Status-Dependent Impacts of Multiple Drivers on Agricultural Land Conversion

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Introduction

Growing attention has been drawn to the issue of urban encroachment onto agricultural land, as expanding development from agricultural land often causes serious environmental, social and economic ramifications. These influences include the increasing pressure on food production, diseconomies of scale in existing farm businesses and the loss of wildlife habit, open spaces and scenic amenities.

To implement policies that balance the preservation of agricultural land and urban expansion, decision-makers need to understand the extent of agricultural land conversion as well as the factors that cause urban encroachment onto farmland. Literature has claimed different factors that influence the expected future net returns under agricultural uses versus the urban rents after conversion.

However, current studies generally assume the homogeneous impact of explanatory variables on a response along the entire distribution of land values and thus land use conversions. Such restrictions neglect the important observation that some factors inevitably impose different effects on land rents at different locations.

The objective of this study is therefore to examine the status-dependent (i.e., different levels of conversion values) impacts of multiple factors on agricultural land conversion using quantile regression models. The application is to the Edmonton-Calgary Corridor, Canada, where extensive agricultural land conversion to development has occurred.

Conceptual and Empirical Models

The value of a land parcel at location *z* at time *t* can be written as:

$$P(t,z) = \int_t^{\infty} R(\tau,z)e^{-r(\tau-t)}d\tau \qquad (1)$$

where $P(t,z)$ is the price of land parcel *z* at time *t*, $R(\tau,z)$ is the rent of the same land location and *r* is the discount rate.

We assume that a piece of land can be allocated to two alternative uses: agriculture and development. The price of a piece of agricultural land at time *t* can thus be expressed as:

$$P(t^*,t,z,C) = \int_t^{t^*} A(\tau,z)e^{-r(\tau-t)}d\tau + \int_{t^*}^{\infty} R(\tau,z)e^{-r(\tau-t)}d\tau - Ce^{-r(t^*-t)} \qquad (2)$$

where $A(\tau,z)$ is the agricultural rent, $R(\tau,z)$ is development or urban rent, *C* is the cost of conversion from agricultural land to development and $t^* \in [0,\infty]$ is the time of conversion.

$$y_i = \alpha + \sum_{p=1}^{P} x_{ip}\beta_p + \varepsilon_i \qquad (3)$$

where y_i is the agricultural land conversion to development in absolute values at study unit *i*, x_{ip} is a factor that represents either agricultural or development rents, β_{ip} is the corresponding coefficient to be estimated and ε_i is an *i.i.d.* unobserved error term.

$$Q(\beta_q) = \min_{\beta\in\mathbb{R}} \left[\sum_{i\in\{i:\,y_i\ge x_i\beta\}}^{N} q\left|y_i - x_i\beta_q\right| + \sum_{i\in\{i:\,y_i< x_i\beta\}}^{N} (1-q)\left|y_i - x_i\beta_q\right|\right] \qquad (4)$$

Instead of estimating means, quantile regression can estimate any point on the distribution by estimating conditional quantiles, $Q(\beta_q)$. The selected q^{th} quantile regression estimator minimizes the above equation, which consists of a weighted sum of absolute values of errors with different weights assigned to positive and negative errors.

Data Sources

- Land use and land cover data between 2000 and 2012 was based on the 30-meter resolution raster images that were derived from Agriculture Agri-Food Canada (AAFC).
- Land suitability for agricultural uses was generated based on the Land Suitability Rating System (LSRS) provided by the Alberta Agriculture and Rural Development (ARD).
- The raw weather data was also from ARD. The authors calculated the daily mean temperature and accumulative precipitation for the growing season (i.e., April through September).
- The 1-km resolution elevation raster data came from the Commission for Environmental Cooperation. Road network raster data (e.g., road lengths) for 2012 was from AltaLIS Ltd.
- Population data was retrieved from Statistics Canada 2011.

Empirical Results

Table 1. Coefficient estimates from OLS and quantile regressions (N=435)

Variables	Selected Quantile 10%	25%	50%	75%	90%	OLS
Constant	0.036	0.093	0.247	0.683**	0.982	2.384***
	(0.056)	(0.075)	(0.153)	(0.348)	(0.744)	(0.570)
Pasture Percentage	-0.021	-0.032*	-0.122***	-0.280***	-0.339*	-0.457***
	(0.013)	(0.019)	(0.034)	(0.080)	(0.190)	(0.121)
Crop Percentage	-0.023**	-0.024	-0.099***	-0.211**	-0.031	-0.312***
	(0.012)	(0.017)	(0.032)	(0.090)	(0.191)	(0.112)
High Suitability AgLand	0.002	-0.006	-0.038**	-0.109**	-0.360***	-0.061
	(0.006)	(0.009)	(0.016)	(0.050)	(0.127)	(0.059)
Elevation	0.006	-0.007	-0.086**	-0.292***	-0.754***	-0.700***
	(0.014)	(0.023)	(0.040)	(0.112)	(0.250)	(0.139)
Temperature	-0.000	-0.003	-0.006	-0.011	-0.000	-0.092**
	(0.004)	(0.005)	(0.010)	(0.018)	(0.047)	(0.039)
Precipitation	-0.131**	-0.200**	-0.389**	-0.746**	-0.076	-1.584***
	(0.058)	(0.081)	(0.165)	(0.343)	(0.751)	(0.531)
Road Density	0.325***	0.689***	1.979***	3.585***	4.748***	3.045***
	(0.110)	(0.222)	(0.365)	(0.657)	(1.037)	(0.257)
Population Density	-0.006	-0.025	-0.073**	-0.123**	-0.186**	-0.138***
	(0.008)	(0.017)	(0.034)	(0.054)	(0.075)	(0.013)
Distance to City	-0.010	-0.028*	-0.066*	-0.192**	-0.479**	-0.357***
	(0.012)	(0.015)	(0.034)	(0.086)	(0.237)	(0.129)
Adjusted R^2	0.079	0.107	0.198	0.358	0.503	0.474

***, **, and * indicate the coefficient is significant at 1%, 5%, and 10% level, respectively. Standard errors are in parentheses.

Empirical Results

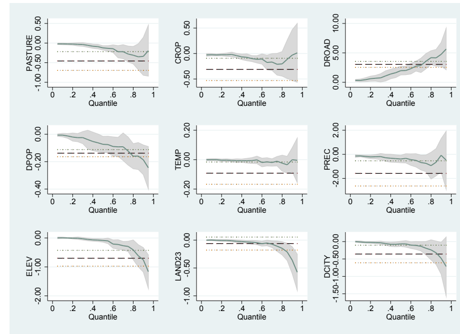

Figure 1. Quantile regression coefficients and related confidence intervals

Conclusions

- The significance and magnitude of impacts vary by the current conversion status. Overall, drivers have larger effects in the higher quantile ranges (corresponding to areas that have experienced more extensive conversions).
- Land suitability for agricultural uses is significant only in mature cities and their surrounding areas where more extensive agricultural land conversion occurred.
- Road density contributes to agricultural land conversions. As expected, a longer distance to urban areas discourages urban expansion onto agricultural land.
- For regions experiencing higher agricultural land conversions (e.g., those near urban areas), it is more difficult to maintain the existing agricultural land due to factors indicative of urban expansion.

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