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Grocery-Retailer Pricing Behavior with Implications for Farmer Welfare

Chenguang Li and Richard J. Sexton

In the standard model of food pricing, retailers set price equal to the farm or wholesale price plus a markup based on retailing costs. However, predictions from a markup-pricing model—such as high correlations between retail price and farm price and among prices across retailers in a city—are not supported empirically. We document three common alternatives to markup pricing: fixed (constant) pricing, periodic sales, and high-low pricing. These results inform the development of a structural model of the vertical market chain in order to study the relationship among retailers and producers in a prototypical fresh produce market. A series of simulations under different pricing regimes are conducted to evaluate these pricing strategies' affects on farm price, farm income, and the variability of farm income. Results show that the alternative pricing strategies to markup pricing exacerbate farm price and income volatility compared to markup pricing. This enhanced farm-price volatility is also generally detrimental to farm income.

Key words: farm income, farm price, fresh produce, grocery retailer, markup pricing

Introduction

Rising concentration and consolidation of sales among large supermarket chains worldwide have accelerated concerns about their role in influencing food prices paid by consumers and received by farmers (Cotterill, 1993; Cotterill and Harper, 1995; Connor, 1999; Cotterill, 1999; Kaufman et al., 2000; MacDonald, 2000; Reardon et al., 2003; Hu et al., 2004). Nonetheless, the standard model of retail pricing assumes that retailers set price equal to the farm or wholesale price plus a markup based on retailing costs (Buse and Brandow, 1960; George and King, 1971; Gardner, 1975; Heien, 1980; Wohlgenant and Mullen, 1987; Elitzak, 1996; Wohlgenant, 2001).

Due to consumers' ability to arbitrage among multiple purchasing opportunities, cost-based markup pricing is equilibrium behavior in a competitive retailing sector. If such markup pricing is the standard, we should observe both high correlation between retail price and farm price for any given commodity and high correlations among retail prices for a given product across retailers in the same city. Neither prediction is borne out in reality. Rather, the transmission of price changes between farm and retail is generally delayed, incomplete, and asymmetric (e.g., Azzam, 1999; Peltzman, 2000; Chen et al., 2008). Significant price dispersion exists among retailers in the same market area (Sexton, Zhang, and Chalfant, 2003; Hosken and Reiffen, 2004), and retail price variations commonly reflect changes in retail margins rather than changes in costs, as would be true under markup pricing (Conlisk, Gerstner, and Sobel, 1984; MacDonald, 2000; Pesendorfer, 2002; Hosken and Reiffen, 2004).

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If markup pricing is not descriptive of food retailer pricing, then what is? And what are the consequences of these pricing policies for farm prices and incomes? This study is the first to address these questions in detail.[1] Prior work has been limited to brief discussions in Sexton, Zhang, and Chalfant (2003) and Li, Sexton, and Xia (2006). We focus specifically on retail price setting for produce commodities in the United States. Produce represents a key department in modern supermarkets, and produce commodities provide a clear avenue to examine impacts of retailer pricing in the United States because most go directly from grower-shippers to retailers, so relationships are not confused by the roles of market intermediaries.

We focus on three commonly observed alternatives to the baseline case of markup pricing—fixed (constant) pricing, periodic sales, and high-low pricing—and develop a structural model of the vertical market chain to study the relationship between retailers and producers in a prototypical fresh produce market under the four alternative grocery-retailer pricing patterns. The demand side of the market in this model is characterized by two sectors: grocery retail and all other outlets, which we call food service. We assume that the food-service sector acts competitively when selling and procuring the farm commodity. Thus, we model food service as using cost-based, markup pricing, while grocery retailers may use any of the aforementioned pricing alternatives.

The farm supply side of the market is modeled in a simple way that nonetheless captures the essential aspects of produce production. Following Sexton and Zhang (1996), short-run supply for a perishable produce commodity is assumed to be perfectly inelastic for price levels greater than the marginal cost of harvesting the commodity and perfectly elastic at the level of the marginal harvest cost. When the marginal harvest-cost constraint on price does not bind, the short-run supply is fixed at the exogenous level of farm production, which is subject to random shocks, and farm price depends on the realization of production, the market clearing condition, and sellers' ability to arbitrage between the alternative market outlets—food service and grocery retail.

We next parameterize the model to represent prototype produce markets and conduct a series of simulations under different pricing regimes to evaluate how retailers' alternative pricing strategies affect farm price, farm income, and the variability of farm price and income. Under each of the alternatives to markup pricing, price changes in the grocery retail sector, if any, are depicted in a stylized manner intended to reflect actual pricing strategies pursued by some grocery retailers. Prices under these alternative strategies are unrelated to farm supply shocks. Thus, these alternative pricing strategies exacerbate farm price and income volatility compared to markup pricing because market clearing must be achieved through price adjustments in the competitive food-service sector.

The impact of these alternative price strategies on mean farm income relative to markup pricing depends on the extent to which the harvest-cost constraint on price binds. If harvest cost is sufficiently high as a share of total production costs and the market is sufficiently volatile such that the harvest-cost constraint binds frequently, then increased farm price volatility induced by retailers' alternative pricing strategies may result in higher farm income, compared to markup pricing. In essence, the harvest-cost constraint places a lower bound on the farm price without placing a comparable upper bound, meaning that farmers benefit fully from volatility-induced price increases but are protected from severe price decreases. However, when the harvest-cost constraint does not bind, retailers' use of alternative pricing mechanisms unequivocally reduces average farm income, and the increased price volatility inherent under these pricing strategies causes further decrement to farmer welfare under risk aversion.

Grocery-Retail Pricing Patterns for Produce Commodities

Fassnacht and El Husseini (2013) provide a recent and convenient summary of literature on retail pricing strategies. The four different retail pricing patterns for fresh produce commodities studied

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[1] Bolton and Shankar (2003) examined retail pricing and promotion strategies for six product categories, but only two, spaghetti sauce and frozen waffles, were food categories.

here are based primarily on Li (2010), who analyzed data on weekly farm and retail prices and volumes for fifteen major produce commodities in twenty U.S. retail-chain location combinations covering a substantial geographic cross section of the U.S. market.

Fixed pricing occurs when a retailer maintains a product's price at a given level for an extended period of time regardless of fluctuations in farm price. Fixed pricing is consistent with the so-called "everyday low price" strategy (e.g., Lal and Rao, 1997).

Markup pricing results when a retailer sets price for a commodity by appending a markup to the wholesale or farm cost of the commodity. Lacking data on retailers' costs, Li (2010) identified markup pricing using high correlations between retail and farm prices and observed that certain commodities were more likely to be priced according to markup-pricing strategy than others.

Periodic sale pricing involves a retail price that stays at a certain level for extended periods but is interrupted by temporary price reductions unrelated to changes in farm price, after which the price returns to its original level. Such pricing is thus characterized by (i) a single, regular price or several mass-point prices, (ii) mostly downward price changes, and (iii) little correlation between farm and retail prices. The periodic sale pricing strategy is consistent with "weekly specials" offered and advertised by some retailers.

Finally, *high-low pricing* is characterized by frequent price fluctuations between different high and low levels. Under high-low pricing (i) the modal price is not observed with high frequency (in contrast with the periodic-sale strategy), (ii) retail price changes do not reflect fluctuations in the farm price (so the correlation is low), (iii) price changes are more frequent than under the periodic-sale strategy, and (iv) price increases under high-low pricing may exceed price decreases in frequency.

The Vertical-Market Model

We develop a vertical-market model for a perishable (nonstorable) produce commodity that will then be parameterized for purposes of conducting simulation analysis of the impacts of alternative grocery-retailer pricing strategies. We consider two aggregate market outlets—grocery retail and food service—and assume constant per unit costs for shipping, handling, and selling the commodity in each broad market.

Figure 1 illustrates the model structure. The left quadrant depicts the grocery-retail market, D^R shows grocery-retail demand from final consumers for the commodity, and d^R denotes the derived farm demand from grocery retailers under perfect competition in procurement. The right quadrant depicts the food-service market, where D^F denotes the final demand for the commodity in food service and d^F shows the derived farm demand of the food-service sector under perfect competition in procurement. For ease of exposition, d^R and d^F are assumed to be identical on the graph. This assumption is relaxed in the analytical model and simulations.

Potential farm production, Q_t^*, in any period t is exogenous to the current market price. It consists of a mean potential harvest, $\overline{Q}$, determined by acreage committed to the product months (in the case of an annual) or years (in the case of a perennial) in advance of harvest, and a mean-zero random supply shock, $\Delta_t : Q_t^* = \overline{Q} + \Delta_t$. Harvest costs, denoted by H, are assumed to be constant per unit and over time. The actual farm supply is $Q_t \leq Q_t^*$, where strict inequality applies only when production is so great that the harvest-cost constraint binds and places a lower bound on the farm price.

We assume that the food-service sector operates competitively in selling and procuring the commodity, and thus applies a markup-pricing rule. Grocery retailers may, however, use the different price retail behaviors discussed previously. Arbitrage by sellers between the two market outlets ensures that the farm prices paid in each outlet are equal regardless of the strategy retailers adopt in

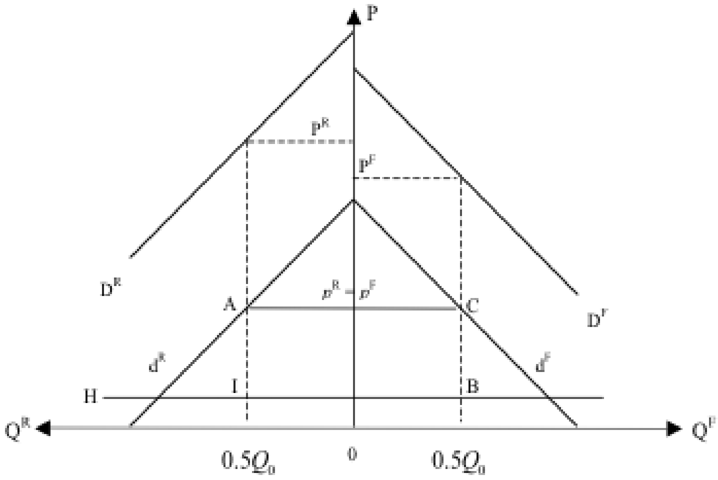

Figure 1. The Vertical-Market Model

setting prices to consumers.[2] Sexton, Zhang, and Chalfant (2003) ignored this arbitrage relationship between the two retail market outlets in their analysis of fixed retail pricing.

Given equal demands and competitive pricing, the harvest, Q_0 in figure 1 is divided equally between the two markets. Final prices are P^R and P^F in the retail and food-service markets, and farm price is given by $p^R = p^F$. Gross farm income (revenue minus harvest costs) is the area AIBC.

Impact of Alternative Grocery-Retailer Pricing Behaviors

Figure 2 compares fixed retail pricing with markup pricing to illustrate how departures from markup pricing may affect farmer welfare. Suppose at time 0 production is at the mean $Q_0 = \overline{Q}$, but at time 1 production experiences a positive random shock, Δ_1, and the harvest-cost constraint does not bind. Thus, $Q_1 = \overline{Q} + \Delta_1$. If both markets use markup pricing, allowing the downstream price to change in response to the increase in production, then each sells $0.5Q_1$ and the farm price falls to $p_1^R = p_1^F$. Farm income from both markets changes from area AIBC to area MKUP in figure 2a.

However, if grocery retailers use a fixed pricing strategy, then the retail price in time 1 is unchanged, $P_1^R = P_0^R$, and grocery-retail sales remain at $0.5\overline{Q}$. In order for the market to clear, food service must sell $0.5\overline{Q} + \Delta_1$, with the farm price in the food service market falling to $\tilde{p}_1^F$. Due to seller arbitrage between grocery retail and food service, the farm price paid by retailers equals the farm price paid by the food service sector: $\tilde{p}_1^R = \tilde{p}_1^F$. The farm income from both markets is the area FIXD < MKUP. Thus, total farm income declines (by the diagonally shaded area in figure 2a) under fixed retail pricing compared to markup pricing in response to a positive supply shock.

Figure 2b illustrates a farm production decrease to $Q_2 = \overline{Q} - \Delta_1$ in period 2. If both sectors allow their prices to change in response to the decrease in production, each sells $0.5Q_2$ and farm price in each market increases to $p_2^R = p_2^F$. If instead retailers keep their price fixed at $P_2^R = P_0^R$, then grocery-retail sales remain at $0.5\overline{Q}$. The food-service sector now sells $0.5\overline{Q} - \Delta_1$, and the farm price paid by the food-service sector is higher in response to the decreased sales and, due to arbitrage, equal to the farm price paid by grocery retailers: $\tilde{p}_2^R = \tilde{p}_2^F$.

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[2] Although many food retailers contract with suppliers, most contracts are not long term, and they often don't specify a fixed price but peg the contract price to some measure of the "market price" (Calvin et al., 2001). Thus, arbitrage between alternative market outlets remains possible in the presence of contracts and is simply the result of buyers and sellers seeking the best prices.

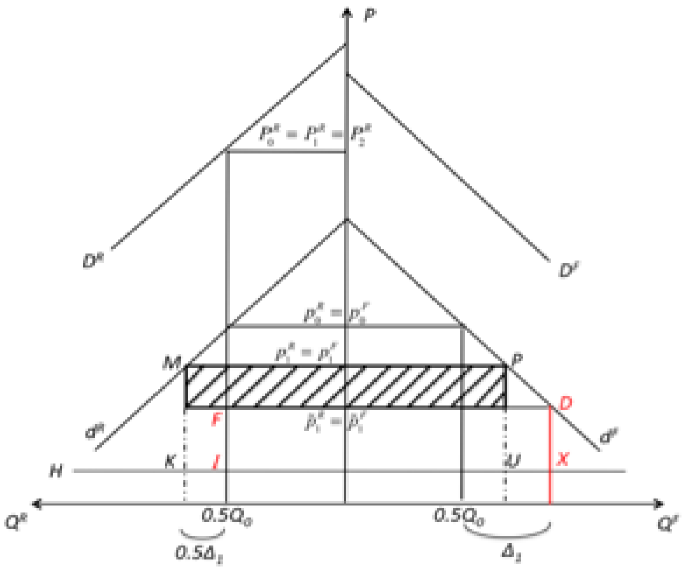

Figure 2a. Implication of Fixed Retail Pricing on Farm Price and Income. Time 1: Positive Supply Shock

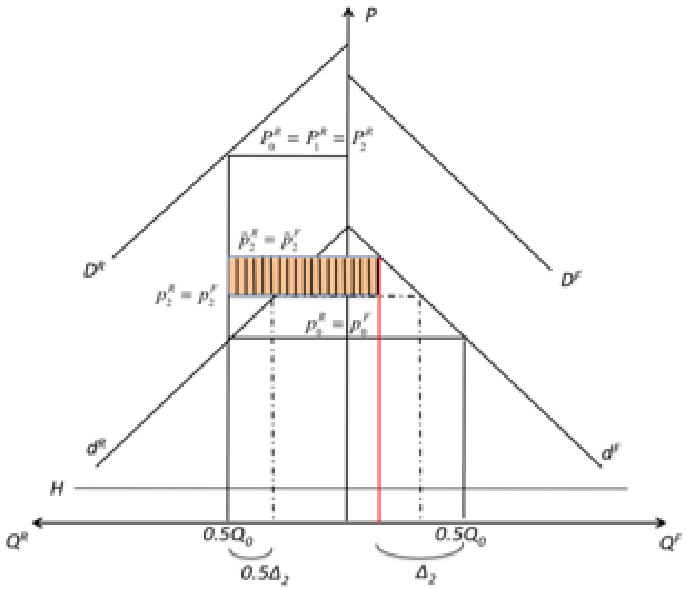

Figure 2b. Implication of Fixed Retail Pricing on Farm Price and Income. Time 2: Negative Supply Shock

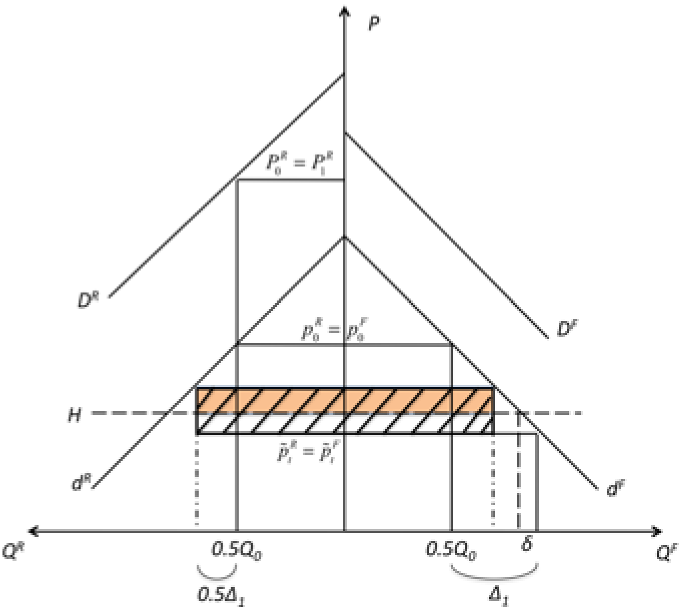

Figure 3. Harvest-Cost Constrains Farm Income Loss under Positive Supply Shock

As a result, with the negative supply shock, total farm income when grocery retailers adopt a fixed-pricing strategy is greater than total farm income when both sectors adopt markup price. The farm income gain is represented by the area shaded with vertical lines in figure 2b.

Comparison of figures 2a and 2b illustrates that under fixed retail pricing the income loss from a positive supply shock outweighs the gain from a negative supply shock of equal magnitude. In addition, fixed retail prices increase farm price volatility compared to markup pricing, which may further reduce producer welfare under risk aversion.

Impact When the Harvest-Cost Constraint Binds

Harvest costs account for a large percentage of the total production cost for many agricultural products, especially those that are highly perishable. For example, Sexton and Zhang (1996) found that the harvest-cost constraint determined price about one third of the time for California iceberg lettuce. Figure 3 illustrates the impact of the harvest-cost constraint for a large positive supply shock. Total potential farm supply at time 1 is $Q_1 = Q_0 + \Delta_1$. If both the grocery-retail and food-service sectors adopt markup pricing, the total farm supply is the potential supply and farm price is $p_1^F = p_1^R > H$.

But if grocery retailers use fixed pricing, the additional production, Δ_1, must be sold exclusively through food service. In the absence of the harvest-cost constraint, farm price would drop to $\tilde{p}_1^F = \tilde{p}_1^R < H$. However, crops will not be harvested for a price less than the harvest cost, so a portion, δ, of the potential crop is not harvested, total farm supply is $Q_1 = Q_0 + \Delta_1 - \delta$, and farm price is H. The total farm income loss as a result of retailers using fixed pricing is $(p_1^F - H)(Q_0 + \Delta_1)$, indicated by the shaded area in figure 3. Absent the harvest-cost constraint, the welfare loss from fixed pricing would be $(p_1^F - \tilde{p}_1^F)(Q_0 + \Delta_1)$, indicated by the crosshatched area in the figure. The harvest-cost constraint reduces the loss by the amount $(H - \tilde{p}_1^F)(Q_0 + \Delta_1)$.

The offsetting increase in farm income under fixed grocery-retail pricing for a negative supply shock is unaffected by the harvest-cost constraint. In the absence of a binding harvest-cost constraint, fixed retail pricing reduces farmer income compared to markup pricing under very general conditions. The welfare comparison between the two pricing strategies under random supply shocks is ambiguous in settings in which the harvest-cost constraint may bind. The specific results are dependent on conditions in each market, making the issue ripe for simulation analysis under model parameterizations intended to approximate actual market conditions.

Analytical Model

Let total farm demand for a representative produce commodity under perfect competition in procurement be written as $Q = a - bp$, where p denotes prices at the farm level. Derived demand for the farm commodity under perfect competition in procurement is $Q^R = \rho(a - bp^R)$ for grocery retail and $Q^F = (1 - \rho)(a - bp^F)$ for food service, where ρ, $0 < \rho < 1$, represents the share of the total demand going to the grocery-retail market.[3] We use the linear form only to facilitate parameterization of the model to simulate representative impacts. The qualitative results of the model hold under very general conditions.

Under perfect competition in procurement of the farm commodity, we can recover the consumer demands for each market segment by adding a constant per unit marketing and handling cost to the farm-level demands. Grocery-retail demand is therefore $Q^R = \rho(a + c^R - bP^R)$ and food service demand is $Q^F = (1 - \rho)(a + c^F - bP^F)$, where c^R and c^F are the per unit costs associated with downstream buyers' marketing and handling costs for retailing and food service and P denotes prices at the consumer level. The inverse demands are $P^R = \frac{a}{b} + \frac{c^R}{b} - \frac{1}{b\rho}Q^R$ for grocery retail and $P^F = \frac{a}{b} + \frac{c^F}{b} - \frac{1}{b(1-\rho)}Q^F$ for food service. The terms c^R/b and c^F/b represent the markups in each downstream sector under perfect competition.

Without loss of generality, we normalize the mean harvest to be $\overline{Q} = 1$, so that $Q_t = \overline{Q} + \Delta_t = 1 + \Delta_t$, where Δ_t can now be interpreted as a percentage supply shock. Farm prices at the mean harvest are also normalized to be $p_0^R = p_0^F = 1$. The absolute value of the price elasticity of total farm demand evaluated at the mean harvest level is: $\varepsilon = -(dQ/dp)(p/Q) = b(1/1) = b$. Using $\varepsilon = b$ and the normalizations, we can write the farm demand intercept as $a = 1 + \varepsilon$. Given these relationships, the derived demand for the competitive food-service sector is $Q_t^F = (1 - \rho)(1 + \varepsilon - \varepsilon p_t^F)$.

The equilibrium farm price is found by equating total farm supply and total derived farm demand, $1 + \Delta_t = a - bp_t \Rightarrow p_t = p_t^F = p_t^R = \frac{1+\varepsilon-(1+\Delta_t)}{\varepsilon} = 1 - \frac{\Delta_t}{\varepsilon}$. Gross farm income, R_A, under markup pricing is

$$R_{A,t} = p_t^R Q_t^R + p_t^F Q_t^F - HQ_t = (p_t^F - H)Q_t = (1 - \frac{\Delta_t}{\varepsilon} - H)(1 + \Delta_t). \tag{1}$$

If instead the grocery-retail sector maintains a retail price that is fixed for all t based on the mean harvest, $P_t^R = P_0^R$, where $P_0^R = \frac{a}{b} + \frac{c^R}{b} - \frac{1}{b\rho}\rho$, then the derived farm demand by retailers is perfectly inelastic at the quantity $Q_t^R = Q_0^R = \rho$. Farm price is determined by equating supply of the product to the food-service sector with the food-service derived demand:

$$1 + \Delta_t - \rho = (1 - \rho)(1 + \varepsilon - \varepsilon p_t^F) \Rightarrow \tilde{p}_t^F = \frac{\varepsilon - \rho \times \varepsilon - \Delta_t}{(1 - \rho)\varepsilon}. \tag{2}$$

Due to the arbitrage condition, $\tilde{p}_t^R = \tilde{p}_t^F$, farm income under fixed retail pricing is

$$R_{B,t} = (\tilde{p}_t^F - H)(1 + \Delta_t) = \frac{(1 + \Delta_t)(\varepsilon - \varepsilon\rho - \Delta_t - H\varepsilon + H\varepsilon\rho)}{(1 - \rho)\varepsilon}. \tag{3}$$

The difference in farm income between the fixed retail pricing and markup pricing regimes is $R_{B,t} - R_{A,t} = -\frac{1}{\varepsilon}\frac{\rho}{\varepsilon(1-\rho)}(\Delta_t + \Delta_t^2)$, where $R_{B,t} - R_{A,t} < 0$ for a positive supply shock and

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[3] Note that ρ represents the share of total market demand going to grocery retail. The quantity share going to grocery retail may differ from the demand share due to differences between grocery retail in per unit costs and, hence, consumer price.

$R_{B,t} - R_{A,t} > 0$ for a negative supply shock. The absolute difference in farm income between the fixed-pricing case and the markup-pricing case is decreasing in the elasticity, ε, of farm demand, increasing in the volatility of farm supply, Δ^2, and increasing in the share of the market demand going to grocery retail, ρ.

Moreover, for a positive and negative shock of equal magnitude, $|R_{B,t} - R_{A,t}|$ is larger for the positive supply shock (i.e., the farm income loss exceeds the farm income gain). Thus, under symmetric, mean-zero supply shocks, $E[R_{B,t}] < E[R_{A,t}]$, fixed retail pricing reduces expected farm income compared to markup pricing. Li (2010) proves that this result holds as $\Delta \to 0$ for a normal distribution of Δ and for all downward-sloping farm demand functions that are differentiable at the mean harvest. Intuitively, the greater farm price volatility caused by retailers' failure to use markup pricing reduces farm income more for positive supply shocks and low prices than it increases farm income for negative supply shocks and higher prices. This is because the quantity harvested and sold at the higher price is less than the quantity harvested and sold at the lower price.[4]

Simulation Analysis

The conceptual model demonstrates that fixed grocery-retailer pricing reduces expected farm income in the absence of a binding harvest-cost constraint. However, many questions remain unanswered. First, how important are these impacts on income likely to be in prototype produce markets? Second, given that grocery retailers use a variety of pricing strategies in addition to markup and fixed pricing, how do these other strategies, individually and in combination, affect farm income? Third, how much do departures from markup pricing exacerbate the volatility of farm income? Finally, given the previous question, how are conclusions affected under producer risk aversion?

These questions are best addressed in a simulation framework parameterized to represent prototype produce markets. In all cases we simulate fifty-two harvests and pricing periods by making fifty-two draws of Δ_t from a normal distribution, $\Delta_t \sim N(0, \sigma^2)$, and compute farm price, farm income, and standard deviation of farm income under the simulated retail pricing strategy. In all cases the results for the alternative grocery-retail pricing behaviors are compared to results generated for the baseline of markup pricing (subscript A), given the same distribution of draws of Δ_t. In addition to fixed pricing (subscript B), periodic sales (subscript C), and high-low pricing (subscript D), we also consider a "composite" setting in which each of the four pricing strategies is used by some retailers.

Choices of Parameter Values

Under producer risk neutrality and no harvest-cost constraint, the model is characterized by four parameters: ρ, σ^2, ε, and c^R. From the USDA marketing bill, about 60% of the total consumer expenditure for domestically produced farm goods are made in retail stores and 40% are made elsewhere (i.e., in "food service"). Thus the share of mean farm supply going to the grocery-retail market was set at $\rho = 0.6$.

The variances of actual monthly U.S. total shipments of fresh lettuce (iceberg, romaine, and all other) and tomatoes (including both domestic production and imports) for 2008–2009 were computed from USDA data and used to derive a base value of the variance of supply shocks, σ^2. Since mean farm supply is normalized to be 1, σ^2 was computed for each of these four commodities by dividing the actual farm supply at each time t by its mean for 2008–09 and then calculating the variance of the normalized supply. We used the simple average of the variances for these four commodities as the base value for $\sigma^2 : \hat{\sigma}^2 = 0.0117^2$.

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[4] Extension of the model to accommodate the case of a binding harvest-cost constraint is very straightforward and is omitted for parsimony of presentation.

Estimates of the price elasticity of demand for produce commodities, including oranges and apples, range generally from 0.1 to 0.9 in absolute value. For example, Huang (1993) reported estimates of -0.14 for lettuce, -0.56 for tomatoes, -0.20 for apples and -0.996 for oranges. Henneberry et al.'s (1999) estimates are -0.23 for tomatoes and -0.59 for apples. We set $\varepsilon = 0.4$ in the base simulation model, roughly midpoint of the range for produce commodities found by these previous studies and also consistent with Sexton, Zhang, and Chalfant's 2003 estimate of $\varepsilon = 0.433$ for fresh iceberg lettuce.[5]

The cost parameter, c^R, can be derived from the farm share of the retail value, p^R/P^R. This ratio was set at 26%, the simple average of the farm share for iceberg lettuce (26%), apples (26%), grapes (19%), and fresh, field-grown tomatoes (32%) for 2007–2011. Since the farm price at the mean harvest level is normalized to $p^R = 1$, the equilibrium retail margin under perfect competition given the 26% farm share is 2.85, (i.e., $c^R/\varepsilon = P^R - p^R = 2.85$ and $c^R = (2.85)0.4 = 1.14$.)

Alternative Pricing Scenarios

Under *markup pricing*, our baseline case, grocery retailers set retail price equal to acquisition costs plus a constant per unit cost of retailing: $P_t^R = p_t^R + c^R/\varepsilon$.

Under *fixed pricing*, the grocery-retail price in all periods equals the normalized equilibrium farm price at the mean harvest plus a fixed retail margin. In all simulations of alternative pricing strategies, we want to focus on the impacts on the level and variability of farm income due to the pricing strategy per se and not on the strategy's impact on sales. In the case of fixed pricing this is accomplished by using the same markup, c^R/ε, as with markup pricing, which yields $P_t^R = 1 + c^R/\varepsilon, \forall t$.

To simulate a *periodic sale pricing* strategy we need to specify a non-sale retail price, $\overline{P}_C^R$, number of periods between sales, μ_1, and the price discount in the sale period, μ_2, so that $\overline{P}_C^R - \mu_2$ is the sale price. To isolate the impact of the pricing strategy itself and not the impact of the strategy on total sales, we impose the constraint that total sales under the periodic sale strategy equal total sales under markup pricing.

The total quantity sold in the grocery-retail market under markup pricing is $Q_A^R = \sum_{t=1}^{52} \rho(1+\Delta_t)$. Under the periodic sale strategy total quantity sold is

$$Q_C^R = \rho\left[(1+\varepsilon+c^R-\varepsilon\overline{P}_C^R)\mu_1 + (1+\varepsilon+c^R-\varepsilon)(\overline{P}_C^R-\mu_2)\right][\frac{52}{(\mu_1+1)}], \tag{4}$$

where the second bracketed term is the number of sale "cycles" completed in the fifty-two periods. Setting $Q_C^R = Q_A^R$, we then solve the equality for the non-sale price that equates total demand under the two strategies:

$$\overline{P}_C^R = \frac{1}{\varepsilon}[1+\varepsilon+c^R - \frac{1}{52}\sum_{t=1}^{52}(1+\Delta_t) + \frac{1}{(\mu_1+1)}\varepsilon\mu_2]. \tag{5}$$

We simulate a stylized *high-low pricing* strategy as follows: P_D^R denotes a modal retail price and $k_1 > 0$ and $k_2 > 0$ represent a price increase and price discount. Based on insights by Chen et al. (2008), who observed that small price increases occur in grocery stores more frequently than small price decreases, we simulate asymmetric high-low pricing, in which $k_1 \neq k_2$. Chen et al. (2008) theorize that retailers' use this strategy because of "rational consumer inattention." Consumers may rationally not process small price changes, meaning prices can be increased in small increments without engendering much consumer reaction. Price decreases, on the other hand, need to be large to capture consumers' attention. Thus, beginning with modal price P_D^R, price increases to $P_D^R + k_1$ in period 1, increases to $P_D^R + 2k_1$ in period 2 and then to $P_D^R + 3k_1$ in period 3 before declining by $k_2 = 3k_1$ in period 4 and restoring the mode price.

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[5] Most demand elasticity estimates for produce commodities are estimated at the consumer level. Derived (farm) demand in most cases is less elastic than final demand (George and King, 1971)

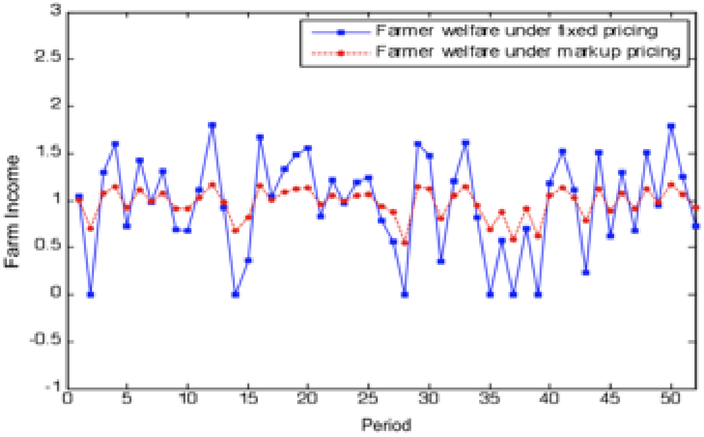

Figure 4. Farm Income under Fixed Pricing and Markup Pricing

We again impose the constraint that total grocery-retail sales under high-low pricing and markup pricing be equal: $Q_D^R = Q_A^R$. This equation is solved for the mode price, P_D^R, which insures that the sales equality holds for given choices of k_1 and k_2:

$$P_D^R = \frac{1}{\varepsilon}[1 + \varepsilon + c^R - \frac{1}{52}\sum_{t=1}^{52}(1 + \Delta_t)] - \frac{1}{4}(k_1 - k_2). \tag{6}$$

Pricing Strategies in Combination

In most cases, multiple strategies for pricing a given product will be operating simultaneously. The frequency with which grocery retailers use a given strategy varies by commodity, and generalizations are hard to make. However, Li (2010) suggests that fixed pricing and periodic sales may be used more frequently for produce commodities than markup pricing or high-low pricing. Thus, we simulate two scenarios regarding pricing strategies used in combination—(i) each is used for 25% of total demand and (ii) fixed pricing and periodic sales are each used for 1/3 of demand and markup pricing and high-low pricing are each used for 1/6 of demand.

Timing is also important in considering pricing strategies in combination. A limited empirical literature offers some support for both synchronization and staggering of sales among chains (Lach and Tsiddon, 1996; Rátfai, 2006; Volpe, 2010). Given the mixed evidence, we simulate the combination of pricing strategies using both synchronization and staggering of sales between high-low pricing retailers and periodic-sale retailers.

Simulation Results

A fifty-two-period market was simulated 10,000 times for each of the pricing scenarios considered. Results for all scenarios are summarized in table 1. Although no positive harvest-cost constraint was included in the base model, the farm price in all cases was constrained to be nonnegative (a *de facto* harvest-cost constraint). Scenarios 3–6 involve periodic sales and high-low pricing; when the retail price variations under these strategies were "large," the nonnegativity constraint on farm price bound in several periods, thus limiting farm income loss relative to the baseline of markup pricing to the range of 1.02% to 1.35%. The mean reduction in farm income over the 10,000 simulations relative to markup pricing was consistent across most of the other retail-pricing scenarios, ranging from 1.66% for fixed pricing to 2.07% for the combination scenario involving staggered sales.

Table 1. Simulation Results

Pricing Strategy	Parameterization	% Change in Farm Income Relative to Baseline	Standard Deviation of Farm Income
1. Competitive markup (baseline)		0.00	0.19
2. Fixed pricing		−1.66	0.55
3. Periodic sale	$\mu_1 = 3, \mu_2 = 10\%$	−1.33	0.56
4. Periodic sale	$\mu_1 = 4, \mu_2 = 10\%$	−1.35	0.56
5. Periodic sale	$\mu_1 = 4, \mu_2 = 20\%$	−1.23	0.56
6. High-low pricing	$k_1 = 0.1, k_2 = 0.3$	−1.02	0.57
7. Combination: equal weights, synchronized sales	$\mu_1 = 4, \mu_2 = 20\%$ $k_1 = 0.1, k_2 = 0.3$	−2.00	0.48
8. Combination: unequal weights, synchronized sales	$\mu_1 = 4, \mu_2 = 20\%$ $k_1 = 0.1, k_2 = 0.3$	−1.77	0.51
9. Combination: equal weights, staggered sales	$\mu_1 = 4, \mu_2 = 20\%$ $k_1 = 0.1, k_2 = 0.3$	−2.07	0.48

These income reductions are a result of using pricing strategies that do not allow the grocery-retail price to respond to conditions in the market for the farm commodity. Retailer market power is required to implement these strategies because arbitrage among consumers would compel markup pricing otherwise. However, these farm income losses are not due to higher retail prices and reductions in retail and, hence, farm sales that we normally associate with the exercise of retail market power. In all cases the simulations were conducted so that the total volume of sales transacted at retail under the alternative scenarios was the same as that under markup pricing. Any farm income losses due to grocery retailers using market power to raise price and reduce sales would be in addition to the income losses reported here.

The mean standard deviation of farm income was 0.19 under markup pricing. Under the alternative pricing scenarios, the mean standard deviation of farm income ranged from 0.48 to 0.57, or roughly three times as high as when grocery retailers use markup pricing. Figure 4 illustrates the greater variability of farm income for one set of simulations under fixed pricing compared to markup pricing.[6]

To understand the consistency of results across pricing scenarios (except when the nonnegativity constraint on farm price binds), consider that in scenarios 2 through 6 in table 1, sellers who pursue a pricing strategy that does not allow consumer price to respond to conditions in the farm market comprise 60% of the consumer market, meaning that market clearing must be accomplished through the 40% of sellers in the consumer market (i.e., food service) who allow purchases and price to vary with market conditions. The results show that, averaged over 10,000 simulations, the precise alternative strategies being pursued by grocery retailers don't matter that much in determining farm income, given that any of them involve setting retail prices independent of shocks incurred at the farm level.

Incorporating the Harvest-Cost Constraint

Marginal harvest costs, which can be substantial for produce commodities, place a lower bound on farm prices. For example, cost and returns studies conducted by University of California Cooperative Extension indicate per unit harvest costs as a share of farm value are 60% for fresh lettuce and tomatoes, 50% for table grapes, and 40% for apples or oranges. Figure 5 shows the effect of incorporating $H = 0.6$ into the base simulation run for the combined-pricing case 7 from table 1. The constraint binds about 1/3 of the time, fully consistent with Sexton and Zhang (1996).

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[6] Figure 4 also illustrates the zero constraint on the farm price binding for six periods in this simulation.

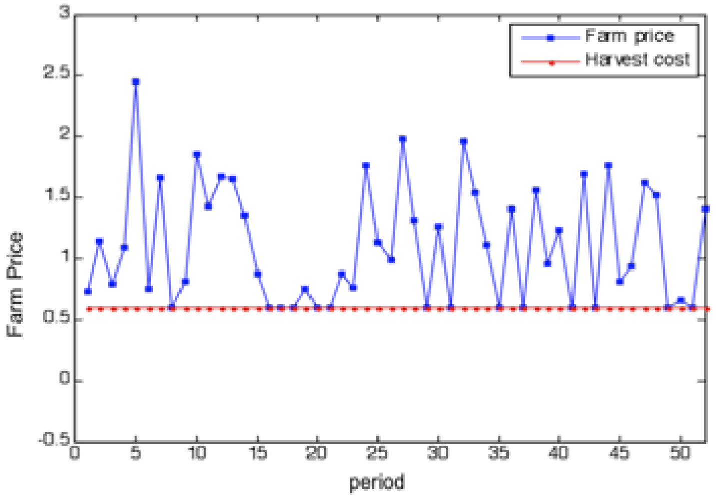

Figure 5. Harvest Cost Serves as a Lower Bound for Farm Price

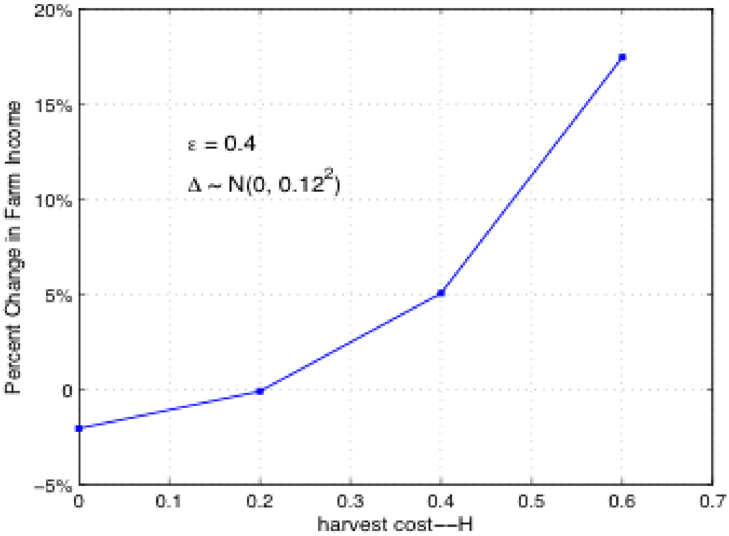

Figure 6. Change in Farm Income for the Combined-Pricing Case Relative to Markup Pricing for Alternative Harvest Costs

Figure 6 shows the impact of the harvest-cost constraint on the difference in gross farm income between the combined-pricing case 7 and markup pricing (case 1). Zero harvest cost represents the 2.0% income loss contained in table 1. $H = 0.2$ results in mean income being roughly the same between the two scenarios, and mean income is higher under diversified grocery-retail pricing for higher values of H, with the increase becoming substantial—in excess of 15% for values of H in the range of 60%. The increased price variability due to grocery-retailer diversified pricing strategies can cause higher farm income when harvest costs limit downside variation in price.

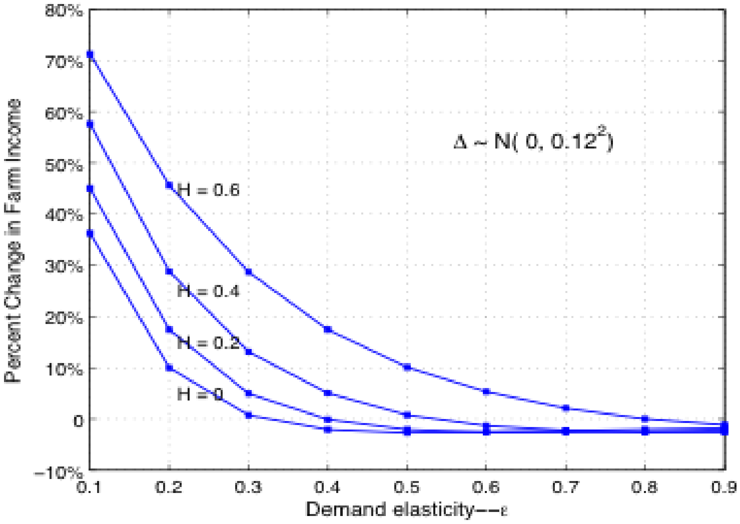

Figure 7. Impacts of the Farm Demand Elasticity on the Change in Farm Income due to Diversified Grocery-Retailer Pricing for Alternative Values of *H*

Sensitivity Analysis

We focus the sensitivity analysis on alternative choices of the price elasticity of farm demand, and consideration of farmer risk aversion. Li (2010) reports sensitivity analysis for other parameters of the simulation model. Figure 7 shows the change in mean farm income for the combined pricing regime relative to markup pricing for values of $\varepsilon \in [0.1,\ 0.9]$ and for alternative values of H. Figure 7 makes the important point that the role of the harvest-cost constraint in mitigating downside movements of the farm price diminishes as demand for the farm product becomes more elastic. This result is simply a consequence of the farm price and farm income being less volatile and, hence, the harvest-cost constraint binding less often for a given value of H as demand becomes more elastic. For most values of H, farm income losses due to diversified retail pricing converge to the 1.5–2.0% range indicated in the base simulation (table 1) as ε increases.

Farmers are typically risk averse (Antle, 1987; Chavas and Holt, 1990; Pope and Just, 1991; Saha, Shumway, and Talpaz, 1994). Saha, Shumway, and Talpaz (1994) surveyed empirical estimates of risk-aversion coefficients and reported absolute risk-aversion coefficients from 0 to 15, with most estimates falling between 0 and 6. Meyer (1987) reported relative risk-aversion coefficients in the 1.6–4.4 range for U.S. corn, wheat, and soybean farmers.[7] The alternative grocery-retail pricing strategies cause farm income to be about three times more volatile than under markup pricing, and this additional income volatility is detrimental to risk-averse farmers.

We use a mean-variance utility framework to study the impact of risk aversion on farmer welfare given alternative grocery-retailer pricing behaviors. The mean-variance framework is more convenient than expected utility and yields the same ordinal ranking under broad conditions (Sinn, 1983; Meyer, 1987; Hlawitschka, 1994; Eichner, 2004). Specifically, we assume that farmers have utility functions of the form $V(\mu,\sigma) = \overline{R} - \lambda\sigma_R^2/2$, where $\overline{R}$ is mean income, σ_R^2 is the variance of income, and λ is the parameter measuring the degree of risk aversion. This utility specification is consistent with both constant absolute risk aversion and increasing relative risk aversion (Meyer,

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[7] The wide range of estimates need not reflect disagreements in the literature, but, rather, the fact that farmers' risk aversion likely differs greatly across countries and economic environments.

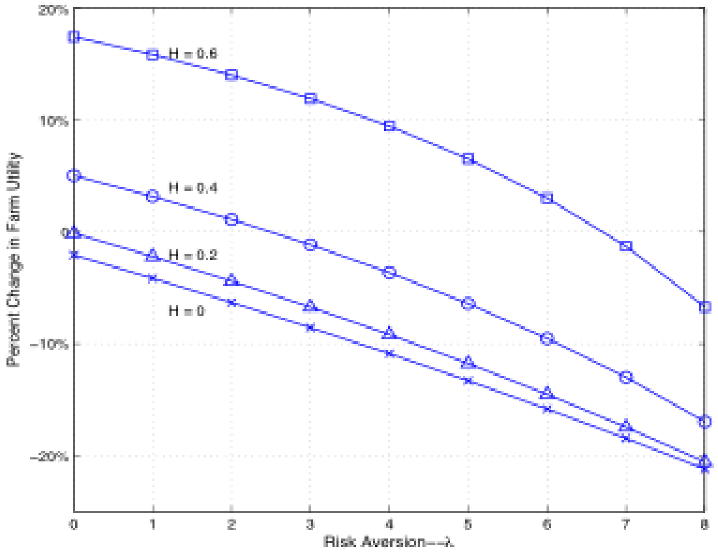

Figure 8. Risk Aversion, Harvest Cost, and Farmer Utility

1987). We conduct simulations for $\lambda \in [0,\ 8.5]$ to examine the impacts of differences in risk attitudes.

Figure 8 shows the effect of different levels of farmer risk aversion and harvest costs on the welfare impacts of the combined grocery-retail pricing regime (case 7, table 1) relative to markup pricing holding other parameters at their base values.[8] Not surprisingly, the greater a farmer's risk aversion, the worse off they are under the combination of retail pricing strategies compared to markup pricing, because farm income is more variable when retailers depart from markup pricing. Modestly risk-averse farmers still benefit from price variability when H is high, but in all other scenarios (high risk aversion or low H) farmers are worse off under the combination of retail pricing strategies. As the figure shows, the welfare loss under the assumed utility specification can be quite high, 15% or more, given the cardinal utility interpretation, in settings when harvest costs are low and farmers are highly risk averse.

A final consideration regarding the impacts of grocery-retailer pricing strategies given risk averse farmers is skewness in the farm price and income distributions and the issue of downside income risk. Antle (1987, 2010) and others have stressed the importance of downside income risk in agriculture,[9] and it is a prospectively important consideration in the present study, given the limitations on downside price volatility under retailers' pricing strategies when harvest-cost constraints limit downward price movements. To get a sense of this impact, we modify the mean-variance utility function to incorporate the third moment of the income distribution:

$$V(\mu,\sigma_R) = \overline{R} - \lambda\sigma_R^2/2 + \lambda\psi_R/6, \tag{7}$$

where $\psi_R = \frac{E[(X-\mu)^3]}{\sigma^3}$.

Figure 9 repeats the simulation analysis summarized in figure 8, substituting this utility function in place of the mean-variance utility function. The main impact is observed for the case of $H = 0.6$ when the harvest-cost constraint binds frequently. By severely limiting downside price and income

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[8] This comparison requires a cardinal interpretation of utility, which is common in studies of risk aversion (Von Neumann and Morgenstern, 1947; Hey, 1979).

[9] See Antle (2010) for a listing of studies that have incorporated downside risk aversion in agriculture and finance.

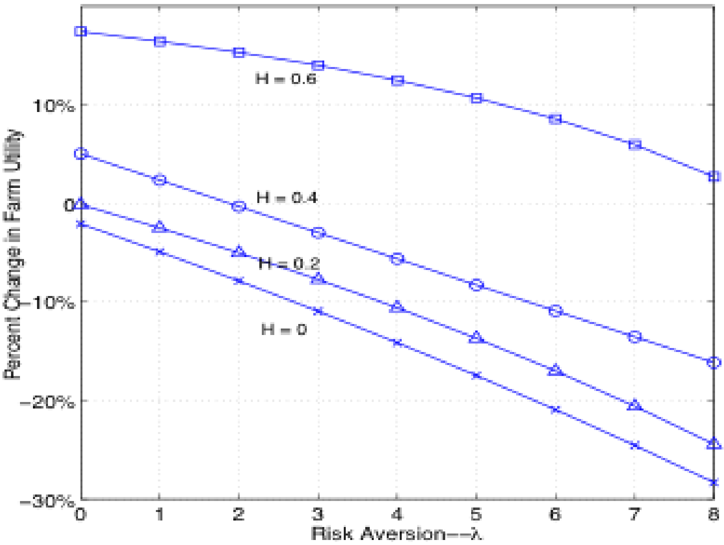

Figure 9. Risk Aversion, Harvest Cost, and Farmer Utility with Downside Risk Aversion

volatility, even the most risk-averse farmers benefit from the diversified retailer pricing strategies. Impacts relative to the mean-variance case are minor for the other levels of harvest cost in the simulation.[10]

Conclusion

The traditional markup-pricing model of grocery-retailer behavior does not apply to most modern retailers for most food products. Rather, retailers pursue a wide variety of pricing strategies designed to differentiate themselves in an imperfectly competitive market environment and maximize overall store profits. Nonetheless, vertical-market models of agricultural product pricing have not for the most part been adapted to reflect these realities of contemporary food pricing.

This paper addressed some key issues regarding the relationship between farm prices and incomes and grocery-retailer pricing strategies, with a specific focus on pricing for perishable produce commodities. However, the key results likely apply to a much broader range of farm products.[11] We focused on three alternatives to markup pricing—constant (fixed) pricing, periodic sales, and high-low pricing—and showed that farm prices are made more volatile and farm incomes are generally reduced when retailers pursue these pricing strategies. Retail prices under these strategies are unrelated to movements in the farm price for the basic farm commodity, meaning that in those sectors where the consumer price is free to fluctuate, it must fluctuate more to clear the market than if all sectors employed markup pricing. This enhanced farm price volatility is detrimental to farm income under very general circumstances. Farmer welfare losses are generally magnified under farmer risk aversion due to this enhanced price and income volatility.

A key exception to this conclusion occurs when per unit harvest costs impose a lower bound on the farm price. In these cases the enhanced price volatility due to retailers' pursuing diversified

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[10] The magnitudes of utility changes should not be compared across figures 8 and 9 because the utility functions are different.

[11] A caveat to this claim is the importance of processing and wholesaling sectors of the market for many nonproduce commodities, such as grains and livestock. These firms may possess market power in their own right and pursue pricing strategies that are not based purely on costs. The presence of such firms surely attenuates the clear linkage between farm and consumer markets present in this study.

pricing strategies causes the harvest-cost constraint to bind more frequently, limiting the downside price volatility with no comparable limit on price increases. In these cases, retailers' diversified pricing strategies may lead to higher farm incomes. Furthermore, the attenuation of downside price risk in these cases also benefits farmers under cases of aversion to downside price and income risk.

The pricing behavior studied here is made possible by imperfect competition in food retailing; otherwise consumer arbitrage would insure that markup pricing prevailed in equilibrium. These impacts on the level and volatility of farm prices are a hidden cost (or possible benefit) to farmers from grocery-retailer market power. Impacts on farm incomes from retailers exercising oligopoly power through restricting sales to consumers and/or oligopsony power by restricting procurement from farmers would be in addition to the impacts described here. Although this study was based on data for the United States, the "supermarket revolution" has spread worldwide, including to developing countries (Reardon et al., 2003; Hu et al., 2004). Likely the results of this analysis also apply, at least to a degree, in many other countries.

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