

A revealed preference econometric analysis of land use choice in Andalusia

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Introduction

- Land allocation among different uses is vital for the provision of commodities and environmental services to society.
- Land use modeling is relevant for policy-making and for evaluating the potential impact of policies on land use allocation.
- In Europe, the CORINE LAND COVER DATABASE (CLC) provides information of land uses for years 1990, 2000 and 2006.

Previous research

- Existing models predict that carbon sequestration in forests and bioenergy produced in Europe can have a significant contribution, already for 2020 (Ovando and Caparrós, 2009: *Energy Policy*).
- Existing models in Europe are based on Computable General Equilibrium framework, while no model have used real observations on land use decisions.
- Lubowsky et al (2006; *Journal of Environmental Economics and Management*) provides an application of econometric models of land uses decisions in US based exclusively on commercial net returns to different land uses.

Existing models may fail taking into account

- Land-owners inertia or liquidity constraints
- Impact of non-commercial values (aesthetics and recreation)
- Landowners may want to retain options for future land-use decisions
- There may be private, market benefits or costs of alternative land uses of which the analyst is unaware

LUC model description

- LUC (land use choice) is an econometric model based on landowner's revealed preferences about competitive agroforestry land uses:
 - Crop
 - Range
 - Forest
- The model estimates the effects of different factors on land use choice and land use transitions between two years (1990-2000; 1990-2006; 2000-2006).

Drivers of land use choice

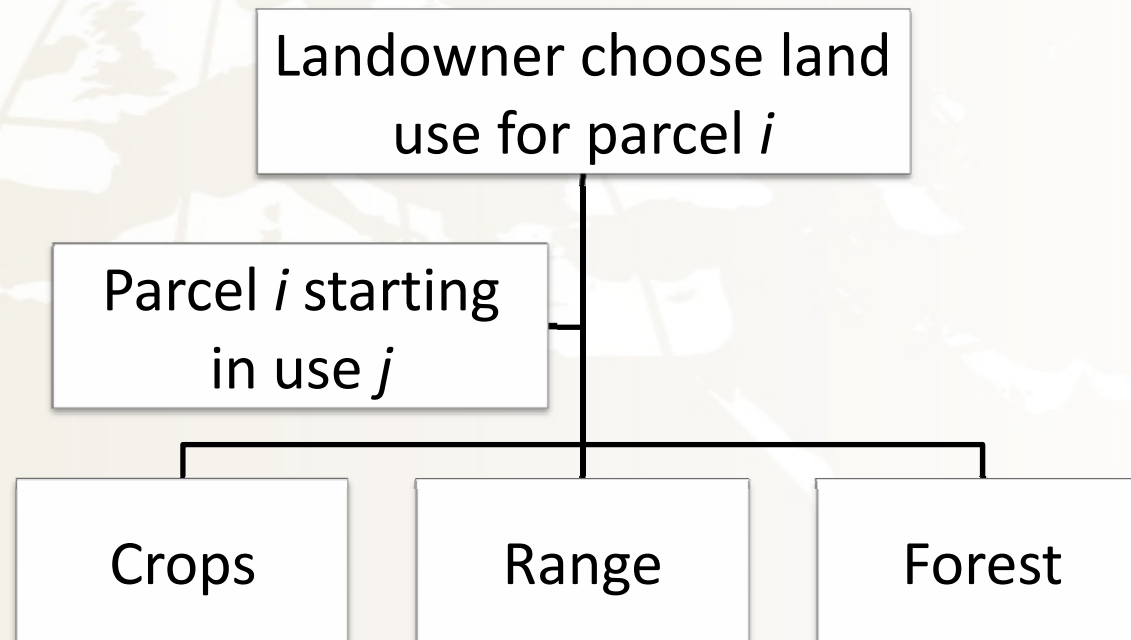
- **Market-related factors:** landowner net income (returns) associated to alternative land uses.
- **Subsidy-related factors:** landowner net subsidies associated to specific land uses and related commodities.
- **Environmental-related factors:** protection figure affecting the land parcel, parcel slope, distance to nearest urban center, population of the municipality where parcel is located....

Model goals

- To **estimate** transition probabilities among crops, range and forest land uses.
- To **identify** explanatory factors (market, subsidy and/or environmental) of land use decisions.
- To **quantify** the effects of these factors.
- To **predict** the impact of regional, national or European policies that would affect these factors (e.g., climate change mitigation policies).

Econometric specification

- For K potential land uses ($j, k = 1, \dots, K$), a landowner will choose for parcel in use j the use k at time t that provides the highest utility after land conversion costs.



Econometric models

- **Conditional logit model:** errors are independently and identically distributed with an extreme value distribution across the K alternatives and i individuals.
- **Nested logit model:** error terms are allowed to be correlated within the alternatives of the same class.
- **Random parameters or mixed logit model:** allows for correlated errors terms and relax the IIA assumption. Each parameter has now a random component with a distribution set a priori.

Pilot study: Andalusia region

- The Andalusia region is the case study selected for the pilot application of the LUC – Andalusia model.
- Andalusia is located in the south of Spain:



Model inputs

- **Dependent variable:** panel data of cross-sectional observations of land parcels.
- **CORINE LAND COVER database:** GIS software (ARCInfo) to get land uses for each parcel in 1990, 2000 and 2006 (discrete-choice response for multiple alternatives).
- **Sample:** 9,937 parcels (points). We lose 63 points that fell into a non-agroforestry land use (developed or water).

9,937 sampling points



Model inputs

- **Explanatory variables:**
 - Net income and subsidies for crop and range: European and Spanish FARM ACCOUNTANCY DATA NETWORK (European Commission).
 - Net income and subsidies for forest: own studies (GEA research group) and legislation.
 - Environmental data for all: parcel-specific using GIS databases.
- Data at **parcel-level** for some observed land uses and at **municipality-level** for others.

Model specification

- Utility function of the alternative land use k starting in use j in the land parcel i at time t :

$$U_{ijkt} = V_{ijkt} + \varepsilon_{ijkt}$$

- V_{ijkt} includes proxy variables for market (MRK), subsidy (SUB) and environmental (ENV) factors:

$$V_{ijkt} = \alpha_{jkt} + \beta_{jklt} MRK'_{jklt} + \lambda_{jkltm} SUB'_{jkltm} + \eta_{jklt n} ENV'_{jklt n}$$

- β_{jklt} , λ_{jkltm} , $\eta_{jklt n}$ are vectors of parameters, and α_{jkt} are specific intercepts for the k land use starting in land use j at time t .

Model results

- **Starting land use specific models:** three models per analyzed period ($T-t - t$) where each model include observations starting in the same land use in $T-t$.
 - Crop starting land use model
 - Range starting land use model
 - Forest starting land use model
- We present results for the **period 1990-2006**, but models for the period 1990-2000 and 2000-2006 are also being analyzed.

Land use transitions between 1990-2006 (9,937 sampling points)

		2006																	
1990	Non-irrigated arable land	Permanently irrigated land	Rice fields	Vineyards	Fruit trees ...	Olive groves	Pastures	Annual crops ...	Cultivation patterns	Land occupied by agriculture	Agro-forestry areas	Broad-leaved forest	Coniferous forest	Mixed forest	Natural grasslands	Sclerophyllous vegetation	Transitional woodland-shrub	Bare rocks	Sparsely vegetated areas
Non-irrigated arable land	87.25	2.63	0.06	0.06	0.84	6.04	0.00	0.11	2.40	0.17	0.11	0.00	0.06	0.00	0.11	0.06	0.11	0.00	0.00
Permanently irrigated land	0.54	94.07	0.27	0.00	0.27	1.08	0.00	0.27	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice fields	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vineyards	3.33	0.00	0.00	93.33	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fruit trees and berry plantations	0.00	1.33	0.00	0.00	98.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olive groves	0.07	0.22	0.00	0.00	0.14	99.35	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pastures	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Annual crops associated with permanent crops	0.00	0.00	0.00	0.00	0.00	25.00	0.00	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Complex cultivation patterns	0.34	3.28	0.00	0.00	0.52	3.79	0.00	0.00	91.55	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00
Land occupied by agriculture, with natural vegetation	2.56	1.28	0.00	0.00	0.64	0.64	0.00	0.00	0.00	94.57	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
Agro-forestry areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.07	0.27	0.00	0.00	0.00	0.00	0.67	0.00	0.00
Broad-leaved forest	0.25	0.25	0.00	0.00	0.25	0.00	0.12	0.00	0.12	0.25	1.23	87.16	0.12	0.00	0.00	0.62	9.63	0.00	0.00
Coniferous forest	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	97.77	0.00	0.00	0.68	1.20	0.00	0.00
Mixed forest	1.12	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	88.76	0.00	1.12	5.62	0.00	0.00
Natural grasslands	6.95	0.00	0.00	0.00	1.54	0.39	0.00	0.00	0.00	0.77	0.00	0.00	0.39	0.00	86.10	2.70	1.16	0.00	0.00
Sclerophyllous vegetation	1.65	0.10	0.00	0.00	0.58	0.87	0.19	0.00	0.19	0.68	0.10	0.00	0.29	0.00	3.11	87.28	4.95	0.00	0.00
Transitional woodland-shrub	0.18	0.18	0.09	0.00	0.36	0.18	0.36	0.09	0.27	0.27	3.58	1.16	2.15	0.09	0.00	1.25	89.70	0.00	0.09
Bare rocks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
Sparsely vegetated areas	0.67	3.33	0.00	0.00	0.50	0.17	0.50	0.00	1.17	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	92.33

Land use transitions between 1990-2006 (9,937 sampling points)

1990	2006		
	crop	range	forest
crop	99.79	0.04	0.17
range	7.59	91.05	1.36
forest	1.69	0.91	97.40

Conditional logit model results

Parameters	Period 1990-2006		
	Crop initial use	Range initial use	Forest initial use
Crop constant	3.5555***	-0.9080***	-1.0569***
Crop net income	0.0019**	0.0002***	0.0001
Range constant	-2.3421***	2.6911***	-1.6971***
Range net income	-0.0001	-0.0001***	0.0000
Forest constant	-1.2134**	-1.7831***	2.7540***
Forest net income	-0.0008	0.0030	-0.0037***
n	4,607	883	4,364
McFadden pseudo r ²	0.037	0.055	0.010

Conditional logit model results

Parameters	Period 1990-2006		
	Crop initial use	Range initial use	Forest initial use
Crop constant	133.4298	0.9744	29.7984
Crop net income	0.0028***	0.0002***	0.0002***
Crop subsidies	0.0079***	0.0029*	-0.0018*
Crop protection figure	-2.0812***	-2.6034*	-1.5994*
Crop slope	0.0176	-0.0528*	-0.0883**
Crop land capability	0.6024	-0.7699	-0.6114
Crop altitude		-0.0005**	0.0011**
Range constant	-169.4010	1.4870	-60.1965
Range net income	0.0014	-0.0001**	0.0006
Range subsidies	0.8046	0.0089*	0.3442
Range protection figure	1.6596***	1.6532***	0.2820
Range slope	-0.0263	0.0338**	0.0358*
Range land capability	-0.5472***	0.0763	0.4297
Range altitude		0.0018***	-0.0020**
Forest constant	35.9712	-2.4614*	30.3981
Forest net income	0.0003	0.0102**	0.0014
Forest subsidies	0.0006	0.0100	0.0048
Forest protection figure	0.4217**	0.9502	1.3174***
Forest slope	0.0086*	0.0191	0.0524***
Forest land capability	-0.0552	0.6936	0.1817
Forest altitude		-0.0012	0.0008**
n	4,597	875	4,364
McFadden pseudo r ²	0.192	0.160	0.110

Results highlights

Factors affecting the probability of moving from CROP LAND USE to

CROP LAND USE		RANGE LAND USE		FOREST LAND USE	
+	-	+	-	+	-
Crop net income	Protection figure	Protection figure	Land capability	Protection figure	
Crop subsidies				Slope	

Factors affecting the probability of moving from RANGE LAND USE to

CROP LAND USE		RANGE LAND USE		FOREST LAND USE	
+	-	+	-	+	-
Crop net income	Protection figure	Range subsidies	Range net income	Forest net income	
Crop subsidies	Slope	Protection figure			
Altitude		Slope	Altitude		

Factors affecting the probability of moving from FOREST LAND USE to

CROP LAND USE		RANGE LAND USE		FOREST LAND USE	
+	-	+	-	+	-
Crop net income	Crop subsidies	Slope	Altitude	Protection figure	
Altitude	Protection figure			Slope	
	Slope			Altitude	

More to do...

- To refine data to specify explanatory variables at parcel level.
- To improve data on forest uses and variables.
- To perform nested and random parameter models (working with nested structures within same land use categories).
- To simulate land use shares under different scenarios of incentives to land uses.