ANALYZING THE EFFECT OF AGRI-ENVIRONMENT MEASURES ON NITRATE CONCENTRATION IN GROUNDWATER FOR AUSTRIA

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Abstract

The Austrian agri-environment program (ÖPUL) from 2000-2006 introduced several measures to reduce nitrate concentration in groundwater. We apply spatial econometric methods on a country-wide panel dataset to assess the partial effects of ÖPUL and other determining factors on nitrate concentration in groundwater. Preliminary results reveal that organic farming and refraining from using inputs on arable land have a measurable negative effect on nitrate concentration.

Keywords

Nitrate concentration, Groundwater, Agri-Environment Measures, Spatial Regression.

1 Introduction

The threshold of acceptable nitrate concentration in groundwater is set to 50 mg/l by the EU Directive 91/676/EEC. In Austria the average nitrate concentration in groundwater has decreased from 26 mg/l in 1992 to 21 mg/l in 2008, though, there is variation among provinces, e.g. nitrate is traditionally high in Eastern Austria (WICK ET AL., 2012). From 1995 onwards agri-environment measures (ÖPUL) were introduced, which, by 2004, covered 89% of agricultural land. ÖPUL 2000-2006 (aka ÖPUL 2000) offered 32 programs, thereby explicitly targeting the reduction of nitrate in groundwater (BMLFUW, 2005). Analyses on farm/field-level found measures to implement e.g. fallow fields, greening of agricultural land in fall/winter and reduction of nitrogen fertilizer effective in reducing nitrate concentration (BWA und WPA 2008, WPA 2003). We use a panel dataset covering ~1200 Austrian municipalities from 1999 and 2002 to 2006, allowing to assess the partial effects of (i) 9 ÖPUL 2000 measures and of (ii) other factors (e.g. land use, soil, weather) on nitrate concentration. We apply spatial econometric methods to control spatial correlation of nitrate content across neighboring municipalities, e.g. due to shared groundwater aquifers.

3 Data and method

We use the panel dataset from Wick et al. (2012), who provide a description of variables and their sources. The dataset includes nitrate, iron and manganese concentration in groundwater (mg/l); precipitation sums (mm) and average maximum temperature (degrees Celsius); field water capacity (cm3/cm3) and land use information. Additionally we incorporate 9 groundwater-relevant ÖPUL 2000 measures in hectare (cp Table 1) from the IACS database (BMLFUW 2010). Variables, aggregated on annual and municipality level, are available for ~ 1200 municipalities from 1999, 2002-2006. Here we discuss a non-spatial fixed effects (FE) model (Eq. 1), a spatial FE model (Eq. 2) – both estimated with Maximum Likelihood (ML) estimations – and a spatial pooled Ordinary Least Squares (OLS) model (Eq. 3), to estimate municipality-specific and non-ÖPUL management variables. FE models account for municipalities' specific characteristics, e.g. altitude, slope, which may influence nitrate concentration. The strength of spatial dependence of nitrate concentration of two nearest municipalities is estimated by a spatial lag term in Eq. 2 and 3 (Millo and Piras, 2012).

Equation 1

$$N_{it} = \alpha_i + X_{it}\beta + \mu_i + v_{it}$$

Equation 2

$$N_{it} = \alpha_i + \lambda \sum_{j=1, j\neq i}^{M} w_{ij} \cdot N_{jt} + X_{it}\beta + \mu_i + v_{it}$$

Equation 3

$$N_{it} = \alpha + \lambda \sum_{j=1, j\neq i}^{M} w_{ij} \cdot N_{jt} + X_{it}\beta + u_{it}$$

The equations include following variables: N_{it} is nitrate concentration in groundwater of municipality $i= 1,\ldots,M$ in period t; X_{it} a matrix of explaining variables; α the regression constant, varying by individual in Eq. 1 and 2; β are the regression coefficients; $\lambda\sum_{j=1,j\neq i}^{N} w_{ij}\cdot N_{jt}$ denotes the spatial lag term where w_{ij} specifies observable spatial weights; u_{it} and v_{it} are independent error terms and μ_i is the municipality specific fixed value.

Preliminary results and conclusion

Preliminary model results reveal that in all specifications, subsidies for organic farming (measured in ha) have a significant negative effect on nitrate concentration. In some model specifications, e.g. spatial FE, refraining from using inputs on arable land also has a measurable negative effect. The significant spatial lag shows the importance of considering nitrate content in neighboring municipalities. The municipality-specific variables such as soil or weather prove to be important, as well as farming systems and management. Future work should integrate robust standard errors, subsamples for Easter/Western Austria and the effect of the level of ÖPUL payments.

Table 1: Regressions Results for fixed effects (FE) and pooled models.

	FE Model[(a)]		Spatial FE[(a)]		Spatial Pooled OLSl[(a)]		
Organic farming	-0.0027	*	-0.0027	**			
Refrain. inputs grassland	-0.0016		-0.0016				
Refrain. inputs arab.land	-0.0103		-0.0095				
Reduct. inputs grassland	-0.0004		-0.0004		Constant	113.6640	**
Reduct. inputs arab.land	-0.0003		-0.0003	#	Field water cap.	-1.9901	**
Green cover arable land	0.0017		0.0015		Fertilizer/ha (kg)	0.0551	**
EcoPoints Niederösterr.	-0.0018		-0.0019		No. hogs/ha	0.9264	**
Reg. measures Salzburg	0.0008		0.0007		No. cows/ha	-15.5834	**
Prev. water protection	0.0002		0.0002		Maize (ha)	-0.0005	
Sum precip. (mm)	-0.0021	**	-0.0019	**	Sum precip.	-0.0063	**
Mean max. temp. (C°)	-0.3961	#	-0.3668	#	Mean max. tem.	-1.5517	**
Iron (mg/L)	0.1617		0.1648		Iron (mg/L)	-0.7691	**
Manganese (mg/L)	-7.6267	**	-7.5476	**	Mangan. (mg/L)	-3.7111	**
Lambda			0.0729	**	Lambda	0.2214	**
Obs. (balanced panel)	4884		4884		4812		
R^2 (within)	0.024				0.188		

Sign. levels: # = 10%; *=5%,**=1%; (a) time dummies not shown. Source: Own calculations

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