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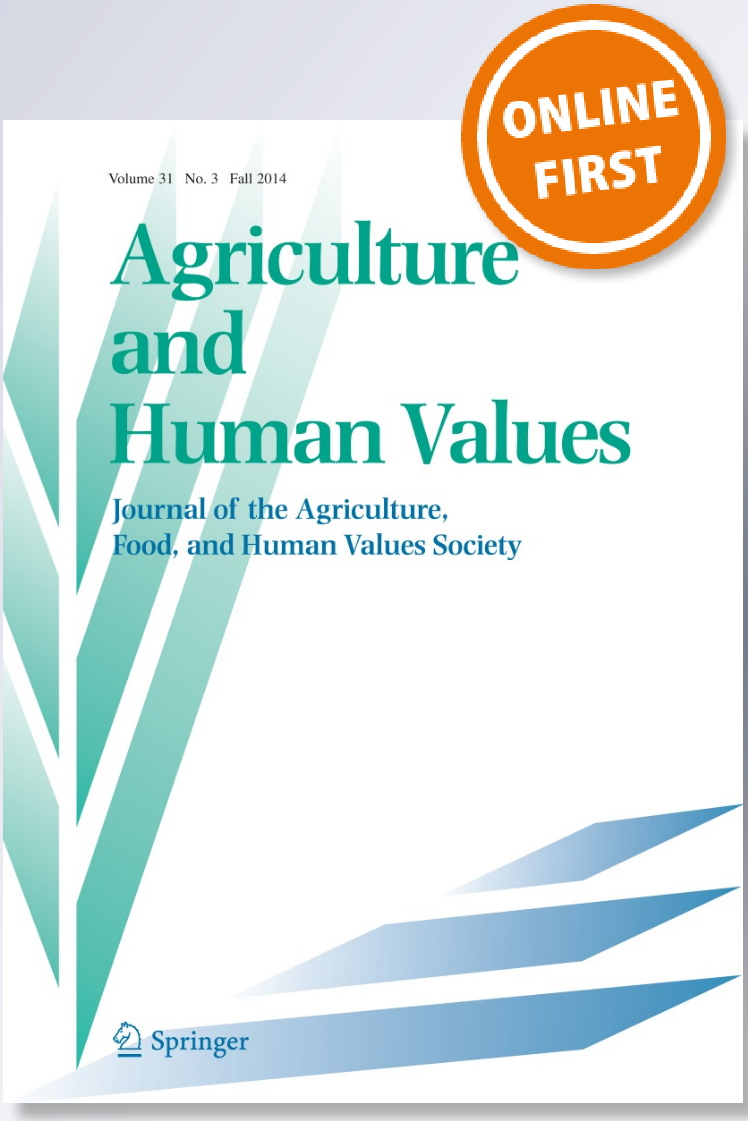

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Abstract The increasing prevalence of ecologically sustainable products in consumer markets, such as organic produce, are generally assumed to curtail anthropogenic impacts on the environment. Here I intend to present an alternative perspective on sustainable production by interpreting the relationship between recent rises in organic agriculture and greenhouse gas emissions from agricultural production. I construct two time series fixed-effects panel regressions to estimate how increases in organic farmland impact greenhouse gas emissions derived from agricultural production. My analysis finds that the rise of certified organic production in the United States is not correlated with declines in greenhouse gas emissions derived specifically from agricultural production, and on the contrary is associated positively overall agricultural greenhouse gas emissions. To make sense of this finding, I embed my research within the conventionalization thesis. As a result I argue that the recent USDA certification of organic farming has generated a bifurcated organic market, where one form of organic farming works as a sustainable counterforce to conventional agriculture and the other works to increase the economic accessibility of organic farming through weakening practice standards most conducive to reducing agricultural greenhouse gas output. Additionally, I construct my own theoretical framework known as the displacement paradox to further interpret my findings.

Keywords Organic farming · Greenhouse gas emissions · Conventionalization

Introduction

Organic agriculture has become increasingly popular in the United States over the past decade, currently accounting for 3 % of total sales within the food industry (USDA 2012). This is mostly attributed to escalating consumer concerns over the impacts of pesticides and chemical fertilizers on human health. However, environmental pollution derived from modern agricultural practices, such as rising greenhouse gas emissions and water contaminations, have also been cited as a growing concerns that drive consumers toward organic markets (Kirchmann and Lars 2009). But does organic agriculture's current role in the agricultural market actually displace the environmental impacts commonly associated with conventional agriculture?

My aim here is to analyze whether or not certified organic farming in the United States reduces greenhouse gas emissions from agricultural production. To accomplish, this I estimate two fixed-effects panel regressions that test the correlation between growth in organic agricultural production and greenhouse gas emission derived specifically from agriculture. My results find that rises in certified organic farmland 2000–2008 are correlated positively with greenhouse gas emissions from agricultural production, suggesting that certified organic farming is currently working to increase emissions of greenhouse gases. To reconcile with this somewhat counterintuitive discovery, I will present potential explanations situated within recent sociological and ecological literature that problematizes organic farming practices, certified organic farmland, and corporate involvement in organic food markets (see Buck et al. 1997; Guthman 2004; Constance et al. 2008; Jaffee and Howard 2010; Venkat 2012; Williams 2006). My research is intended to broaden both sociological and ecological understandings of certified organic farming as

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well as help to develop an emerging theoretical perspective within environmental sociology known as the displacement paradox.

Current studies on organic farming have mostly been small-scale empirical projects, and have largely been theoretically driven. This study is intended to act as one of the first large-scale empirical analysis of certified organic farming and agricultural greenhouse gas emissions. The conclusions here are intended to be exploratory and act as a call to action to both social and natural scientists to further explore how certified organic farming functions within the United States.

Literature review

The following section will explore the social and natural processes behind certified organic agricultural production. It will engage with literature that demonstrates how organic agriculture can work to mitigate the emission of greenhouse gases and potentially add to overall greenhouse gas emissions from agricultural production. Specifically, I will assess the rise of certified organic agriculture in the United States, its potential problems, the organic practices that mitigate greenhouse gas emissions, and the organic practices that increase greenhouse gas emissions. This literature will be utilized in the discussion section to explore the consistency between my findings and social and ecological science research.

The rise of certified organic agriculture and its problems

In an effort to address the growing demand for organically produced goods as well as streamline their consumption, the United States Department of Agriculture (USDA) created a national standard for organic production under the Food, Agriculture, Conservation, and Trade Act of 1990. Defining organic as food "produced without using most conventional pesticides; fertilizers made with synthetic ingredients or sewage sludge; bioengineering; or ionizing radiation" (USDA 2012). The USDA national standard for organic agricultural production has had two major effects on the organically produced foods in the US. (1) It has allowed organic practices to continually be weakened. (2) It has allowed for larger corporate involvement in organic markets, which has in turn led to the subsequent centralization of the market. These effects have specific implications regarding organic farming's ability to reduce the emission of greenhouse gases. Thus, the point of this section is to briefly present the social ramifications of certified organic production to situate later discussion of how these outcomes may potentially affect certified organic farming's relationship to greenhouse gas emissions.

While organic farming practices are commonly understood as a more sustainable approach to agricultural production, many argue that the certification processes leads to the "conventionalization" of organic farming. Buck et al. (1997) and Guthman (2004) claim that the organic movement at its inception was a counter cultural movement driven by social, political, and ecological philosophies, however, as its demand increased, regulatory standards developed as a method by which consumers identified organically produced products. Over time, regulation became the responsibility of several certifying entities, which eventually became motivated and driven by economic endeavors, rather than the original ideals behind the organic movement. This inevitably led to organic standards being reduced from a social, political, and ecological philosophy to a "regulatory label that focused on—or some would say, fetishized—the regulation of agricultural inputs" (Johnston et al. 2009, p. 513). The shift from organic as an activist-driven counter-market to a widespread niche market led to the weakening of ecologically beneficial standards (Buck et al. 1997; Guthman 2004; Govaerts et al. 2009).

Some characterize the organic market as now having two separate functions within society; one "made up of larger conventional operations that mix input substitution strategies with monoculture production of high value crops targeted to indirect markets," and another made up of "smaller farms that employ artisanal practices to grow a variety of crops using more sustainable agronomic practices targeted to direct markets" leading to the bifurcation of organic farming (Constance et al. 2008, p. 213). While the latter half of these two types of organic still has the capability to reduce and counteract environmental problems, such as greenhouse gas emission associated with conventional farming, the former leads one to question the level of sustainability certified organic farming can promote in its current form. The overall importance of the conventionalization and subsequent bifurcation of the organic market is that both point to the separation of organic agriculture and specifically characterize certified organic farming as less ecologically sustainable and more economically driven. The findings that are presented in this study help to fill the gap within the conventionalization thesis literature by empirically analyzing certified organic land and determining whether or not it has a sustainable impact on society.

Further exploring the social ramification of the certification process, Jaffee and Howard (2010) discuss how the organic markets are co-opted by corporations through regulatory capture. Regulatory capture occurs when agencies "entrusted with serving the public interest instead come to serve the commercial or special interests they are charged with regulating." Jaffee and Howard (2010) argue that the certification of organic farming creates a "ceiling" and a "floor" by prohibiting stricter standards and making them irrelevant in specific market contexts. Additionally, Howard (2009) argues that this corporate cooptation allows corporations that are already dominant within the agribusiness to centralize control over the organic market, in addition to the conventional markets.

Contrasting organic and conventional farming relationship to greenhouse gas emissions

Since as early as the 1940s organic farming has been an alternative to the industrialized methods used in mainstream agriculture, promoting agricultural practices that are more in line with natural ecology, less intensive on soil, and more humane toward animals (Guthman 2004). Organic farming practices are also known to be more effective at mitigating climate change. Methods commonly used in organic agriculture as opposed to conventional agriculture, such as conservative tilling and crop rotations, have been found to lead to carbon sequestration (Soil Association 2012; Govaerts et al. 2009), a process by which atmospheric carbon dioxide is absorbed by plants through photosynthesis and stored as carbon in biomass and soils (FOA 2011). Additionally, organic agriculture has been found to have larger sinks for carbon dioxide in soil compared to conventional agriculture due to its higher rates of biomass levels and lower rates of soil respiration (OECD 2003).

Recent analyses have also looked comparatively at organic and conventional agricultures' relationship to climate change through life cycle analysis. In these studies, organic farming is implemented on the scale of conventional agricultural production, which is problematized within the conventionalization thesis literature as a breach of the initial ideals of the organic movement (see Buck et al. 1997; Guthman 2004), in an effort to determine which farming practices emit the most greenhouse gases. Williams (2006) analyzed the life cycle impacts of conventional and organic wheat, oilseed rape, potatoes, and tomatoes, and found that while organic used less energy than conventional agriculture on average, due to organic avoidance of synthetic nitrogen, it was offset by lower organic yields and higher energy requirements for field work. Additionally, Williams found that organic tomatoes emitted 30 % more greenhouse gases than conventional agriculture mainly as a result of lower yields.

Similarly, Pelletier et al. (2010) studied a hypothetical national transition from conventional to organic production of canola, corn, soy, and wheat in Canada. They found that organic production would generate 23 % lower greenhouse gas emissions than conventional production, without considering soil carbon sequestration. This difference was almost entirely related to the production of synthetic nitrogen fertilizers for conventional farming. The models in this analysis assumed that organic yields produce at the rate of at least 90 % of conventional yields, that on-farm energy use is similar to conventional farms, and that all organic nitrogen inputs are derived from intercrops or cover crops.

Leifeld and Fuhrer (2010) investigated the ability of organic farming to sequestrate carbon from the atmosphere compared to conventional farming. In an analysis of 68 case studies that dealt with carbon sequestration and conventional and organic agriculture, the authors concluded it was premature to assert that organic agriculture yielded higher benefits in this specific area. Furthermore, the authors found that the advantages of organic agriculture were largely determined by disproportional application of organic fertilizer compared to conventional farming.

In an analysis of the life cycle patterns of 12 conventional and organic crops in California, Venkat (2012) found that greenhouse gas emissions from organic production were on average 10.6 % higher (excluding walnuts as an outlier) than conventional production. Venkat cited lower yields and higher on-farm energy use in organic farming, the production and delivery of large quantities of compost in some organic systems, and the fact that emissions from the manufacture of synthetic fertilizers and pesticides used in conventional farming are not large enough to offset the additional emissions in organic farming as reasons for this phenomenon.

The studies above all focused on the life cycle patterns of organic and conventional farming for specific regions, limiting the ability for these analyses to be applied more generally. While two of the three analyses point to organic agriculture being associated with higher levels of greenhouse gas emissions, the global consensus still recognizes organic agriculture as a way of reducing anthropogenic climate change. This can be seen in the following statement by the Food and Agriculture Organization of the United Nations (FOA):

> FAO promotes organic agriculture as an alternative approach that maximizes the performance of renewable resources and optimizes nutrient and energy flows in agroecosystems. Life cycle assessments show that emissions in conventional production systems are always higher than those of organic systems, based on production area. Soil emissions of nitrous oxides and methane from arable or pasture use of dried peat lands can be avoided by organic management practices. Many field trials worldwide show that organic fertilization compared to mineral fertilization is increasing soil organic carbon and thus,

> sequestering large amounts of CO2 from the atmosphere to the soil. Lower greenhouse gas emissions for crop production and enhanced carbon sequestration, coupled with additional benefits of biodiversity and other environmental services, makes organic agriculture a farming method with many advantages and considerable potential for mitigating and adopting to climate change. (FOA 2011)

The findings presented in this analysis are meant to fill the gap in recent literature that assessed organic agriculture's relationship to climate change by introducing the first large-scale analysis of organic agriculture and greenhouse gas emissions. In this way I explore how the overarching trends in certified organic practices relate to greenhouse gas emissions. The goal of the following section will be to determine other potential causes/reasons for organic agricultures positive relationship with greenhouse gas emissions that have yet to be discussed through an investigation of an emerging theoretical perspective in sociology.

The displacement paradox

The question of whether or not organic agriculture is suppressing greenhouse gas emissions is tangled within a broader question of environmental sustainability in capitalist economies. One major challenge to society's ecological pursuits is the complex dynamics that exist between market economies and nature. Throughout the history of capitalist economies, ecological paradoxes have arisen that call into the question the ability of capitalism to be a sustainable form of material production (see Polimeni 2008; York 2010; Clement 2011). In this section, I will discuss a new ecological paradox within capitalist societies known as the displacement paradox. The displacement paradox illuminates theoretically why sustainable/alternative forms of production are limited in reducing particular forms of environmental degradation, and specifically how organic agriculture's relationship to greenhouse gas emissions is a part of a larger pattern.

While the displacement paradox has not been discussed prior to this study, the concept has been put forth several times within the last few decades. It was first suggested by Sellen and Harper (2002) in their book *The Myth of The Paperless office*. Sellen and Harper challenged the assumption that the rise of computers and storage capacity for documents in electronic form would eventually lead to a "paperless office," by showing that the use of paper increased between 1995 and 2000 in the United States. This was contrary to the expectation of many who believed the presence of the World Wide Web, computers, and electronic mail would lessen our destructive impact on forest ecosystems by reducing our consumption of wood. Sellen and Harper were unable to determine the concrete casual patterns behind to this paradox, but they were able to see that the presence of ecologically sustainable tools did little to combat the use of products that are environmentally disastrous.

A more recent study by York (2012) showed this same process occurring with energy. York found that the increased presence of non-fossil energy sources, such as hydro and wind power, only minutely displaced fossil fuel use on a global level. He concludes that "the shift away from fossil fuel does not happen inevitably with the expansion of non-fossil-fuel sources, or at least in the political and economic contexts that have been dominant over the past 50 years around the world" (York 2012, p. 443). He continues, "polices aimed at addressing global climate change should not focus principally on developing technological fixes, but should also take into account human behavior in the context of political, economic, and social systems."

While neither of these studies places substantial emphasis on the causes behind the displacement paradox, collectively these analyses empirically demonstrate a potential pattern in alternative and sustainable forms of production. These patterns suggest that certain forms of sustainable production are not necessarily reductive to more environmentally hazardous ones. While Sellen Harper's study is observational, one can imagine that the consistent growth of paper usage is in part facilitated by the paper industry's expanding profits. York's conclusions offer more insights into the social problems associated with introducing sustainable technologies, specifically when arguing that the political and economic history of traditional or unsustainable forms of production give a unique context to these technologies, which newer and more sustainable processes may not always address.

The displacement paradox is potentially a result of supply stimulating its own demand. This would suggest that sustainable forms of production function to produce particular niches within existing markets; creating a scenario in which sustainable processes are an expansion of existing markets. Furthermore, the presence of ecologically sustainable products alone provides no evidence for positive outcomes on overall environmental quality. The growing prevalence of ecologically sustainable products in capitalist markets may in fact be a reaction to declines in environmental quality, instead of a counterforce to the products that drive environmental impacts. This is to say that consumer demands for sustainable goods can stimulate new manufacturing processes that are independent from the production of traditional/ecologically hazardous goods, and in this way increase the consumption of sustainable goods in a way that has little to no impact on the production processes of unsustainable products.

Hypotheses

The presence of a displacement paradox between sustainable and unsustainable production can potentially result in increases in sustainable production being additive to the overall environmental degradation associated with a specific market. As such, sustainable practices must be understood as an additional driver of environmental impacts, but only insofar as they relate to environmental impacts themselves. Even though the implication of sustainable practices is that they are environmentally benign, sustainable processes most often contribute in some way to environmental degradation (Clark and York 2008). In the case of organic farming, it is known that organic farming practices release greenhouse gases, however, organic farming is often understood as a sustainable alternative because it is assumed to release less greenhouse gas than its conventional counterpart. Thus, the question over organic farming's role as a sustainable market is whether or not rises in certified organic farmland help to reduce the amount of greenhouse gas emitted from agriculture each year. To explore this question, I have created two hypotheses that demonstrate the potential outcomes of growth in organic farmland and agriculturally based greenhouse gas emissions.

H1 A one-unit increase in certified organic farmland is correlated positively with agricultural greenhouse gas emissions when controlling for all factors driving agricultural greenhouse gas emissions.

H2 A one-unit increase in certified organic farmland is correlated negatively with agricultural greenhouse gas emissions when controlling for all other factors driving agricultural greenhouse gas emissions.

H1 is based on the displacement paradox theory, where the assumption is that a one-unit increase certified organic farmland stimulates its own demand external to traditional forms of agricultural production, and therefore adds to the surmounting level of greenhouse gases emitted from agricultural production. Additionally, this hypothesis is consistent with existing ecological and social science literature that has problematized certified organic farming practices (see Buck et al. 1997; Guthman 2004; Williams 2006; Venkat 2012).

H2 is based on the assumption that many have regarding organic agriculture's relationship to climate change, which is that due to soil management practices and low reliance on synthetic chemicals, rises in organic farming, relative to conventional farming, help to mitigate greenhouse gas emissions (FOA 2011). Additionally, the assumption here is that a one-unit increase in organic farmland is a result of a shift within the agricultural industry from conventional farming practices to organic farming practices, leading to a decline in the growth rate of greenhouse gas emissions from agricultural production. Also implicit in this assumption is the notion that organic farming practices most commonly argued to release less greenhouse gas emissions than conventional farming practices are prevalent in certified organic farming practices. These hypotheses will be tested using the data I discuss below.

Data and methods

I use state-level data on both organic agricultural land and agricultural greenhouse gas emissions to assess how organic agriculture is correlated with greenhouse gas emissions derived from agricultural production in the United States. Additionally, I gathered data on multiple socioeconomic and agricultural indicators that potentially influence the growth trends in both organic and overall agricultural production: population, GDP, and total agricultural land.[1] The data was obtained for 49 states from the years 2000–2008 creating an N of 439.[2]

Since my data is stratified by states and through time, I chose to use a fixed-effects panel regression to estimate the correlation between greenhouse gas emissions from agricultural production and organic farming. This method was chosen based on its use in similar environmental sociological studies (see Jorgenson et al. 2009; York 2012; York et al. 2003). A fixed-effects panel model controls for any unobserved, time-constant features between states, as well as events that occurred in each year that effected states simultaneously. In other words, by using fixed-effects for my time series panel data, my models indirectly control for any variables linked to greenhouse gas emissions from agricultural production that are not observed within the model. Additionally, I included time dummy variables to account for general period effects. This assumes that individual specific effects are correlated with each independent variable. Thus, my models specifically focus on change within states from time observed. The fixed effects econometric equation is presented below.

$$\mathrm{y_{it} = B_1(x_{it}) + B_2(x_{it}) + \cdots + u_i + w_t + e_{it}}$$

Here the subscript *i* represents each unit of analysis (states) and the subscript *t* the time period, $\mathrm{y_{it}}$ is the dependent variable for each state at each point in time, $\mathrm{x_{it}}$ represents the independent variables for each state at each point in time, *ui* is a state specific disturbance term that is

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[1] Data on the number of farms and average farm size was also gathered but found to be insignificant in relation to agricultural greenhouse gas emissions.

[2] The models exclude Alaska in the years of 2000 and 2001, and Louisiana due to absent data in the NASS, resulting in an N of 439.

constant overtime (i.e., the state specific y-intercept), *wt* is a period specific disturbance term constant across states, and e_{it} is the stochastic disturbance term specific to each state at each time point. My variables relationship in this equation is presented below.

$$\begin{aligned} \textit{Model 1}\quad & \text{Agricultural greenhouse gas emissions}_{it} \\ & = \beta_1(\text{organic farmland}_{it}) + \beta_2(\text{GDP}_{it}) \\ & + \beta_2(\text{population}_{it}) + \beta_3(\text{total agricultural land}_{it}) \\ & + \mu_i + w_t + e_{it} \end{aligned}$$

$$\begin{aligned} \textit{Model 2}\quad & \text{Agricultural greenhouse gas emissions} \\ & \text{per acre of total farmland}_{it} \\ & = \beta_1(\text{percent organic farmland}_{it}) + \beta_2(\text{GDP}_{it}) \\ & + \beta_3(\text{population}_{it}) + \mu_i + w_t + e_{it} \end{aligned}$$

The dependent variable agricultural greenhouse gas emissions in model 1 measures total amount of greenhouse gas emissions from agricultural production in metric tons. This data was gathered from the most recent report of the World Resource Institute (2010). The WRI obtains sector-based data on greenhouse emissions from the United States Environmental Protection Agency's (EPA) Inventory Improvement Program. The Inventory Improvement Program uses standard methods to obtain annual sector based data on greenhouse gas emissions for each state and the District of Columbia annually. The data is gathered through assessing three major types of agricultural practices that are known drivers of greenhouse gas emissions and several smaller practices. The three major types include soil management (the most influential factor), which consists of fertilizer application and tillage practices, emissions from livestock production, and manure management. The smaller sources of emissions include rice cultivation and burning crop residue.

The dependent variable greenhouse gas emissions per acre of agricultural land in model 2 was created by dividing the total amount of greenhouse gas emissions from agricultural production by the total acres of farmland in the United States. Thus, this variable is intended to measure the average intensity of agricultural greenhouse gas emissions per acre of land. I chose to use agricultural greenhouse gas emissions specifically, as opposed to total greenhouse gas emissions, because it limits the need to control extraneous factors in my models. Also by choosing to look specifically at agricultural greenhouse gas emissions, I limit the potential for my findings to be influenced by external forces, such as other drivers of greenhouse gas emissions. In essence, by using the dependent variable agricultural greenhouse gas emissions I am able to control for most, if not all, of the major drivers of agriculturally based greenhouse gases by controlling for the total amount of agricultural land in the United States.

The data for organic agricultural land was obtained from the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) (2012). The NASS measures the total amount of certified and exempt organic farmland in acreage per state.[3] A major draw-back to USDA data on organic agriculture is that it excludes informal organic practices, which may lead to underestimation of organic farming. Furthermore, definitions of organic vary within what is considered certified organic by the USDA (i.e. some organic farms use much stricter practices than what is required by the USDA), which may result in the data not reflecting the mitigating effects of stricter organic practices. Additionally, while certified organic farms account for a large portion of the organic products developed and used within the United States, they do not capture organic farming practices utilized for non-traditional consumer outlets, such as community gardens, farmers markets, and community supported agricultural programs. Therefore, I interpret my results cautiously and approach this study as a preliminary understanding of organic agricultural production's relationship to greenhouse gas emissions in the United States.

In order for my data to accurately determine the correlation between greenhouse gas emissions from agricultural production and USDA certified organic farming, I included three indicator variables—total agricultural land, gross domestic product, and population—to control for other drivers of greenhouse gas emissions from agricultural production (Table 1). Total agricultural farmland, my first indicator variable, measures the amount of agricultural land within each state in acres. By using total agricultural land as an indicator variable, I am able to control for the amount of greenhouse gas emitted by agriculture, allowing the model to specifically show the effect of organic farmland on greenhouse gases. Data on total agricultural land was acquired from the NASS (2012). My second indicator variable, gross domestic product (GDP), measures the average gross domestic product within each state, allowing the model to control for the variations in economic size and economic growth in the years measured within each state. The data on GDP was acquired from the United States Economic Research Service (ERS) (2012). My last indicator variable, population, was acquired from the United States Census Bureau (2012). This allows me to control for the amount of people in each state, which potentially affects the amount of food and other agricultural products produced in each state and therefore the amount of agricultural greenhouse gas emissions. Additionally, I estimated the variance

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[3] In order to be truly exempt from organic certification, NOP policy states that an organic farm cannot sell more than $5,000 worth of organic agricultural products annually. That $5,000 is total gross sales, not net sales.

Table 1 Summary statistics of variables

Variables	Mean	SD	Minimum	Maximum
Agricultural greenhouse gas emissions (measured in metric tons)	15.98	56.69	0.03	479.95
Organic farm acreage	60,645	122,240	0	1,460,205
GDP (measured in billions of US dollars)	230	280	14	1,900
Population	5,852,225	6,427,392	492,982	36,600,000
Total agricultural land	6,587,393	7,386,347	10,000	25,000,000

inflation factors (VIF) of each of my independent variables to test for potential multi-collinearity and found that none of my independent variables reached a VIF of 10 or higher. This means that coefficients in each of my models are not affected by a collinear relationship between my independent variables[4] (see Belsley et al. 1980; O'Brien 2007).

Note that each model is designed to substantively illustrate the correlation between certified organic farmland and greenhouse gas emissions, specifically the emissions generated from agricultural land. Additionally, it is important to note that the two models presented here are not intended to illustrate how specific practices used in either form of farming effect the emission of greenhouse gases. Therefore, the variables agricultural land and organic farmland should only be interpreted in the broadest sense.

Results

The logic of model 1 is to control for any potential drivers of greenhouse gas emissions from agricultural production (e.g., the economic output of a state, the amount of people in a state, and the total amount of agricultural land producing crops in a state), and assess specifically the correlation between rises in organic agricultural land and the average output of greenhouse gas from agricultural production in states between the years 2000–2008. Keep in mind that because my data is interpreted using fixed effects, my models explicitly focus on how change in organic farming within states relates to greenhouse emissions. In model 1 the variables, total farm acreage, population, and GDP, are found to be insignificant in relation to greenhouse gas emissions from agriculture (Table 2). However, organic agriculture is positively associated with greenhouse gas emissions from agricultural production, indicating that changes in the amount of certified organic farmland were associated positively with changes in the amount of greenhouse gases released from agricultural production.

Table 2 Agricultural greenhouse gas coefficients for fixed effects panel regression, measured in metric tons

Independent variables	Coefficients (standard errors)
Organic farm acreage	0.014*** (0.003)
Total farm acreage	-0.0001 (1.65×10^{-7})
GDP (in billions of dollars)	3.500** (0.002)
Population	-0.273×10^{-7} (2.69×10^{-7})
R^2 within	0.205
R^2 between	0.202
R^2 overall	0.155
High VIF	1
N	439

* $P < .05$; ** $P < .01$; *** $P < .001$

Table 3 Greenhouse gas emitted per acre coefficients for fixed effects panel regression, measured in metric tons

Independent variables	Coefficients (standard errors)
Percent organic farm acreage	2.260×10^{-6}* (1.020×10^{-6})
GDP (in billions of dollars)	0.027*** (0.006)
Population density	-4.570×10^{-9} (4.900×10^{-9})
R^2 within	0.116
R^2 between	0.0001
R^2 overall	0.000
High VIF	0.9
N	439

* $P < .05$; ** $P < .01$; *** $P < .001$

The logic of model 2 is a slightly nuanced version of model 1, in that it demonstrates how the proportion of organic land to conventional land affects the intensity of greenhouse gases emitted from agricultural production while holding constant other potential driver of agricultural greenhouse gas emissions (e.g., GDP and population). This is accomplished by having the dependent variable in model 2 illustrate the average amount of greenhouse gases emitted per acre of agricultural land (Table 3). Unlike model 1, model 2 is also aimed at addressing the social problems associated with organic farming, such as corporate co-optation and conventionalization. Just as in model 1, the variables total agricultural land, population, and GDP are all insignificant. However, similar to model 1 the independent variable organic farmland (here presented as a proportion of total farm land) is positive and significant.

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[4] VIFs for independent variables in model 1: GDP per capita 0.7, Organic farmland 0.9, total agricultural land 1, population 0.9. VIFs for independent variables in model 2: GDP per capita 1, percent organic farmland 1, total agricultural land 0.9, population 0.9.

The subtle distinction here is that rises in organic land are correlated with rises in the intensity of agricultural greenhouse gases emitted per acre of agricultural land. Therefore, models 1 and 2 understood together demonstrate that organic agricultural land is correlated positively with greenhouse gas emissions from agricultural production, as well as the intensity of greenhouse gas emitted per acre of agricultural land.

Discussion

These findings suggest that rises in certified organic farming is increasing both the total amount of greenhouse gas emitted from agricultural production and the intensity of greenhouse gases emitted per acre of agricultural land. This relationship supports the conventionalization thesis. As Buck et al. (1997) and Guthman (2004) argue, the conventionalization of certified organic farming has generated a bifurcation of the organic market—one that is more activist driven and serves as a counterforce to conventional farming, and another that is a market reaction to consumer demands for more sustainable forms of agricultural production. Certified organic farming falls into the latter of these two categories, making its ability to suppress the negative environmental outcomes of conventional agriculture questionable. Specifically, the certified organic market has experienced a rise in corporate participation, which has facilitated the weakening of standards though regulatory capture, and perpetuated the overall scale of organic production (Jaffee and Howard 2010). This is not to say that all certified organic farms are conventionalized, but that recent trends in the certified organic market increasingly push the market towards conventionalization. My findings support the claims within the conventionalization thesis by demonstrating that certified organic farming is not associated with reductions in agriculturally based environmental degradation which is an understood outcome of the conventionalization process.

These results also align with the sentiment of Venkat (2012) and Williams' (2006), who argue that organic farming practices applied at the scale of conventional agricultural production emit more greenhouse gas than conventional farming due to its lower yields and its reliance on machinery to maintain crops. My findings support these claims by demonstrating that a one-unit rise in organic land relative to total agricultural land is correlated with an increase in the total amount of greenhouse gas emitted from agricultural production. Additionally, my results align with Williams' (2006) finding that some organic crops (i.e., tomatoes) produce more greenhouse gases than their conventional counterparts when produced on a similar scale, as well as his conclusion that reductions in energy consumption through utilizing organic management practices are often offset by the heightened demand for crop maintenance. Similarly, Lefeild and Fuhrer's (2010) caution against claims that assume organic farming is a "more sustainable" form of agricultural production in regards to climate change because a link has yet to be established between organic farming and its higher levels carbon sequestration are partially supported by my findings. While my findings do not support a link between organic farming and lower greenhouse gas emission, it should be noted that this could be a result of the aggregate relationship between organic farming and agricultural greenhouse gas emissions. Specifically, my model is only demonstrating the relationship between organic farming and total greenhouse gas emissions from agricultural production, which limits its ability to capture the relationship between organic farming and specific types of greenhouse gas emissions. For instance, organic agriculture may be reducing carbon emissions from agricultural production while simultaneously increasing the emissions of other greenhouse gases at a level that offsets any counteracting relationship between organic farming and carbon emissions. In this way, my findings do not reject the claim that organic agriculture has higher levels of carbon sequestration, as there is no way of determining through my modeling approach organic farming's specific relationship to carbon dioxide emissions.

Conclusion

Cohesively these points demonstrate a potential displacement paradox of certified organic farming—where organic farming as an alternative to conventional agriculture does little to reduce the consequences of conventional farming practices. Sellen and Harper (2002) and York (2012) also find that sustainable/alternative forms of production in capitalist economies drive up the consumption and/or outcomes of ecologically hazardous goods. This suggests that my findings are part of a larger pattern of capitalist markets. However, more research is necessary to establish whether or not this correlation is truly a function of a displacement paradox. What these findings ultimately suggest is that organic farming is not working as a counterforce to greenhouse gas emissions stimulated by agricultural production, and is currently positively correlated with the problem. Furthermore, while there is a consensus of organic farming's virtues in regards to overall human health and water pollution, there is no such consensus pertaining to the merits of organic farming and climate change.

The findings I have presented here offer a counterintuitive representation of organic farming's relationship to climate change. However, it is not my intention to argue that the only outcome of rises in organic farmland is increases in greenhouse gas emissions. The task at hand for both social and ecological scientist is to establish the true causation to this counterintuitive correlation and deepen our knowledge on sustainable agricultural production. For social scientists this means further investigating the processes that lead to the watering down of organic standards within USDA certification. While for ecological scientists this means further understanding specific organic practices' and their relationship to greenhouse gas emissions, as well as other forms of environmental degradation, in the hopes of identifying the most essential practices for sustainable organic production.

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