Estimating Ricardian Functions Using Panel Data

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Introduction - 1

The traditional Ricardian model is a cross sectional analysis that measures the long term impacts of climate change on agriculture (Mendelsohn, Nordhaus, and Shaw, 1994)

The technique has been applied successfully in over 27 countries across the world (Mendelsohn and Dinar, 2009)

Traditionally, Ricardian models –and many nonmarket valuation models– have been estimated using cross-sectional methods with a single year:

$$V_i = X_i \boldsymbol{\beta} + Z_i \boldsymbol{\gamma} + C_i \varphi + u_i \qquad (1)$$

Introduction - 2

Oliver Deschenes and Michael Greenstone (DG) (2007) recently extended the Ricardian method by applying it to panel data in the US (1978, 1982, 1987, 1992, 1997, 2002)

Using repeated cross sectional analysis, they find the results are not stable over time. The model they estimate is the following:

$$V_{i,t} = X'_{i,t}\,\boldsymbol{\beta}_t + Z'_i\,\boldsymbol{\gamma}_t + C'_i\,\varphi_t + u_{i,t} \qquad (2)$$

They argue that intertemporal methods that eliminate cross sectional variation and focus on year to year changes in weather are preferred

Climate vs Weather

In this particular application of panel data, the intertemporal data is not as useful as the cross sectional variation

- Interannual changes in weather are a poor proxy for climate
- Farmers only have limited opportunities to adapt to weather
- Farmers can do a great deal to adapt to changes in climate

DG, however, raise an intriguing issue with respect to cross sectional analysis:

- How should traditional cross sectional models such as the Ricardian model be estimated if panel data are available?
- The issue applies to far more than just the Ricardian model

The Paper

In this paper, we argue that the poor results found by DG were due to misspecifications of their model

Once the model is carefully specified, the results are robust

We present two panel data approaches: a two stage model by Cheng Hsiao (2003) and a single stage "pooled" model

Using US data from the same Census time periods as the DG study, we show that both panel data approaches yield stable results

The results imply that panel methods would likely work not only for Ricardian studies but also for other cross sectional models such as hedonic and travel cost studies

Improved Repeated Cross Section Method - 1

In order to compare the results in DG and our panel data method, however, we must first correct a number of technical problems in the DG analysis

1. Poor job of inferring climate in counties across the US (as first noted by Fisher et al., 2008)
   - DG use average climate from 1970 to year of Census
   - We use 1970-2000 climate normals

2. DG fail to use a constant farmland weights when comparing coefficients across models, this introduces unwanted noise
   - Fixed quantity of farmland so that only climate coefficients vary over time

Improved Repeated Cross Section Method - 2

3. A substantial fraction of counties with agriculture in the United States is omitted

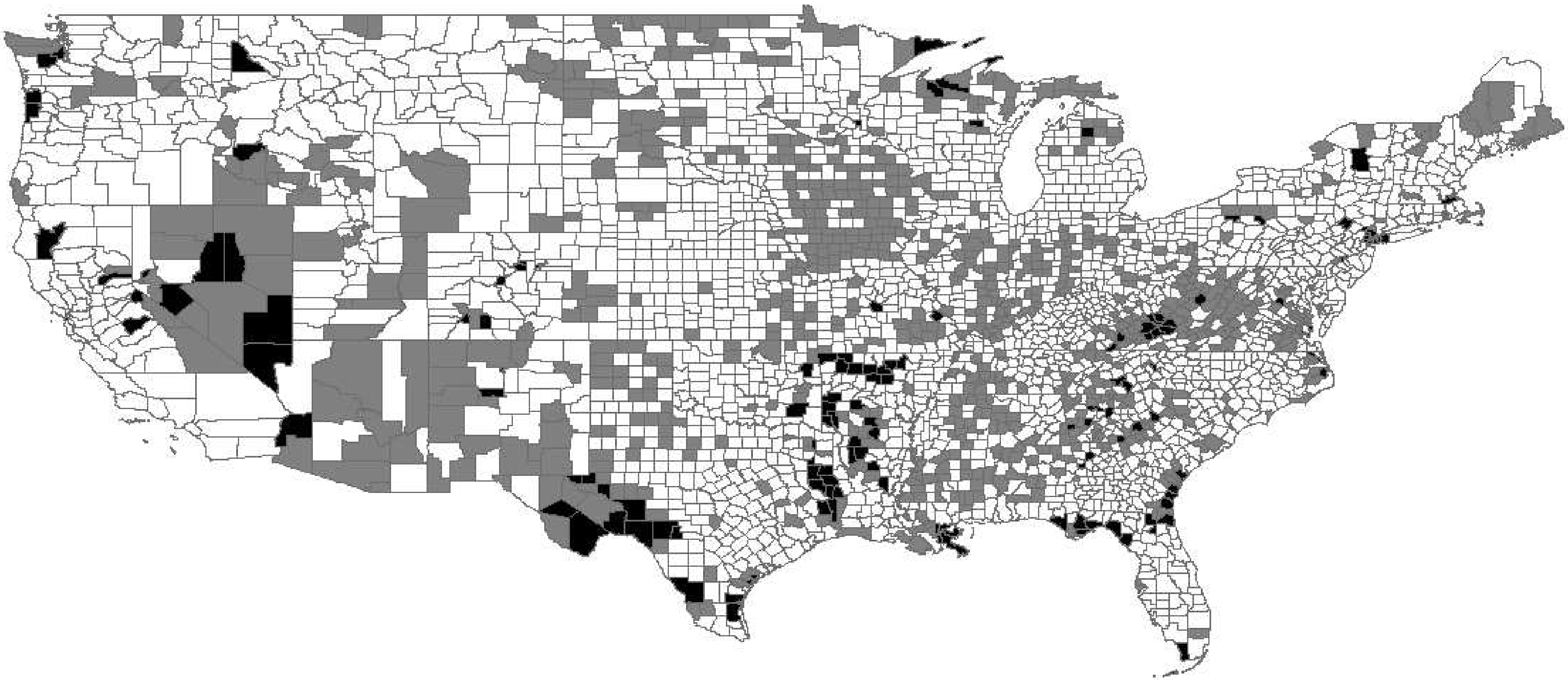
   - Larger sample of counties: from 2124 to 2914, from 72% to 97% of US agricultural land

4. DG fail to correct for the lognormal distribution of farmland values in the US

5. Several important explanatory variables are not included in the DG analysis

   - Surface water withdrawals (largely exogenous, time constant)
   - Opportunity cost of land (owner occupied housing, time varying)

Counties Covered by DG and our Panel Data Set



Missing in both Panels

Missing in DG Panel

Present in both Panels

Welfare Result of Improved DG

Table 1—Welfare Measurement in the Repeat Cross Section Method

Model	DG	Improved Climate	Improved Climate and Expected Farmland	Improved Climate, Expected Farmland and More Counties
1978	154.70	134.14	128.50	137.00
	15.0%	*13.0%*	*16.0%*	*13.4%*
1982	40.80	101.58	99.59	92.68
	4.0%	*10.7%*	*12.4%*	*9.1%*
1987	-8.70	25.57	25.26	36.51
	-0.8%	*4.0%*	*3.1%*	*3.6%*
1992	-8.10	34.23	35.42	33.01
	-0.8%	*5.5%*	*4.4%*	*3.2%*
1997	-33.50	22.50	23.93	13.02
	-3.2%	*3.2%*	*3.0%*	*1.3%*
2002	-101.00	-46.74	-48.52	-54.91
	-9.8%	*-5.4%*	*-6.0%*	*-5.4%*

Notes: All dollar figures are in billions of 2000 USD. Percentage impacts are in parenthesis. Welfare impacts correspond to a uniform increase of temperature of 2.7°C and of 8 percent of precipitation.

Welfare Result of Improved DG

Table 2—Welfare Impact of an Enhanced Repeat Cross Section Model

Model	Improved Climate, Expected Farmland and More Counties	Loglinear	Loglinear with Additional Variables
1978	137.00	281.53	127.32
	13.4%	*27.5%*	*12.5%*
1982	92.68	190.70	98.31
	9.1%	*18.7%*	*9.6%*
1987	36.51	112.54	-52.31
	3.6%	*11.0%*	*-5.1%*
1992	33.01	101.87	-50.38
	3.2%	*10.0%*	*-4.9%*
1997	13.02	90.09	15.17
	1.3%	*8.8%*	*1.5%*
2002	-54.91	47.71	37.60
	-5.4%	*4.7%*	*3.7%*

Notes: All dollar figures are in billions of 2000 USD. Percentage impacts are in parenthesis. Welfare impacts correspond to a uniform increase of temperature of 2.7°C and of 8 percent of precipitation.

The Ideal Panel Data Ricardian Model

We argue that the repeated cross-section DG Ricardian model is mispecified

The coefficients of the time varying variables should not change over time

In an ideal panel data model, the coefficients of the time invariant variables should also not change:

$$V_{i,t} = X'_{i,t}\,\boldsymbol{\beta} + Z'_{i}\,\boldsymbol{\gamma} + C'_{i}\,\varphi + u_{i,t} \qquad (3)$$

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The Two-Stages Hsiao Model

1. Land value is regressed on the time varying variables with county fixed effects:

$$V_{i,t} = X_{i,t}^{'}\boldsymbol{\beta} + \mathbf{e}\alpha_i + \varepsilon_{i,t} \tag{4}$$

where **e** is a vector of county fixed effects (dummies) and ε is the resulting error term.

2. The time−mean residuals are regressed on the time invariant variables:

$$\overline{V_i} - \overline{X}_i^{'}\hat{\boldsymbol{\beta}}_{CV} = \mathbf{e}\alpha_i + \overline{\varepsilon_i} = Z_i^{'}\boldsymbol{\gamma} + C_i^{'}\varphi + \overline{u}_i \tag{5}$$

The Pooled and Hsiao Models: Welfare Estimates

Table 4—Welfare Estimates of Climate Change Impacts

Model	Hsiao		Pooled	
	Absolute	*Percentage*	*Absolute*	*Percentage*
Uniform	14.83 (-164.96 , 208.34)	1.5% (-16.20% , 20.47%)	15.21 (-161.21 , 201.75)	1.5% (-15.81% , 19.90%)

Notes: All dollar figures are in billions of 2000 USD. Bootstrap confidence intervals are in parenthesis.

Test of Time Stability of Climate Coefficients

In order to test whether the climate coefficients are stable over time, we estimate a variant of both panel models

Pooled model:

we interact the time invariant variables with year dummies. They are then combined with the time varying variables in a single regression on land value:

$$V_{i,t} = X_{i,t}^{'}\boldsymbol{\beta}_t + Z'_i\,\boldsymbol{\gamma}_t + C'_i\,\varphi_t + u_{i,t} \qquad (6)$$

Hsiao Model:

The first stage of the model remains the same. In the second stage, we estimate a separate set of coefficients, γ *and* ϕ, for each year:

$$V_{i,t} - X_{i,t}^{'}\hat{\boldsymbol{\beta}}_{CV} = Z_i^{'}\boldsymbol{\gamma}_t + C_i^{'}\varphi_t + u_{i,t} \qquad (7)$$

Test Time Stability: Welfare Estimates

Model	Hsiao Time Varying	Pooled Time Varying	Repeated Cross Section
1978	-7.64 (3.1%)	9.47 (0.9%)	127.32 (12.5%)
1982	9.15 (0.9%)	3.91 (0.4%)	98.31 (9.6%)
1987	6.47 (0.6%)	18.44 (1.8%)	-52.31 (-5.1%)
1992	18.32 (1.8%)	5.51 (1.8%)	-50.38 (5.3%)
1997	28.33 (2.8%)	19.49 (1.9%)	15.17 (1.5%)
2002	-6.22 (-0.6%)	-14.57 (-1.4%)	37.60 (-3.7%)

Note: All dollar figures are in billions of 2000 USD. Percentage impacts are in parenthesis. Welfare impacts correspond to a uniform increase of temperature of 2.7°C and of 8 percent of precipitation.

Thank you for your attention!

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