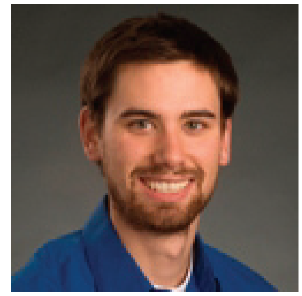
Climate Change and Idaho Agriculture: Is Farm Size a Determinate of Adaptive Capacity?



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Economics

Abstract

Determining how agriculture will be affected by climate change is not only a question biophysical change in crop production; it also depends on the adaptation of the farmer to these changing conditions. A flaw in models using nationally aggregated cross sectional data is that the adaptive capacity of unique farms is not captured in the analysis. In order to understand the local effect of climate change on welfare models must capture attributes specific to the study area. Factors that must be taken into consideration include farm characteristics local policy and institutional frameworks (Antle et al. 2004; Mendelsohn, Nordhaus, and Shaw 1994). This study looks at weather and crop characteristic specific to Idaho agriculture by utilizing county data over a fifty year period. This approach captures local conditions, although adaptation under climate change is hard to determine because of the prevalence of advanced adaptation techniques, such as irrigation and cultivation technology, across all farm sizes.

Introduction

Determining how agriculture will be affected by climate change is not only a question biophysical change in crop production; it also depends on the adaptation of the farmer to changing climate conditions. The capacity to adapt to changing climate conditions can depend on many variables. These can be factors such as access to financial instruments, suitability of land for alternative uses, available inputs, such as water and fertilizer, and farm management skill. Because these various adaptation strategies are very difficult to estimate with empirical methods a rich source of literature has emerged concerned with measuring adaptive capacity through other means.

The two dominant methods in the literature are process based (Antle et al. 2004) and Ricardian (Reidsma, Ewert, and Oude Lansink 2007; Reidsma et al. 2009; Mendelsohn, Nordhaus, and Shaw 1994). A theme that has emerged from research using both methodologies is that analysis on specific regions is important in understanding how each type of farm will be affected. This involves taking into account local changes in climate, farm characteristics, local policy and institutional frameworks (Reidsma et al. 2009; Antle et al. 2004; Mendelsohn, Nordhaus, and Shaw 1994). The current study will use site specific data to look at a critical farm characteristic for understanding adaptive capacity: economic size.

Understanding the adaptive capacity among farm sizes is a relevant research goal because structural changes in the distribution of farm sizes has implications for rural economies, consumers in both export and local markets, and for new producers entering the industry. Heady and Sonka (1974) cite farms as a tax base and source of employment for local economies and makes the argument that a greater number of small farms will necessarily raise tax revenues and employment opportunities. Counter to this positive view of small farms, Hall and LeVeen (1978) note that competitive agricultural markets transfer the increased production costs associated with labor intensive small scale farming into decreased rents, rather than transferring the higher costs to consumers, which would lower the potential welfare of this type of farm. The implication for current agricultural trends can be seen in the high growth of small scale farmers focusing on local and organic production. These farmers are made up of relatively young individuals breaking into the industry for the first time and growing mainly vegetables and fruit for either direct sale or farmers markets (ARMS cite needed). While this study does not presume to determine the economic benefits of farm size or the viability of recent industry trends, discovering what group of farmers is most adaptable to climate change can help inform policy decisions for desired economic outcomes.

Literature Review

Pytrik Reidsma et al. (2008) identify two main approaches to understanding the economic impact of climate change for agriculture. The first is process based and combines crop and economic models (Antle et al. 2004), and the second is through Ricardian analysis (Reidsma et al. 2009; Mendelsohn, Nordhaus, and Shaw 1994; Schlenker, Hanemann, and Fisher 2005). The limitation of process based models is that decisions within the model refer to projected yields that are stipulated by the parameters of the model. Because the model does not use actual crop production figures, the results show how well a farm was predicted to perform given assumed management efficiency (usually either optimal adaptation or no adaptation), but does not say how well the farm performed in reality, thus is difficult to quantify adaptive capacity (Reidsma et al. 2009). The Ricardian approach is limited because it cannot easily discern spatial adjustments from temporal changes and because it has been employed using cross sectional data across a large sample size, it fails to take into account regional differences in production methods (Mendelsohn, Nordhaus, and Shaw 1994; Schlenker, Hanemann, and Fisher 2005).

To address these deficiencies Reidsma et al. (2007) uses a multi-level Ricardian approach using both farm level and regional data. This captures spatial changes among regions, and by using actual crop yields, it is possible to measure the real adaptations by farmers to changing climate conditions. Because adaptive capacity is difficult to quantify, a key assumption of the study is that performance is implicitly linked to adaptive capacity. Thus farms that perform well are well adapted to their current technology and environment (Reidsma, Ewert, and Oude Lansink 2007). In this analysis factors influencing farm performance were identified in two different groups. The first was farm characteristics, and the second was regional factors including the biophysical environment, socio-economic conditions and policy. The results show that farm characteristic such as input intensity, economic size and land use were more significant than climate in explaining variability in farmer income. This indicates that farmers within the study region are well adapted to local climates (Reidsma, Ewert, and Oude Lansink 2007).

The same multi-level approach is used again in Reidsma et al. 2008, but it is used to determine if farm characteristics affect the response to temporal changes or variability in climate. An important observation made here is that aggregation can have a large impact on how the results are interpreted. Agriculture at the regional level may seem less susceptible to damage from climate effects because of the diversity of farms helps to mitigate aggregate damages while individual farms could be more vulnerable than others (Reidsma et al. 2009). The benefit of using a multi-level approach that considers both farm and regional level influences will capture more contributing factors than either a regional or farm level analysis could capture alone. In order to achieve a generalized picture of how climate variability affects farm economics, data sets focus on comparing annualized trends among regions rather than inter-annual data. This allows the use of larger data sets in more coherent fashion than could be achieved by looking at fluctuations within the regions themselves (Reidsma et al. 2009).

Mendelsohn, Nordhaus and Shaw (1994) pioneered the use of the “Ricardian” approach in order to address the how farmer welfare would ultimately be effected by climate change (Mendelsohn, Nordhaus, and Shaw 1994). Rather than use a production function for a single crop and then estimating production along this curve, the Ricardian approach takes into account the ability of the farmer to adapt their land use to maximize welfare. This adaptation can include adjustments in cultivating techniques, fertilizer application and land use changes towards more profitable uses. In the case of wheat farming, if production falls to the point where corn or soybeans would yield a higher return of investment, then it is likely that the farmer will chose to plant these crops. This welfare maximizing behavior will continue and lead to a production function that is a composite of many land uses, and ultimately flattens the long term curve. By measuring the economic value of the farmer’s land along this production frontier it is possible to discover the farmer’s capacity to adjust land use.

The Mendelsohn, Nordhaus, Shaw study is a valuation of climate in the agricultural industry, as such, data is collected that expresses changes in long term climate trends rather than short term variations in weather. Also, because this is a cross sectional analysis using data across the contiguous U.S., it is difficult to understand the influence of climate on distinct growing regions. The authors admit that most weight in the regression analysis is given to the grain belt region because the model weights counties based on the total area of cropland and the value of these crops. By giving more weight to the citrus regions on the coast there is a more comprehensive picture of total agriculture, but this leaves out farms west of the 100th meridian where irrigation predominates. The authors also acknowledge that their regression models fit data on east side of the 100th meridian better than data on the west side. This could be attributed to the much more extensive use of irrigation in the western region and may indicate that these farms are less sensitive to changes in climate trends.[1] This is similar to what Reidsma et al. (2010) observed in the Mediterranean region, which shares a similar climate with the western United States. These farms often choose more heat resistant crops and have more extensively adopted irrigation as an adaptation technique than farms in northern latitudes (Reidsma et al. 2010).

The problem of combining irrigated with dry-land farming in a hedonic analysis is examined Schlenker, Hanemann and Fisher (2005). Because irrigated farming is dependent on water storage both surface and ground data on precipitation and temperature will not reflect an irrigated crop's production. Rather, it is will be dependent on the farmer's ability to apply sufficient stored water to the crop during the growing season. However, data on quantities of stored water is problematic because current county level data is merely an estimated figure and thus unreliable in modeling. Accurate measures of water use reside within irrigation districts, of which many can exist within one county. Because this level of aggregation is not sufficient to carry out a nationwide cross sectional analysis, Schlenker et al. (2005) found the model employed by Mendelsohn, Nordhaus and Shaw (1994) to be insufficient in capturing the effects of climate change on irrigated and dry-land farming using pooled data. Some evidence is given as to why climate change would damage irrigated farming, including higher evapotranspiration rates leading to a higher demand for irrigation water, and greatly increased costs for modern water storage capabilities, but because water supplies are determined uniquely for each region, it is difficult to measure this damage precisely.

Methods

Study area

The study area for this research is the state of Idaho. The majority of agricultural production in this area is focused along the Snake River in the south. This area is characterized as semi-arid land and is reliant on irrigation for high levels of production, although dry cropping is also common. The other notable region of crop production is located in the west central portion of the state along the Washington-Idaho border. This area produces mostly wheat, although at a lower average yield than the southern regions. Along the Upper Snake River basin, Central Plains, and Southwest annual precipitation is typically less than 10 inches and summer temperatures.[2] In the more northern latitudes rainfall is varied due to the geophysical variations of the state, although the areas of the Clearwater, Payette and Boise River Basin receive 40 to 50 inches of rainfall annually.[3]

Agricultural production within the state is predominately livestock and their products. This segment of the industry accounted for 57% of total agricultural products sold in 2007, and of the crops that make up the rest of the agricultural receipts, 36% is devoted to forage material and corn silage as an input to livestock production. The remaining crops are wheat (summer, spring and durum varieties), barley, potatoes, corn (predominately for seed) and specialty crops such as mint and hops that are grown in smaller quantities.

[1] Long term climate trends may be less important for irrigators, but this study does not addressee short term variability that is expected to accompany the climate change phenomena.
[2] Western Region Climate Center historical summary.
[3] Western Region Climate Center historical summary.

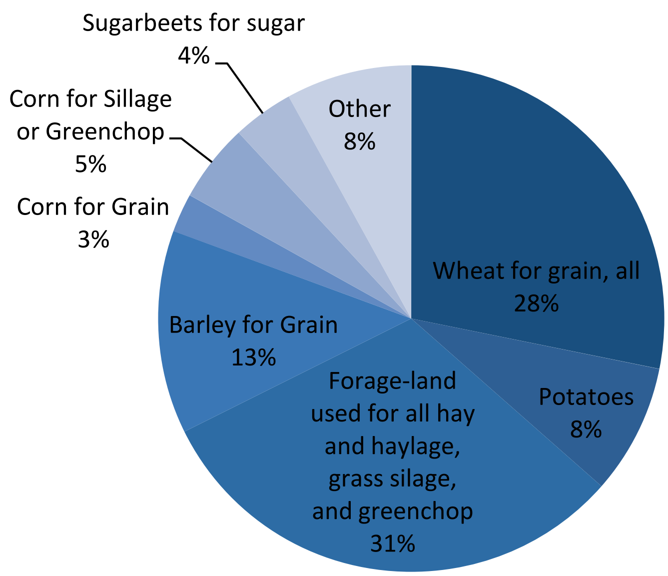

Figure 1. Crops harvested in Idaho by type (2007)

The total number of farms in 2007 was 25,349 with an average size of 454 acres.[4] As figure two and three show, small farms less than 50 acres greatly outnumber the number larger farms, but the acreage operated by large farms greatly outweighs that of smaller farms. Within this distribution the largest 15% of farms in Idaho are responsible for 85% of production.[5] Despite this biased production distribution, the segment of small farms has risen significantly over the years, with a 50% increase in farms of 1 to 49 acres from 1978 to 2007.[6]

Empirical Model

This framework describes the effect of farm size and climate variables (Palmer Drought Intensity Index) on either the dollar amount of production or crop failure.

$$Y_{c,t} = \alpha + \beta_1 FS_{c,t} + \beta_2 PD_{c,t} + \beta_3 FS_{c,t} \times PD_{c,t} + \beta_4 X_{c,t} + n_c + \delta_t + \varepsilon_{c,t}$$

FS = Average farm size per county
PD = Palmer Drought Intensity Index
FSxPD = Interaction variable for average farm size and climate
X = Control variables such as soil quality and topography
n = Fixed effects for county over time
δ = Fixed effects across time by counties
ε = Error term

Results

The results show insufficient evidence to support the hypothesis that farm size has an effect on adaptability. The two models of interest used crop land failure and market value of agricultural goods as dependent variables. Regression on crop failure, as measured by total crop land less crops harvested, showed a positive coefficient on the

[4] USDA NASS 2007 Agricultural Census data
[5] Anecdotal figure provided by NASS (NEEDS VERIFICATION)
[6] USDA NASS 2007 Agricultural Census data

independent variable Palmer Drought Index (1876.503), as would be expected, but a low t value for this variable (.53) and a low R-squared value (0.5107) for the model makes the finding insignificant. The model using market value of agricultural products shows better results. The coefficient on the Palmer Drought Index is negative (-16246.01) with a significant t-value (-3.77), whereas average farm size has a positive effect on market value (66.46) and has a significant t-value (4.99). Both of these results are intuitive, larger farms should experience a positive return to scale and periods of drought should reduce the productivity of farms, although together their interaction term is insignificant with a t-value of 0.728. Also, the R-squared value for the overall model does not point to a strong relationship (0.7534).

Conclusion

The relationship between farm size and adaptation on a regionally scaled basis is difficult to establish for many reasons. First, the sampling technique used was limited to census years for agriculture data while climate and weather data was available over single year intervals. This disparity could allow the effects of single drought years to go unnoticed if it is not in close proximity to the next census. Also, the effects of non-crop farming, such as livestock production, are difficult to separate from data containing only cropland farming. These different types of farming will respond to climate and weather changes in much different ways which confounds the data.

A large factor in determining adaptive capacity to climate change is the access to technology to cope with changing environmental circumstances. As stated earlier, the study region is heavily reliant on irrigated farming. This means an effective adaptive technology is already established in the area and is extensively employed by farmers. Some of the insignificant relationships between farm size and climate may be explained by the even distribution of irrigation technology to farms of all sizes.

Because of these limitations, future research on this topic should consider the level of aggregation and the timing interval of census or sample data. If obtainable, this data could be used to focus more closely on the relationship between climate and water availability, both temporally and spatially. In an area that depends so heavily on irrigated farming the question of how changing climate conditions will affect water scarcity will only grow in importance as the natural environment changes.

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