The Effects of Government Payments on Agricultural Land Use

By Chengyu Si and Denis Nadolnyak

Invited presentation at the 2018 Southern Agricultural Economics Association Annual Meeting, February 2-6, 2018, Jacksonville, Florida

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Introduction

Land, as an important resource for agriculture production and urban development, has been a popular topic in agricultural and environmental economics for a long time. Land use often reflects the patterns of regional development. In addition, land use change has significant environmental. Affuso and Hite (2013) developed a model for sustainable land use in biofuel production. They found that participatory land-use decision will increase biofuel energy value and reduce carbon emissions.

Generally, land allocation among different uses depends on a number of demographic and economic factors, as well as land quality. In particular, agricultural land use is influenced by prices and market volatility and government policies.

Lubowski et al. (2008) focused on the factors that drive land-use change. They analyzed the change in the U.S. land-use between 1982 and 1997 and considered the net returns as the drivers of land-use change. In their model, the factors from both supply and demand sides are included. The results showed that private land-use decisions were dependent on land quality, economic returns, and policies. Veldkamp and Fresco (1996) used a conceptual model to study land use. They claimed that land use change depended on both biophysical characteristics of and the demand for land. Typical biophysical drivers were biophysical suitability, land use history, and spatial distribution of infrastructure. Important human land use drivers are population density, regional technology level, economic conditions, attitudes, and values. Newburn et al. (2004) claimed that the site-selection of land-use was influenced by three important factors: biological benefits, land prices, and likelihood of land-use change. After comparing different targeting strategies, they found that the relationship between economic factors and land use change is important. Schatzki (2003) focused on the effects of uncertainty and sunk costs on land use change. He found that higher uncertainty in returns to potential use will decrease the likelihood of conversion. Wang et al. (2014) developed a spatial autoregressive multinomial probit model to analyze land development decisions, including spatial clustering and cross-alternative correlation. The explanatory variables included parcel area, parcel perimeter-to-area ratio, network distances, and soil slope. The results showed that the distance to a Central Business District (CBD) has a positive effect on the likelihood of residential development.

For agricultural land use, government policies and supports are an important factor. Yu et al. (2016) investigated the effects of crop insurance premium subsidies on crop acreage and found that the subsidies affect crop acreage in two ways. The first is by increasing expected returns, and the second is by reducing riskiness of crop production. Both encourage farmers to increase crop acreage. The results show that a 10% increase in the crop insurance premium subsidy increases crop acreage by 0.43%. Biofuel policies also impact farm land allocation. Motamed et al. (2016) found that, in the United States, the corn planted area had a significant and large response to local ethanol markets.

As, for other factors that impact agricultural land use, Miao (2013) applied a logit land-share model by using panel data from 1997 to 2009. He found that corn-based ethanol plants had a significant effect on the share of land planted with corn. Plantinga et al. (2002) developed a spatial model to estimate agricultural land prices that reflected not only current but also potential uses of land. Therefore, the current land value reported was influenced by agricultural production rents and the expected future rents from developed uses. Mann et al. (2010) used a spatially efficient logit model to explore the development of cropland. The results show that, apart from transportation costs, the expected returns from the also affect agricultural expansion. Lichtenberg (1989) focused on the effect of land quality on land use, crop choice, and technological change. He found that land quality had a significant impact on cropland allocation. New technologies tended to be applied primarily on land with low quality. Otherwise, irrigation was sensitive to tax policies.

Hardie and Parks (1997) did research on land use in the Southeast by applying an Area Base Model and analyzing the effect of land quality on the probability on different types of land use. The variables that they used were crop revenue, crop cost, sawtimber price, pulpwood price, timber cost, land class that reflects land quality, population density, per capita income, and regional dummies. The analysis was based on the rent maximization hypothesis and used variables such as costs and price. However, the authors did not consider the impacts of government policies, which are an important factor affecting economic returns. They also did not include the distance to a city/central area, which was a crucial geographic characteristic according to previous research.

The objective of this paper is to investigate the effect of government payments on agricultural land use. According to the Census of Agriculture definition, government payments consist of "*direct payments by the 2008 Farm Bill, payments from the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Farmable Wetlands Program (FWP), and Conservation Reserve Enhancement Program (CREP), loan deficiency payments, disaster payments, other conservation programs, and all other federal farm programs under which payments were made directly to farm operators*". In order to find the effects of the payments, we apply the Area Base Model. According to Hardie and Parks (1997), the Area Base Model defines land use categories and allocates land use in an area (county) among them. In this paper, we classify land use type in two ways. The first is classifying farmland into irrigated farmland and unirrigated farmland. The second is classifying land in agricultural uses into cropland, woodland, pasture, and land in Conservation Reserve Program (CRP). According to Stubbs (2014), the Conservation Reserve Program (CRP) is the largest federal, private-land retirement program in the United States. The target of the CRP is to provide environmental benefits, such as reducing soil erosion and improving water quality.

In this paper, we will focus on the land use in three major states in the Southeast U.S.: Georgia, Alabama, and Florida. The objective is to determine the effect of government payments on land use allocation. Government payments are considered an important instrument for adjusting the supply of agricultural commodities. Therefore, government payments could be a potential factor driving land use. Knowing the effects of government payments on land use allocation may be helpful in policy design and implementation. The main hypothesis of this paper is that government payments positively impact farmland allocation, especially for land enrolled in Conservation Reserve Program (CRP). With regard to Georgia, we are particularly interested in the impact of the proximity to Atlanta, which has the eighth highest economy in the country and hosts many global corporate headquarters Coca-Cola, Delta Air Lines, AT&T, and UPS.

Conceptual Framework

In order to analyze the allocation of land to different uses, the theoretical model of profit maximization is specified following Hardie and Parks (1997)

$$\pi(q) = p * q - C(q)$$

where π is profit, p is price, q is total quantity of output, and C is the cost of output.

As Hardie and Parks (1997) considered irrigation important, land use is classified into irrigated farm land, unirrigated farm land, and urban/other land. In order to investigate the effect of government payments on more specific land uses, the second classification of land use type is cropland, woodland, pasture land, land enrolled in CRP, and urban/other land. As the total acreage of each county is constant, efficient land allocation maximizes total profits from all land uses. The total profit of a county is the sum of rents (profits) from all land in different uses. For the (non-)irrigated land use classification, the model can be written as:

$$\pi = \sum_{j=1}^{J} [\bar{R}_j(gov_j) - \bar{C}_j(z_{jk})]Ap_j \quad , j = 1,2,3$$

where j represents the type of land use, j = $[1, 2, 3]$ represents irrigated and non-irrigated farm land and urban/other land. $\bar{R}_j(gov_j)$ represents the average revenue per acre, which is the function of average government pay, $\bar{C}_j(z_{ji})$ is the cost function, p_j is the proportion (share) of each type of land, and A is the total acreage of county. z_{jk} is the vector of independent variables that affect costs such as operation cost and production expenses.

For a specific type of land use, the maximized profit function can be expressed as:

$$\max_{p_j} \pi = [\bar{R}_j(gov_j) - \bar{C}_j(z_{jk})]Ap_j + A(1 - p_j)\sum_{i=1}^{J} [\bar{R}_i(gov_i) - \bar{C}_i(z_{ik})] \quad ,$$

$j = 1,2,3, \qquad i \neq j$

Therefore, the share of land in use j could be written as a function of independent variables:

$$p_j = P(gov_j, z_{jk})$$

where the independent variables include average government pay, county average market value of crop sold, average net farm income, average farmland rent, average farm expenditure (operation cost), median household income, and dummy variables representing time difference. In the case of Georgia, we also use road distance to Atlanta as an independent variable.

We focus on the effect of government payments on land allocations, with the main hypothesis being that the government payments increase the county share of farmland. The logic to be tested is that government payments reduce the farmers' income and production risks and thus encourage more extensive agricultural production by converting the land otherwise considered marginal into farmland. Marginal land is the land that sensitive to the demand of different land use. This increases the share of farmland in the county totals. Similar logic applies to the CRP payments.

Data and empirical methodology

We use county level data from the Southeastern states of Georgia, Alabama, and Florida. The data are collected from the USDA Census of Agriculture database, which provides county level data of farmland acreage, market value of agricultural products, farmers net income, total expenditure, and information on the CRP enrollment. We use the data from 2007 and 2012, which are the most recent two years that reported by Census Dummy variables are used for the two years. As our focus is on agriculture, we use data only on rural counties. Table 1 summarizes provides descriptive statistics of the variables. There are 219 counties in these three states. The average farmland is 89,860 acres with 11,865 of them being irrigated farmland. The average county acreage enrolled in the CRP is 4,400 acres. The average government payment per acre is $18.33.

Table 1. Data summary

Variable	N	Mean	Std Dev	Minimum	Maximum
Total land acreage	438	362,477.6	202,472	91993.6	1278925
Farmland acreage	438	89,859.81	94,319.6	4	549071
Cropland acreage	437	31,410.41	43,837.4	4	450665
Woodland acreage	435	29,941.79	27,268.21	82	195190
Pasture land acreage	437	33,777.67	53,660.29	12	377568
Irrigated farmland	401	11,865.64	32,676.96	3	387755
Farmland enrolled in CRP	355	4,339.95	5,887.45	45	40377
Land value per acre	438	3,330.15	3,178.3	24	27648
Net income per acre	439	233.2994	653.9885	-452.601	8752.1
Expenditure per acre	439	354.7706	953.9878	0	14090.34
Government pay per acre	424	18.33281	18.95076	0.142305	140.1195
Market value of crop sold per acre	208	902.8428	1,950.06	45.07578	22,762.61

For the econometric model, we use the Multinomial Fractional Logit (MFLOGIT) Model. The MFLOGIT Model is used when the outcomes are fractional variables, such as rates and proportions. For example, Mullahy and Robert (2010) applied this model to the time budget problem. They explored how people with different education level allocated time to physical activities, where the allocation of time is a fractional outcome. Papke and Wooldrodge (1993) introduced the quasi-maximum likelihood estimator (QMLE) to avoid the wrong distribution assumption, leading to a relatively efficient estimator. Based on Papke and Wooldrodge (1993), Mullahy (2010) discussed the application of this model on economic share data outcomes. He extended their univariate fractional regression to the multivariate fractional logit model. For the application in land use, Molowny-Horas et al. (2015) applied this model to investigate the effect of nature forces and landscape on land use. Based on the fractional regression from Papke and Wooldrodge (1993), they used multivariate data from Barcelona province, Spain. The results showed that the land use was not only influenced by geographical and environmental variables, but also the neighboring landscape. In this paper, the logit regression equation is

$$\ln\left(p_{jt}\right) = y_j = \sum_{k=1}^{K} \beta_{jk} z_{tk} + \varepsilon_{jt} \qquad j = 1,2$$

where p_{jt} is the proportion (share) of land use in type j at time t, β_{jk} is the vector of coefficients, and z_{tk} is the vector of independent variables. The odds ratio shows the related probability of those two types of land use.

Results

Table 2 shows the results of the logit estimation of the shares of irrigated and unirrigated farmland uses. Among the three states, government payments have a significant positive effect on both irrigated and unirrigated land allocation, except for irrigated land in Florida. This result is consistent with our hypothesis that government payments increase farmland allocation. For Florida, the negative effect could be due to less agricultural land use and other farmer incentives that may exist in the state. In Alabama, average farmland value has a positive significant effect on irrigated farmland allocation. The coefficient of average agricultural expenditure is significant and negative for non-irrigated land in Florida and Georgia, which indicates that as the average expenditure such as operation cost increase, farmers are more likely to transfer their nonirrigated farmland to other use. In Georgia,the net income per acre also has a negative and significant impact on the nonirrigated farmland shares. The net income variable was dropped in Alabama and Florida as it is highly correlated with land values. The positive coefficients at the distance to Atlanta for Georgia counties are also plausible, indicating that the longer distance to Atlanta, the higher the farmland allocation.

Table2. Estimated Coefficients on Land Use of Irrigated Farmland, Unirrigated Farmland in Multinomial Fractional Logit Model

	Alabama		Florida		Georgia	
Variable	Irrigated land	Unirrigated land	Irrigated land	Unirrigated land	Irrigated land	Unirrigated land
Intercept	-8.527***	-1.619***	-0.505	0.311	-8.875***	-2.441***
	(0.570)	(0.356)	(0.801)	(0.615)	(0.672)	(0.335)
Land value	0.00106***	0.0000432	-0.000316*	-0.0000975	-0.0000395	0.0000760*
	(0.000221)	(0.000183)	(0.000148)	(0.0000898)	(0.0000553)	(0.0000357)
Net income					-0.0540	-0.259**
					(0.109)	(0.0984)
expenditure	-0.0103	-0.00235	-0.00221	-0.00181*	-2.168	-1.937*
	(0.00535)	(0.00275)	(0.00123)	(0.000851)	(2.225)	(0.761)
Government pay	0.0323***	0.0157***	-0.0694***	-0.0141	0.0888***	0.0338***
	(0.00589)	(0.00392)	(0.0195)	(0.0110)	(0.00816)	(0.00431)
Market value	0.00738	0.00234	0.00148	0.00102*		

	(0.00435)	(0.00216)	(0.000778)	(0.000516)		
year	-0.0458	-0.0401	-0.192	-0.138	0.785***	0.0571
	(0.244)	(0.117)	(0.406)	(0.320)	(0.167)	(0.0892)
Distance to ATL					0.0571***	0.0183***
					(0.00922)	(0.00476)
Squared diatance					-0.000176***	-0.0000683***
					(0.0000320)	(0.0000177)

Tables 3-5 show estimation results for the cropland, woodland, pasture and CRP enrolled land use classification. In Alabama, the effects of government payments on the four types of agricultural and forestry land use allocation are significant and positive, which means that the government payments encourage land transfer to these uses. The effect of (average) county land value has positive effect on cropland allocation, but negative effects on allocation of woodland and land in CRP, which is plausible. The negative impact on woodland could be because it gets converted into more developed uses when it becomes valuable. Also, forest ownership in the three states is small sized, mostly family owned, and not viewed as a rent earning asset. Farmers intend to transfer the valuable land to cropland due to the high profit from crop production.

For land allocation in Florida, government payments have positive and significant effect on the land in CRP and marginally significant negative effect on pastureland. As the government payment increase, the land allocation to pasture land decrease, and more land is transferred into CRP. For the Georgia land uses, government payments have positive and significant effect on cropland, pastureland, and land enrolled in CRP. This result corroborates our hypothesis. The effect of distance to Atlanta is also positive and significant. As the distance to Atlanta increase, the allocation of cropland, woodland and land in CRP increase.

Table 3. Estimated Coefficients on Alabama Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Intercept	-4.262***	-1.631***	-2.694***	-3.800***
	(0.414)	(0.174)	(0.321)	(0.449)
Land value	0.000572**	-0.000368***	0.0000408	-0.000684***
	(0.000214)	(0.0000681)	(0.000147)	(0.000177)
expenditure	-0.00340	-0.00415**	0.000654	-0.0108**
	(0.00345)	(0.00152)	(0.00203)	(0.00406)
Government pay	0.0235***	0.0112***	0.00501	0.0328***
	(0.00402)	(0.00251)	(0.00305)	(0.00499)
Market value	0.00284	0.00369**	0.0000197	0.00943**
	(0.00277)	(0.00122)	(0.00161)	(0.00332)
year	-0.279*	0.0381	-0.175	-0.103
	(0.134)	(0.0675)	(0.113)	(0.163)

Table 4. Estimated Coefficients on Florida Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Intercept	-1.424*	-2.261***	-0.772	-7.351***
	(0.678)	(0.521)	(0.639)	(1.814)
Land value	-0.000159	0.0000231	-0.0000389	0.000557
	(0.000108)	(0.0000953)	(0.0000869)	(0.000359)

expenditure	0.000392	-0.00103	-0.00107	-0.00326**
	(0.000818)	(0.000826)	(0.00103)	(0.00126)
Government pay	-0.00969	0.000659	-0.0255	0.0490***
	(0.00922)	(0.00760)	(0.0136)	(0.0129)
Market value	-0.000183	0.000675	0.000565	0.00133
	(0.000512)	(0.000480)	(0.000627)	(0.000699)
year	-0.281	-0.0388	-0.0296	-0.177
	(0.324)	(0.219)	(0.380)	(0.627)

Table 5. Estimated Coefficients on Georgia Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Intercept	-6.006***	-4.130***	-2.479***	-8.240***
	(0.647)	(0.477)	(0.455)	(0.607)
Land value	0.000111	-0.0000443	0.000131*	0.0000269
	(0.0000599)	(0.0000442)	(0.0000514)	(0.0000461)
expenditure	-1.931	-0.576	-6.053*	-3.015
	(1.683)	(1.455)	(2.460)	(2.408)
Government pay	0.0243*	0.0122	0.00722	0.0311***
	(0.00961)	(0.0101)	(0.00765)	(0.00685)
year	-0.00282	0.0516	-0.255	0.157
	(0.185)	(0.146)	(0.160)	(0.123)
Distance to ATL	0.0466***	0.0267***	-0.00617	0.0547***
	(0.00905)	(0.00759)	(0.00760)	(0.00853)
Squared diatance	-0.000147***	-0.0000946***	0.00000233	-0.000197***
	(0.0000324)	(0.0000272)	(0.0000279)	(0.0000313)

Finally, tables 6-9 show the estimated marginal effects on irrigated and nonirrigated cropland shares. Table 6 shows the effect on irrigated farmland and unirrigated farmland. For Alabama, a 1% increase in government payments increase irrigated farmland proportion by 0.5% and unirrigated farmland by 10.7%. For land use in Georgia, 1% increase in government payments also increases irrigated and unirrigated farmland shares by 5.8% and 7.6%, respectively. 1% increase in average market value of crop increases irrigated land shares by 1.4% in Alabama, and by 12.5% of nonirrigated land in Florida. For the different land use types in Alabama, 1% increase in government payments increases cropland shares by 6.9%, woodland by 3.8%, and land in CRP by 2%. In Florida, 1% increase in government payment decreases pasture land shares by 5.3%, and increases the land in CRP by 2.8%. However, the effects on cropland and woodland shares are not significant. In Georgia, government payments' increase by 1% increases cropland shares by 2.5% and land in CRP shares by 0.5%. For all three states, government payments show positive effects on CRP land shares.

Table 6. Estimated Marginal Effects on Land Use of Irrigated Farmland, Unirrigated Farmland in Multinomial Fractional Logit Model

	Alabama		Florida		Georgia	
Variable	Irrigated land	Unirrigated land	Irrigated land	Unirrigated land	Irrigated land	Unirrigated land
Land value	0.01012***	0.02131	-0.04959**	-0.08789	-0.00272	0.03543**
	(0.00283)	(0.09058)	(0.02375)	(0.07828)	(0.00376)	(0.01721)
Net income					-0.00035	-0.01042***
					(0.00068)	(0.00355)
expenditure	-0.01697*	-0.24376	-0.04862*	-0.18797**	-0.00166	-0.00796***
	(0.00875)	(0.28536)	(0.02777)	(0.08584)	(0.00164)	(0.00298)

Government pay	0.00464***	0.10756***	-0.02525***	-0.05409	0.05806***	0.07574***
	(0.00135)	(0.02779)	(0.00613)	(0.03879)	(0.00716)	(0.00968)
Market value	0.01406*	0.28049	0.04284*	0.12519**	-0.00011***	-0.00021
	(0.00835)	(0.26045)	(0.02506)	(0.06299)	(0.00004)	(0.00035)
year	-0.00009	-0.00397	-0.00377	-0.01435	0.01399***	0.00538
	(0.00047)	(0.01147)	(0.00746)	(0.03251)	(0.00381)	(0.00848)
Distance to ATL					0.31172***	0.45526***
					(0.05182)	(0.11556)
Squared diatance					-0.15652***	-0.25115***
					(0.02836)	(0.06253)

Table 7. Estimated Marginal Effects on Alabama Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Land value	0.11693**	-0.08354***	0.00899	-0.02210***
	(0.04833)	(0.01515)	(0.03230)	(0.00552)
expenditure	-0.14727	-0.18912***	0.03227	-0.07194***
	(0.14980)	(0.06988)	(0.10022)	(0.02678)
Government pay	0.06878***	0.03770***	0.01428	0.02015***
	(0.01511)	(0.00925)	(0.00893)	(0.00467)
Market value	0.14304	0.19400***	0.00113	0.07275***
	(0.14009)	(0.06514)	(0.09228)	(0.02591)
year	-0.01082**	0.00190	-0.00756*	-0.00068
	(0.00471)	(0.00342)	(0.00454)	(0.00102)

Table 8. Estimated Marginal Effects on Florida Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Land value	-0.05383	0.00826	-0.02317	0.03592
	(0.03765)	(0.03426)	(0.05056)	(0.02222)
expenditure	0.01720	-0.03738	-0.07313	-0.01506**
	(0.03620)	(0.03047)	(0.07010)	(0.00591)
Government pay	-0.01341	0.00110	-0.05254**	0.02847**
	(0.01173)	(0.01275)	(0.02092)	(0.01195)
Market value	-0.00983	0.02823	0.04733	0.00635*
	(0.02733)	(0.02079)	(0.05318)	(0.00377)
year	-0.01072	-0.00163	-0.00205	-0.00042
	(0.01157)	(0.00907)	(0.02602)	(0.00144)

Table 9. Estimated Marginal Effects on Georgia Land Use of Cropland, Woodland Pastureland and Land in CRP in Multinomial Fractional Logit Model

Variable	Cropland	Woodland	Pasture land	Land in CRP
Land value	0.01906*	-0.00663	0.01589**	0.00063
	(0.01103)	(0.00640)	(0.00724)	(0.00110)
expenditure	-0.00303	-0.00088	-0.00427***	-0.00065
	(0.00252)	(0.00215)	(0.00146)	(0.00048)
Government pay	0.02451**	0.01002	0.00295	0.00507***
	(0.01103)	(0.00887)	(0.00322)	(0.00136)
year	-0.00010	0.00177	-0.00451*	0.00081
	(0.00656)	(0.00512)	(0.00250)	(0.00068)
Distance to ATL	0.50626***	0.24687***	-0.02870	0.08566***
	(0.10661)	(0.07340)	(0.03501)	(0.01450)

Squared diatance	-0.24993***	-0.13047***	0.00143	-0.04621***
	(0.05738)	(0.03850)	(0.01707)	(0.00776)

Conclusion

This paper uses the Area Base Model and Multinomial Fractional Logit Model to investigate the effect of government payment on land use allocation. The method follows Hardie and Parks (1997). We focus on land use in three states in the Southeast U.S. The county level data on Georgia, Alabama and Florida are collected from the USDA Census of Agriculture. The estimated results are consistent with the main hypothesis of positive impact of government payments on the shares of farmland. The effect of the CRP payments on enrollment in the CRP is also positive and significant. This suggests that agricultural payments are an effective policy tool for land use change and the related changes in environmental quality, particularly with regard to the CRP. Apart from the impacts of government payments, average farmland value and distance to CDB are also important factors in land use allocation. Higher land values are negatively associated with the shares of land in agricultural uses. In Georgia, the distance to the Atlanta CBD is positively associated the shares of agricultural land uses, which corroborates the findings of previous research.

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