How Do Sustainability Investments Effect Financial Performance? An Instrumental Variable Approach

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This study investigates the relationship between sustainability investments and financial performance by observing a natural experiment in an industry that is saturated with firms engaging in sustainability practices: agriculture. We analyzed the financial statements of almond farms over a ten-year period to investigate financial outcomes. The findings of this study support a positive, indirect relationship between sustainability investments and financial performance through the significant increase in almond yield across farms and overtime (even when considering the endogenous relationship between investments and financial performance).

Keywords: sustainability, financial measurement, endogeneity, agriculture

INTRODUCTION

The financial impact of corporate investments has been extensively examined in multiple studies and is identified as a key factor in firm strategy. This study acknowledges and analyzes a specific type of investment that has become relevant in firm practice: sustainability investments. The purpose of this paper is to investigate the financial performance outcomes of firm sustainability behavior. Sustainability is a term that is broadly used to account for activities that allow firms to control their environmental footprint or societal impact, both strategically and voluntarily. Recently, sustainability adoption and corporate responsibility have become more prevalent in firm strategy. The 2017 KPMG Survey of Corporate Responsibility Reporting analyzed survey responses from 4,900 mid-size and large corporations globally (including the top 100 companies from 49 countries) and found that 75% of the sample included 'non-financial' corporate responsibility performance rates as part of their annual reports, a percentage that had increased 2 % since 2015 (2017, p.10). This provides evidence that firms are not only engaging in sustainable ventures, they are publishing their efforts as well. Accounting standards have also acknowledged the vast increase in sustainability adoption in firm strategy with the creation of the Sustainability Accounting Standards Board. This generates a natural call for research to investigate the possible outcomes that adoption of these practices can generate, and gain a further understanding of what inspires decision makers to consider strategies that improve their sustainability performance. This paper contributes to the current literature by providing both researchers and practitioners a deeper understanding of the financial effect of investing in a sustainable future.

The sustainability practices investigated in this paper focus on environmental considerations regarding the consumption of natural resources. To operationalize our research questions regarding financial performance outcomes, data from California almond growers was collected in order to analyze firm financial behavior as it relates to the investment in sustainability practices overtime in a natural experiment environment during a time of tremendous uncertainty (i.e. severe drought conditions). From the current literature, there appears to be inconsistent results when analyzing the relationship between sustainability and financial performance. Additionally, very few papers utilize a model that addresses the endogenous relationship between these variables. As such, this study first analyzed the relationship overtime using several financial performance measurements (equation 1) and then, we analyzed the relationship overtime by constructing a model utilizing the instrumental variable method to address endogeneity, omitted variable bias and measurement error (see equations 2 and 3). When building our instrumental variable model, we identified the random variation in rainfall over time and across farms as an appropriate instrument for investments in sustainability. Our results found a positive, indirect relationship between sustainability investments and financial performance through the significant increase in almond yield across farms and overtime (even when applying the instrumental variable method to consider the endogenous relationship between the investment and financial performance). Also, this study suggests that the increase in sustainability investments could be positively related to financial performance one year after the initial investment, but negatively related to financial performance two years after the initial investment (utilizing EBITDA per Acre as the dependent variable measurement), when considering firm fixed affects over time. There was no significant effect between sustainability investments and financial performance when using ROA and ROA-Sustainable Assets as the dependent variable measurement or when utilizing the instrumental variable method. However, these findings provide critical insight into financial statement measurement and suggest that when considering the accumulation of investments overtime, the measurement choice plays a critical role in drawing conclusions as to overall financial performance.

The remainder of the paper is organized as follows. Section II will provide a review of the existing literature as it relates to the agriculture environment as a population and sustainability, Section III identifies our research question and hypothesis, Section IV will discuss the data, Section V will describe the method, Section VI will discuss the results and Section VII will provide our conclusions, limitations, and suggestions for future research.

LITERATURE REVIEW

Agriculture and Almonds

Irrigation is a crucial component to agricultural strategy and irrigation techniques have been widely researched by scholars, mostly focusing on the plant science aspect. Many studies have investigated this relationship for a variety of crops, and almonds are no exception. Northcutt (2014) found that almond trees will respond negatively to over-watering during abundancy periods and under-watering in dryer periods. Thus, incorporating an irrigation plan to not only save water, but to only utilize the exact amount the tree needs is essential. This finding exposed a major vulnerability in California agriculture (as not watering a tree could have severe negative effects for years to come).

There have been several studies in agricultural research that investigate the effects of choosing irrigation systems. Zekri and Parsons (1988) tested water stress levels of grapefruit trees in Florida using three different types of watering systems (drip, undertree microsprinker, and overhead sprinkler) and found that the water stress levels were highest using the drip irrigation. Lamm (2002) highlighted several advantages to drip irrigation such as more efficient water use, higher water quality, water application uniformity, improved plant health, higher crop yield, and improved pesticide management (to name a few). Specifically related to almond trees, Goldhammer, Fereres and Salinas (2003) found that utilizing a system that automatically measures the maximum daily trunk shrinkage (which is an indicator of water shortage, or tree stress) would allow farmers to allocate water to the trees at precisely the moment they become in stress; they found this to be beneficial for yield and overall tree health during periods in which water is scarce. Romero, Botia and Garcia (2004) provided empirical evidence regarding the influence subsurface drip irrigation has on the almond yield and the tree itself. They concluded that utilizing drip irrigation can effectively decrease water consumption up to 50% without causing excessive water stress on the tree (measured by soil water content, predawn leaf water potential, osmotic potential, relative water content and gas exchange rates), which could negatively affect yield. Based on our review of the agriculture literature, the financial performance effect on irrigation adoption has not been fully investigated.

Agriculture: Implementation Challenges & Trade-offs

As previously discussed, there is little scientific debate regarding the relationship between water efficiency and agriculture outputs. This poses the question as to why all farms have not officially adopted sustainable practices. This section identifies and highlights research regarding two major implementation problems that farmers may face: 1) substantial upfront investment and 2) government water allocation.

Substantial Upfront Investment

For a newly established almond farm, it would be logical to incorporate an irrigation friendly system from inception (based on the above plant science literature and from a cost standpoint as well). However, the majority of farms are not newly established. The USDA census data (2012) reported that 82% of U.S. farms have been established for ten years or more. This means that adopting an irrigation friendly system may not only be invasive, but extremely costly. The farms would have to purchase and install the new system, and pay to remove the old system as well. This could create a major financial setback in which the short-term profitability of the irrigation system would be pushed back substantially. Also, when using a flood (or less efficient) type irrigation system, tree roots expand further in the soil. When you reduce the amount of water given to these trees, the roots shrink back to become more concentrated to where the water is dense (Fernandez, et al., 1990). This could create a shortage of production for the period in which the trees are going through the transition of root shrinkage, further effecting the profitability of the irrigation system. As the farms in this study have been established for more than 30 years (and the irrigation friendly systems were installed around year 21), this aspect will be fully investigated and analyzed to understand the effect water efficiency has on financial performance when changing irrigation systems.

In addition to the upfront financial investment, implementing an expensive irrigation friendly system may decrease water use but could increase other costs. Caswell and Zilberman (1986) investigated reasons farms choose one irrigation method over another. Their results showed that while irrigation friendly systems, such as drip or sprinkler technologies, reduce overall water usage, they could potentially increase energy use (causing the investment to be less profitable). In a similar study, Negri and Brooks (1990) determined that the main factors present when farms make irrigation system choices are soil characteristics (high-water holding capacity versus low-water holding capacity) and climate.

Government Water Allocation

It is important to acknowledge that even if you install irrigation friendly systems, without a deep well, there is no guarantee you will have access to water. The California government highly regulates their water appropriation and is known for extraordinarily high transaction costs (Rosegrant and Gazmuri, 1995). The canals and reservoirs are owned by either the Federal Government or the State of California. In both cases, water allocation decisions are primarily based on who registered their land in California first (basically a "first come, first serve" basis) dating all the way back to the 19^{th} century (Zilberman et al., 1994). If one is low on the list, then the odds of getting allocated any water are very slim. There are alternative government resources available for water purchase; specifically, special water districts that have built their own canals and sell water to its farmer members. These special water districts charge a monthly fee to their members based on rainfall and water storage capacity. The problem with these special districts is that they do not always allocate water; thus, farmers are potentially paying the fee for water they will never receive.

Another trade-off (associated with government water allocation) has to do with environmental factors. The primary example is a small fish called 'the Delta Smelt'. This fish resides in the San Joaquin River Delta (an inland river that runs through Northern California) and was identified by the Federal and California State Endangered Species Acts as an endangered species (Bennett, 2005). Because the 'Delta Smelt' has created a habitat in the river, there are environmental restrictions as to how much water can be taken from the Delta River and allocated to farmers and residents (which has created great animosity between the environmentalists and the farmers).

The combination of a severe drought and extensive government water regulations has created a huge barrier to entry in regards to agriculture in California. If you do not own land with a deep well, you have the potential of not being able to buy water from the government (even at extraordinary rates) or be allocated water. This not only puts additional pressure on local farmers, it ups the stakes when it comes to investing in irrigation friendly practices.

Sustainability & Value Creation

Incorporating societal and environmental needs into business strategy has been extensively researched. Many working theories have been successfully linked to performance including Corporate Social Responsibility (Waddock et al. 1997) and Corporate Sustainability (Eccles, Ioannou and Serafeim, 2014). To formally address this relationship, Porter and Kramer (2011) documented the potential benefits for both society and the organization when a socially conscious business strategy is in place (i.e. creating shared value).

Creating shared value (CSV) is a theory developed by Porter and Kramer (2011) which projects the notion that business strategy should incorporate both societal needs and financial performance, but in a way that these two elements are complements, not substitutes. In other words, by finding ways to invest in societal/environmental needs, it can benefit a company financially (i.e. everybody wins). In this theory, there are three main outlets in which organizations have value creation opportunities: reconceiving products and markets, redefining productivity in the value chain, and enabling cluster development. Our study focuses on how the agriculture industry in California has redefined productivity in the value chain by implementing irrigation practices that maximize the efficiency of water use, a precious resource in that geographical region.

Measuring shared value can be a difficult, yet important task. Porter et al. (2011) recognized this dilemma and identified four important ways to address this issue: identify the social issues, identify the business potential, track progress and measure results. The authors went on to provide working examples of these steps in companies such as Coca Cola (youth employment in Brazil), Novo Nordisk (diabetes care), Intel (technology education), and Intercontinental Hotel Groups (water and waste conservation) as evidence that not only does CSV exist, but it works. As an expansion of Porter and Kramer's (2011) theory, Pfitzer, Bockstette, and Stamp (2013) identified five important elements that organizations must address in order to successfully create value: incorporate a social purpose, define the social need, measure shared value, estimate business and societal value, and establish measures and track progress.

There have been limited studies that test the application of 'creating shared value' utilizing firm data. Aravossis and Pavlopoulou (2012) suggested ways of incorporating CSV into eco-friendly Ballast Water Treatment Systems. Spitzeck, H., & Chapman, S. (2012) employed a shared value case study in Brazil and identified successful ways of redesigning productivity in the value chain between a chemical company and an agricultural conglomerate. Yet, empirical evidence supporting the notion of creating shared value is missing in the literature. This paper addresses the gap in the current literature and tests the implications of this modern theory.

Sustainability & Accounting

There is little debate that accountants have a financial expertise that proves useful when quantifying outcomes of business practices, including items such as capital investments or sustainability investments. Ballou et al. (2012) conducted a survey of 178 corporate sustainability officers and found that even though 90% of firms consult with outside parties when investigating in sustainable initiatives, only 15%

utilize an external accountant. Further, their study provided insight into three areas of accounting expertise (risk identification and measurement, financial reporting, and independent review/assurance) that can add value and help firms make informed decisions. As such, there is little surprise that sustainability practices are deemed an important topic in accounting research, with many papers investigating the relationship between corporate sustainability performance and corporate financial performance. Based on our review, there is no clear consensus in the literature regarding the true relationship between these variables as findings range from positive, negative and even neutral. For example, Aupperle et al. (1985) found a negative relationship between corporate social responsibility (CSR) and financial performance by measuring CSR through CEO surveys; their conclusions supported the notion that firms that invest in social responsibility are at a competitive disadvantage than those that do not. Conversely, McWilliams and Siegel (2000) found no relationship between sustainability performance and financial performance due to adjusting for the firm level investment of R&D in their model, a specification they find lacking in other studies. Even though the research does not agree on the direction of the relationship (i.e. positive, negative, neutral), it does appear to be weighted more heavily towards a positive connection. Lu and Taylor (2016) performed a meta-analysis focusing on articles that investigate the relationship between corporate financial performance (CFP) and corporate sustainability performance (CSP). Amongst the 36 articles selected in the study, they found that overall, corporate sustainability performance positively effects corporate financial performance, especially in the long term (even with the inconsistent results among the papers analyzed). Khan, Serafeim, and Yoon (2016) investigated firm investments in sustainability by first classifying sustainability issues into material vs. immaterial issues (based on industry membership) and then analyzing firm performance based on these investments. Their results indicated that firms with high investments in material sustainability issues and low investments in immaterial sustainability issues yielded the best future performance. More specifically (and more relevant to the findings of this paper from an environmental standpoint), firm eco-effectiveness was investigated by Burnett, Skousen, and Wright (2011) by examining the connection between eco-effective management practices and firm value utilizing Fortune 500 firm data. Their findings suggest that firm adoption of eco-effective practices (i.e. decisions aimed at reducing environmental impacts), increases firm value long term.

RESEARCH QUESTION & HYPOTHESIS

The purpose of this paper is to analyze the financial outcomes over time after investing in sustainability. There is not a clear consensus in the literature regarding the relationship between sustainability and financial performance (as highlighted above); however, several researchers have come to the conclusion that that relationship is positive (e.g. Lu and Taylor, 2016; Eccles, Ioannou and Serafeim, 2014). Additionally, the agriculture literature confirms a significant relationship between irrigation and yields (e.g. Romero, Botia and Garcia, 2004; Lamm, 2002). For this research, sustainability investments are accumulated annually (with very few disposals due to long estimated useful lives). As such, we expect to see a positive relationship as sustainability investments increase over time. We offer the following hypothesis:

Hypothesis: *The more a firm's investment in sustainability increases over time, the more the firm's financial performance increases*

DATA & MEASURES

Data

The data for our study was collected from almond farms, all located in the central valley of California, a state that is plagued with inconsistent weather patterns and relies on water for both citizen consumption and agriculture. The U.S. Geological Survey reported that in 2014, 80% of California's water consumption was allocated to agriculture. This figure is not surprising given that two-thirds of the

United States fruit and nuts and one-third of the vegetables are all grown in California (Westland's Water District 2014 Fact Sheet). More specifically, according to the United State Department of Agriculture (USDA) and the National Agriculture Statistics Survey's (NASS), almonds are the number one agricultural commodity produced in California having over 1.9 billion pounds of almonds shipped in 2014 (almost double that of shipments from 2007). This equates to California providing roughly 80% of the foreign supply and almost 100% of the domestic supply (with the vast majority of almond trees growing in the Westland's Water District located in the Central Valley of California).

The data in this experiment was derived from seven almond farms all located in the central valley of California from 2005 – 2015, an area named the "bread basket of the world" for high agriculture output. This was also an area that has been considered "ground zero" as it relates to water allocation (see Appendix Figure H). For each year included in the study, we collected all financial information and relevant non-financial data (i.e. precipitation rates, water usage, yield). See Table 1 below for descriptive statistics, which highlight how different each firm is within the dataset as there is large variation within the variables. EBITDA, sustainability investment, pounds generated, and water used were all normalized in the table below by a 'per acre' amount in order to control for firm size.

TABLE 1
DESCRIPTIVE STATISTICS

	Mean	Standard Deviation	Observations
Dependent Variable			
Financial Performance Measures (2005 - 2015)			
ROA	1.25	1.37	77
ROA - Sustainable Assets	2.19	3.25	77
EBITDA per Acre	2,607	2,235	77
Independent Variable			
Sustainability Investment Measures (2005 - 2015)			
Sustainability Investment per Acre	1,768	1,542	77
Sustainability Investment per Acre, time t - 1	2,034	1,559	70
Sustainability Investment per Acre, time t - 2	2,218	1,531	63
Sustainability Investment per Acre, time t - 3	2,442	1,470	56
Instrument			
Rainfall Measures (2005 - 2015)			
Annual Rainfall	5.80	2.56	77
Annual Rainfall, time t -1	5.60	2.51	70
Annual Rainfall, time t -2	5.49	2.61	63
Annual Rainfall, time t -3	5.72	2.67	56
Control Variables			
Firm Characteristics (2005 - 2015)			
Pounds per Acre	2,247	541	77
Water per Acre	3.97	.20	77

Note. Population for financial performance measures, sustainability investment measures, and firm characteristics were collected from farm data provided by seven individual almond farms (June 29, 2017). Rainfall data was collected from measurements recorded by land based stations in the direct vicinity of the farm and published by the National Climate Center Database retrieved from http://www.ncdc.noaa.gov/cag/ (September 29, 2016).

Measures

The dependent variable of financial performance was measured utilizing a variety of accounting-based measures to fully grasp the financial outcomes of sustainability and give insight into the application of the various financial statement measurement tools. These measures included: return on assets (ROA), return on assets only for assets labeled as 'sustainable assets' (ROA – Sustainable Assets), and earnings before interest, taxes, depreciation and amortization (EBITDA). The measures were chosen in order to compare financial outcomes when utilizing a ratio analysis and an income statement analysis. EBITDA was normalized 'per acre' to account and adjust for firm size.

The sustainability investments were measured by calculating the sustainability investment per acre per year. These investments were identified using the cost principle followed by US GAAP for all assets that met the definition of "sustainable agriculture" as defined by the Food, Agriculture, Conservation, and Trade Act of 1990:

> An integrated system of plant and animal production practices having a site-specific application that will, over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole. (p. 347-348)

To test the validity of our measure, we assessed water usage and water costs for all years in the dataset to ensure these systems are, in fact, saving water and meet this definition. Water usage was tracked and calculated through GPS software (measured in acre-feet) and sustainability was assessed by water usage levels per crop year (per acre-feet). Almond output (yield) for each year was measured in pounds purchased by the United States Department of Agriculture (USDA). Utilizing this calculation, quality was automatically controlled for as the data incorporates only the almonds that were up to the quality requirements for purchase by the USDA.

Rainfall for this region was measured using the monthly rainfall totals collected by the National Climate Data Center database, which is compiled and published by the National Oceanic and Atmosphere Administration (NOAA). As a sensitivity analysis, this instrument was tested utilizing current rainfall levels and lagged rainfall levels (with a one-year lag, two-year lag and three-year lag) to fully incorporate and analyze the influence rainfall had on the timing of sustainability.

METHODOLOGY

To test our research questions, we used the context of a natural experiment to analyze the relationship between sustainability investments and financial. This natural experiment was observed in an environment where the treatment of the independent variable (i.e. sustainability investments) was not completely randomized and a fully controlled environment was not feasible. Amongst the farms in this sample, there is significant variation in key variables (including financial performance measures and sustainability investments) not only over time, but across farms as well. This variation is depicted in the Appendix (Figures A, B, C, and D) for all performance measures and sustainability investment per acre.

For the purpose of our model, we incorporate a time lag (t, t-1, t-2, and t-3) for the investment in sustainability per acre to acknowledge a potential delay in the effect of financial performance. See Table 2 for a summary of these variables, how they are measured, and the expected relationship.

TABLE 2
VARIABLE SUMMARY

Variable	Measures	Expected Relationship
Dependent Variable		
PERFORMANCE	Return on Assets (ROA)	
	Return on Sustainability Assets (ROA-Sustainable Assets)	
	EBITDA per Acre	
Independent Variable		
SUSTAINit	Sustainability Investment per Acre	Positive
SUSTAINit-1	Lag Sustainability Investment per Acre, 1 Year	Positive
SUSTAINit-2	Lag Sustainability Investment per Acre, 2 Years	Positive
SUSTAINit-3	Lag Sustainability Investment per Acre, 3 Years	Positive
Instrumental Variable		
R it	Rainfall (in inches)	
R it-1	Lag Rainfall, 1 year (in inches)	
R it-2	Lag Rainfall, 2 years (in inches)	
R it-3	Lag Rainfall, 3 years (in inches)	
Control Variables		
POUNDSit	Yield (in pounds) per Acre	
WATERit	Water (in gallons) Used per Acre	

Note. Population for the dependent variable, independent variable and control variables were collected from farm data provided by seven individual almond farms (June 29, 2017). Rainfall data was collected from measurements recorded by land based stations in the direct vicinity of the farm and published by the National Climate Center Database retrieved from http://www.ncdc.noaa.gov/cag/ (September 29, 2016).

Our model was constructed with the focus on the financial performance of firm *i* in year *t* (*PERFORMANCE*), while considering within firm variation over time. EBITDA, sustainability investment, pounds, and water used were normalized to incorporate farm size (i.e. measured in 'per acre' increments) and we chose to measure financial performance utilizing three alternative financial calculations to understand the full picture of how sustainability is effecting farms in different ways. The first used the traditional method of Return on Assets to include, at a high level, how well all assets are performing. Our second method only included those assets that have been identified as 'sustainable assets' in order to isolate how the sustainable investment is effecting net income. More specifically, examples of these assets include the following: installation and equipment for drip irrigation systems, flow meters, moisture probes, pipelines and technology hardware/software for tracking water usage. The last method (Earnings Before Interest Taxes Depreciation Amortization per Acre), focused on the operational aspect of how these investments are effecting the financial performance of the farms and adjusts for how the investment is being financed, depreciated, or how much tax each entity pays (which all can vary significantly depending on the structure of each farm).

The independent variable identified is sustainability investments. This variable was measured using the total sustainable assets listed on the balance sheet of each given year (and normalized by calculating the 'per acre' amount for each year). Most of these farms begin investing in sustainability around year 3 (i.e. 2008) and the majority of these assets carry a minimum useful life of 10 years; thus, this number steadily increases over time with very few disposals present in the timeframe of our study. As the independent variable was measured using the capitalized amount on the balance sheet, it should be noted that this does not include repairs, maintenance or any other ongoing expenses incurred relating to these sustainable assets. Those particular expenses directly impact financial performance through net income in any given year. Also, it was important to acknowledge a potential delay in the financial performance effect as the costs to maintain the equipment would potentially be incurred as expenses in year 2 or 3 (as a reduction to income on the income statement). Thus, we measured sustainability investments incorporating a lag of one, two and three years and included EBITDA as a financial performance measure to analyze these effects. We also included both yield (in pounds per acre) and water used as control variables (see Appendix Figure E and F for the variation of these variables over time) and incorporated firm fixed effects and year indicators.

To test our hypothesis, we utilized the following model:

$$PERFORMANCE_{it} = \beta_0 + \beta_1 SUSTAIN_{it} + \beta_2 SUSTAIN_{it-1} + \beta_3 SUSTAIN_{it-2} + \beta_4 SUSTAIN_{it-3} + \beta_5 POUNDS_{it} + \beta_6 WATER_{it} + d_i + year_t + \varepsilon_{it} \quad (1)$$

To test this relationship further, we created a model using the instrumental variable estimation method to address the endogenous relationship between sustainability investments and financial performance and attempt to isolate this variable as the sole cause of financial performance fluctuations. This method was computed using a two-stage least squares regression where the relationship between the instrument and the independent variable is established in the first stage, and the fitted value from stage one is then analyzed to establish the relationship with the dependent variable in the second stage. The instrument we identify in this study is the variation in rainfall across farms and over time. As displayed in Table 2, we included a time lag for rainfall as it would be logical that rainfall of prior years could affect sustainability behavior in future years. We include a time lag for up to three years to analyze the full depiction of this instrument during the first stage of this method. Although all farms in this study are located within a 70-mile radius of each other, we were able to observe slight variation in rainfall across farms. This is not the first paper to analyze rainfall as an instrumental variable as a predictor for behavior. Miguel, Satyanath and Sergenti (2004) successfully estimated the effect of economic conditions on civil conflict utilizing rainfall as an instrument for economic growth. The model in this paper is adapted from their approach as it has been validated in other research contexts (e.g. Sovey and Green 2011 where it was used to offer application standards for instrumental variables, specifically for political science research).

The model of the first stage test (to deem rainfall as a suitable instrument for sustainability investments) is as follows:

$$SUSTAIN_{it} = \beta_0 + \beta_1 POUNDS_{it} + \beta_2 WATER_{it} + \beta_3 R_{it} + \beta_4 R_{it-1} + \beta_5 R_{it-2} + \beta_6 R_{it-3} + d_i + year_t + \varepsilon_{it} \quad (2)$$

For the second stage of this estimation method, we utilized the fitted value calculated in stage one to analyze the effect sustainability investments had on financial performance through the variation in rainfall over time and across firms as an instrument. The model of the second stage is as follows:

$$PERFORMANCE_{it} = \gamma_{2,0} SUSTAIN^*_{it} + \gamma_{2,1} SUSTAIN^*_{it-1} + \gamma_{2,2} SUSTAIN^*_{it-2} + \gamma_{2,3} SUSTAIN^*_{it-3} + \beta_7 POUNDS_{it} + \beta_8 WATER_{it} + d_{2i} + year_{2t} + \varepsilon_{2it} \quad (3)$$

Both regressions above include firm fixed effects and year indicators. When applying this method, it was important to choose an appropriate instrument, which means that it needed to be correlated with the explanatory variable, but not correlated with the dependent variable, or the error term. Rainfall was a suitable candidate to use as an instrument for sustainability investments as it had been randomly observed in each period for each farm, and it would be logical that the variation in rainfall would affect the decision to invest in sustainability. To solidify our instrument choice, rainfall should be significantly correlated to sustainability while showing no direct effect on financial performance. Also, from a theoretical perspective, rainfall made sense. Almond trees can only absorb as much water as the tree will allow, which means identifying the optimal amount of water the tree needs is key (the premise behind these irrigation efficient systems). Thus, weather shocks in these farms would have a short term effect on well and groundwater, but no direct effect on financial performance for a given crop year (i.e. in a wet year, the excess water goes back into the ground or into wells and in a dry year they would utilize their own well water first creating no short term financial performance effects).

To fully support our use of rainfall as an appropriate instrument (and address concerns of an omitted variable bias or correlation with the error term), we performed the ordinary least squares regression on financial performance (dependent variable), rainfall (instrument) and sustainability investment (endogenous variable). This addressed the main concerns with utilizing instruments and provided evidence our estimates are unbiased. Further, to test the strength of our instrument, we added future rainfall as an explanatory variable in a separate regression as an identification check to ensure it is in fact, statistically independent to financial performance (where the coefficient estimate is near zero).

It would be a logical argument that utilizing rainfall as an instrument for sustainability could violate the exclusion restriction in that the weather shocks could be directly affecting financial performance independently of the sustainability investment (as more rain could lead to better financial performance even if the farms are not investing in sustainability). This valid concern is addressed in this this estimation method in the first stage of the ordinary least squares regression in that there was no direct effect found between rainfall and financial performance.

It is a plausible argument that weather shocks in California play a key role in the motivation behind the investments in sustainability, especially in a region highly reliant on agriculture. It is important to note this identification strategy may not be appropriate for other regions that are also heavily engaged in agriculture. The severity of weather swings in California have highlighted the need for sustainability, but may not prove to be an appropriate instrument in regions where rainfall is more uniform and the weather shocks are less extreme or less common. As the California almond industry dominates the competitive market both nationally and internationally (as discussed earlier), this concern is less of an issue as we are using data from a region that would be representative of a significant portion of the population.

RESULTS

Hypothesis Test

We ran regression (1) to assess the relationship between sustainability investments and financial performance utilizing all three financial performance measurements and found mixed results. When using ROA and ROA-sustainable assets, we could not confirm a significant relationship between financial performance and sustainability investments, even when lagging the independent variable up to three years. However, when measured using EBITDA per acre, sustainability per acre at t, and t-1 was found to be positively related to financial performance at the 95% confidence level (see Table 4, regressions 11, 12 and 15). Additionally, we found a negative relationship (at the 90% confidence level) between sustainability per acre at *t*-2 when utilizing EBITDA per Acre (see Table 4, regression 15). This finding suggests that farms may see a positive increase in financial performance in the initial year and one year after the investment in sustainability, but then experience a potential decrease in financial performance two years after the investment (when not considering interest, taxes or depreciation, these investments). It should be further noted that the results in Table 4, regression 15 estimate that one year after the investment, for every dollar invested in sustainability per acre, farms experience an increase in EBITDA per acre of approximately \$.38, and then lose approximately -\$.28 two years after the investment. This result estimates that overall, even with a potential decrease in EBITDA in year two, the farms are experiencing an increase in financial performance as it relates to sustainability per acre.

Our findings also support a positive relationship between almond yield and financial performance at the 95% confidence level when utilizing ROA and EBITDA per Acre as financial performance measures

(See Table 4, regressions 1, 2, 3, 4, 5, 11, 12, 13, 14 and 15). This confirms an indirect relationship between sustainability investments and financial performance and provides the logical conclusion that the increase in almond yield has a positive effect on financial performance.

These findings provided some surprising insight into the relationship between financial performance and water usage. In regressions 4, 5, 13, 14 and 15 (see Table 4), water usage per acre was found to be positively related to financial performance (at the 95% confidence level), which is when sustainability is measured 2 and 3 years after the initial investment. As this study confirms that overall water usage per acre has decreased overtime and across farms (as displayed in Table 4 and Appendix Figure F), this finding suggests two critical conclusions. First, water sustainability is focused around utilizing the amount of water that is most efficient for the tree to grow (not to reduce water to absolute minimum levels). This positive relationship being confirmed during year 2 and 3 after incorporating a sustainable irrigation system provides evidence that water is first reduced and then slowly increased over time to find the correct and most efficient amount of water. Secondly, this highlights the effect severe drought periods have on how much water needs to be used in order to compensate for a lack of rainfall. This finding suggests that there is an increase in financial performance, even though they need to use more water.

TABLE 4
SUSTAINABILITY INVESTMENTS AND FINANCIAL PERFORMANCE DEPENDENY VARIABLE: FINANCIAL PERFORMANCE

	Dependent Variable														
	ROA	ROA	ROA	ROA	ROA	ROA - Sustainable Assets	ROA - Sustainable Assets	ROA - Sustainable Assets	ROA - Sustainable Assets	ROA - Sustainable Assets	EBITDA	EBITDA	EBITDA	EBITDA	EBITDA
Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Sustainability Investment Measures (2005 - 2015)															
Sustainability Investment Per Acre	0.0000				-.0001	-.0003				-.0002	.3250**				-.1948
	(.0000)				(.0001)	(.0003)				(.0005)	(.1530)				(.1484)
Sustainability Investment Per Acre, time t - 1		.00001			.00010		-.0003			-.0003		.3113*			.3803**
		(.0001)			(.0001)		(.0003)			(.0006)		(.1705)			(.1633)
Sustainability Investment Per Acre, time t - 2			-.0000		-.0001			-.0004		.0001			-.0394		-.2820*
			(.0001)		(.0001)			(.0003)		(.0005)			(.1165)		(.1472)
Sustainability Investment Per Acre, time t - 3				-.0000	.0000				-.0007	-.0005				-.0948	-.0178
				(.0001)	(.0001)				(.0004)	(.0005)				(.1310)	(.1443)
Control Variables															
Firm Characteristics (2005 - 2015)															
Pounds Per Acre	.0009***	.0008***	.0009***	.0008***	.0009***	.0013*	.0012	.0011	.0013	.0015	2.3798***	2.2260***	2.1757***	1.9224***	1.912***
	(.0002)	(0.0002)	(.0002)	(.0002)	(.0002)	(.0007)	(.0008)	(.0009)	(.0010)	(.0010)	(.4512)	(.4479	(.2963)	(.2881)	(.2840)
Water Per Acre	0.4844	0.6616	0.8417*	.9647**	0.8919**	1.523	1.410	1.5294	1.2536	0.5292	1562.22	1757.73	1617.34**	1731.55***	1950.34***
	(.5467)	(.5473)	(.3650)	(.3903)	(.4082)	(1.7447)	(1.9431)	(2.0384)	(2.1547)	(2.310)	(1091.26)	(1121.65)	(708.02)	(638.24)	(839.166)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R square	0.2870	0.1682	0.3292	0.3146	0.3771	0..2504	0.2300	0.2213	0.2624	0.2823	0.3855	0.3362	0.5460	0.5263	0.5735
Root Mean Square Error	0.7899	0.482	0.4963	0.5197	0.5173	2.5208	2.6562	2.7720	2.8693	2.9275	1576.70	1533.32	962.80	849.93	813.42
Observations	77	70	63	56	56	77	70	63	56	56	77	70	63	56	56

**p-value* < .10
***p-value* < .05
****p-value* < .0

Note. Population for financial performance measures (ROA, ROA-Sustainability and EBITDA), sustainability investment measures, and firm characteristics were collected from farm data provided by seven individual almond farms (June 29, 2017).

To test this relationship further, we ran our second model using the instrumental variable method which was designed to address the endogenous relationship between financial performance and sustainability investments. In the first stage of our estimation method (see regression 2), we aimed to determine whether the variation in rainfall was an appropriate instrument for sustainability per acre and we analyzed this on several levels. We lagged the rainfall measurements for up to three years to determine which resulted in the best fit. We found that the relationship between sustainability per acre and rainfall is strongly negative when considering a rainfall at time *t*-3 at over 95% confidence (Table 5, regression 4 and 5). The strength of this relationship is further supported with the inclusion of firm fixed effects. The geographical region in the study has gone through severe drought periods and our results show that as rainfall has decreased, there is a lag of three years before it effects sustainability investments per acre. Additionally, the relationship between sustainability investment per acre and water used per acre is significantly negative at over the 99% confidence level in all regressions (Table 5, Regression 1, 2, 3, 4 and 5). This provides support for the notion that as a farm's water usage decreases over time, the more the farm's sustainability investment increases. We also further confirmed a positive relationship between sustainability per acre and pounds per acre (yield) at over a 99% confidence level for within-firm variation over time (Table 5, regression 1, 2 and 3). As yields are improving, sustainability investments are also increasing, even when considering rainfall at time *t, t-1* and *t-2*. As the results support a significant relationship at the 95% confidence level between sustainability per acre at *t* and rainfall at *t-3* (see Table 5, regressions 4 and 5), we utilized the measurement of rainfall at *t-3* for the fitted value for stage 2.

TABLE 5
RAINFALL AND SUSTAINABILITY INVESTMENTS (FIRST-STAGE)
DEPENDENT VARIABLE: SUSTAINABILITY INVESTMENT PER ACRE, *T*

	Ordinary Lease Squares				
	Sustainability Per Acre, *t*	**Sustainability Per Acre, *t***	**Sustainability Per Acre, *t***	**Sustainability Per Acre, *t***	**Sustainability Per Acre, *t***
Explanatory Variable	(1)	(2)	(3)	(4)	(5)
Rainfall	-33.40				-93.98
	(59.38)				(86.57)
Rainfall, time t -1		63.23			4.55
		(70.13)			(72.29)
Rainfall, time t -2			15.49		26.18
			(62.39)		(62.22)
Rainfall, time t -3				-127.09**	-187.16**
				(61.32)	(83.65)
Pounds Per Acre	.60*	.79*	.65*	.25	0.14
	(.36)	(.41)	(.38)	(.40)	(.50)
Water Per Acre	-1,770.17**	-1,940.64**	-2,011.19**	-2,074.26**	-2,139.29**
	(843.59)	(878.27)	(942.82)	(926.87)	(946.99)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Time Trend	Yes	Yes	Yes	Yes	Yes
R square	0.11	0.10	0.10	0.12	0.15
Observations	77	70	63	56	56

**p-value* < *.10*
***p-value* < *.05*
****p-value* < *.01*

Note. Population for sustainability investment measures, and firm characteristics were collected from farm data provided by seven individual almond farms (June 29, 2017). Rainfall data was collected from measurements recorded by land based stations in the direct vicinity of the farm and published by the National Climate Center Database retrieved from http://www.ncdc.noaa.gov/cag/ (September 29, 2016).

In the second stage, we assessed the relationship between financial performance and the fitted value found in stage one (Table 5, Regression 4) utilizing all three financial performance measures as dependent variables (ROA, ROA-Sustainable Assets, EBITDA Per Acre). The only relationship that could be confirmed is the positive effect pounds per acre have on financial performance (as shown in Table 6), when it is measured utilizing ROA and EBITDA per acre (at the 99% confidence level).

TABLE 6
RAINFALL AND FINANCIAL PERFORMANCE (REDUCED-FORM)

	Dependent Variable		
	ROA	**ROA -Sustainable Assets**	**EBITDA Per Acre**
Explanatory Variable	(1)	(2)	(3)
Estimated Investment in Sustainability per Acre	-0.0002	-0.0013	-0.0026
	(.0002)	(.0012)	0.3578
Pounds Per Acre	.0009***	.0020	1.6921***
	(.0002)	(.0011)	(.3264)
Water Per Acre	0.5507	-0.5966	1655.20*
	(.5702)	(3.22)	(999.02)
Firm Fixed Effects	Yes	Yes	Yes
Firm Time Trend	Yes	Yes	Yes
R square	0.8084	0.3805	0.6905
Root Mean Square Error	0.5038	2.8415	763.54
Observations	56	56	56

**p-value < .10*
***p-value < .05*
****p-value < .01*

Note. Population for financial performance measures (ROA, ROA-Sustainability and EBITDA), sustainability investment measures, and firm characteristics were collected from farm data provided by seven individual almond farms (June 29, 2017). Rainfall data was collected from measurements recorded by land based stations in the direct vicinity of the farm and published by the National Climate Center Database retrieved from http://www.ncdc.noaa.gov/cag/ (September 29, 2016).

Additional Analysis – Financial Performance Measures

To provide even further insight into financial statement performance measures (and take advantage of this unique dataset), we deemed it appropriate to test Model 1 utilizing several other calculations for financial performance. This additional analysis supplements our current results and provides a better understanding of matters to consider when accountants assist their clients in evaluating business processes. The additional measures included the following calculations: ‘EBITDA/Average Assets’, ‘EBITDA/Sustainable Assets’, ‘EBIT per Acre’, ‘EBIT/Average Assets’, and ‘EBIT/Sustainable Assets’.

The measures were chosen with the intent of isolating the relationship between income statement outcomes in relation to total assets and sustainable assets over time and consider the effect depreciation expense has on determining overall profitability of these expensive investments.

The results using the additional measures supported the positive relationship between financial performance and pounds per acre already established in the current results (see Table 4 above) utilizing EBIT per acre, EBITDA/Average Assets, and EBIT/Average Assets. When only using sustainable assets in the ratio calculations, the results were primarily not supported which is also consistent with our findings in Table 4. However, the relationship between sustainability investment per acre and EBIT per acre provided a different perspective of how depreciation expense effects the measurement of financial performance. As discussed above, a positive relationship between sustainability per acre and EBITDA per acre was confirmed at t and t-1, while a negative relationship was confirmed at t-2. When using EBIT per acre, a negative relationship was found in the initial year of the investment (at the 95% confidence level) and a positive relationship one year after the investment at the 95% confidence level (see Table 7, Regression 5). The negative relationship between EBIT per acre and sustainability at *t* makes logical sense with the initial depreciation that is incorporated in the measure. More specifically, for every dollar they have invested in sustainability per acre, the findings support a loss of approximately -$.39 in the first year, and an increase of $.40 one year later. This suggests that while the initial investment may cause financial performance to decrease (primarily through depreciation expense as supported when compared to the findings utilizing EBITDA per acre), there could be an immediate increase the following year. It should be noted that all farms in this study utilize the straight-line method of deprecation, which make these results more compelling. As depreciation expense is recorded equally over the assets' useful life (varying from 10 – 15 years), this indicates that while this expense negatively effects financial performance in the initial year of the asset, there is a positive relationship between sustainability per acre and EBIT per acre one year after the purchase (even when considering the same depreciation expense).

TABLE 7
SUSTAINABILITY INVESTMENTS AND FINANCIAL PERFORMANCE
DEPENDENT VARIABLE: EBIT per ACRE, *t*

	Dependent Variable				
	EBIT per Acre	EBIT per Acre	EBIT per Acre	EBIT per Acre	EBIT per Acre
Explanatory Variable	(1)	(2)	(3)	(4)	(5)
Sustainability per Acre, time t	0.2066				-.3865**
	(.1585)				(.1559)
Sustainability per Acre, time t -1		.2276			.3985**
		(.1743)			(.1716)
Sustainability per Acre, time t -2			-.0932		-.2390
			(.1225)		(.1547)
Sustainability per Acre, time t -3				-.1195	-.0094
				(.1418)	(.1515)
Pounds Per Acre	2.28***	2.06***	1.99***	1.68***	1.76***
	(0.47)	(0.31)	(0.31)	(0.31)	(.30)
Water Per Acre	1,150.02	1,385.02	1,325.73	1,469.49	1,5522.03
	(1,130.93)	(1,146.38)	(744.40)	(690.46)	(674.37)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Time Trend	Yes	Yes	Yes	Yes	Yes
R square	0.3576	0.3002	0.5042	0.4640	0.5520
Observations	77	70	63	56	56

**p-value < .10*
***p-value < .05*
****p-value < .01*

Note. Population for sustainability investment measures, and firm characteristics were collected from farm data provided by seven individual almond farms (June 29, 2017).

CONCLUSIONS, LIMITATIONS & FUTURE RESEARCH

We are able to draw conclusions regarding the relationships in our model. In the first stage of our model, we found that water used per acre has gone down tremendously during the timeframe in our sample. It appears to portray the notion that farming in the central valley of California has acknowledged the scarcity of this resource and has taken critical steps in order to reduce the amount of water they use when growing almonds. Additionally, given the severity of drought periods and inconsistent weather patterns in California (more specifically, six of the ten-year period in this study were designated as drought periods by the state), there could be policy implications that are also influencing how much water is being used per farm (including farm transparency reporting, maximum water usage rates, forced fallow lands, etc.).

Although our results relating to the causal relationship between sustainability and financial performance were inconclusive when only considering firm fixed effects (as opposed to fully adjusting for endogeneity using an instrument), we were able to propose a model that provides insight into this relationship (see Model 1) and provide key insight into financial performance measures that should be considered when assessing profitability of assets. The results of this model found that one year after investing in sustainability, firms may see an increase financial performance (measured using EBITDA), and a decrease in financial performance two years after investing in sustainable assets (measured using EBITDA). It appears as though there is an initial financial benefit, once you invest in sustainability, mostly explained by initial water savings and improved yields. The negative relationship in year 2 provides insight into the extensive maintenance of these expensive systems.

There are several limitations of this study that should be highlighted. The first, and most critical, is the sample size. The sample size affects the statistical power of the hypothesis test. The dataset consisted of seven farms over a ten-year period which created a small number of observations. Further, it was appropriate to lag variables in this study (specifically rainfall and sustainability investments) which further contributed to our sampling problem by reducing the number of observations. The limited sample and restricted power make it challenging to detect the hypothesized effect. Another key limitation in this study was the geographic location of these farms. As mentioned earlier, these farms lie within a 70-mile radius of each other, which makes the variation in rainfall slight and hard to observe. We believe that this study in a different region could have drawn more conclusive results. Specifically, expanding this study to include farms in a country like Spain (the second leading almond producer in the world) would give a better environment for the use of rainfall as an instrument as they do not have the water shortage California faces and the argument that rainfall has no direct effect on financial performance would be stronger.

This paper contributes to the very important discussion of sustainability and encourages future research to continue to investigate various aspects of this fascinating topic. Additionally, this paper examines the sustainability investment as a dollar amount spent in a given year during the early adoption period for these farms. Future research could focus on the timing related to sustainable technology adoption and analyze financial performance focusing specifically on expenses incurred related only to sustainable technology (i.e. the investment itself, maintenance, repairs, monitoring, etc.) during a period where firms are fully invested and fully operational sustainability wise (i.e. installed, running, employees trained, etc.).

The farms in our population ranged in size dramatically. This poses the question of whether the size of the farm plays a role in determining the strength of the effect that investing in sustainability has on financial performance. As an extension to this idea, future research could consider firm size as a potential moderator between sustainability investment and financial performance.

For this study, the financial performance measures used were ROA, ROA for sustainable assets and EBITDA. The intent was to gain an understanding of the financial performance from a high level (i.e. ROA), a more specific level (i.e. ROA only for sustainable assets) and from an annual net income level (i.e. EBITDA). It should be acknowledged that when using ROA and ROA for sustainable assets, the inclusion of interest and depreciation in the financial performance measurements could potentially be masking the true financial performance of these systems. For example, for a firm that doesn't require financing, their financial performance would appear to be higher than a firm that is paying interest on a loan for these expensive sustainable assets (thus making the asset appearing to be less profitable when calculating ROA). Also, there are tax implications in the year of installation and purchase (which can vary depending on the type of entity) and there could be tax motivations that were not mentioned in this paper that make adoption of these systems more attractive. This makes EBITDA the most useful measure in this study as it removes the effect of tax and depreciation to get closer to isolating the financial performance based on the operational aspect of sustainability. It should be acknowledged that EBITDA is also flawed as it does not account for the level of water reliance that varies across all farms. Farms that have deep wells operate at an advantage when it comes to financial performance as they do not need to purchase water at very expensive rates during drought periods. In this case, farms that rely heavily on natural rainfall and water district allocation could potentially see a bigger effect to their financial performance when sustainable assets are installed, as water expenses should decrease dramatically as compared to farms that were using their own water to irrigate their land. Future studies could analyze the various financial measurements to indicate the strength of these measures in order to identify the most appropriate tool to measure the financial performance variable. Additionally, there could be non-financial measures that could be investigated to see how sustainability effects operational efficiency (i.e. employee morale, job satisfaction, retention rates etc.).

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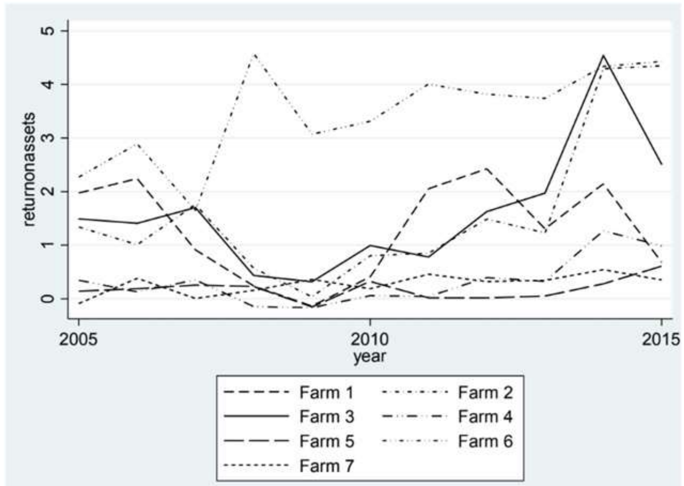
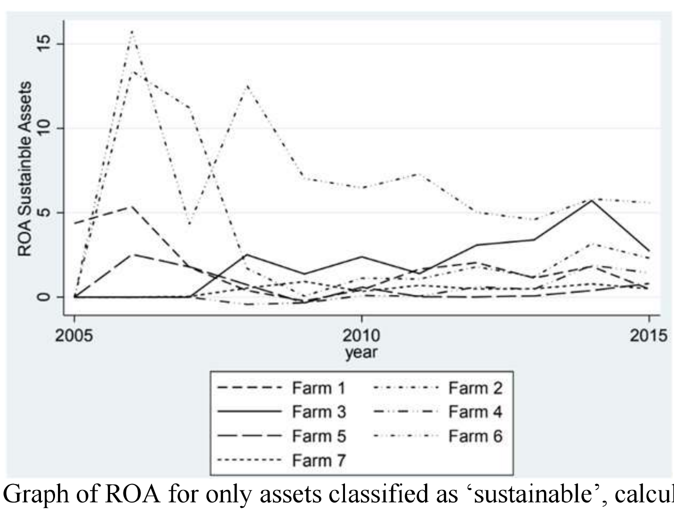
APPENDIX

FIGURE 1
RETURN ON ASSETS BY FARM (2005 – 2015)



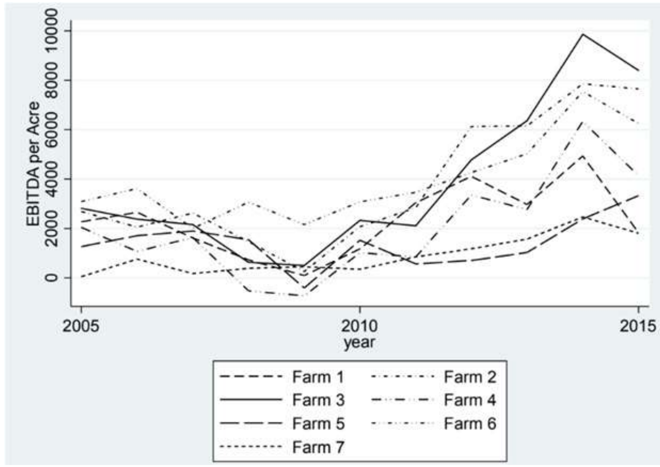
Graph of ROA calculated per farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved.

FIGURE 2
RETURN ON SUSTAINABLE ASSETS BY FARM (2005 – 2015)



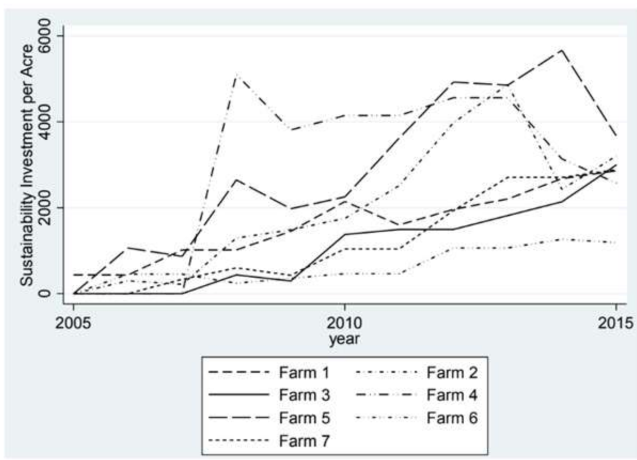
Graph of ROA for only assets classified as 'sustainable', calculated per farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved.

FIGURE 3
EBITDA PER ACRE BY FARM (2005 – 2015)



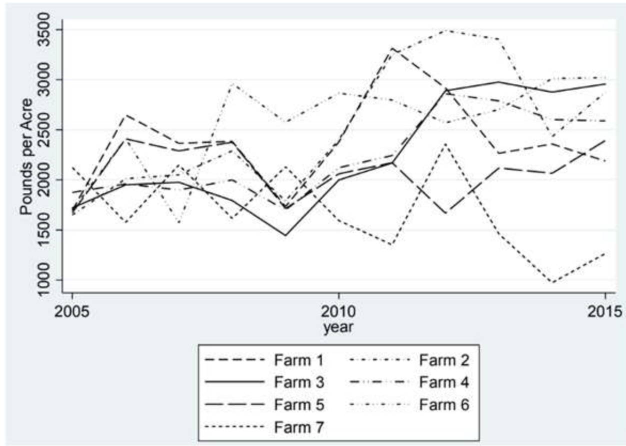
Graph of EBITDA per acre for each farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved.

FIGURE 4
SUSTAINABILITY INVESTMENT PER ACRE BY FARM (2005 – 2015)



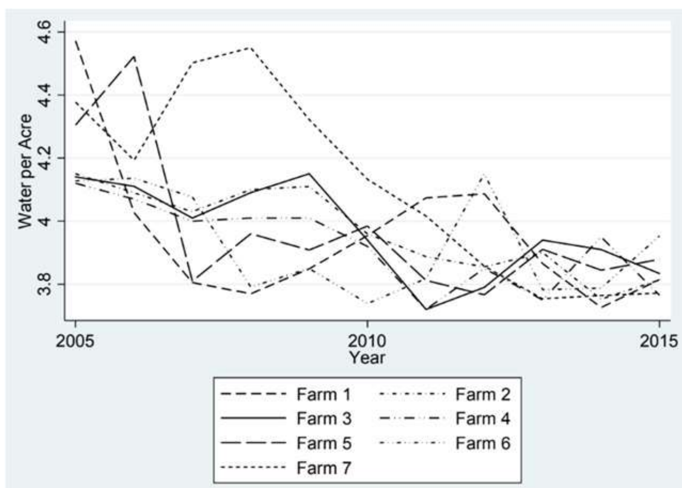
Graph of total assets classified as 'sustainable', per acre for each farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved

FIGURE 5
POUNDS PER ACRE BY FARM (2005 – 2015)



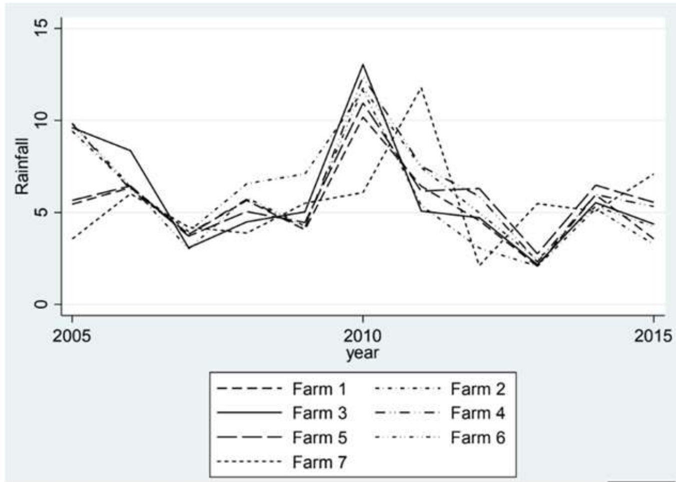
Graph of pounds produced per acre for each farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved.

FIGURE 6
Water Used per Acre by Farm (2005 – 2015)



Graph of water used per acre for each farm and graphed over a 10-year period: 2005 – 2015. Computation based off individual financial statements for each entity, June 29, 2017, retrieved.

FIGURE 7
RAINFALL BY FARM (2005 – 2015)



Graph of rainfall inches for each farm and graphed over a 10-year period: 2005 – 2015. NOAA National Centers for Environmental information, Climate at a Glance: U.S. Time Series, Precipitation, published September 2016, retrieved on September 29, 2016 from http://www.ncdc.noaa.gov/cag/

FIGURE 8
GOVERNMENT WATER SUPPLY ALLOCATION 2005 - 2015

		Contractors - South of Delta		
Year	**Agricultural Contractors (Ag)**	**Urban Contractors (M&I)**	**Wildlife Refuges (Level 2)**	**Settlement Contractors/ Water Rights**
2005	85%	100%	100%	
2006	100%	100%	100%	
2007	50%	75%	100%	
2008	40%	75%	100%	
2009	10%	60%	100%	100%
2010	26%	70%	100%	100%
2011	65%	89%	100%	100%
2012	37%	75%	92%	92%
2013	21%	71%	100%	100%
2014	0%	50%	48%	48%
2015	0%	25%	75%	75%

Note. Total water allocation percentage for the Westland's Water District was from the Summary of Water Supply Allocations at https://www.usbr.gov/mp/cvo/vungvari/water_allocations_historical.pdf (retrieved September 12, 2017)