Do Changes in Orchard Supply Occur at the Intensive or Extensive Margin of the Landowner?

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Abstract

In this paper we seek to improve understanding of the dynamics of perennial crop supply by comparing acreage change on land owned by incumbents compared to landowners entering or exiting perennial crop production. Spatially explicit land cover and land ownership data is integrated at the field level which provides a novel data set for analyzing supply changes at the level of the landowner. We contend that, in contrast to annual crops where operators drive crop choice, the landowner is the primary decision maker when determining whether to plant orchards or vineyards due to associated establishment costs and the long investment time horizon. This motivates viewing the landowner as the firm within the context of the existing literature on firm entry and exit, which has primarily focused on manufacturing. Results from our analysis generally agree with findings from the existing literature on manufacturing. This provides a foundation for future research that incorporates related theory that posits causal relationships and connects entry and exit at the firm level with market level dynamics.

1 Introduction

Understanding aggregate supply response for a given market over time often depends critically on having a handle on the dynamics of firm entry and exit relative to the productive capacity of incumbent firms. This has been the subject of a great deal of theoretical and applied research in economics over the last thirty years. In this paper we employ this literature in a novel way by considering the dynamics of perennial crop supply. The literature on perennial crop supply started in ernest in the 1950s but has continued to be relatively understudied compared to other sectors in agriculture. This is likely due, in part, to a lack of data on factors central to perennial crops that are non-existent or less important for annual crops. Our integration of data on perennial crop acreage with parcel landowners data seeks to address one of these existing holes in the data.

Our approach is to model the landowner as the firm and use a field level land cover data set combined in a spatially explicit manner with parcel landowner data to identify perennial crop acreage, plantings, and removals by landowner. This allows us to identify entry and exit in perennial crop supply, changes in perennial crop plantings for incumbent landowners, and the scale of landownership and degree of diversification across crops by landowner. Another way to phrase this question is to ask whether perennial crop supply change primarily occurs at the intensive or extensive margin of the landowner. This research also contributes to the general economics literature on entry and exit by analyzing a sector of the economy outside of manufacturing which has been the focus of the majority of empirical work (Samaniego, 2010), even within agriculture (Anderson et al., 1998; MacDonald, 1986).

Most research on production decisions in agriculture focus on the operator, which makes sense for operator owners, but half of all farmland is in the U.S. is leased. The role of the non-operator landowner in crop choice can plausibly be ignored for many types of agriculture. A non-operator landowner with land in annual row crops using a cash rent contract should not care what crop is planted as long as rotations are maintained. However, a non-operator landowner should be expected to play a significant part in deciding whether or not perennial crops are planted because of the large adjustment costs incurred in switching crops once an orchard or vineyard is planted if market conditions change.

While our focus is on perennial crops this paper does seek to address the need to better understand the role of farmland owners across U.S. agriculture more generally. The last national survey of farmland owners was conducted in 1996 (AEOLOS Survey, USDA), which has likely played a large role in the lack of research. Unfortunately, limited funding for landowner surveys has coincided with a time when there are signs of a large scale shift in the characteristics of rural landowners due to demographic trends and escalating farmland values that have attracted institutional investors.

From a modeling perspective perennial crop planting decisions may have more in common with housing and manufacturing than with annual row crop production. This is part of our motivation for drawing from the entry and exit literature. Fruit production requires much higher fixed capital investment in crop specific technologies compared to annual crops. There are also more significant managerial fixed costs for tasks such as hiring farm labor for crop maintenance and harvesting, as well as gaining entry and negotiating with upstream packers and processors. Orchards and vineyards also require significant establishment costs, have three to five year delays between planting and first harvest, and have investment horizons of many decades. Similar to housing markets, orchard and vineyard crops also tend to have markets that clear regionally. This presents the risk of boom and bust cycles due to producers falling prey to a fallacy of composition where acreage is adjusted in response to recent price events without an adequate appreciation for the similar response of others.

While we do not directly observe and measure the role of technological change driven investment in this paper it is worth considering as a potentially important factor explaining results. Specifically, research on the impact of process and product innovation on entry and exit has some interesting relevance to perennial crop industries. Product innovation is related to offering new products that consumers do not have fully formed preferences over. At this stage firm entry directly affects market evolution. Once consumer preferences are set innovation tends to focus on production processes that aim to lower costs or increase price (Geroski, 1995). The apple industry, while not being a new market, has experienced significant product and process innovation in the last twenty years that likely play a role in entry. Process innovations have included the adoption of dwarf root stocks and high density orchards that have reduced per unit production costs. At the same time, they have increased orchard establishment costs which raise the barriers to entry for new firms. There has also been extensive efforts for product innovation through the development of new varieties of apples. In contrast, there has been little process or product innovation in terms of vineyard production.

Given the novelty of extending the entry and exit literature to farm level production our overarching objective for this paper is to measure industry turnover to determine whether perennial crop production matches stylized facts observed in the manufacturing literature. This provides a basis for relying on existing theory that posits causal relationships that can explain industry dynamics. Results for orchards and vineyards are contrasted because the two industries differ in their stage of development and level of technological innovation.

Previewing findings, we find general agreement with results from the manufacturing literature. We observe high rates of entry and exit that would be hidden if one only looked at the net. Entering firms achieve moderate to low levels of market penetration and are smaller than incumbent firms. As predicted by the previous literature, entrants into the older orchard industry are larger, relative to an industry incumbent, than for the younger vineyard industry. Also, entrants and exiters are more significant drivers of aggregate supply change than incumbents for vineyards than for orchards. This also agrees with the manufacturing literature. In total, these results provide a strong case for extending existing theory to explain the evolution of market dynamics over time which will be a goal of future research.

The paper proceeds with a more detailed review of relevant literature. This is followed by a discussion of the theoretical foundation. The data is then described and a summary of entry and exit statistics are provided. This is followed by an analysis of landowner level characteristics related to exit. The paper concludes with a discussion of future research.

2 Literature Review

2.1 Perennial Crop Supply

Research on perennial crop supply started with analysis of cocoa (Ady, 1949; Bateman, 1965) in a developing country context, and in a U.S. context in a series of papers co-authored by Ben French (French, 1956). French and Bressler (1962) is the first paper to consider plantings and removals rather than the net change in aggregate area harvested. French and Matthews (1971) provides the foundational theoretical model of aggregate perennial crop supply by specifying planting and removal decisions as function of desired production over time where producers form expectations on the long-run market equilibrium. French, King, and Minami (1985) attempt to directly deal with the problem of missing data on the age profile of orchards by specifying separate equations for plantings and removals that incorporate age related yield dynamics.

Baritelle and Price (1974) focus on apple supply in Washington, as does this study, in response to the initial rapid expansion of orchard plantings in the state in the 1960's that followed the completion of the large irrigation projects that began in the 1930's. They were motivated by the concern that the expansion of acreage would cause output price to drop below marginal cost. This is a concern, often voiced in terms of problems of "over-supply", that seems to return to the industry with regular frequency. In a more recent paper Devadoss and Luckstead (2010), who note the continued paucity of research on the supply dynamics of perennial compared to annual crops, estimate a structural model of apple plantings, removals, and yield using data for Washington State that relies on rational expectations. There is also a line of research that extends the general investment decision making literature to perennial crops (Dorfman and Heien, 1989; Akiyama and Trivedi, 1987; Knapp, 1987; Kalaitzandonakes and Shonkwiler, 1992).

2.2 Entry and Exit

The early general economics literature on entry and exit was marked by an increasing appreciation for the importance of strategic behavior beyond what was assumed in relatively simple limit pricing models (Bhagwati, 1970). Dunne, Roberts, and Samuelson (1988) is a highly cited empirical paper that analyzed entry in U.S. manufacturing industries. They consider the relative importance of brand new firms entering a market relative to existing firms engaged in other markets that diversify into a new market to better understand the fundamentals driving long-term market structure. Agarwal and Gort (1996) looks at the relationship between the stage of a market's evolution and entry and find that exit and entry is determined by interactions between firm characteristics and market maturity.

Geroski (1995) provides a review of the literature to that time and highlights the findings that had become stylized facts. Those that are of greatest relevance to this study are:

1. Many firms enter but few of them gain significant penetration which results in low rates of success and slow growth for new firms.
2. Entry and exit rates are highly positively correlated so that net entry rates are small relative to gross.
3. Most entry is by completely new firms but they are less successful than pre-existing firms that are entering a new industry for diversification.
4. Entry into an industry tends to be clustered in time where different periods of high entry tend to consist of different types of firms.

As discussed in the previous section, our goal is to empirically test the robustness of these findings in the context of perennial crop production. The fourth stylized fact has received considerable focus more recently. Empirical analysis of industry level capital adjustment identified clear spikes (Doms and Dunne, 1998) spurred on by the widespread availability of a new technology that instigates capital replacement. There is evidence that these spikes coincide with increased rates of firm entry and exit. Rates of entry and exit seem to be driven by the stage of a market's development which is characterized by technical innovation and capital investment. Samaniego (2010) finds a correlation between rates of entry and exit across industries and the industry level of investment-specific technical change (ISTC).

3 Theoretical Background

The perennial crop supply literature has extensively characterized the acreage adjustment problem for an agent with some land already in a perennial crop. Our objective here is to describe a version of that theoretical foundation and then extend it to include the entry and exit decision.

Following Devadoss and Luckstead (2010) most closely, adjusting land in a perennial crop can be written in terms of investment in the orchard capital stock and removal of existing stock where Q, A, and Y denote production quantity, acreage, and yield per acre that are a function of time t. Baring acreage is equal to last years plantings, A_t, plus investment in new orchard stock lagged by n years where n is time from planting to new harvest (I_{t-n}), minus removals removal of orchards the previous year R_{t-1}. Production (F) is a function of capital K, a fixed input L, and weather W. While L can be a vector it makes sense for our purposes to focus on land because of the importance of the constraint at the landowner level. The capital stock evolves according to investment in new stock and proportional loss of existing stock (δ).

$$
\begin{aligned}
Q_t &= A_t Y_t \\
A_t &= A_{t-1} + I_{t-n} - R_{t-1} \\
K_t' &= I_t - R_t \\
R_t &= \delta K_t
\end{aligned}
$$

From these equations the agent's problem of choosing the level of perennial crop capital stock and the allocation of land that maximizes the present value of the discounted stream of profits, subject to constraints on total land holdings and capital available for investment, can be written as shown below.

$$\max_{K_t, L_t} \quad \int_{t=0}^{\infty} e^{rt}[P_t F_c(K_t, L_t, W_t) - V_t L_t - C(K_t^{'} - \delta K_t)]dt$$

$$\text{subject to} \quad L_t \leq \overline{L_t}$$

$$I_t \leq \overline{I_t}$$

where V represents the land rental rate and r is the discount rate. The first order conditions of the Lagrangian can be used to solve for the optimal investment path as a function of the exogenous variables.

Given that the incumbents decision has been described it makes sense to consider how exit costs enter into the problem. As the capital stock depreciates there is a point where the landowner must decide whether to plant a new orchard or vineyard, or exit perennial crop production and switch, say, to an annual crop. The land will be kept in the perennial crop as long as some reservation profit level is met which is set by the alternative land use. It should be recognized that for simplicity complicating factors related to multi-output production technologies are ignored. If there have been changes in the exogenous variables (input costs, output prices, climate change, or the opportunity cost of capital) that reduce the profitability of the perennial crop then it is optimal to switch from the perennial to the annual crop. If production is concentrated in the hands of a few large producers then it will be necessary to account for the additional profits accrued to a firm relative to their market share (Anderson et al., 1998). However, our subsequent analysis of the data shows orchard and vineyard production to be fairly competitive.

Justification for the inclusion of an additional cost associated with exiting is given by Chavas (1994). Using the concept of asset fixity, Chavas shows that when one introduces uncertainty sunk costs can reduce asset mobility. Another justification related to uncertainty is given by Dixit (1989). Dixit considers the accelerated degradation of capital assets that occur as a result from not being used. The degradation of managerial knowledge of the perennial crop market that would result from exiting would be costly to reverse. The result is that a landowner may not switch land out of the perennial crop and into an annual crop even if the latter is generating higher returns. For a number of reasons the landowner is uncertain whether this will continue in the future. While these costs can also be associated with annual crops the interaction between fixed capital investment and uncertainty associated with perennial crops make them more significant than for annual crops.

The adjustment cost term associated with entry is more obvious. In terms of the problem described it means that there is larger investment required when making the initial investment in the perennial crop than for any subsequent expansion. Firms are induced to enter when price expectations exceed marginal cost to a degree that exceeds the fixed costs associated with entry. Much of the entry literature is concerned with the ability of incumbents to ward off entry by taking advantage of economies of scale. The high level of competition in perennial crop production does not make it likely that any one landowner has an adequate level of market power to engage in this sort of strategic behavior. Economies of scale could also induce larger landowners to buy out smaller landowners. While this is likely happening the low level of agricultural land sales points to significant frictions. One explanation is non-pecuniary returns to farming or owner agricultural land (Key and Roberts, 2009). Another is that farmland has performed well as an investment compared to equities, bonds, and treasuries which reduces the opportunity cost of holding onto farmland.

4 Data

The region of study includes twelve counties in Central Washington east of the Cascade Mountains, as shown in Figure 1. This includes almost all of the arid production regions in the state where most crop production is irrigated. The twelve counties extend from the Oregon to the Canadian border.

The agriculture data is at the field-level and is drawn from a cropland GIS data layer for all of Washington State for 2006 and 2012. Fields in these data include crop type, irrigation technology, field size, field shape, and rotational crops. The data set was prepared by the Washington State Department of Agriculture by combining a set of remotely sensed data sources along with extensive post-processing and ground truthing to check the accuracy of

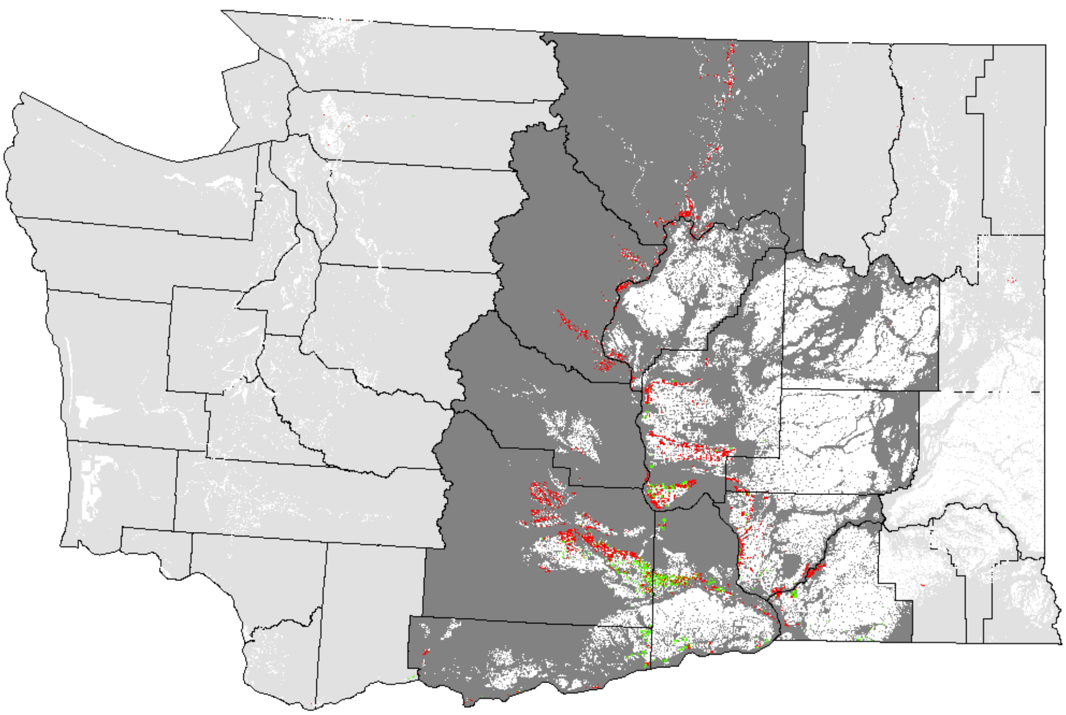

Figure 1: Central Washington counties (dark grey) with highlighted agriculture (white), orchards (red), and vineyards (green).

the data.

The land cover data is spatially joined to parcel data with associated land ownership attributes for the entire state of Washington. These data were compiled from county assessor data for all twelve counties. The cropland cover and parcel ownership data were spatially joined using the Identity procedure in ArcGIS.

After the cropland fields have been associated with a parcel, ownership data makes it possible to aggregate cropland by landowner. When analyzing farmland by owner we only consider land that is currently irrigated for a couple reasons. First, irrigated land is the best measure of any landowners capacity for expanding orchards or vineyards. Washington water law, which is based on prior appropriations, ties a water right to specific fields. It is generally not permissible to spread water to additional fields without acquiring an additional right. Therefore, current irrigated fields provide the most accurate measure of the potential to expand perennial crops. In the arid part of Washington east of the Cascade Mountains, all orchards and vineyards are irrigated.

Second, non-irrigated pasture and rangeland is less accurately measured by remotely sensed land cover data, so total agricultural land that includes dryland is likely to be poorly measured. This should not be a significant problem when considering farm level financial and capital asset allocation decisions. In Central Washington irrigated land is typically worth ten to twenty times or more as much as equivalent land that is not irrigated. Therefore, irrigated land provides a fairly complete picture of land holdings in terms of total value in most cases.

There are some additional limitations to the data. There is not a one-to-one match at the field level between the 2006 and 2012 cropland cover data. This is because field boundaries change over time. As a result, the 2006 and 2012 cropland data was joined to the parcel layer separately. Due to measurement error in the parcel and field boundaries this match is not perfect and results in small slivers of cropland being attributed to neighboring parcels. An alternative that was attempted is to convert the field polygon data to point data where each point is the centroid of each field. This eliminates the problem of unaligned boundaries. However, non-regular shaped fields can generate centroids that are outside of the parcel boundary, which happened to a significant enough degree to prevent using this method. Therefore, a polygon-to-polygon join was used but very small areas that were likely the result of non-perfectly aligned polygon boundaries were dropped.

Another limitation is that there is only a parcel layer for 2012. It would be ideal to have a 2006 parcel layer to account for a change in land ownership. However, this requires extensive string matching across parcel databases and the generation of normalized names. This effort is currently underway but is not yet available. We do not believe this will significantly affect results because very little agricultural land is sold in a given year. An effort was made to collect data on agricultural land transactions to identify which parcels changed ownership between 2006 and 2012.

We also do not have land ownership data for neighboring states. This may lead to an underestimate of the land owned by an individual. We believe it is unlikely that this is a significant issue given the region of study. Canada is to the north and most of the perennial crop area is relatively far from the Idaho border. There is some risk that land in Southern Washington is owned by entities that also own land in Oregon.

5 Analysis

The empirical analysis proceeds as follows. We first summarize industry concentration and diversification by examining the cross-sectional data of acreage owned by crop type by landowner. We then exploit the panel nature of the data to look at entry and exit as a function of crop type, landowner characteristics, and other covariates. The analysis concludes with an evaluation of the extent to which supply dynamics for perennial crops are driven by entering and exiting firms relative to acreage adjustments for incumbent firms. We conclude with a discussion of remaining questions and future research.

5.1 Firm Size and Industry Concentration

Table 1 shows total area planted in orchards and vineyards, total number of landowners, and the percentage of all land owned by the largest 20% of landowners as ranked by each crop type by year. In terms acreage owned by the largest landowners. In general agreement with estimates from USDA survey data, total orchard acres decreased from 2006 to 2012 while vineyard acreage increased. Moving in a similar direction, the number of landowners with orchards decreased while the opposite was true for vineyards. The corresponding drop in orchard acres and orchard owners provides some hint that the reduction in acreage was due to exiting firms rather than incumbents reducing the amount of their land in orchards. As measured by each crop type, the largest 20% of landowners in each category owned just under 78% total orchard acres in both 2006 and 2012. Concentration of vineyards decreased. There was a small increase in the concentration of irrigated farmland.

Table 1: Scale and Concentration of Cropland by Landowner

Land Use Type	Year	Acres	Total Landowners	Median Landowner	Acres Owned by Largest 20% of Owners	% of Total
Orchard	2006	244,522	6,062	11 acres	192,794	79%
	2012	219,655	5,090	11 acres	173,960	79%
Vineyard	2006	57,859	1,148	16 acres	43,882	76%
	2012	73,535	1,265	15 acres	49,730	68%
Irrigated	2006	1,409,063	13,864	19 acres	1,192,458	85%
Farmland	2012	1,544,582	13,981	21 acres	1,353,661	88%

The median number of orchard acres stayed at 11 between 2006 and 2011. The median vineyard owner's acres decreased slightly from 16 to 15 while the same value for irrigated acres increased from 19 to 21. The adoption of a new technology for apple orchards has created a disconnect between acres planted and physical production. The adoption of high-density orchards using dwarf rootstocks and trellises has increased the average number of trees per acre from about 300 to well over 1,000. High-density orchards can yield 50% more production by weight than traditional orchards, and they have shorter time from planting to first harvest. Dwarf rootstocks have not bee adapted to other tree fruits like cherries and pears which may be an important difference that helps identify the role of process innovation in entry and exit.

While it is acknowledged in the region that orchard production is highly concentrated in the hands of small number of landowners this data reveals, to our knowledge, the most accurate estimate to date. Figure 2 shows the number of landowners by perennial acres

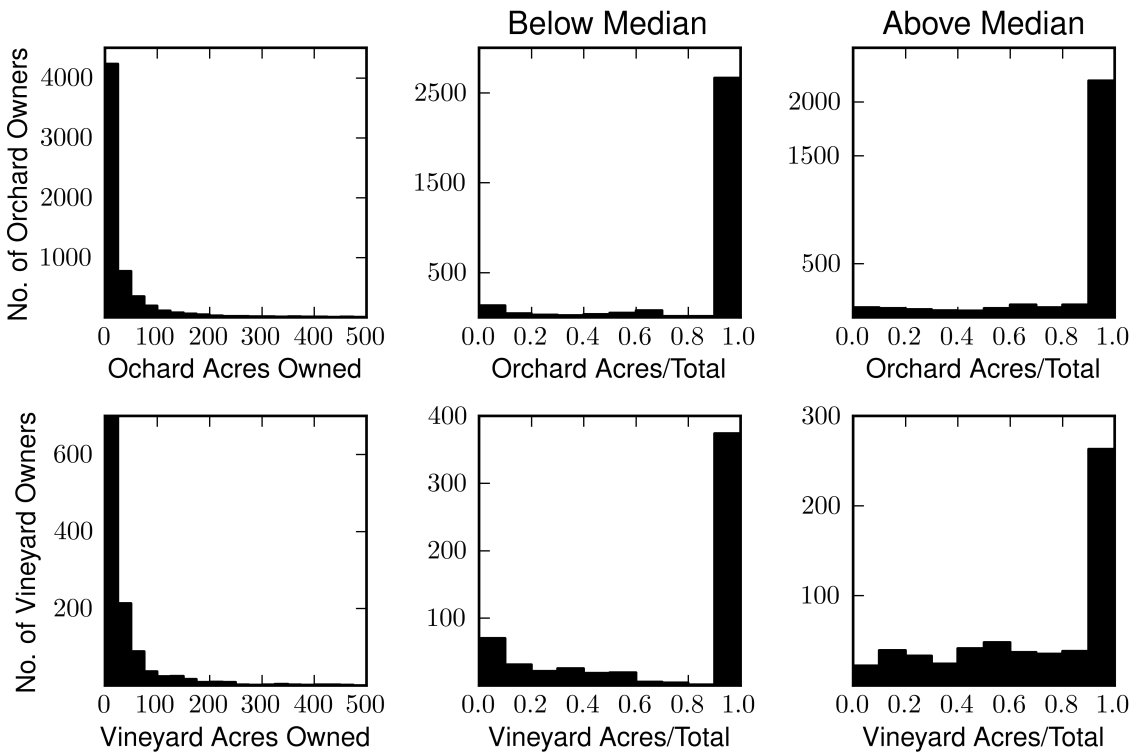

Figure 2: Density of landowners by total orchard and vineyard acres owned (range cutoff at 500) and by the ratio of orchard and vineyard acres to total irrigated acres owned for landowners above and below sample median (median values are given in Table 1).

owned. What is particularly striking is the very large number of agricultural landowners with only a few acres of perennial crops. A total of 7,891 landowners had at least 1 acre of land in orchards or vineyards in 2006 or 2012. There are other crops that have production time horizons of greater than 1 year, such as alfalfa and hops, but they are much shorter than for orchards and vineyards and represent a fundamentally different decision-making process from an entry and exit perspective. A quarter of the landowners had fewer than 4.0 and 4.5 irrigated acres in 2006 and 2012, respectively.

Also shown in Figure 2 is the density of landowners by the ratio of perennial crop acres to total irrigated acres separately for each year for the sample above and below the median. As expected, nearly all of the landowners below the median for the respective year had 90% or more of their land in perennials. However, when looking at landowners above the median there is still a considerable mass at 90% and above. There is an additional mass closer to zero. This group of landowners with only a small percentage of their irrigated land in perennials is the group of incumbent perennial crop suppliers that can expand acreage of perennials, but may also be more likely to exit perennial production.

Calculating the Herfindahl-Hirschman (HH) Index provides a measure that can be compared to other industries. Where s_i is the market share for firm i, which we base on acreage, the HH Index is calculated as

$$HH = \sum_{i=1}^{N} s_i^2 \tag{1}$$

Results are shown in Table 2. An HH Index at or below 1 is corresponds to a highly competitive industry. The value for orchards is well below 1. Vineyards are just above 1. While there are some very large landowners both markets appear to be competitive based on this measure. However, there are factors such as vertical integration that do not factor into this measure.

Table 2: Herfindahl-Hirschman Index for Perennial Crop Landowners.

	2006	2012
Orchards	0.16	0.21
Vineyards	1.15	1.05

5.2 Entry and Exit

Based on information in Table 1 it can be shown that the percentage of irrigated farmland owners with orchards dropped from 43% to 36%. The same value for vineyards increased from 8% to 9%. Following Dunne, Roberts, and Samuelson (1988), entry and exit rates are calculated using the following terms; $NE_{i,t}$ is the number of firms entering industry i from $t-1$ to t, $NT_{i,t}$ is the total number of firms in industry i in year t, $NX_{i,t-1}$ is the total number of exiting firms from $t-1$ to t for industry i, AE_i is total acreage of entering firms for industry i, AX_i is the total acreage of exiting firms for industry i, and AT_i is total acreage for industry i for the relevant year. The set of crops is $i = \{orchards, vineyards\}$ which will be represented by the abbreviations o and v, respectively, through the remainder of the paper. Results for this section are summarized in Table 3

Entry (ER) and exit (XR) rates are calculated as:

$$ER_{i,t} = NE_{i,t}/AT_{i,t-1} \qquad (2)$$

$$XR_{i,t} = NX_{i,t-1}/AT_{i,t-1} \qquad (3)$$

The total number of entering orchard and vineyard landowners is 407 and 355, respectively, which results in values of $ER_o = 8\%$ and $ER_v = 31\%$. There were 1,379 landowners that exited orchards while 238 entered vineyard production. The corresponding exit rates are $XR_o = 22\%$ and $XR_v = 20\%$. For comparison, Dunne, Roberts, and Samuelson (1988) found entry and exit rates in the 30% to 40% range for manufacturing industries from the 1960s to the 1980s. Given the maturity of the tree fruit industry in Washington it is not surprising to find these value to be lower.

Vineyards are a different story. The wine industry in Washington is relatively young. Most of the growth has occurred in the last 20 years. The stylized facts from manufacturing that entry and exit rates are high and also positively correlated extends fairly well to vineyard production. Importantly, these results show that a great deal is missed by only looking at net entry.

A related measure that adds another vital piece of information of the relationship between entry, exit, and the competitiveness of a market is the degree of market penetration. Market penetration for exit and entry firms is measured as their share of industry output.

$$ESH_{i,t} = AE_{i,t}/AT_{i,t} \qquad (4)$$

$$XSH_{i,t} = AX_{i,t-1}/AT_{i,t-1} \qquad (5)$$

Entering orchard and vineyard owners accounted for 14,598 and 11,126 acres. Plugging these values into the relevant share equations gives $ESH_o = 6.7\%$ and $ESH_v = 15.1\%$. The market share of exiting landowners is $XSH_o = 7.4\%$ and $XSH_v = 4.13\%$. Similar to entry and exit rates, these values are a bit lower than those found for manufacturing in Dunne, Roberts, and Samuelson (1988) where exiter and entrant market share varied between 13% and 18%. Again, it is interesting to find that the entrant rate for vineyards is very close to those found in manufacturing.

As another measure of market penetration, we compare the average size of entering and exiting firms relative to incumbents.

$$ERS_{i,t} = \frac{AE_{i,t}/NE_{i,t}}{(AT_{i,t} - AE_{i,t})/(NT_{i,t} - NE_{i,t})} \tag{6}$$

$$XRS_{i,t} = \frac{AX_{i,t}/NX_{i,t-1}}{(AT_{i,t-1} - AE_{i,t-1})/(NT_{i,t-1} - NE_{i,t-1})} \tag{7}$$

The entrant relative firm size for orchards is $ERS_{o,t} = 81.9\%$ while the exiter firm size is $XRS_{o,t-1} = 26.9\%$. This says that entrants are about 80% as big as incumbent firms, which is a fairly high number compared to much of the manufacturing literature. Also, entrants have a much larger market share than exiting firms. The firm size for entrants and exiters in vineyard production are $ERS_{v,t} = 40\%$ and $XRS_{v,t} = 21.2\%$. These results provide some initial evidence that characteristics of entering and exiting firms depends on the stage of market development as was mentioned in the stylized facts. It makes sense that entrants into more mature industries need to be larger relative to incumbents than for younger markets, such as Washington wines.

Using parts of Equation 6 and Equation 7 it can be shown that 13% of the net change in acreage in orchards from 2006 to 2012 can be attributed to firm entry and exit. The same value for vineyards is much higher at 51.5%. This provides support for the extension of the stylized fact that there are important dynamics over the life cycle of a market for entry, exit, and changes in supply that extend to perennial crop industries.

Table 3: Entry and Exit Summary Statistics.

	Entry Rate	Exit Rate	Market Penetration		Firm Size	
			Entrants	Exiters	Entrants	Exiters
Orchards	6.7%	22.0%	8.0%	7.4%	81.9%	26.9%
Vineyards	31.0%	20.0%	15.1%	4.1%	40.0%	21.2%

5.3 Drivers of Entry, Exit, and Acreage Adjustment

In addition to summarizing how entry and exit rates are related to market penetration and firm size in the past, these data are also well suited for providing information about which landowners are likely to exit or adjust acreage of perennial crops in the future. In the exit and entry literature it is always easier to analyze exit decisions because the population is well-defined. All firms that were in production in the beginning of the time period may exit or enter. Entry is more difficult because it is difficult to define realistically the population of firms that may enter in the following period. In this study we could assume that any landowner with irrigated land could enter orchard production. However, many of them have land that is not suited for orchards or vineyards. A field level analysis could factor this in but many landowners have land in multiple parcels that constitute a variety of growing conditions. It is difficult to create an aggregate owner level variable that encapsulates this.

In constructing the data for regression analysis that attempts to explain exit decisions is to drop the smallest producers that constitute less than 1% of acreage. This is a common approach adjustment made in the entry and exit literature that helps to reduce the noise associated with the large number of very small firms (Dunne, Roberts, and Samuelson, 1988). It is justified on the premise that the goal is to understand the impact of entry and exit on industry level competition. Dropping firms that constitute such a small amount of production provides a more accurate estimate of the factors that influence entry and exit for firms that have a greater influence on aggregate supply.

Model specification will be explained for orchards but the same set-up applies to vineyards. Let the observed decision variable $Y_{i,o} = 1$ if landowner i had land in orchards in 2006 but not in 2012. $Y_{i,o} = 0$ otherwise. We assume that the landowner exits if the discounted value of net returns in orchards is less than returns generated from the alternative crop plus adjustment costs associated with exiting. While firm level prices are not observed we do have a set of variables (X_i) that explain the size and scope of the operation which influence profitability in orchards versus an alternative crop. Profitability then can be written, in the usual way, as a function of the observed covariates and an error term that captures the unobserved factors.

$$\Pi_i = \boldsymbol{\beta}'\mathbf{X_i} + \epsilon_i \tag{8}$$

A probability that a landowner exits can be written stochastically, where F is the distribution function of the error, as

$$\begin{aligned} P(Y_i = 1) &= P(\Pi_i < 0) && (9) \\ &= P(\epsilon_i < -\boldsymbol{\beta}'\mathbf{X_i}) && (10) \\ &= 1 - F(\boldsymbol{\beta}'\mathbf{X_i}) && (11) \end{aligned}$$

A probit model is used to estimate the vector of parameters.

After cleaning the data there are 4,790 landowners in the sample that had orchard crops in 2006. The covariates that are included in the regression are total irrigated acres, total orchard acres, total number of crop types, and a dummy equal to one of another perennial crop is grown. The first two variables capture scale effects. Total number of crop types captures scope effects. For landowners with orchards the perennial dummy is equal to 1 if they have vineyards, and vice versa. The rationale for including this term is derived from the costs associated with exiting perennial crop production explained previously. We hypothesize that the deterioration of human capital associated with perennial crops will degrade less slowly following exiting if the landowner has land in another type of perennial crop. There are potentially a couple reasons for this. One reason is hired farm labor which constitutes almost half of variable costs for orchards. Both grapes and orchards require hiring farm labor so this knowledge will remain if the other perennial crop is being grown. Dummies for land in other types of crops are included to control for scope effects.

For the orchard regression the majority of landowners, 3,817 out of 4,790, only had orchard crops. There were 695 that had one additional crop type in 2006. The number of landowners in the sample with three or more types of crops, including orchards, was 176 (3 types), 76 (4 types), 19 (5 types), and 7 (6 types). The aggregation of crops into types is based on the system developed by the Washington State Department of Agriculture which includes berries, cereal grains, hay and forage, herbs, vegetables, vineyards, and other. Due to collinearity induced by large numbers of zeroes dummies are only included for vineyards, cereal crops, hay and forage crops, and vegetables.

Marginal effects, standard errors, z-statistics, sample means, and elasticities at the sample mean for the covariates are shown in Table 4. As expected, a strong relationship is demonstrated between scale in terms of orchard production and exit measured by both statistical significance and economic magnitude. Larger orchard producers are less likely to exit. While the there is a statistically significant relationship for the vineyard ownership variable it is in the opposite direction as would be expected based on the argument just given which posited that vineyard owners would be more likely to exit orchard production all other things equal. The coefficients for the dummies for cereal and vegetable crops were also negative. Taken together this points towards the existence of economies of scope where landowners benefit from having land in multiple crops. This trend does not extend to all other categories. Those with hay and forage crops are more likely to exit relative to owners with only orchards (the omitted category).

Table 4: Regression analysis of exit from orchards using a probit model.

Variable	Marginal Effect	s.e.	z-stat	Sample Mean	Elasticity
Irrigated acres	6.84E-06	0.00004	0.19	98.7785	0.0030711
Orchard acres	-0.0012264	0.00012	-10.07	50.5301	-0.281682
Cereal crop dummy	-0.0634137	0.0232	-2.73	0.047182	-0.0136
Hay crop dummy	0.1011407	0.0269	3.76	0.120877	0.0555708
Vineyard dummy	-0.0640332	0.02037	-3.14	0.068894	-0.020052
Vegetable dummy	-0.0573543	0.02674	-2.14	0.035282	-0.009198
Orchards share of total	-0.08649	0.03509	-2.46	0.877774	-0.345085

There are ommitted factors that likely explain some of these results. The most important is likely the geographic area of the land. One challenge with working with landowners is that many own multiple parcels often spread out over a large area. This makes it difficult to include variables that are spatially or geographically based. It is likely that the dummies for other types of crops are capturing geographic differences in growing conditions that make a landowner more likely to exit or spatial relationships like distance to a the nearest processor. One approach for addressing this shortcoming is to estimate a field level model of land use change that includes covariates that represent different characteristics of the landowner along with geographic and spatially based variables.

Table 5: Regression analysis of exit from orchards using a probit model.

Variable	Marginal Effect	s.e.	z-stat	Sample Mean	Elasticity
Irrigated acres	-1.57E-06	3.00E-05	-0.06	184.401	-0.001447548
Vineyard acres	-0.0013797	0.00021	-6.43	63.1828	-0.435866546
Cereal crop dummy	-0.0535541	0.03217	-0.08	0.106946	-0.028636984
Hay crop dummy	-0.0045322	0.0304	-0.15	0.117971	-0.002673341
Orchard dummy	-0.0146474	0.02492	-0.59	0.072767	-0.005329237
Vegetable dummy	-0.0287036	0.03344	-0.86	0.338479	-0.048577829
Vineyards share of total	-0.0535541	0.04148	-1.29	0.727779	-0.194877747

Results from the regression analysis of vineyard exit decisions, shown in Table 5, continue to demonstrate the importance of scale. Landowners with fewer vineyard acres are more likely to exit. In contrast to orchards there are no obvious scope effects. This is somewhat surprising given the variation in the other types of crops owned. 33% of vineyard owners also own orchards. The next most common crop is hay and forage at 11%. Vegetables are the least common at 7% of owners. However, ownership of these crops is not associated with a higher or lower probability of exit.

One potential explanation for the lack of significance in the vineyard model are the complex objectives of the landowners. While there is little hard evidence there is a perception in the Washington wine region that profit maximization is a poor approximation for the objective function of many landowners with vineyards. There are believed to be a large number of owners that want to have land in vineyards for less easily quantified motivations related to lifestyle. This is a difficult hypothesis to test with a customized survey tool but it likely plays a part in the noise involved in explaining entry and exit for vineyards.

6 Conclusions

In this paper we sought to improve understanding of the dynamics of perennial crop supply by comparing acreage change on land owned by incumbents compared to landowners entering or exiting perennial crop production. This research contributes to the perennial crop supply literature by analyzing acreage changes at the farm level, which has not been done previously. It contributes to the entry and exit literature by investigating whether stylized facts that have been primarily identified in manufacturing industries extend to another sector of the economy. The basic premise underlying the study is to view the landowner as the entity, or firm, that makes planting decisions. This is based on the capital investment required for these crops and the length of the production horizon.

We find that results from the entry and exit literature do match trends found in the data on perennial crop supply changes. By contrasting vineyards and orchards we test whether the stage of market development is important. In short, it is. The vineyard industry is relatively young in Washington compared to the orchard industry. As would be predicted by previous research, one should then expect to find that changes in aggregate supply are driven much more by firm entry and exit in vineyards than in orchards. We find strong evidence in support of this. Entering firms in mature industries also have been shown to gain more significant market penetration at the point of entry. We find that landowners entering orchard production are 80% as large as incumbents while vineyard entrants are only 40% as large.

In summary, this paper provides a justification for assuming that theory developed to fit observed stylized facts in manufacturing will fit perennial crop production. A fruitful path for future research will incorporate more recent theoretical work on entry and exit as a function of technology driven capital investment.

References

Ady, P. (1949). "Trends in cocoa production". *Bulletin of the Oxford University Institute of Statistics* 11, pp. 375–404.

Agarwal, R. and M. Gort (1996). "The evolution of markets and entry, exit and survival of firms". *The Review of Economics and Statistics* 78.3, pp. 489–498.

Akiyama, T. and P. K. Trivedi (1987). "Vintage production approach to perennial crop supply: an application to tea in major producing countries". *Journal of Econometrics* 36.1, pp. 133–161.

Anderson, D. W., B. C. Murray, J. L. Teague, and R. C. Lindrooth (1998). "Exit from the meatpacking industry: a microdata analysis". *American Journal of Agricultural Economics* 80.1, pp. 96–106.

Baritelle, J. L. and D. W. Price (1974). "Supply response and marketing strategies for deciduous crops". *American Journal of Agricultural Economics* 56.2, pp. 245–253.

Bateman, M. J. (1965). "Aggregate and regional supply functions for Ghanaian cocoa, 1946–1962". *Journal of Farm Economics* 47.2, pp. 384–401.

Bhagwati, J. N. (1970). "Oligopoly theory, entry-prevention, and growth". *Oxford Economic Papers* 22.3, pp. 297–310.

Chavas, J.-P. (1994). "Production and investment decisions under sunk cost and temporal uncertainty". *American Journal of Agricultural Economics* 76.1, pp. 114–127.

Devadoss, S. and J. Luckstead (2010). "An analysis of apple supply response". *International Journal of Production Economics* 124.1, pp. 265–271.

Dixit, A. (1989). "Entry and exit decisions under uncertainty". *Journal of Political Economy*, pp. 620–638.

Doms, M. and T. Dunne (1998). "Capital adjustment patterns in manufacturing plants". *Review of Economic Dynamics* 1.2, pp. 409–429.

Dorfman, J. H. and D. Heien (1989). "The effects of uncertainty and adjustment costs on investment in the almond industry". *The Review of Economics and Statistics*, pp. 263–274.

Dunne, T., M. J. Roberts, and L. Samuelson (1988). "Patterns of firm entry and exit in US manufacturing industries". *The RAND Journal of Economics*, pp. 495–515.

French, B. C. and R. G. Bressler (1962). "The Lemon Cycle". *Journal of Farm Economics* 44.4, pp. 1021–1036.

French, B. C., G. A. King, and D. D. Minami (1985). "Planting and removal relationships for perennial crops: an application to cling peaches". *American Journal of Agricultural Economics* 67.2, pp. 215–223.

French, B. C. and J. L. Matthews (1971). "A supply response model for perennial crops". *American Journal of Agricultural Economics* 53.3, pp. 478–490.

French, B. C. (1956). *The long-term price and production outlook for apples in the United States and Michigan.* Michigan State University, Agricultural Experiment Station, Department of Agricultural Economics.

Geroski, P. A. (1995). "What do we know about entry?" *International Journal of Industrial Organization* 13.4, pp. 421–440.

Kalaitzandonakes, N. G. and J. Shonkwiler (1992). "A state-space approach to perennial crop supply analysis". *American Journal of Agricultural Economics* 74.2, pp. 343–352.

Key, N. and M. J. Roberts (2009). "Nonpecuniary benefits to farming: Implications for supply response to decoupled payments". *American Journal of Agricultural Economics* 91.1, pp. 1–18.

Knapp, K. C. (1987). "Dynamic equilibrium in markets for perennial crops". *American Journal of Agricultural Economics* 69.1, pp. 97–105.

MacDonald, J. M. (1986). "Entry and exit on the competitive fringe". *Southern Economic Journal*, pp. 640–652.

Samaniego, R. M. (2010). "Entry, Exit, and Investment-Specific Technical Change". *American Economic Review* 100.1, pp. 164–92.