Consolidation in the Fresh Florida Grapefruit Packing Industry

Kathy J. Davis, Suzanne D. Thornsbury, and Ronald W. Ward

Department of Food and Resource Economics
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida

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Consolidation in fresh produce markets has raised concerns over the way buyers and sellers do business and the possibility for gaining market power (Kaufman; Dimitri; Patterson and Richards). A visible illustration is the changing structure in domestic retail food markets where in 1999 the 20 largest U.S. food retailers controlled 52 percent of total grocery store sales compared with 37 percent in 1987. A 2001 USDA study of trade practices in fresh fruit and vegetable markets was motivated, in part, by shipper concerns that retail concentration would lead to an increase in buyer demands for fees and services. Interviews with 57 produce shippers representing seven commodities indicated that while the incidence and magnitude of fees and services did increase between 1994 and 1999, other factors such as changes in consumer preferences, food safety issues, technological advances, and shipper consolidation were also driving adjustments in trade practices (Calvin et. al).

This study evaluates structural adjustments between the 1970/71 and 1999/00 seasons in fresh produce packing for Florida grapefruit, one commodity included in the previous USDA project.[1] An earlier paper examined the structure of the Florida fresh grapefruit market between the 1960/61 and 1970/71 production seasons and concluded that trends in the number and absolute size of grapefruit shippers and the tendency for firm entry and exit in the fresh grapefruit market indicated movement toward a more competitive model (Ward and Smoleny). A current focus is whether there have been changes in the patterns of adjustment among firms within this downstream sector in response to aggregate forces facing the industry since the 1970s. As early as 1956, Galbraith noted that an increase (or perceived increase) in market power by a seller might act as an inducement for structural change among

[1] Grapefruit production is reported by growing season (August to July) rather than calendar year.

those firms either selling to or buying from that sector. Such adjustments have been observed as more firms formalize food supply chain relationships (Cook). This article begins with an assessment of some significant forces of change as they relate to fresh grapefruit markets in the United States. A first-order, homogeneous, stationary Markov model is introduced and used to evaluate whether there has been a shift in the patterns of adjustment among Florida fresh grapefruit packers in response to aggregate trends, including consolidation of produce retailers and wholesalers.

Forces of Change

In 1997, the USDA Census of Agriculture reported total sales of agricultural products of approximately $197 billion, of which $13 billion resulted from sales of fruits, nuts and berries (NASS). Total U.S. grapefruit production in that year was valued at about $137 million or 1.1 percent of U.S. fruit sales with Florida production valued at about $75 million, approximately 55 percent of the total U.S. value (FASS). Grapefruit are utilized in both the fresh and processed (primarily juice) market, but there have historically been significantly higher prices per box and grower returns in the fresh market.

Fresh Florida grapefruit packers have encountered numerous forces of change in their markets including competition from alternative production regions, changing consumer preferences, access to new markets, and adjustments in retail trading practices. Since public data to document such changes is limited, it is augmented with primary data collected through a series of written surveys and personal interviews that compared marketing practices between 1994 and 1999 among fresh grapefruit shippers from all the producing regions of Florida.[2]

World production of grapefruit is highly concentrated geographically with the United States producing almost one-half of the total supply of grapefruit and pommelos (FAO).[3] Only four states

[2] This section draws heavily on information found in Thornsbury and Spreen, and Calvin et. al.
[3] Grapefruit (*citrus paradisi*) are often classified as a subspecies or botanical variety of pommelos (*citrus grandis*) which generally are larger, have a firmer flesh texture and lower juice content than grapefruit. Pommelo production on a commercial basis has been restricted to a limited geographic area within East Asia (Saunt). If the FAO data for pommelos could be separated from that of grapefruit, the U.S. would be expected to have a larger share of world grapefruit production.

(Florida, California, Texas, and Arizona) produce grapefruit commercially with, on average, 76, 11, 10, and 3 percent of the national bearing acreage, respectively, during the 1990s. U.S. production is concentrated in relatively small semi-tropical areas and supplies have been particularly susceptible to weather-related risks associated with frost or freeze conditions (Elmer et. al).[4] The eight shippers interviewed accounted for over 54 percent of the volume of fresh Florida grapefruit sales (40 percent of U.S. volume) during the 1998/99 season.[5]

Per capita domestic shipments of fresh grapefruit have declined in the face of a strong economy, increased population, and expansion of overall fruit consumption. As a result of economic conditions, a measurable percentage of fruit has been abandoned in four of six years since 1995/96. Per capita consumption fell from 8.35 pounds in 1978, to 6.6 pounds in 1989, to only 5.8 pounds in 1999 (ERS). Consumers often find grapefruit difficult to eat as it needs to be sliced, and can be too juicy and/or too tart or bitter. Consumption is also sometimes associated with aging. Overall population increases have not been enough to offset per capita declines in fresh consumption from the previous decade. Even among consumers increasingly aware of the health benefits from fresh fruit and vegetable consumption, the largest increase in per capita fresh consumption has occurred in non-citrus fruits. Availability and quality of numerous fresh fruit alternatives have had a negative impact on grapefruit consumption.

Partially as a consequence of the stagnant domestic demand, the Florida grapefruit industry has been outward looking and increasingly active in the global economy. During the 1990s U.S. exports accounted for approximately 42 percent of world fresh grapefruit trade, 69 percent of world trade in grapefruit concentrate, and 28 percent of world trade in single strength grapefruit juice. International markets are even more critical in Florida where more than one-half of all fresh grapefruit was exported during the 1999/00 season. Major markets for Florida fresh grapefruit include Japan, the European Union, and Canada. Interview results confirm trends in fresh grapefruit sales with 38 percent of reported sales

[4] The 1980s is often referred to as the "freeze decade" with moderate damage in Florida during 1981 and 1982 and severe freezes in 1983, 1985, and 1989. The 1983 and 1989 freezes were so damaging nationally that marketings in Texas were completely eliminated during the 1984/85 and 1990/91 seasons.

[5] Since interviews results are based on a limited number of observations they should be interpreted with caution. Nevertheless, they do serve to further illustrate the trends identified by public data.

value from exports compared with 37 percent from domestic grocery retailers. Prior to 1986 fresh grapefruit imports were very close to zero. Although import volumes as a percentage of domestic consumption remained less than five percent during the 1990s, they are increasing minimally as U.S. firms attempt to become year-round, full-line citrus suppliers to their larger buyers.

Fresh grapefruit has not been immune to other emerging market trends in produce. Based on interview results, the perception among grapefruit shippers was that the total number of buyers for their product had decreased since 1993/94. On average, there were 95 regular buyers per firm interviewed in the 1993/94 season compared to 78 in the 1998/99 season. Over the five-year period, not only the number but the types of buyers for fresh grapefruit had changed, even for product targeted to domestic users. On average, sales to grocery retailers and retail cooperatives combined (such as Flemming or Associated Grocers) decreased 4.27 percent between 1993/94 and 1998/99. Percentage of sales through mass merchandisers increased more than eight percent during the same period. Sales through produce wholesalers, distributors, and brokers fell on average approximately three percent. Food service remained a very small market for fresh grapefruit with only two percent of sales reported to enter these outlets in 1998/99. Total sales volume to individual buyers showed little change in concentration over the five-year period for the firms interviewed. On average, the top four buyers accounted for 26 percent of total sales in 1993/94 and 29 percent in 1998/99. Conversely, the share of sales to top ten buyers decreased from 54 to 51 percent over the same time period.

All the grapefruit shippers interviewed reported an increase in requests from buyers for fees and services, with an average of 5.4 fee and 6.4 service requests reported during 1999 per firm. In general, shippers indicated that their response depended on the specific request, cost of compliance, and anticipated impact on firm resources. When shippers were asked to compare types of requests, fees were perceived as much more harmful to their business, in general, than services. Of the specific fees requested, only eight percent were seen as beneficial by individual firms compared to 34 percent of services.[6]

Even if supply and demand signals are efficiently passed through the market channels for fresh grapefruit, there are still significant lags in the industry's ability to respond (Kalaitzandonakes and Shonkwiler). Unlike many produce industries, there can be significant costs associated with exit from perennial crop production, limiting growers' season-to-season ability to adjust production levels. Permanent exit entails, at minimum, the cost of tree removal. There are also sunk costs at the packing/processing levels that are hypothesized to contribute to continued excess capacity within the industry. Once supplies are reduced, for example from a freeze event, recovery is longer than that for most horticultural crops due to the approximate six-year period between tree-set and sufficient maturity to allow harvest of the first economically viable crop.

At least partially as a result of changes in buyer types and marketing channels, individual shippers indicated they had undertaken a variety of strategies to better position their firms (e.g.: extending both the length of time and types of citrus supplied, a specific focus on identifying and promoting product quality, export market development), some of which involved changes in firm size through either formal or informal alliances. Factors influencing the distribution of firm sizes within any industry are many and complex and this study makes no attempt to quantify the influence of individual forces of change on market structure in the fresh Florida grapefruit packing sector. The focus is not on the individual forces at work, but rather the long-term trends in firm movement under the aggregate influence of those forces. Further, it is assumed that an individual packer's competitive behavior depends largely on the firm's accumulated resources and experience, both of which are reflected in the firm's absolute and relative size at any point in time.

[6] The nine types of fees considered were volume incentives, promotional allowances, other rebates, free product discounts, e-commerce fees, buy-back or failure fees, capital improvement fees, pay-to-stay fees, and slotting fees. The eight types of services considered were third-party food safety certifications, use of returnable containers, special packs, electronic data interchange, private labels, automatic inventory replenishment, special displays, and category management.

Measuring Patterns of Adjustment in Fresh Grapefruit Packing

As in many seminal market structure studies the Florida fresh grapefruit packing sector is modeled as a first-order, homogeneous, stationary Markov process (Adelman; Padberg; Hallberg). A Markov chain is a suitable probability model for time series in which the observation at a given time can be described as a category or state into which an individual element falls. In the most general case, a Markov chain is a discrete-state, discrete-time model, associated with a finite or countable state space S, for a sequence of binary random variables

$$Y^f_j(t) \quad = 1 \text{ if element f is in state j at time t } (j \in S)$$
$$= 0 \text{ otherwise}$$

such that the probability distribution of $y^f_j(t)$ is specified as a function of $y^f_k(r)$ for times r = (t-1),(t-2),..., and states $k \in S$. The model is characterized by an initial distribution, $\{\pi^f_j\}_{j \in S}$, representing the probability that element f is in state j at time t=0, and conditional probabilities

$$\{p(y^f_j(t) = 1) \mid y^f_k(r), k \in S \text{ and } r = (t-1),(t-2),... \}.$$

The simplest Markov model is a first-order homogeneous chain. A Markov chain of this type incorporates the simplifying assumptions that the probability that an element is in state j at time t depends only on its state at time t-1 (i.e., the process is of order 1) and that the probability distribution is identical for every element in the model (i.e., the process is homogeneous). The model can be represented by transition probabilities, $\{p_{ij}(t)\}_{ij \in S}$, consisting of non-negative numbers such that $\Sigma_j\, p_{ij}(t) = 1$ for each $i \in S$, and t = 1, 2, ... An element of the model is initially in state i with probability π_i; $p_{ij}(t)$ represents the conditional probability that an element is in state j at time t, given that element was in state i at time t-1. The Markov chain is stationary if the transition probabilities are independent of time, i.e., if $p_{ij}(t) = p_{ij}$ for all t. For a finite state space, $|S| = m$, a first-order, homogeneous, stationary Markov chain is generally described by the m*m transition matrix $\mathbf{P} = [p_{ij}]$.

The central question in this study is whether there has been a change in the patterns of adjusting market structure for fresh grapefruit packers. The market structure itself is assumed to be in flux and evolving under the influence of aggregate market forces – the question is whether there is evidence of a change or disturbance in that evolutionary process. Independent Markov models are developed for two periods within the data set and for the pooled observations. For each of the independent Markov models, the initial distribution, $p_i(0) = \pi_i$, is estimated by $n_i(0)/N$ where $n_i(0)$ is the number of firms in state i at time 0, and $N = \Sigma_i n_i(0)$, the total number of firms in the model. For each i and j and for $t = 1, \ldots T$ (where the value T depends on the length of the period modeled), the transition probability $p_{ij}(t)$ is estimated by $n_{ij}(t)/n_i(t-1)$ where $n_{ij}(t)$ is the number of elements in state i at time t-1 *and* in state j at time t, and $n_i(t-1)$ is the number of elements in state i at time t-1. If the process is stationary, the time-invariant transition probability p_{ij} can be estimated by N_{ij}/N_i, where $N_{ij} = \Sigma_t n_{ij}(t)$ and $N_i = \Sigma_t n_i(t-1)$.[7]

The null hypothesis is that the Markov processes at work in the two periods are identical (Anderson and Goodman). Because the process is assumed to be first order and only two samples are compared, the test statistic is:

$$\chi^2 = \Sigma_i \chi^2_i \quad \text{where} \quad \chi^2_i = \Sigma_j C_{ij}(p_{ij1} - p_{ij2})^2/p_{ijo}.$$

N_{i1} and N_{i2} are N_i as defined previously, restricted to period 1 and period 2, respectively. C_{ij} is defined such that $C_{ij}^{-1} = (1/N_{i1}) + (1/N_{i2})$; p_{ij1}, p_{ij2}, and p_{ijo} are the estimated i to j transition probabilities for period 1, period 2, and the pooled data, respectively. The test statistic χ^2 is distributed as chi-squared with m(m-1) degrees of freedom, where m is the number of states in S. The null hypothesis is rejected if χ^2 exceeds the threshold for $\alpha = 0.05$. The subsequent conclusion then is that there has been a change in the underlying Markov process describing structural adjustment between two periods; i.e., that the process of firm adjustment has itself changed.

A critical assumption is stationarity. If the Markov process itself is inherently non-stationary in either period, it will be impossible to detect changes in the processes associated with aggregate market forces including retail and wholesale consolidation. Thus each independent matrix is tested for time-invariance prior to testing for differences between matrices (Amemiya; Ward and Smoleny). The null

[7] The estimate for $p_{ij}(t) = n_{ij}(t)/n_i(t-1)$ is not well-defined if $n_i(t-1)=0$. In this case, $p_{ij}(t)$, which is intended to represent the probability of a transition from state i to state j at time t, is defined to be 0. Similarly, the time-invariant estimate for $p_{ij} = N_{ij}/N_i$.

hypothesis is that $p_{ij}(t) = p_{ij}$ for all i, j, t, that is, that the Markov process does not change with time within the specified period. The likelihood ratio test statistic $-2 \log \Pi_t \Pi_i \Pi_j [(p_{ij} / p_{ij}(t))]^{nij(t)}$ has a chi-square distribution with m(m-1)(T-1) degrees of freedom, where T is again defined as appropriate for the period and m is the number of states in the model. If the statistic is not significant there is insufficient evidence to reject the assumption of time-invariance.

The equilibrium distribution is of special interest in the study of market structure, as it indicates the asymptotic distribution expected if the market forces represented by the transition matrix continue to act. Let **P** be the transition matrix, $p_i(t)$ represent the probability that an element is in state i at time t, and (p_t) be a row vector of size m with entries $p_i(t)$. Then $(p_t) = (p_{t-1})\mathbf{P}$ and, recursively, $(p_t) = (p_0)\mathbf{P}^t$, where (p_0) is a row vector with entries $p_i(0) = \pi_i$, the initial probability distribution. If $\lim_{t\to\infty} \mathbf{P}^t$ exists, then $(p_\infty) = (p_0)\mathbf{P}^\infty$ is referred to as the equilibrium distribution. The Markov process may converge to the equilibrium distribution in some finite number of steps, k. Then $(p_t) = (p_{t+1})$ for $t \geq k$.

A stationary distribution is any distribution $\{\alpha_i\}_{i\in S}$ such that $(\alpha)\mathbf{P} = (\alpha)$. A Markov process which has a stationary distribution and which is aperiodic and irreducible converges to that distribution, i.e., the stationary distribution is the equilibrium distribution (Rosenthal). The period of a state $i\in S$, the state space of the Markov process, is the g.c.d. of the times at which it is possible to transition from state i back to i. By definition, a Markov chain is aperiodic if the period of every state is 1. A Markov chain is irreducible if for any states i and $j\in S$, there exists some number r with $p_{ij}^r>0$, that is, if it is possible for an element to move from any state i to any state j in some finite number of steps.

Empirical Issues

Packers of fresh Florida citrus are licensed by the Florida Department of Agriculture and Consumer Services [FDACS] and report the total boxes handled under each license in each citrus season. A box of Florida grapefruit is defined to be 4/5 bushel, and the number of boxes reported under a license varies from one to over one million per year. Data were collected for the 1970/71 through 1999/00 production seasons and used to measure changing patterns of adjustment in fresh Florida grapefruit packing.[8]

Defining a Firm

Unfortunately, raw packer data does not correspond directly to firm-level activity, as a firm may hold multiple licenses under one or more names and in one or more locations in Florida. Further, firm mergers and name-changes are not always readily apparent in the records. To approximate firm-level data, the shipment records were examined and collapsed according to the following system: shipment records were combined for multiple licenses issued under *identical* names or when transitional bridging names indicated continuity (for example, Sefco → Sefco/Blue Goose → Blue Goose), regardless of the location of the packinghouses; records for firms with suggestively *similar but not identical* names were only combined if the firms were licensed at the same physical location (town or city in Florida) and never reported shipments in the same year – this was true for only four licensed packinghouses during the period of interest. This conservative system is highly unlikely to have resulted in the erroneous combination of shipment records for distinct firms, but may have failed to combine records for a single firm holding multiple licenses under multiple names.

Although firms may participate in cooperative marketing agreements and essentially function as a single entity in the market structure, these agreements may be informal, are often confidential, and are not revealed in the packing reports.[9] Data on such arrangements are only available through word-of-mouth of intermittent public announcements, for example in *The Packer* or *Citrus News* reports. Since consistent reliable data cannot be compiled, further adjustments to FDACS data are not undertaken. Failure to combine records if appropriate would result in an overestimate of the number of distinct firms as well as an underestimate of the true market share of some firms.

[8] Continuous data is not available prior to 1967.
[9] A cooperative packing for grower-members will hold a license with FDACS and be included as a packing firm.

Defining the Pool

In order to calculate probabilities, it is necessary to define the pool of potential businesses that could enter fresh grapefruit packing in Florida. The number of active shippers (after collapse of the shipment records as described above) ranged from 167 in 1970/71 to 94 in 1999/00 (Figure 1). Due to a special “canker rule” that was in effect during the 1984/85, 1985/86 and 1986/87 seasons, roadside fruit stands were included with commercial packinghouses in the reports for those years; these fruit stands are normally excluded from the report. To avoid inconsistency, all data from those three seasons were excluded from this study and shippers who were active only during those three seasons were eliminated from the pool.

The number of participants in the model is defined to be the total number of shippers active at any level in any season during the years of interest. A total of 410 shippers were active during the period 1970/71 through 1999/00, excluding the seasons 1984/85 through 1986/87. This is considered the size of the pool available for market entry.

Defining Periods of Interest

For the purposes of this study, the Markov process initiated with the 1970/71 production season. Transition probabilities are estimated for four separate sub-periods plus the pooled data. In the first model, periods are defined as 1970/71 to 1983/84 and 1987/88 to 1999/00. These two periods are separated by the data that were dropped from the time series and divide the remaining prominent freeze years of the 1980s into both periods. As illustrated in Figure 1, 1987/88 was the first season with fewer than 100 packers licensed by FDACS. Periods in the second model are defined for 1970/71 to 1994/95 and 1995/96 to 1999/00. The shorter second period separates the years of rapidly accelerating retail consolidation (Kaufman et al.).

Defining the States

The states of the model are defined as firm share of U.S. fresh grapefruit utilization (Table 1). Defining the states as a percentage of national utilization implicitly incorporates information about aggregate forces of change in grapefruit markets including competition from other U.S. production regions. Export volume is included in the total volume packed per firm. Import volumes are not included; however, imports of fresh grapefruit were negligible in the period of interest.

Total U.S. fresh grapefruit utilization and U.S. utilization of Florida fresh grapefruit are reported as thousands of 1 3/5 bushel boxes by the Florida Agricultural Statistics Service [FASS], a division of the National Agricultural Statistics Service of the USDA. Although the average weight of a box of grapefruit varies by state, fresh grapefruit is sold by volume so the box count is a uniform measure. U.S. utilization of Florida fresh grapefruit reported by FASS ranged from a low of 13,345,000 boxes in 1989/90, the year of a severe freeze, to a high of 23,923,000 boxes in the following season, while total U.S. utilization ranged from a low of 22,614,000 boxes in 1989/90 to a high of 34,627,000 boxes in 1988/89. Florida's total share of the U.S. fresh grapefruit utilization ranged from a low of 57 percent in 1982/83 to a high of 78 percent in 1990/91.[10]

Since the model states are defined as market share, firm size is a relative measure. A firm can move between states without altering its absolute level of production. Similarly, sizable adjustments in production may not result in a state change if proportional changes occur among other firms and utilization. A firm's state at any time is a function not only of it's own output, but also the output of all other fresh grapefruit packing and shipping firms in the U.S. Thus the transition probabilities represent general trends in the market, rather than the competitive behavior of individual firms.

The initial distribution of firms among seven defined states is shown in Table 1. Note that state 0 in the initial distribution consists of the pool of participants who were not active in the market in 1970/71 but who will enter the market during the period of interest, 1970/71 through 1999/00 (excluding 1984/85

[10] Total shipments of Florida fresh grapefruit reported by FDACS are lower than utilization of Florida grapefruit reported by FASS due in part to FDACS reporting exemptions for roadside stands.

through 1986/87). Over one-half (59.3%) of the firms in the pool were in the inactive category during 1970/71. Only two firms packed shares greater than two percent of U.S. utilization during the first year. Together these two firms accounted for 9.01 percent of the shipments from Florida and 4.96 percent of national utilization. Of the active firms, the majority were small with less than one-half percent of U.S. utilization.

Results

Transition matrices were estimated for each sub-period of interest in Model 1, 1970/71-1983/84 and 1987/88-1999/00, as well as for the pooled data (Table 2). The (i,j) element of the transition matrix is the probability that a firm would move from state i at time t-1 to state j at time t. Examination of these matrices is instructive. In almost all cases the most likely transition for a firm is to remain in the same state, reflecting inertia in the market. The tendency to remain in a given state is less pronounced for firms in state 5 (2.0 to 2.5 percent market share), where firms are about equally likely to move to state 4, the next lower state. The very low probabilities associated with transitions from the zero state to any other state (the first row of the transition matrix) indicate minimal chance of a new firm entering the market in any given year. Similarly, the first column shows the propensity for firm exit. Firms in the very lowest active state, less than 0.5 percent market share, are the most likely to exit the market completely (to transition to the zero state).

Similar transition matrices were estimated for the 1970/71-1994/95 and 1995/96-1999/00 periods defined in Model 2 (Table 3). Again the diagonal elements clearly indicate that firms are most likely to remain in the same size category, especially in the second period. Results indicate that in both sub-periods the firms with less than 0.5 percent market share are the most likely to exit the industry and new firms almost always enter in this small size category.

The period of a state $i \in S$, the state space of the Markov process, is the g.c.d. of the times at which it is possible to transition from state i back to i. The diagonal elements of each of the transition matrices are all nonzero so it is immediately evident that for every state i it is possible to remain in that state, i.e., to transition from state i back to i in a single step, thus the period of every state is 1 and the processes are aperiodic. Again by examination of the transition matrices, each of the Markov processes is also clearly irreducible. The subdiagonal and superdiagonal elements of each of the transition matrices are all nonzero so it is possible to move from any state i to a neighboring state in one step. Consequently, it is possible to move from any state i to any state j in no more than six steps.

Results from the statistical tests of the transition matrices are shown in Table 4. For each matrix, there is insufficient evidence to reject the null hypothesis of time-invariance, so the assumption of a stationary chain is supported. The test for whether two samples are from the same Markov chain is applied to compare the sub-periods in each model. In Model 1, the test statistic is calculated at 36.6092 with 42 degrees of freedom and a significance of 1.000. There is insufficient evidence to reject the null hypothesis that the two samples are in fact from the same process. Thus, there is no evidence of a change in the underlying Markov process associated with consolidation of retail and wholesale outlets or other forces of change about 1987. Likewise, the same test is applied to observations from the sub-periods as defined in Model 2. The test statistic is calculated at 48.4038 with 42 degrees of freedom and a significance of 0.2303. Again, there is insufficient evidence to reject the null hypothesis that the two samples are in fact from the same process. Thus, there is no evidence of a change in the process of transition about 1996.

It is clear that the transition matrix is stationary, thus pointing to a level of stability in terms of the patterns of entry and exit as well as movement among states. Stationarity in the transition matrix does not, however, imply that the industry is in equilibrium, but since the Markov process of change is stationary, the matrix of probabilities can be used to predict a distribution of firms in subsequent time periods. Depending on the actual transition probabilities, there may be substantial differences between current and projected distributions indicating that adjustments are still occurring among states, although the process of these adjustments continues in the same manner.

It is possible to derive a stationary distribution α for each of the Markov models. Let α be a row vector such that $(\alpha)\mathbf{P} = (\alpha)$. This produces a system of m equations in m unknowns, but the equations are not independent because **P** is row stochastic. However, since α is a probability distribution, $\Sigma_i \alpha_i = 1$. This constraint may be substituted for any of the original m equations to produce a linearly independent set that may be solved for $\{\alpha_i\}_{i \in S}$ (Adelman; Padberg). Since the transition matrices are aperiodic and irreducible, the stationary distribution is the equilibrium distribution (Table 5). Over some period of time, each process will asymptotically converge to the distribution shown.

The most robust model to derive the equilibrium distribution is that developed for the pooled data, omitting only the 1984/85 through 1986/87 seasons. Figure 2 first compares the actual number of inactive firms in 1970/71 and 1999/00 with the projected number of inactive firms in the equilibrium distribution derived from this pooled data set. Between 1970/71 and 1999/00 the actual number of inactive firms in the data set increased by 30 percent from 243 to 316. There is only a five percent difference in the number of inactive firms in 1999/00 and the equilibrium projection. Comparing the same two years, the actual number of active firms declined by nearly 44 percent; 94 firms in 1999/00 compared to 167 in 1970/71. Among these active firms approximately 76 percent had less than 0.5 percent market share and 14 percent had a market share between 0.5 and 1.0 percent in 1970/71, as shown in the lower left portion of Figure 2. The total number of active packinghouses has declined between 1970/71 and 1999/00 with almost all the decline being from the smaller firms. At equilibrium, the small firms with less than a 1.0 percent share account for only 78 percent of the active firms, while there is a corresponding increase in the probability that firms will have a market share greater than 1.0 percent, if they are active. The lower right portion of Figure 2 shows these relative changes across the states of active firms. Clearly, within the pool of active firms, there is evidence of an increasing proportion of large firms in the industry between 1970/71 and 1999/00. The estimated equilibrium indicates that by 1999/00 the industry was very close to the total number of large firms projected.

It is also possible to track the movement of individual firms in specified categories across the period of interest to evaluate how they have moved between size categories. The first state is defined to be small firms (active but less than 0.5 % market share), the next three states are defined to be midsize firms (0.5% to 2.0 % market share), and the last state is defined to be large firms (greater than 2 % market share). There were 127 small and 38 midsize firms active in the 1970/71 season. The vertical bars in Figure 3 represent the movement of these particular firms over the 30-year period with height differential between a bar in any given period and 1970/71 representing those firms who exited the industry. So for example, of the 127 small firms in 1970/71, 93 remained small, four had grown to midsize, and 30 exited the industry by 1971/72. Consistent with the results presented in the transition matrices, attrition was greatest among the small firms. By 1999/00, 111 of the original 127 small firms had exited the industry. Of the 38 midsize firms that were active in 1970/71, four had become small, three had become large, and none had exited the industry by 1971/72. By 1999/00 five of the original midsize firms were in the small category, four were in the large category, and 17 had exited the industry.

Conclusions

This study evaluates structural adjustments between the 1970/71 and 1999/00 seasons in produce packing for fresh Florida grapefruit. A first-order, homogeneous, stationary Markov model is introduced and used to evaluate shifts in the patterns of adjustment among Florida fresh grapefruit packers in response to sweeping trends in produce markets, including consolidation of produce retailers and wholesalers. Based on aggregate forces of change facing the Florida grapefruit industry, two separate models were estimated. The first compares changes in the aggregate adjustments of firms between the 1970/71-1983/84 and 1987/88-1999/00 periods. The second compares similar changes between the 1970/71-1994/95 and 1995/95-1999/00 periods. Despite numerous forces impacting fresh produce markets, in each model, there was insufficient evidence to identify significant differences in the patterns of adjustment in the packing sector during the later time periods.

Stationarity in the transition matrix does not, however, imply that an industry is in equilibrium or that individual firms do not enter and exit. Depending on the actual transition probabilities, there may be substantial differences between current and projected distributions indicating adjustments are still occurring among states, although the process of these adjustments continues in the same manner. An equilibrium distribution was estimated from the pooled data set. Comparisons with actual firm numbers during 1999/00 are indicative of an industry near equilibrium with little expectation of change in the distribution of firm sizes unless there are significant alternations in the underlying patterns of adjustment represented by the Markov process. While individual firms enter and exit the different states, there are no profound structural changes pointing in the direction of major concentration among the active firms even though some shares have increased among the larger firms.

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References

Adelman, I.G. "A Stochastic Analysis of the Size Distribution of Firms." *Journal of American Statistical Association*. 53(December 1958):893-904.

Amemiya, T. *Advanced Econometrics*. Cambridge, Massachusetts: Harvard University Press, 1985.

Anderson, T.W. and L.A. Goodman. "Statistical Inference about Markov Chains." *Annals of Mathematical Statistics*. 28(March 1957):89-110.

Calvin L., R. Cook, M. Denbaly, C. Dimitry, L. Glaser, C. Handy, M. Jekanowski, P. Kaufman, B. Krissoff, G. Thompson, and S. Thornsbury. *U.S. Fresh Fruit and Vegetable Marketing: Emerging Trade Practices, Trends, and Issues*. Washington D.C.: US Department of Agriculture, Economic Research Service Agricultural Economic Report Number 795, January 2001.

Cook, R. "An Overview of Key Food Industry Drivers: Implications for the Fresh Produce Industry." *Journal of Food Distribution Research*. XXX(March 1999):1-4.

Dimitri, C. "Integration, Coordination, and Concentration in the Fresh Fruit and Vegetable Industry." *Fruit and Tree Nuts*. Washington D.C.: US Department of Agriculture, Economic Research Service FTS-285, March 1999.

Elmer, N., A. Thurow, J. Johnson, and C. P. Rosson, III. "An Ex Ante Assessment of Investments in Texas Grapefruit under Uncertainty." *Journal of Agricultural and Applied Economics*. 33(December 2001):391-402.

Economic Research Service (ERS). "Fruit and Tree Nuts Situation and Outlook Yearbook." Washington D.C.: US Department of Agriculture, Economic Research Service FTS-287, October 1999 and FTS-290, October 2000.

Foreign Agricultural Organization (FAO). "FAO Statistics Database." http://apps.fao.org/, 2000.

Florida Agricultural Statistics Service (FASS). "Citrus Summary." Orlando, FL, 1970/71 season through 1999/00 season.

Florida Department of Agriculture and Consumer Services (FDACS), Division of Fruit and Vegetables. "Season Annual Report." Tallahassee, FL, 1970/71 season through 1999/00 season.

Galbraith, J.K., *American Capitalism: The Concept of Countervailing Power*. Cambridge, Massachusetts: The Riverside Press, 1956.

Hallberg, M.C. "Projecting the Size Distribution of Agricultural Firms – An Application of a Markov Process with Non-Stationary Transition Probabilities." *American Journal of Agricultural Economics*. 51 (May 1969):289-302.

Kalaitzandonakes, N. G. and J.S. Shonkwiler. "A State-Space Approach to Perennial Crop Supply Analysis." *American Journal of Agricultural Economics*. 74(May 1992):343-352.

Kaufman, P.R. "Food Retailing Consolidation: Implications for Supply Chain Management Practices." *Journal of Food Distribution Research*. XXX(March 1999):5-11.

Kaufman, P.R., C.R. Handy, E.W. McLaughlin, K. Park, and G.M. Green. *Understanding the Dynamics of Produce Markets: Consumption and Consolidation Grow*. Washington D.C.: US Department of Agriculture, Economic Research Service Agricultural Information Bulletin Number 758, August 2000.

National Agricultural Statistics Service (NASS). "1997 Census of Agriculture, State and County Geographic Area Series, Florida." Washington D.C.: US Department of Agriculture, 1997.

Padberg, D.I. "The Use of Markov Processes in Measuring Changes in Market Structure." *Journal of Farm Economics*. 44(February 1962):189-199.

Patterson, P.M. and T.J. Richards. "Produce Marketing and Retail Buying Practices." *Review of Agricultural Economics*. 22(Spring/Summer 2000):160-171.

Rosenthal, J.S. *A First Look at Rigorous Probability Theory*. University of Toronto, Canada :World Scientific Publishing Co. Pte. Ltd., 2000.

Saunt, J. *Citrus Varieties of the World*. Norwich England: Sinclair International Limited, 2000.

Thornsbury, S. and T. Spreen. "The U.S. Grapefruit Market." *Fruit and Tree Nuts*. Washington D.C.: US Department of Agriculture, Economic Research Service FTS-289, September 2000.

Ward, R.W., and C. Smoleny. "The Market Structure of Florida Fresh Grapefruit Packers: An Application of Markov Chain Analyses." Gainesville, FL: Florida Department of Citrus, University of Florida. Economic Research Department Report 73-1, February, 1973.

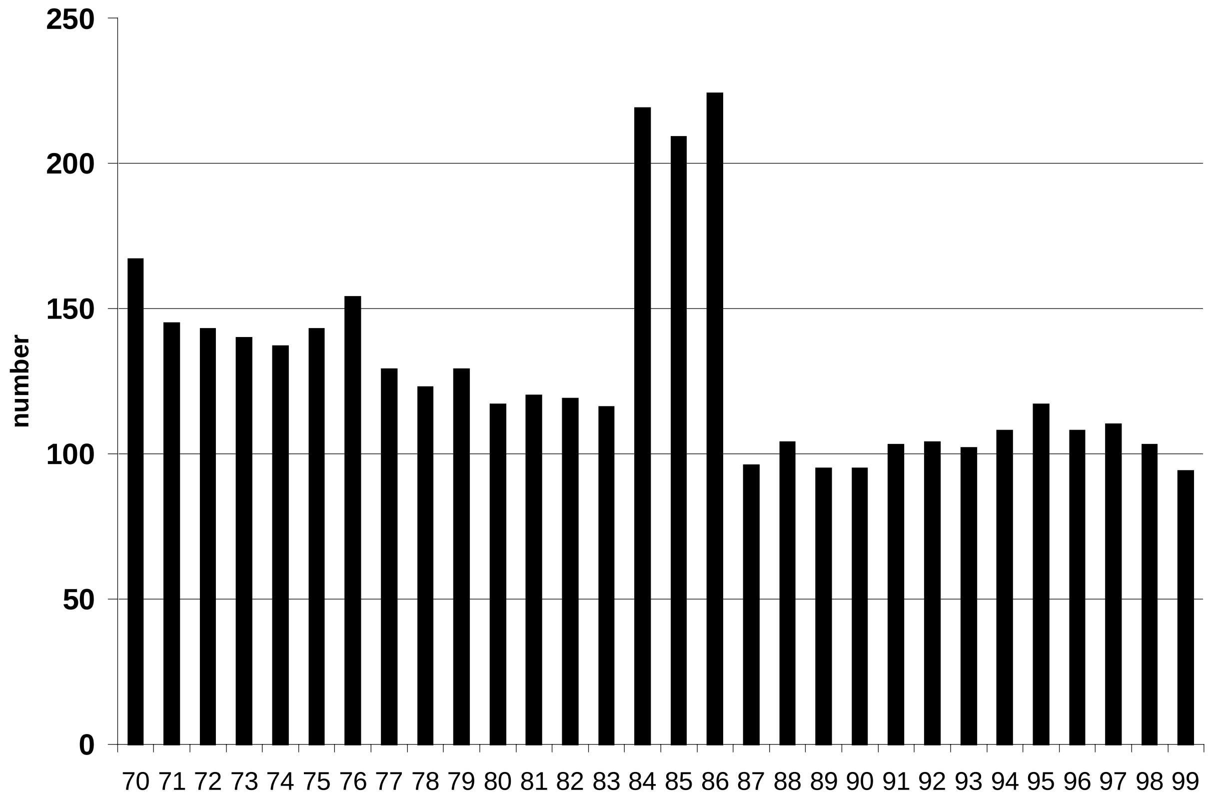

Figure 1. Florida grapefruit packers licensed by the Department of Agriculture and Consumer Services, 1970/71 to 1999/00

Table 1. 7-State Model: Definitions and Initial Distribution, 1970/71 Season

State	Market Share: Firm % of U.S. Utilization	Number of Florida Packer/Shippers	Share of Florida Packers/Shippers	Total Share of U.S. Utilization	Total Share of FL Shipments
	---%---		--------- % --------		
0	0 (inactive)	243	59.3	0.00	0.00
1	0.0 - 0.5	127	31.0	12.04	21.86
2	0.5 - 1.0	23	5.6	15.41	27.99
3	1.0 - 1.5	7	1.7	8.42	15.28
4	1.5 - 2.0	8	2.0	14.24	25.85
5	2.0 - 2.5	1	0.2	2.20	3.99
6	2.5 -	1	0.2	2.76	5.02

Table 2. Matrices of Transition Probabilities for the two periods in Model 1 and pooled data set

Matrix of Transition Probabilities for 1970/71 through 1983/84

State**	0	1	2	3	4	5	6
0	**0.9512**	0.0435	0.0028	0.0011	0.0011	0.0000	0.0003
1	0.1697	**0.7998**	0.0272	0.0024	0.0008	0.0000	0.0000
2	0.0302	0.1810	**0.6293**	0.1293	0.0302	0.0000	0.0000
3	0.0303	0.0000	0.2500	**0.5152**	0.1667	0.0379	0.0000
4	0.0104	0.0104	0.0417	0.2604	**0.4688**	0.1875	0.0208
5	0.0000	0.0000	0.0000	0.0811	**0.3514**	**0.4054**	0.1622
6	0.0500	0.0000	0.0000	0.0000	0.0500	0.1500	**0.7500**

Matrix of Transition Probabilities for 1987/88 through 1999/00

State**	0	1	2	3	4	5	6
0	**0.9548**	0.0405	0.0019	0.0014	0.0008	0.0003	0.0003
1	0.2022	**0.7678**	0.0273	0.0014	0.0000	0.0000	0.0014
2	0.0640	0.1221	**0.6512**	0.1279	0.0174	0.0058	0.0116
3	0.0432	0.0072	0.1871	**0.5971**	0.1295	0.0216	0.0144
4	0.0104	0.0000	0.0625	0.1563	**0.5521**	0.1875	0.0313
5	0.0167	0.0000	0.0333	0.0667	**0.3667**	**0.3500**	0.1667
6	0.0217	0.0000	0.0217	0.0870	0.0217	0.3261	**0.5217**

Matrix of Transition Probabilities for 1970/71 through 1999/00*

State**	0	1	2	3	4	5	6
0	**0.9530**	0.0420	0.0023	0.0012	0.0010	0.0001	0.0003
1	0.1817	**0.7880**	0.0273	0.0020	0.0005	0.0000	0.0005
2	0.0446	0.1559	**0.6386**	0.1287	0.0248	0.0025	0.0050
3	0.0369	0.0037	0.2177	**0.5572**	0.1476	0.0295	0.0074
4	0.0104	0.0052	0.0521	0.2083	**0.5104**	0.1875	0.0260
5	0.0103	0.0000	0.0206	0.0722	**0.3608**	**0.3711**	0.1649
6	0.0303	0.0000	0.0152	0.0606	0.0303	0.2727	**0.5909**

* Data from 1984/85, 1985/86, and 1986/87 seasons omitted.

**	State	Market Share
	0	Inactive
	1	0.0 – 0.5
	2	0.5 – 1.0
	3	1.0 – 1.5
	4	1.5 – 2.0
	5	2.0 – 2.5
	6	> 2.5

Table 3. Matrices of Transition Probabilities for the two periods in Model 2

Matrix of Transition Probabilities for 1970/71 through 1994/95*

State**	0	1	2	3	4	5	6
0	**0.9498**	0.0446	0.0026	0.0014	0.0010	0.0002	0.0003
1	0.1825	**0.7859**	0.0280	0.0024	0.0006	0.0000	0.0006
2	0.0478	0.1612	**0.6269**	0.1284	0.0299	0.0030	0.0030
3	0.0327	0.0000	0.2383	**0.5374**	0.1449	0.0374	0.0093
4	0.0139	0.0069	0.0625	0.2222	**0.4792**	0.1806	0.0347
5	0.0000	0.0000	0.0270	0.0811	**0.3649**	**0.3378**	0.1892
6	0.0370	0.0000	0.0185	0.0741	0.0185	0.2778	**0.5741**

* Data from 1984/85, 1985/86, and 1986/87 seasons omitted

Matrix of Transition Probabilities for 1995/96 through 1999/00

State**	0	1	2	3	4	5	6
0	**0.9725**	0.0258	0.0000	0.0008	0.0008	0.0000	0.0000
1	0.1838	**0.7978**	0.0184	0.0000	0.0000	0.0000	0.0000
2	0.0377	0.1132	**0.7547**	0.0755	0.0000	0.0000	0.0189
3	0.0652	0.0217	0.1522	**0.6087**	0.1522	0.0000	0.0000
4	0.0000	0.0000	0.0256	0.1282	**0.6154**	0.2308	0.0000
5	0.0526	0.0000	0.0000	0.0526	**0.3158**	**0.5263**	0.0526
6	0.0000	0.0000	0.0000	0.0000	0.1111	0.3333	**0.5556**

**	State	Market Share
	0	Inactive
	1	0.0 – 0.5
	2	0.5 – 1.0
	3	1.0 – 1.5
	4	1.5 – 2.0
	5	2.0 – 2.5
	6	> 2.5

Table 4. Tests of the Transition Matrices

	Model 1		Model 2		Pooled Data
	1970/71 to 1983/84	**1987/88 to 1999/00**	**1970/71 to 1994/95**	**1995/96 to 1999/00**	**1970/71 to 1999/00**
Test of Time Invariance					
Degrees of Freedom	504	462	798	126	1008
Test Statistic	368.3143	382.3384	643.2226	69.7245	793.5025
Significance	1.0000	0.9972	1.0000	1.0000	1.0000
Test of Differences in the Markov Process					
Degrees of Freedom	42		42		n/a
Test Statistic	36.6092		48.4038		n/a
Significance	1.0000		0.2303		n/a

Table 5. Equilibrium distributions of Florida fresh grapefruit packers

State	Market Share	Model 1		Model 2		Pooled Data
	Firm % of U.S. Utilization	1970/71 to 1983/84	1987/88 to 1999/00	1970/71 to 1994/95*	1995/96 to 1999/00	1970/71 to 1999/00*
0	0 (inactive)	0.7109 (291)	0.7555 (310)	0.7189 (295)	0.8387 (344)	0.7313 (300)
1	0.0 - 0.5	0.1897 (78)	0.1503 (62)	0.1800 (74)	0.1168 (48)	0.1724 (71)
2	0.5 - 1.0	0.0379 (16)	0.0337 (14)	0.0392 (16)	0.0158 (6)	0.0362 (15)
3	1.0 - 1.5	0.0244 (10)	0.0243 (10)	0.0258 (11)	0.0094 (4)	0.0247 (10)
4	1.5 - 2.0	0.0188 (8)	0.0186 (8)	0.0184 (8)	0.0113 (5)	0.0187 (8)
5	2.0 - 2.5	0.0097 (4)	0.0104 (4)	0.0101 (4)	0.0065 (3)	0.0100 (4)
6	2.5 -	0.0086 (4)	0.0073 (3)	0.0076 (3)	0.0014 (1)	0.0068 (3)

* Data from 1984-1985, 1985-1986, and 1986-1987 seasons omitted

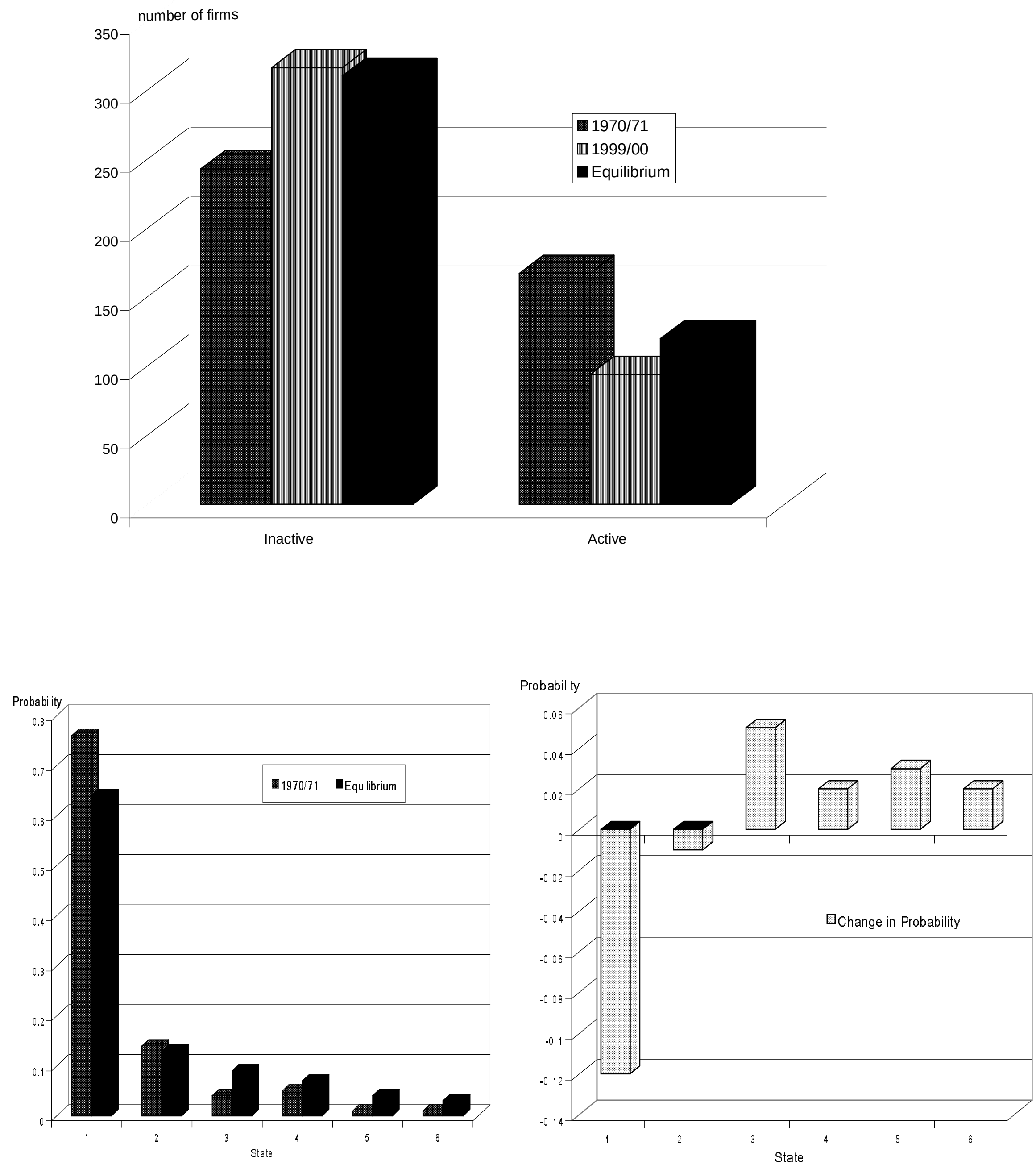

Figure 2. Distribution of active and inactive firms in 1970/71, 1999/00 and projected equilibrium distribution; probability of being in various states given that firms were active; and the change in probability of being in various states between 1970/71 and the projected equilibrium given firms were active

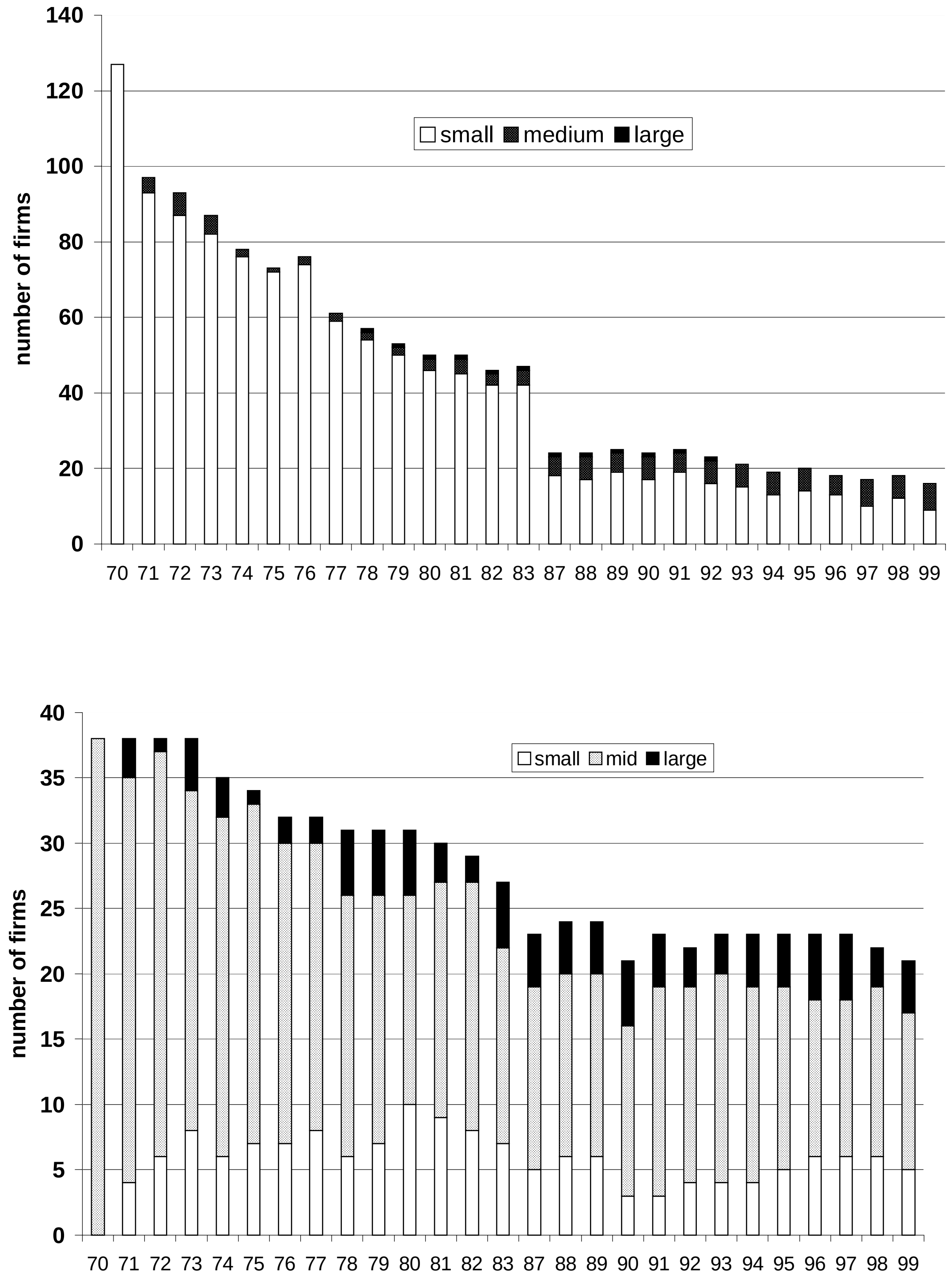

Figure 3. Transition of active small and midsize fresh Florida grapefruit packers from 1970/71 to 1999/00

Small (0.0 to 0.5 % share); Midsize (1.0 to 2.0% share); Large (greater than 2.0% share)