per square foot measure for unionized stores is about 32 percent

higher than for non-unionized stores. Hirsch (1991) reported a strong negative relationship between union coverage at the firm level and company earnings and market value for manufacturing firms, supporting the theory that unions appropriate a share of the returns that accrue to profit-enhancing firms. Food retailing establishments display a different pattern, and it will be interesting to see if a positive relationship between unionization and value-added is observed after controlling for key store-level variables.

Distribution service levels are closely related to store format, the fourth measure of store organization. King, Jacobson, and Seltzer (2002) report considerable variation in median store characteristics and performance measures for stores grouped by format. Store format is not closely related to the hiring of full-time and part-time employees. Across each of the store formats, the ratio of full-time to part-time employees is generally unchanged, varying between 50–54 percent. The model examines whether these format effects can be accounted for by systematic differences in input levels and other productivity shifters across formats. Binary variables for these format categories are included in the empirical model. Stores in the Supermarket Panel are grouped into four mutually exclusive, exhaustive format categories based on store size and distribution service offerings. The store format categories include con-

ventional stores, food/drug combinations, supercenters, and warehouse/super-warehouse formats (*Convl, FoodDrug, Scenter, Superstore*).

### Estimation Results

Discussion of the model results centers around two main issues. First, the key factors that influence retail store performance along with the estimated partial production elasticities and measures of returns to scale are presented. Second, the implications of the elasticities of complementarity for evaluating use of store inputs by food retailers are assessed.

Coefficient estimates and asymptotic standard errors based on heteroscedasticity robust standard errors for the translog model are presented in Table 3. The empirical analysis follows Berger (1983), Grant and Hamermesh (1981), and Kim (2000), who relied on the ordinary least squares model in their applications. King and Park (2004) also provide support for the estimation approach in modeling productivity in supermarket operations. Benefits and incentive packages are closely linked to the size of the store along with staffing decisions, leading us to specify interactions between variables. The four store-level organizational and operational factors (group size, membership in a self-distributing group, unionization, and four store format indicators) enter the specification as factors that shift value-added directly.

We examine whether the production function for food retailing is consistent with homotheticity, which implies that the marginal rate of technical substitution is homogeneous of degree zero in inputs by testing whether

$$\sum_j \beta_{ij} = 0.$$

Restrictions required for a homogeneous production along with linear homogeneity are also tested. Both the homotheticity and homogeneity restrictions apply to the set of variable inputs considered in the model: store size, full-time labor, and part-time labor.

Hausman (1978) exogeneity tests of the benefit and incentive measures for full-time and part-time employees were conducted. Instruments included training hours for new hires in cashiers and other

positions, hours of training for key employees (store managers, grocery department managers, and scanning coordinators), and store adoption of information technologies for data-sharing, decision-sharing technologies and practices, and technologies supporting product assortment, pricing, and merchandising decisions. The exogeneity hypothesis for the benefits and incentives variables was not rejected.

The coefficients associated with the store categories indicate how supermarket performance across each format compares with the average supermarket in the sample. The null hypothesis that the format effects (conventional, food/drug combination, supercenter, and warehouse/super warehouse) are jointly equal to zero is not rejected, as the calculated  $\chi^2$  value of 0.256 was below the critical value  $\chi^2_3$  of 7.81 at the 95 percent confidence level. The store format variables were subsequently excluded from the model.

The Points of Impact Retail Operations Survey (National Grocers Association 2005) compiles average gross profits across different store formats such as conventional, upscale, and discount supermarkets, and both upscale and conventional superstores. The annual report from the 2002 Supermarket Panel also noted the important effect that format has on store performance, commenting that “food/drug combinations, warehouse, superwarehouse, and supercenter/hypermarket stores have performance levels that are significantly different from (but not always better than) performance for stores with conventional and supermarket formats.” The findings are useful for retail industry analysts as they suggest that after controlling for inputs such as store size and labor use (including benefits and incentives), store formats are not a significant component influencing observed value-added.

The calculated returns to scale measure is 1.013, which is not significantly higher than one, implying essentially constant returns to scale for the set of variable inputs (store space, full-time labor, and part-time labor). From the likelihood ratio tests presented in Table 3, the production function for the food retailing establishments does not reject the constant returns to scale restriction. The Hicks elasticity of complementarity is a theoretically valid measure to examine input substitution patterns for the food retailing establishments. Using an aggregate cost function for



**Table 3. Production Function Parameter Estimates for Food Retailing Establishments**

Variable	Estimate	T-ratio
<i>Intercept</i>	-6.808*	-2.354
<i>SSize</i>	0.523	0.691
<i>FTHrs</i>	-0.340	-0.628
<i>PTHrs</i>	0.170	0.401
<i>SSize</i> × <i>SSize</i>	-0.058	-0.952
<i>FTHrs</i> × <i>FTHrs</i>	1.000*	2.007
<i>PTHrs</i> × <i>PTHrs</i>	0.032*	2.630
<i>SSize</i> × <i>FTHrs</i>	0.049	0.513
<i>SSize</i> × <i>PTHrs</i>	0.067	1.146
<i>SSize</i> × <i>FTBen</i>	0.044	1.257
<i>SSize</i> × <i>FTIncen</i>	0.055	0.880
<i>SSize</i> × <i>PTBen</i>	-0.061*	-2.089
<i>SSize</i> × <i>PTIncen</i>	0.024	0.414
<i>FTHrs</i> × <i>PTHrs</i>	-0.141*	-2.881
<i>FTHrs</i> × <i>FTBen</i>	-0.040	-1.427
<i>FTHrs</i> × <i>FTIncen</i>	-0.026	-0.523
<i>PTHrs</i> × <i>PTBen</i>	0.058*	2.436
<i>PTHrs</i> × <i>PTIncen</i>	-0.041	-0.867
<i>FTBen</i>	-0.073	-0.300
<i>FTIncen</i>	-0.340	-0.787
<i>PTBen</i>	0.283	1.311
<i>PTIncen</i>	0.032	0.067
<i>FTBen</i> × <i>FTBen</i>	-0.010	-1.072
<i>FTIncen</i> × <i>FTIncen</i>	-0.016	-0.468
<i>PTBen</i> × <i>PTBen</i>	-0.012	-1.288
<i>PTIncen</i> × <i>PTIncen</i>	0.005	0.132
<i>GSize</i>	0.001	0.336
<i>SelfDist</i>	0.093	1.603
<i>Union</i>	0.163*	2.980

## RESTRICTIONS AND CRITICAL VALUE

F-test for homotheticity 1.2029 (critical value  $F_{4,320} = 2.37$ )F-test for homogeneity 1.1176 (critical value  $F_{5,320} = 2.21$ )

R-squared 0.89

No. of observations 341

Note: Asterisk indicates asymptotic t-values with significance at  $\alpha = 0.10$  level. Heteroscedasticity robust standard errors presented.

U.S. retail food stores based on value-added at retail and three inputs including intermediate services, capital, and labor, Ratchford (2003) found

slightly decreasing returns to scale. Our results for returns to scale align with those reported by Betancourt and Malanoski (1999), who found constant returns to scale with respect to output for a sample of U.S. supermarkets. Oi's (1992) proposition on economies of scale in which large stores are driven by lower operating costs is not confirmed by these results.

Labor expenses account for the largest proportion of operating expenses, so food retailers are naturally interested in evaluating the impact of labor on value-added at the store level. Wages and benefits for store labor account for the largest component of operating expenses, at about 53 percent of operating expenses. Occupancy (excluding utilities) ranks second, with an 11 percent share of operating expenses, followed by advertising and promotion at 7 percent (Food Marketing Institute 2002). From the translog model, the partial production elasticities measure the change in store value-added in response to a one percent increase in labor used. The elasticity for full-time employees (0.43) is about 13 percent higher than that for part-time employees (0.38). Elasticities for the three inputs including store size (0.20) are each significantly different from zero.

The effect for membership in a self-distributing group indicates that these stores attain a value-added which is about 9.7 percent higher than wholesaler-supplied stores, using Kennedy's (1981) procedure to measure the impact of a dichotomous variable on the logarithm of value-added. Retail analysts link the effectiveness of Walmart's supercenters to its superior self-distribution network, while Kmart's competitive disadvantages have been attributed in part to its lack of a self-distribution system. Self-distribution is recognized by retail analysts as a method to reduce supply chain costs and achieve greater efficiency, allowing stores to expand margins, improve in-stock availability, and enhance store productivity.

Part-time employees in self-distributing chains are more productive than their counterparts in wholesaler-supplied operations based on the specified production function. The productivity of labor (both full-time and part-time) is, at 0.89, about 16 percent higher in stores in self-distributing chains, as compared with 0.77 for wholesaler-supplied stores. The result is that self-distributing stores are able to generate greater changes in value-added for each unit of labor employed.

The union workforce binary variable showed a positive and significant relationship with improved margins of about 17.7 percent, providing strong evidence that there are productivity gains associated with a union workforce. Unionization has a positive impact on value-added, providing strong evidence that there are productivity gains associated with having a union workforce. This result suggests some justification for higher wages for union workers, since the marginal product of labor, given the levels of selling area and total labor hours, is higher in stores with a union workforce. Farber and Saks (1980) noted that most analytical work on unions has concluded that unions generally raise the mean and lower the dispersion of the wage distribution within firms. Shifts in the intrafirm distribution of earnings due to unionization typically benefit workers at the lower end of the firm's payscale. In the Supermarket Panel, the average wage bill for union establishments was about 10 percent higher than for nonunion food retailers, while the standard deviation of wages between the union establishments was 66 percent lower than nonunion stores. The wage effects associated with unionization rates apparently have a positive impact on the value-added of food retailers.

Retailers providing an expanded set of benefits to full-time employees show higher performance, as the impact of benefits on store-level value-added is statistically significant. The impact of benefits on value-added is evaluated in an elasticity calculation, accounting for the interaction of the benefits variable with other explanatory variables in the model. An additional employee benefit offered to both full-time and part-time employees adds about 4.0 percent to store-level value-added.

Empirical work in labor economics has documented a positive association between wages and benefits conditional on workforce characteristics. However, the result that firms offering expanded benefits to their workforce attain better performance is a new finding that aligns with emerging results from the labor economics literature. Decressin et al. (2004) show that firms offering benefits are more likely to survive than firms that do not offer benefits, even after controlling for workforce and firm characteristics. The results for the food retailing establishments do not show that value-added is positively influenced by an expanded incentive package for either full-time or

part-time workers. Retail managers can readily use these results to identify the optimal set of benefits and incentives to provide employees, with direct implications for improving store performance.

The own elasticities of complementarity calculated at the mean values of the explanatory variables (Table 4) are all negative, as required for a well-behaved production function. A positive elasticity between store size and part-time employees indicates that as store size increases, the marginal value of labor rises and firms hire more part-time employees, so these inputs are q-complements. Store size and full-time workers are also q-complements, although the effect is not as large as that for the part-time workforce and is not statistically significant.

Inverse price elasticities and the inverse output elasticities evaluated at the means of the explanatory variables are reported in Table 5. The price elasticity shows that a one percent increase in store size decreases the marginal cost of space by 1.59 percent, while increasing the marginal value of productivity (MVP), or the marginal revenue product, for both part-time and full-time workers. The own-quantity inverse price elasticities for employees are small, indicating that increases in the number of workers hired result in wage declines of less than one percent for both full-time and part-time employees (assuming flexible wages). Adjustments in payments to part-time employees are larger than those to full-time workers. Store size has no significant effect on MVP of either full-time or part-time workers.

The expanded use of part-time workers leads to decreases in the valuation of full-time workers at the store level, leading to reduced employment of full-time workers. Negative signs for the estimated inverse output elasticities imply that as value-added expands, the store places a lower value on additional units of the input. Changes in store value-added have a similar effect across each of the inputs.

The findings suggest that in evaluating labor market policies in food retailing, distinguishing between full-time and part-time employees is critical. Incorporating an expanded set of worker characteristics based on demographic groups may also be important, but utilizing information on workforce scheduling (full-time vs. part-time workers) reflects a key store-level decision available to managers in the retail sector. Store size

**Table 4. Estimated Hicks Elasticities of Complementarity**

Marginal Value of Productivity	With respect to quantity of ...		
	<i>SSize</i>	<i>FTHrs</i>	<i>PTHrs</i>
<i>SSize</i>	-0.275* (-2.107)		
<i>FTHrs</i>	1.576 (1.406)	-0.458 (-0.465)	
<i>PTHrs</i>	1.883* (2.486)	0.151 (0.487)	-0.172* (-7.360)

Note: Asterisk indicates asymptotic t-values with significance at  $\alpha = 0.10$  level. Elasticities evaluated sample means of explanatory variables.

**Table 5. Estimated Uncompensated Inverse Price Elasticities and Output Elasticities**

Marginal Value of Productivity	With respect to quantity of ...			
	<i>SSize</i>	<i>FTHrs</i>	<i>PTHrs</i>	Inverse Output Elasticity
<i>SSize</i>	-1.594* (-2.426)	0.357 (0.718)	0.311 (1.181)	-1.025* (-20.764)
<i>FTHrs</i>	0.113 (0.454)	-0.432* (-1.698)	-0.334* (-2.339)	-1.032* (-20.500)
<i>PTHrs</i>	0.173 (0.953)	-0.261* (-1.677)	-0.841* (-9.525)	-1.052* (-21.833)

Note: Asterisk indicates asymptotic t-values with significance at  $\alpha = 0.10$  level. Elasticities evaluated sample means of explanatory variables.

(capital) and both the labor groups used in the model are complements. Incentives that encourage retailers to expand employment by full-time and part-time workers will raise the marginal product, and therefore the rate of return to capital.

#### Interpreting Labor Adjustment at the Store Level

Additional information about labor adjustment can be gained by using the decomposition in equation (8) to predict the adjustments in wages for full-time and part-time employees in response to changes in store size. Consider the development of the Neighborhood Market concept by Wal-Mart, which promotes a smaller store size (limited to about 40,000 square feet). The scenario is based on the partial elasticities of complementarity in Table 4, along with partial production elasticities.

Changes in factor quantities for the scenario are derived from the Supermarket Panel, using mean store size and employee hours for stores which match the profile of Neighborhood Markets. Stores that are operating below the 40,000 square feet mark are assumed to adjust their inputs to match the Neighborhood Markets format. The predicted decrease in the relative earnings of full-time versus part-time workers, or  $\Delta \ln(P_{FTHrs}/P_{PTHrs})$ , is -0.213. Expanded employment of full-time workers has a positive effect on the adjustment in wages (0.168), but is outweighed by reductions in relative wages due to larger stores (-0.082) and lower demand for part-time employees (-0.299). Survey data from the Supermarket Panel allow a comparison of the relative use of full-time versus part-time labor in the two store formats (less than 40,000 square feet and more than 40,000 square feet). The ratio of full-time to part-time labor in stores below the 40,000 square feet mark is 80 percent, and shrinks to 37 percent

for store sizes consistent with the Neighborhood Market concept. Larger stores employ more of both types of workers but shift to a greater reliance on part-timers.

The Hicks elasticity and the decomposition allow us to evaluate changes in relative earnings, which are a key tool monitored by store managers, and the factors driving shifts in relative wages. An advantage of the production function approach which generates Hicks elasticities of complementarities is its flexibility in analyzing the impact of evolving trends in food retailing, particularly changes in relative factor prices.

### Discussion and Conclusion

Retail managers are frequently interested in relating store-level performance to specific management or human resource strategies. Berman and Evans (2001) outlined strategies available to retailers to enhance net profit margin (related to our value-added measure) and mentioned store-level adjustments such as lowering labor costs, reducing costs by emphasizing self-service, or selling exclusive product lines. These strategies will involve changes in store size and the intensity and relative use of full-time and part-time employees, which can be assessed using the Hicks elasticities of complementarity production function approach.

This study presents results from a production function analysis of supermarket operations, using a unique data set from a national survey of supermarkets. We place particular emphasis on modeling returns to scale and elasticities of complementarity using a flexible functional form, linking these measures to store-level workforce decisions on benefits and incentives. The results confirm that the Hicks elasticity of complementarity is an appropriate measure to assess input substitutability for food retailers since the production function exhibits constant returns to scale.

The empirical work documents that food retailing firms that offer an expanded set of benefits [such as individual health insurance, family health insurance, disability insurance, company-funded pension, or a 401(k) plan] attain better performance. These findings address an important distinction in the menu of benefits offered to the retail

workforce, as part-time workers receive very restricted benefits compared to full-time employees. Retailers providing an expanded benefits set achieve higher performance, a finding which aligns with emerging results from the labor economics literature. Retail managers could use these results to focus on identifying the optimal set of benefits for employees in order to improve store performance.

The detailed information on benefits and incentives available in the Supermarket Panel highlights the value of store-level data from food retailers collected with industry cooperation. Additional analysis can be conducted to establish whether the optimal menu of benefits and incentives differs across size of store or should be adjusted for specific store formats. The detailed disaggregate data from the Supermarket Panel also indicates whether the benefits and incentives are provided to store managers, department heads, full-time workers, and part-time workers. This information could be exploited to assess the differential effects across groups of workers and the impact of aligning benefits packages so that different employee groups receive a similar package of benefits.

Future work will expand the sample size by using updated versions of the Supermarket Panel. A primary goal will be to assess learning effects associated with changes in workforce composition between full-time and part-time employees, adjustments in benefits, and the role of turnover using data from multiple years. Finally, we plan to devote added attention to exploring the factors that underlie the strong productivity gains associated with membership in a self-distributing group, since questions about the importance of vertical coordination between stores and distribution centers will be critical to understanding the structural evolution of supermarkets.

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