

## **FACTORS INFLUENCING COMPUTER USAGE AMONG HORTICULTURE FIRMS IN THE UNITED STATES**

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### **Abstract**

*Empirical models describing the factors influencing the levels of computerization of the operations of nurseries and greenhouses in the United States were estimated using the data collected from a regional survey in the Southern States and two national surveys in the United States. The models measure the significant effects of the socioeconomic characteristics of managers and operational characteristics of firms to the level of computer use among nurseries and greenhouses. Results show that the socioeconomic characteristics of the participating owners and managers had exercised limited influence in the decisions involving the computerization of horticulture operations. The operational characteristics of the horticulture operations included in the surveys which have significant influences on the level of computerization included the number of workers hired, level of automation, annual gross sales, wholesale sales, years since establishment, and location. The recent Great Recession encouraged the participating firms to increase the use of computers in their operations.*

**Keywords:** Greenhouses, socioeconomic, survey, automation, economic recession

**JEL Codes:** Q12, Q16

### **1. Introduction**

The nursery and greenhouse industry generates a significant economic impact on the United States economy. Recent estimates showed that the annual economic contribution of the industry amounted to \$31.25 billion (Hodges et al., 2015). The industry also created 240,809 jobs, generated \$13.71 billion labor income, and paid \$713 million in business taxes. Recent U.S. data on industry employment and wages indicate that greenhouses and nurseries paid total annual wages amounting to \$5.27 billion to 154,917 workers in 2018 (BLS, 2019).

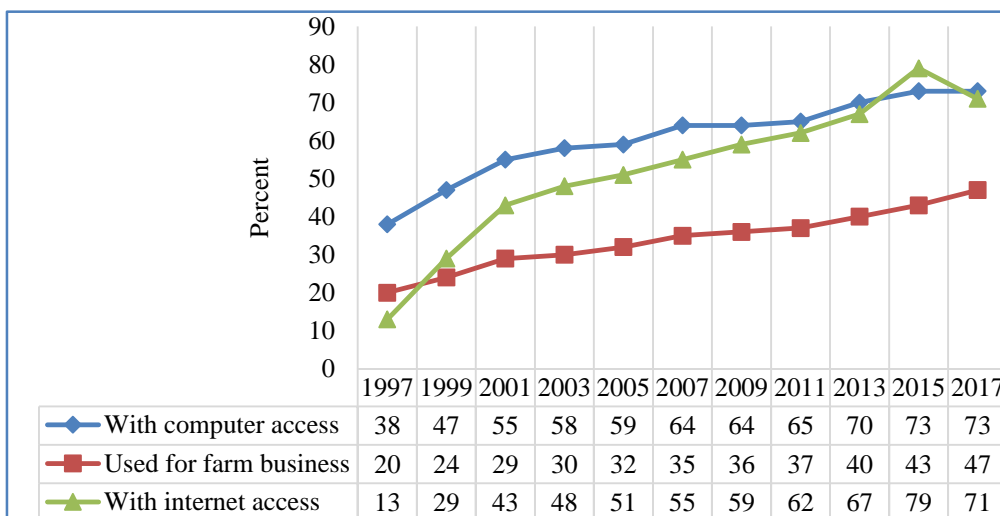
The usefulness of computers in a greenhouse environment had been expressed by Ting (1992) who described computers as ‘effective in rapidly processing information, generate status reports, provide decision support, gather sensor signals, and instruct machines to perform physical tasks.’ Recently, Trafton (2019) reported that researchers at the Massachusetts Institute of Technology Open Agriculture Initiative are demonstrating that the future of agriculture is computerized. Initial results of this initiative showed that “they have created basil plants that are likely more delicious than any you have ever tasted (Johnson et al., 2019).”

The use of computers had significant application to horticulture marketing. Peterson et al. (2018) conducted “a survey to gauge the extent of the use of new-media marketing by ornamental horticulture businesses across the U.S. The results of the survey showed that a majority of the sample (89%) were involved in new-media marketing, and all new-media users made use of at least one new-media tool. Facebook was used by more than 90% of new media users, followed by the business’ website, which was used by 82% of respondents.” Using the 2014 National Green Industry Survey, Torres et al. (2019) managerial decisions involving the

use of online advertising, how much to invest in these methods and determine the factors influencing these decisions such as market outlets, product types, firm characteristics, and owner’s perceptions.

The use of computers had serious implications for the labor market. Plant et al. (2019) assessed the impact of computerization on the U.S. labor market during the past seven decades starting from the use of mainframe computers (1950-1980), personal computers (1980-1994), network era (1994-2007), mobile period (2007-2014), and the internet of things (2014-present). Krahe and Campbell (2016) examined the impacts of technology use on full-time and part-time workers in the green industry.

The 2017 Farm Computer Usage and Ownership report showed that 71 percent of U.S. farms had Internet access, but only 47 percent of the operations used computers for farm business (USDA, 2019a). The number of farm businesses which had access to computers rose from 38 percent in 1977 to 64 percent in 2007, and 73 percent in 2017 (Fig. 1). Less than half of the agricultural operations used computers for the farm business (20% in 1997, 35% in 2007, and 47% in 2017). The number of farm businesses which had access to the internet rose significantly during the 20-year-period (13% in 1997, 55% in 2007, and 71% in 2017).



Source: USDA (2019a).

Figure 1. Computer Use in U.S. Agriculture

Several investigators evaluated the influence of firm and manager’s characteristics on the adoption and successful use of computers in agriculture. Baker (1992) found out that computer adoption among New Mexico agribusinesses was significantly enhanced by firm characteristics such as size and type of business. He concluded, however, that the manager’s characteristics, including age and education, did not have any significant effect on computer use. Further, the success of the computer system was highly influenced by the personal involvement of the agribusiness manager (Baker, 2006).

Among Ohio commercial farmers, Batte et al. (1990) reported that older farmers were less likely to adopt computers. The older farmers considered in as less useful and made fewer computer applications in their business. A positive association between the level of education and computer adoption and a higher number of computer applications was observed among commercial Ohio farmers.

Among German male workers, an analysis of the German Socio-Economic Panel individual data showed that a strong and negative relationship between the age of workers and computer use was observed (Schleife, 2006). The impacts of higher levels of education and better employment status on the use of computers were significantly enhanced.

In a later report, it was observed that Ohio farmers continued to expand the use of computers (Batte, 2003). The primary use for computers by the Ohio farmers were financial accounting and the use of the internet for information collection. Among the Great Plains farmers, however, the use of the internet for farm-related businesses resulted in no economic benefits (Smith et al., 2004).

In a 2003 national survey of the U.S. nursery and greenhouse industry, Campbell et al. (2009) reported that computer usage considerably increased due to every-day tasks involving computer applications. In the same national survey, the Mountain region recorded the highest level of computer adoption for production, marketing, and management (Hodges et al., 2008; 2010). A lower percent of computer use (25%) was estimated at the 2008 National Green Industry Survey as compared to the percent use (27.5%) observed in the 2003 survey. The Mountain region maintained a higher percent of computer use in the 2008 survey.

**Table 1. Computer Usage by Horticultural Firms**

Computer Use (%)	2003-09 Southern United States Nursery Survey <sup>A</sup> (n=215)	2003 National Green Industry Survey <sup>B</sup> (n=2485)	2008 National Green Industry Survey <sup>C</sup> (n=3044)
Word processing	88.2	65.8	57.9
Communications	79.9	59.9	54.6
Internet commerce	56.4	25.07	22.4
Accounting and cost analysis	47.8	58.9	52.2
Inventory management	30.5	40.9	35.6
Financial investment and analysis	23.0	25.47	24.8
Production scheduling	20.1	18.0	14.8
Greenhouse production controls	13.2	8.3	8.4
Digital imaging for disease diagnosis	11.8	3.7	4.1
CD's for marketing	8.8	6.8	8.2
Barcoding	6.4	10.1	8.5
Grading	2.5	-	-

**Notes:** <sup>A</sup> - Posadas et al. (2018) ; <sup>B</sup> - Hodges et al. (2008) ; <sup>C</sup> - Hodges et al. (2010).

Posadas et al. (2018) summarized the initial results of the computer usage of the 215 growers which participated in the socioeconomic of nursery automation survey conducted in Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. Computer usage was measured as a binary variable. The answers to the questions of whether the listed nursery functions are computerized or not are either 1 or 0. All growers surveyed were asked a series of questions to determine what nursery and greenhouse tasks were performed using computers (Table 1). The survey results indicated that “there are extensive and marked differences in computer use in nursery and greenhouse operations throughout the surveyed U.S. Southern States.

The most frequently performed computer tasks in the three surveys described above were word processing, communications, internet commerce, and accounting and cost analysis. The

less frequently accomplished computer tasks were inventory management, financial investment and analysis, production scheduling, and greenhouse production controls. The most infrequently done computer tasks by nursery and greenhouse operations were digital imaging for disease diagnosis, use of CDs for marketing, barcoding, and grading.

Posadas et al. (2018) asserted that “the increased availability and ease of use of computing devices such as tablets and smartphones should contribute to a marked increase in computer usage within the nursery and greenhouse industry. As computers become more widely used in the industry to aid in required tasks, firms can better allocate assets (i.e., labor) to help the firms operate more efficiently, in turn, increasing profits and morale.”

Posadas et al. (2018) concluded that “the statistical results showed stability in the use of computers for word processing by the participating nurseries and greenhouses. However, there remained a sizeable proportion of horticulture growers who did not use computers during the period under study.” They suggested that “further econometric analysis be conducted to identify the significant factors enhancing or limiting the use of computers in horticultural operations. These factors will include, among others, the operational characteristics of the participating establishments and socioeconomic characteristics of its owners and operators.”

This paper attempts to identify the significant determinants of computer usage among nursery and greenhouse operations. Specifically, it identifies and measures the influence of owner/operator characteristics, firm operational characteristics, firm location, and the great recession on computer usage among participating nursery and greenhouse operations.

## **2. Materials and Methods**

A regional socioeconomic survey of randomly selected wholesale nursery and greenhouse operations was conducted in eight selected Southern states as a part of a research program undertaken by the Mississippi Agricultural and Forestry Experiment Station (MAFES) and the U.S. Department of Labor (DOL) entitled ‘Enhancing labor performance of the green industry in the gulf south.’ The survey consisted of eight parts, namely workers’ demographic characteristics, nursery characteristics, nursery mechanization, greenhouse mechanization, labor and capital markets, pesticide and chemicals, working conditions, and respondents’ characteristics (Posadas, 2018a; 2018b; Posadas et al., 2008; 2010a; 2012; 2014). The overall goals of the regional socioeconomic survey were to develop a socioeconomic profile of horticulture workers and to evaluate the impact of automation on their employment, earnings, safety, skill levels, and retention rates.

The scope of this work, however, was limited to the determinants of the decisions involved in the use of computers in the horticulture industry. Earlier publications using the databases mentioned above collected from Louisiana, Mississippi, and Alabama covered the socioeconomic characteristics of workers and working conditions [Posadas et al., 2010a), nursery and greenhouse operational characteristics (Posadas et al., 2010b), and socioeconomic impacts of mechanization and automation (Posadas et al., 2008; 2012). Additional publications covering all the participating nurseries and greenhouses in eight Southern states included current mechanization systems (Coker et al., 2010; 2015), socioeconomic impacts of mechanization and automation (Posadas et al., 2008; 2012), and hiring preferences (Posadas et al., 2014). Recently, the determinants of mechanization (Posadas, 2018a) and socioeconomic characteristics of owners and operators were explored (Posadas, 2018b).

A national survey of nurseries and greenhouses is conducted every five years by a multi-state research committee named Sustainable Practices, Economic Contributions, Consumer Behavior, and Labor Management in the U.S. Environmental Horticulture Industry (NIMSS, 2019). The National Green Industry Surveys conducted by the multi-state research committee in 2003 and 2008 included questions on computer usage by horticulture businesses which participated in the surveys.

From the data collected by the fourth and fifth national nursery surveys conducted by the multi-state research committee, there were 2,485 valid responses in 2003 and 3,043 valid responses in 2008. No questions on computer use were asked in the succeeding national green industry surveys. Hall et al. (2006) reported that the primary research data on the structure of the nursery industry was generated by the Fourth Nursery Industry Survey conducted by the multi-state regional research committee in early 2004. The multi-state regional research committee conducted the Fifth National Nursery Survey in all 50 states in 2009 (Hodges et al., 2011).

## **2.1. Primary Data Collection**

Face-to-face interviews with wholesale nurseries and greenhouses were conducted in eight Southern States - Mississippi, Alabama, Louisiana, Florida, Tennessee, South Carolina, North Carolina, and Georgia from Dec. 2003 to Nov. 2009 (Posadas, 2018a; 2018b). This length of time was required due to the distance traveled to complete the interviews, the availability of the growers, and the major hurricanes in 2005 and 2008. Official lists of certified nurseries were retrieved from state departments of agriculture or state nursery associations. Only wholesale growers were included in the selection of survey participants.

The wholesale growers in each state included in the survey were identified and numbered from 1 to N (Posadas, 2018a; 2018b). Using Excel (Office 2003; Microsoft Corporation, Redmond, WA), 50 random integers were individually generated from 1 to N, where N = the number of wholesale growers in each state. Individual letters of introduction were sent to the 50 selected nurseries and greenhouses in each state in advance. Follow-up telephone calls were made to each of the nursery or greenhouse which were chosen to determine their willingness to participate and availability for the interviews.

The survey respondents were the owners or operators of the selected nurseries or greenhouses (Posadas, 2018a; 2018b). These growers were contacted via mail and were asked to return a prepaid postcard indicating their willingness to participate in the survey. The nurseries or greenhouses showing a willingness to engage were then reached by phone, and interviews scheduled. A total of 215 personal interviews were completed with wholesale nurseries (N = 88), greenhouses (N = 52) and mixed nursery or greenhouse operations (N = 75) in Mississippi (32), Louisiana (29), Alabama (26), Florida (27), Tennessee (17), South Carolina (30), North Carolina (30), and Georgia (24).

The socioeconomic data consisted of variables dealing with labor, technical, and economic information about the nurseries and greenhouses in the eight Southern states (Posadas, 2018a; 2018b; Posadas et al., 2008; 2012; 2014). The owners or operators' characteristics included, among others age, formal education completed, horticulture business experience, and perceptions of the availability of labor and capital. The operational characteristics including but not limited to the quantity and quality of workers, growing area, annual gross sales, level of mechanization, the computer uses, and year established.

The horticulture firm's economic and operational characteristics collected by the 2003 and 2008 National Green Industry Surveys included among many others computer use, firm size in acres, and annual gross sales, number of workers, regional location. Additional economic characteristics included year established and wholesale or retail trade. All the 2003 national survey respondents were recruited to join the survey through the mail survey. About 10 percent of the 2008 National Green Industry Survey participants responded through an online survey. It was expected that the online survey participants have higher levels of computerization in their operations than those who did the mail survey.

## **2.2. Empirical Models**

The empirical model used in identifying and measuring the impacts of the significant determinants of computer usage among nurseries and greenhouses in the eight Southern states is as follows (Eq. 1):

$$\text{Computer use} = \beta_0 + \beta_1 x \text{HC} + \beta_2 x \text{LC} + \beta_3 x \text{QS} + \beta_4 x \text{OC} + \beta_5 x \text{LR} + \hat{E} \quad (1)$$

where computer use = number of computer uses by participating nurseries and greenhouses, HC = characteristics of human capital, LC = perceptions of availability labor and capital, QS = quantity and skills of the workers, OC = operational characteristics, LR = location and recession, E = error term, and  $\beta_i$  = regression coefficients.

The respondents were asked to describe how the computers were used in their nursery and greenhouse operations. The value of the dependent variable, computer use ranges from zero to 12. A value of zero means that no computers were used and 12 shows that all the tasks listed in Table 1 were computerized.

The following independent variables describe the characteristics of human capital (HC) (Posadas, 2018a):

- Age-year = age (yr) was determined by asking the respondents to check their age brackets.
- Educ-year = formal education (yr) was determined by asking the respondents to select their formal educational attainment.
- Resp-expe = horticulture experience (yr) was measured by asking the respondents to specify the number of years in the nursery business.

The following independent variables state the perceptions of owners or operators on their lifestyle satisfaction and availability of labor and capital (LC) (Posadas, 2018a):

- Oper-sati = 1, if the respondents were satisfied/very satisfied with their current lifestyle or = 0, if otherwise.
- Labor-avail = 1, if respondent perceived labor as available/highly available or = 0, if otherwise.
- Lterm-cap = 1, if respondent perceived long-term capital as available/highly available or = 0, if otherwise.
- Oper-cap = 1, if respondent perceived operating capital as available/highly available or = 0, if otherwise.

The following independent variables indicate the quantity and skills of the workers (QS) employed by the nurseries or greenhouses (Posadas, 2018a):

- Work-perm = number of permanent workers.
- Work-part = number of part-time works.
- Work-skill = percent of workers with basic horticultural skills.
- Work-pomw = percent of migrant workers.

The following independent variables represent the operational characteristics (OC) of the nurseries or greenhouses (Posadas, 2018a):

- Nursery = 1, if nursery-only operation or = 0, if otherwise.
- Greenhouse = 1, if greenhouse-only operation or = 0 if otherwise.
- Mixed = 1, if mixed nursery or greenhouse operation, = 0, if otherwise.
- Hectare = land under production (ha).
- Perc-use = land under production (%).
- Sales-year = annual gross sales (\$) was determined by asking respondents to select the sales bracket of their operations.

- Business-year = years since establishment (yr) was measured by asking the respondents the years their operations were established.

- Corporate = 1, if business is a corporation or = 0, if otherwise.
- Sole-prop = 1, if operation is a sole proprietorship or = 0, if otherwise.

The following independent variables capture the location of nurseries and greenhouses, and if the interview was conducted during the recession from 2007–2009 (LR) (Posadas, 2018a):

- State-code = the dummy variable representing the state location
  - 1 = Alabama
  - 2 = Florida
  - 3 = Georgia
  - 4 = Louisiana
  - 5 = Mississippi
  - 6 = North Carolina
  - 7 = South Carolina
  - 8 = Tennessee
- Recession = 1, if the interview was conducted during the recession from Dec. 2007 to Jun. 2009 or = 0, if otherwise.

A second empirical model was developed to measure the effects of selected economic and operational characteristics of horticulture firms on computer usage. The second empirical model which was estimated using the relevant data collected by the 2003 and 2008 National Green Industry Survey is as follows (Eq. 2):

$$\text{Computer use} = \beta_0 + \beta_1 x \text{QS} + \beta_2 x \text{OC} + \beta_3 x \text{LR} + \acute{E} \quad (2)$$

where computer use = number of computer uses by participating horticultural establishments, QS = quantity of workers, OC = operational characteristics, LR = location and recession, E = error term, and  $\beta_i$  = regression coefficients.

The respondents to the National Green Industry Survey were asked to describe how the computers were used in their nursery and greenhouse operations. The value of the dependent variable, computer ranges from zero to 11. A value of zero means that no computers were used and 11 shows that all the tasks listed were computerized.

The following independent variables indicate the quantity of workers (QS) employed by the nurseries or greenhouses:

- Work-perm = number of permanent workers.
- Work-part = number of part-time works.

The following independent variables represent the operational characteristics (OC) of the nurseries or greenhouses:

- Size-code = dummy variable representing size of operation
  - 1 = very small (< 1 acre)
  - 2 = small (1 to < 5 acres)
  - 3 = Medium (5 to <20 acres)
  - 4 = Large (20 acres and above)
- Sales-year = annual gross sales (\$) was determined by asking respondents to select the sales bracket of their operations. The dummy variable representing annual sales are as follows:
  - 1 = Annual sales less than \$249,999
  - 2 = Annual sales \$250,000 to \$499,999
  - 3 = Annual sales \$500,000 to \$999,999

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- 4 = Annual sales \$1,000,000 to \$1,999,999
- 5 = Annual sales \$2,000,000 or more
- Business-year = years since establishment (yr) was measured by asking the respondents the years their operations were established.

The following independent variables capture the location of horticulture firms, and if the interview was conducted in 2003 or 2008 (LR):

- Region-code = the dummy variable representing the regional location of participating horticultural firms
  - 1 = Appalachian
  - 2 = Great Plains
  - 3 = Midwest
  - 4 = Mountain
  - 5 = Northeast
  - 6 = Pacific
  - 7 = Southcentral
  - 8 = Southeast
- Year-survey = 1, if the interview was conducted in 2008, or = 0, if otherwise.

### 2.3. Statistical Analysis

To determine the significant factors affecting computer usage, the empirical models defined by Eq. 1 and 2 were estimated by using the ordinary least square (OLS) procedure. The robust variance procedure calculated the OLS model in Stata 16 (StataCorp, College Station, TX). Precise calculations of the sample-to-sample variations of the parameter estimates are attained with the robust variance procedure (Rogers, 1993; Williams, 2000).

The variance inflation factor (VIF) was calculated using the VIF procedure in Stata 16 to detect the possible presence of multicollinearity. The marginal impacts of the independent variables on computer usage were computed by using the margins procedure of Stata 16.

### 3. Results and Discussion

Linear regression results of the 2003-09 Southern States Nursery Survey showed that 65 percent of the variations in the number of computers use among nurseries or greenhouses were explained by the explanatory variables included in the empirical model defined by Eq. 1 (Table 2). The estimated equation was significant, with at least one of predictors' regression coefficients not being equal to zero ( $F=19.6$ ).

**Table 2. Factors Influencing Computer Usage in Nurseries and Greenhouses in Eight Southern States**

Independent variable	Coefficient	Robust SE
<b>User characteristics:</b>		
Respondent age		
30-39 years old	NA	
40-49 years old <sup>ns</sup>	-0.600	0.549
50-59 years old <sup>*</sup>	-1.301	-3.552
60-69 years old <sup>ns</sup>	-0.064	0.873
70 years old and above <sup>**</sup>	-3.552	1.094
Respondent education <sup>ns</sup>		
High school diploma	NA	
Some college, no degree	0.909	0.817



Associate degree	-0.330	0.907
College diploma	0.691	0.630
Advanced degree	0.955	0.888
Respondent horticulture experience (yr) <sup>ns</sup>	-0.032	0.025
Satisfied with current lifestyle <sup>ns</sup>	0.129	0.558
<b>Input constraints:</b>		
Availability of labor <sup>*</sup>	1.165	0.456
Availability of long-term capital <sup>ns</sup>	-0.469	0.396
Availability of operating capital <sup>ns</sup>	-0.552	0.393
<b>Labor characteristics:</b>		
Permanent workers (no) <sup>ns</sup>	0.049	0.036
Part-time workers (no) <sup>*</sup>	0.061	0.032
Workers with horticulture skills (%) <sup>*</sup>	-0.011	0.005
Migrant workers (%) <sup>*</sup>	-0.014	0.007
<b>Operational characteristics:</b>		
Nursery-only	NA	
Greenhouse-only <sup>ns</sup>	0.213	0.505
Mixed nursery-greenhouse <sup>ns</sup>	0.465	0.488
Level of automation (%) <sup>*</sup>	0.038	0.017
Land used in production (ha) <sup>ns</sup>	0.006	0.011
Land used in production (%) <sup>ns</sup>	-0.006	0.006
Years since establishment <sup>ns</sup>	0.020	0.014
Corporation <sup>ns</sup>	0.098	0.503
Sole proprietorship <sup>ns</sup>	-0.394	0.505
<b>Annual gross sales:</b>		
Annual sales below \$250,000	NA	
Annual sales \$250,000-\$499,999 <sup>ns</sup>	0.139	0.475
Annual sales \$500,000-\$999,999 <sup>ns</sup>	-0.247	0.705
Annual sales \$1,000,000-\$1,999,999 <sup>ns</sup>	1.001	0.711
Annual sales \$2,000,000 and above <sup>ns</sup>	1.439	1.677
<b>Location:</b>		
Alabama	NA	
Florida <sup>*</sup>	-1.687	0.702
Georgia <sup>ns</sup>	-1.169	1.051
Louisiana <sup>ns</sup>	-0.455	0.546
Mississippi <sup>ns</sup>	-0.907	0.587
North Carolina <sup>ns</sup>	-0.338	0.493
South Carolina <sup>ns</sup>	-0.158	0.606
Tennessee <sup>ns</sup>	0.257	0.696
<b>Recession<sup>*</sup></b>	1.198	0.588
<b>Constant<sup>***</sup></b>	4.396	1.233
No. of observations	163	
F-value <sup>***</sup>	19.640	
R-squared	0.646	
Root MSE	1.680	

**Notes:** NA - not applicable. Used as benchmark variable; <sup>ns</sup> – Not significant; <sup>\*</sup> - Significant at 0.05; <sup>\*\*</sup> - Significant at 0.01; <sup>\*\*\*</sup> - Significant at 0.001.

The OLS results of the combined 2003 and 2008 National Green Industry survey explained 29 percent of the differences in the explanatory variables included in the empirical model Eq. 2, as shown in Table 3. The estimated F-value is also statistically significant ( $F=58.9$ ).

### **3.1 Respondent's Age**

The age of owners or operators in the 2003-09 Southern States Nursery Survey exerted some significant influence on computer use among participating nurseries and greenhouses in the Southern United States (Table 2). Results show that older owners or operators tend to be less engaged in using computers in their operations. The coefficients of the dummy variables representing the age of owners or operators are all negative, but not all are significant. The youngest group, '30-39 years old,' consisted of 6.1% of all the respondents. The largest group of owners or operators were '40-49 years old' with 44.2% of the total number of respondents. The '50-59 years old' added 32.4% while the '60-69 years old' consisted of 11.7%, and the '70 years old and above' comprised 5.6%. The operations which were owned or operated by age groups from '40-49 years old' to '60-69 years old' maintained similar levels of computerization as compared to those owned or managed by '30-39-year-olds'. The '70 years old and above' owners or managers reported significantly lower levels of computerization in their operations.

### **3.2 Respondent's Education**

The level of formal education attained by the respondents of the 2003-09 Southern States Nursery Survey had no significant effect on the number of computer usage among participating nursery and greenhouse operations in the Southern United States (Table 2). Similar observations among managers of agribusinesses in the use of computers in their operations (Baker, 1992; Batte et al., 1990). About 10.4 percent of all the respondents had received high diplomas. Owners or operators with some college but received no degree consisted of 19.4 percent of all the respondents, while 11.9 percent had associate degrees. More than one-half of all the participating owners or operators complete college degrees, and 8.1 percent attained advanced degrees. Regression results indicated that owners or operators with some college, associate, college, or advanced degrees were not significantly more prone to computerize their horticultural operations than those with high school education.

### **3.3 Respondent's Horticulture Experience and Lifestyle Satisfaction**

The horticulture experience and the level of satisfaction with their current lifestyle of the owners or managers of the 2003-09 Southern States Nursery Survey did not have any significant impacts on the firm's decisions to computerize their operations (Table 2). At the time of the interview, the majority (86%) of the respondents stated that they were satisfied or very satisfied with their current lifestyle (Posadas, 2018b). The average horticulture experience in the nursery business was 19.4 years, with ten years standard deviation (Posadas, 2018b). Data from the 2012 Census of Agriculture (USDA, 2019b) showed that 81.9% of principal operators of all types of farming operations have been working on any farm for more than ten years.

### **3.4. Respondent's Perceptions**

The perceptions of the respondents of the 2003-09 Southern States Nursery Survey about the availability of labor for the nursery industry have a significant positive influence on computerizing the operations of participating horticultural firms in eight Southern states (Table

2). During the interviews, 65.7% of the participating owners or operators reported that they expect labor to be available or highly available (Posadas, 2018b).

The perceptions of the respondents of the 2003-09 Southern States Nursery Survey about the availability of capital for the nursery industry did not have any significant effects on the number of computer usage of their operations (Table 2). At the time of the interviews, 71.4% of the respondents expected that long-term capital was available or highly available for the horticulture industry. Also, 72.7% of the survey participants thought that operating capital was available or highly available for their operations (Posadas, 2018b).

### **3.5. Number and Quality of Workers**

The number and quality of workers in the 2003-09 Southern States Nursery Survey had mixed effects on the level of computerization of participating horticultural firms (Table 2). The number of permanent and part-time workers displayed positive, but only the number of part-time workers exerted significant impacts on computerization. The participating horticulture firms employed an average of 5.4 permanent workers and 2.4 part-time workers per operation (Posadas, 2018b).

There were mixed-effects of the number of workers in the combined 2003 and 2008 National Green Industry Survey on computer use. The number of permanent and temporary workers showed positive effects, but only the number of temporary workers had significant influence over computerization (Table 3). The average number of permanent workers significantly increased from 9.8 to 12.8 workers per firm from 2003 to 2008 National Green Industry surveys, respectively. Horticulture firms in the Pacific, Southcentral, and Southeast regions employed more permanent workers averaging 19.9, 12.5, and 13.4 workers per firm, respectively. The number of temporary workers in the 2003 and 2008 National Green Industry Surveys grew from 8.9 to 11.5 workers per firm. The Great Plains, Midwest, and Mountain regions hired significantly more temporary workers than the other regions, averaging 14.8, 15.6, and 13.5 workers per firm, respectively.

The percentage of new workers with horticulture skills in the 2003-09 Southern States Nursery Survey exerted a negative and significant effect on their computerization decisions (Table 2). Respondents reported that 58.4% of the new workers hired possessed basic horticulture skills (Posadas, 2018b).

The percentage of migrant workers to the total number of workers in the 2003-09 Southern States Nursery Survey exhibited a negative and significant influence on decisions involving computerization of operations (Table 2). During peak season, the respondents reported that 58.4% of workers hired were overseas migrant workers (Posadas, 2018b)

### **3.6. Type of Operations**

The type of horticulture operations in the 2003-09 Southern States Nursery Survey did not influence the decisions to computerize operations of participating horticulture firms (Table 2). The types of horticultural operations included in the survey were nursery-only (40.9%), greenhouse-only (24.2%), and mixed-type operations (34.9%).

A higher percentage of annual sales sold in wholesale among horticulture firms surveyed in the 2003 and 2008 National Green Industry Surveys tend to have positive but insignificant influence over the level of computerization (Table 3). The proportion of wholesale to total sales remained constant from 2003 to 2008, averaging 56.1 percent. Horticulture firms located in the Appalachian, Pacific, and Southeast regions tend to sell their products in wholesale terms at 63.5, 63.5, and 71.2 percent, respectively.

**Table 3. Factors Influencing Computer Usage in Nurseries and Greenhouses in the United States**

Independent variable	Coefficient	Robust SE
<b>Type of survey:</b>		
Mailed survey	NA	
Online survey ***	1.504	0.255
<b>Labor characteristics:</b>		
Permanent workers (no) <sup>ns</sup>	0.003	0.003
Part-time workers (no) ***	0.010	0.002
<b>Size of operation:</b>		
Very small operation (< 1 acre)	NA	
Small operation (1 to < 5 acres) <sup>ns</sup>	0.215	0.257
Medium operation (50 to <20 acres) <sup>ns</sup>	0.258	0.264
Large operation (20 acres and above) <sup>ns</sup>	0.358	0.271
<b>Business year:</b>		
Years since establishment *	-0.005	0.002
<b>Annual gross sales:</b>		
Annual sales less than \$250,000	NA	
Annual sales below \$250,000-\$499,999 ***	0.905	0.147
Annual sales \$500,000-\$999,999 ***	1.640	0.158
Annual sales \$1,000,000-\$1,999,999 ***	2.577	0.168
Annual sales \$2,000,000 and above ***	3.038	0.191
<b>Location:</b>		
Appalachian Region	NA	
Great Plains <sup>ns</sup>	-0.243	0.340
Midwest Region <sup>ns</sup>	0.194	0.153
Mountain Region ***	1.954	0.429
Northeast Region <sup>ns</sup>	-0.096	0.149
Pacific Region **	0.472	0.178
Southcentral Region <sup>ns</sup>	0.123	0.215
Southeast Region <sup>ns</sup>	-0.044	0.144
<b>Year of survey</b>		
2003	NA	
2008 **	0.062	0.020
<b>Constant *</b>		
	-121.823	41.067
No. of observations	2879	
F-value ***	58.910	
R-squared	0.292	
Root MSE	2.310	

**Notes:** NA - not applicable. Used as benchmark variable; <sup>ns</sup> – Not significant; \* - Significant at 0.05; \*\* - Significant at 0.01; \*\*\* - Significant at 0.001.

### 3.7. Level of Automation and Acreage

The level of automation of horticultural firms in the 2003-09 Southern States Nursery Survey played a direct and significant influence on decisions involving computerizing operations in the participating horticulture establishments (Table 2). The level of automation shows the extent to which nurseries have currently automated or mechanized the various tasks

involved in the production of horticulture products (Posadas et al., 2008). Among all the participating nurseries and greenhouses, the level of automation averaged 20.3 percent.

The land area under production and the percentage of land under production in the 2003-09 Southern States Nursery Survey did not have any significant influence on decisions involving the use of computers in operations (Table 2). The average horticulture firm used 14.9 acres in production and utilized 60.6 percent of all available land area.

The size of the land area devoted to production reported in the 2003 and 2008 National Green Industry Surveys did not influence the level of computerization among horticulture firms (Table 3). The percent distribution of firms by land size are as follows: very small – 9.5%, small – 33.8%, medium – 26.5%), and large – 30.0%.

### 3.8. Years Since Establishment and Form of Organization

The number of years the participating horticulture business in the 2003-09 Southern States Nursery Survey had been in operation, and the type of business organization did not have any significant impacts on decisions dealing with computerizing operations (Table 2). The average horticulture establishment has been in business for 24.4 years. Corporate firms consisted of 28.9 percent, and sole proprietorship added 55.6 percent to the total number of participants.

The number of years in the business reported by the horticulture firms in the 2003 and 2008 Green Industry Surveys exerted significant negative influence over computerization (Table 3). The horticulture firms surveyed in 2003 and 2008 had been in the same number of years in business at the time of the survey, averaging 24.3 years. Those firms located in the Midwest and Northeast regions, however, were in the business longer at 28.7 and 29.1 years, respectively.

### 3.9. Annual Gross Sales

The decisions to computerize operations among horticulture establishments in the 2003-09 Southern States Nursery Survey did not significantly vary among different annual sales groups (Table 2). More than 55 percent of the horticulture establishments reported annual gross sales below \$250,000 (Fig. 2).

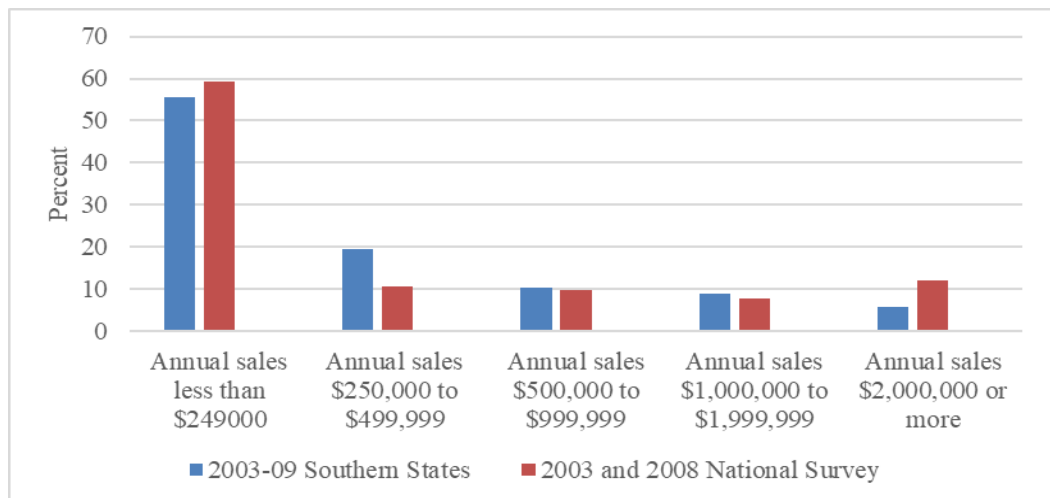


Figure 2. Distribution of Horticulture Firms by Annual Gross Sales

The annual gross sales strongly influenced the level of computerization of horticulture firms which participated in the 2003 and 2008 National Green Industry Surveys. Horticulture businesses with larger annual gross sales maintained significantly higher levels of computerization in their operations (Table 3). Almost 60 percent of the horticulture firms achieved less than \$250,000 annual gross sales (Fig. 2).

### **3.10. Location and Recession**

The state location of horticultural firms in the 2003-09 Southern States Nursery Survey exercised negative but insignificant influence on the decisions dealing with computerizing their operations. Decisions made by horticulture operations located in the state of Florida were negatively influenced and significantly different from the benchmark state, which was Alabama.

The regional location of the horticulture establishments surveyed in 2003 and 2008 showed some significant effects on computerization (Table 3). As compared to the benchmark region, which was the Appalachian, only two regions had higher rates of computerization of the tasks included in the survey, namely the Mountain and Pacific regions. The businesses located in the other five regions did not have any significant differences in the levels of computerization with the base region.

Horticulture firms in the 2003-09 Southern States Nursery Survey interviewed during the recession from Dec. 2007 to Jun. 2009 tend to have significantly enhanced their decisions to computerize their operations (Table 2). About 19 percent of the 215 horticulture firms were interviewed during the recession period.

The level of computerization of the identified tasks was significantly higher in the 2008 National Green Industry Survey as compared to the previous survey conducted in 2003 (Table 3). The 2008 survey asked about activities conducted by the businesses in 2007 and was sent out starting in early 2008 while the 2003 survey collected the data on the previous year's activities conducted by the participating horticultural businesses.

## **4. Summary and Limitations**

There were 215 owners and operators who participated in the 2003-09 regional survey of nurseries and greenhouses in eight Southern States. There were 2,485 horticultural firms with valid responses who participated in the 2003 national survey in 44 states. In 2008, a total of 3,043 valid responses were compiled from the participating horticultural farms from a national survey in 50 states.

The empirical results of the models showed that the socioeconomic characteristics of owners and operators from the eight Southern States have limited influence on the computerization of horticulture operations. It seemed that older owners and operators were less inclined to use computers in their horticultural operations. The level of formal education, horticultural experience, and satisfaction of current lifestyle did not have any significant effects on computerization. The perceptions of the availability of labor to the industry encouraged more use of computers in operations. The perceptions of the availability of capital for the industry did not have any significant effects on computerization. In the 2003 and 2008 national green industry surveys, however, no data on the socioeconomic characteristics of owners and operators were collected.

The number and quality of workers played a significant influence on computerization from both the eight Southern States and the national green industry surveys. The more workers employed by the firms, the higher is the level of computerization reported by these firms.

However, horticulture firms with more new workers with horticulture skills and more migrant workers tend to have a lesser level of computerization of their operations.

The type of horticulture operations exercised mixed influences on the computerization of horticulture operations. Among the nurseries and greenhouses from the eight Southern United States, there were no significant differences in the level of computerization among the nurseries-only, greenhouse-only and mixed greenhouse-nursery operations. Among the horticulture operations with a higher percentage of sales sold wholesale from the 2003 and 2008 national green industry surveys, however, exhibited a slightly higher but insignificant level of computerization.

The level of automation of workers' tasks from horticulture firms in the eight Southern States encouraged the level of computerization of operations. The size of the land area under production in both the regional and national surveys, however, tend to have no significant effects on the level of computerization of operations.

The number of years since the establishment and the form of business organization among the horticulture firms in the eight Southern States did not have any significant influence over the level of computerization. Among the horticulture firms from the 2003 and 2008 national green industry surveys, however, those who have been in business longer tend to have a lesser level of computerization.

The annual gross sales of horticulture firms have significantly influenced the level of computerization among the nurseries and greenhouses from the 2003 and 2008 national green industry surveys. Firms with higher annual gross sales enhanced the level of computerization of their operations. There was no significant influence on computerization among the horticulture firms in the 2003-09 regional survey in eight Southern States.

Finally, the state or regional location of the participating horticultural operations have significant impacts of computerization. The firms located in the Mountain and Pacific regions reported higher level of computerization of their operations. The Great Recession in Dec. 2007 to June 2009 tend to have encouraged the participating firms to improve the computerization of their horticultural operations.

### **Acknowledgment**

This material is based upon work that is supported in part by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project under accession number 1007591. I want to thank Dr. A.W. Hodges and Dr. C.H. Hall for providing the compiled datasets on the 2003 and 2008 national green industry surveys.

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