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Does a Rising Biofuels Tide Raise All Boats? A Study of Cash Rent Determinants for Iowa Farmland under Hay and Pasture

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Does a Rising Biofuels Tide Raise All Boats? A Study of Cash Rent Determinants for Iowa Farmland under Hay and Pasture

Xiaodong Du, David A. Hennessy, and William M. Edwards

Iowa's farmland consists of over 16% hay crops and pastureland, a significant portion of which is under cash rental contracts. This study investigates the comparative relationships between cash rental rates for cropped land and non-cropped land, where the latter includes hay and pastureland. We find that higher crop prices resulting from biofuel demand induces land use conversion from non-cropped land to crop production and thus bids up non-cropped land rents. Compared with changes in cropped land cash rents, non-cropped farmland rents could increase by a higher percentage. Non-cropped land cash rental rates are largely determined by crop and feeder cattle prices, population density, soil quality, and proportion of non-cropped land in a specific area. A primary effect of ethanol subsidies is the redistribution of income between corn growers and livestock producers, whereby higher livestock feed costs together with increasing hay and pastureland cash rents harm the dairy and feedlot beef sectors. Our study shows that, because of the positive effect on rents, the policies have an indeterminate effect on landowners operating in the cow-calf sector.

Key words: biofuel, pastureland, cash rents, random effects model.

JEL classification: C5, G1, Q1.

Although the state of Iowa is well known for corn and soybean production, about 5% of the farmland acres in the state are devoted to hay crops and 11% to pasture (2002 Census of Agriculture). An estimated 60% of the hay and pasture acres are farmed under rental contracts (Iowa State University Extension, 2008), almost all of which involve fixed cash rental payments. If both food and fuel are to be provided by farmland, then lower-quality land in the more fertile regions will need to be cropped. This indeed occurred between 2004 and 2007, when acres planted to corn and soybeans grew by 1.3% in Iowa, and the response will likely increase if Conservation Reserve Program acres leave that program. About 720,000 program acres in Iowa have contract expiration dates between 2009 and 2013.[1] In order to understand what incentives are needed for this acreage reallocation response to occur, and so be better positioned to learn about environmental consequences, a better understanding of factors determining cash rental rates on non-prime farmland is required.

In 2007, 2.2 billion bushels of corn (or 23% of U.S. production) were used to produce ethanol. Farm-level corn prices increased from an average of $2.06 per bushel in 2004/05 to an average price of $6.73 a bushel in the second quarter of 2008. Over the same periods, average soybean farm-level prices jumped from $6.43 per bushel to $10.10 per bushel, increasing animal feed costs correspondingly. According to Iowa State University Extension (1994-2008), this rising demand for corn has pushed up cropland cash rental rates by almost 18% between spring 2007 and spring 2008. The main goals of this study are to investigate how non-cropped land rents relate to cropped land cash rental rates, and how cash rents on non-cropped farmland respond to prices.

Ethanol production and use in the United States depend heavily on a variety of public policy supports (Elobeid and Tokgoz, 2008). From the political economy perspective, the major purposes of government intervention are to support economic surplus and to redistribute

[1] See http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp-st, last visited 9/30/2008.

efficiently that surplus among interested parties. The policy choice outcome is the result of political competition among interested groups. The equilibrium choice is largely determined by the socio-economic characteristics of interest groups (Gardner, 1985). In agricultural markets, factors that determine the political power of a commodity group include, for example, the number of producers, their geographical dispersion, and the importance of the commodity to producers' income. Mancur Olson's framework for studying incentives for potential beneficiaries to form rent-seeking coalitions has proven to be very useful (Olson, 1982). He noted that large heterogeneous groups with low per-capita potential gains will countenance relatively high costs and low benefit-to-cost ratios when attempting to organize for collective action. In political competitions, therefore, groups with large and focused per-capita potential gains may coalesce to win over groups who are less competitive in these regards.

For policy on corn-derived ethanol, there are several involved groups in agricultural and energy markets. These include corn growers, a variety of livestock producers, ethanol producers, and the petroleum industry, in addition to owners and renters of farmland. Although not small in number, corn growers tend to be homogeneous in their economic interests and thus are quite well positioned relative to taxpayers in the policy decision-making process. Livestock producers are not a homogeneous group, differing in the feedstuffs used and the stages of production. Many feel their political capital is best spent on ensuring access to public grazing and raising concerns about other issues, such as contractual relations, concentration in output markets, and animal identification policy. In the United States, and perhaps because of a history of cooperating to market milk, only the dairy sector has traditionally been a significant direct beneficiary of policies involving income transfers. This quiescence may have been due in part to the belief that policies promoting the domestic supply of grain reduce the cost of feed and so promote competitiveness in important international meat and dairy markets.

The reasoning may no longer be valid, and corn users are organizing to influence biofuels policy. Early in 2008, the U.S. Grocery Manufacturers Association initiated funding of a public relations campaign aimed at reducing support for pro-ethanol policies. Officials representing the U.S. chicken, turkey, and beef production sectors have also expressed strong desires to relax policies promoting corn-derived ethanol (Salvage, 2008). While corn growers clearly benefit from pro-ethanol policies, the livestock sector is generally harmed by the high corn prices that result. So, partly driven by relative competitiveness in rent-seeking, one primary effect of ethanol subsidies is to redistribute income between corn growers and livestock producers.

Roughly 60% of all the corn produced in the United States is used domestically for feed grain, so higher crop prices lead to higher livestock production costs. Higher feed costs should lead to lower prices for feeder cattle leaving pasture since feedlots will not bid if the expected future price for fed cattle less the current feeder cattle price is less than the cost of fattening, in which feed is the most important input. But, as we shall show, higher crop prices also likely increase hay and pastureland rents. This has a separate adverse effect on the beef and dairy sectors in addition to a positive effect on returns to land in those sectors. Thus, the overall effect on landowners who farm in these sectors is unclear without further study.

There are a limited number of studies on farmland cash rental rates. Krause and Brorsen (1995) focus on the effect of risk on agricultural land rents, in which risk is defined as variation in the difference between expected revenues and actual revenues. Cropland cash rental rates in the Upper Mississippi River Basin are estimated in Kurkalova, Burkart, and Secchi (2004) based on corn yield estimates. Dhuyvetter and Kastens (2002) use a cost-based method to study the cash rental rate in Kansas over the period 1982-2001. Du, Hennessy, and Edwards (2007) investigate the determinants of Iowa cropland cash rental rates using the Ricardian rent framework. They estimate short- and long-run cash rent responses to corn price changes.

Cash rental rates on other types of non-cropped farmland have not received much attention in the literature, perhaps because data have not been available. Data from the survey we will use indicate non-cropped land cash rental receipts at $550 million for Iowa in 2008, so even a cursory overview shows the issue to be of substantial practical relevance. Several farm extension reports discuss the basic methods that can be used to determine cash rental rates for non-cropland, including grass and pastureland (e.g., Hofstrand and Edwards, 2003; Pflueger, 2007).

This study is organized as follows. A theoretical model is developed in the next section. Then we describe data on cash rental rates for five types of farmland and provides a preliminarily analysis of how they relate. Our empirical analysis follows, which includes analyses of change in cropped land as a share of all farmed land. Determinants of cash rental rates for farmland under hay and grazing are also considered. We close with a discussion of our major findings, as well as suggestions for further study.

Model

Land in a region is heterogeneous, where productivity index θ follows distribution $G(\theta) : [0,1] \rightarrow [0,1]$, the normalizations on domain and range being without loss of generality. There are two uses for the land, namely, in crops and in feeder cattle production (or grassland). In crop production the output price is p^c, while in feeder cattle production the output price is p^f. Let Θ be the land productivity set such that land is cropped whenever $\theta \in \Theta$, and let I_Θ be the indicator function for this set, i.e., $I_\Theta = 1$ if $\theta \in \Theta$ and 0 otherwise. With $S^c(\theta, \cdot)$ as the economic surplus from cropland of productivity and $S^f(\theta, \cdot)$ as that from grazed land, then aggregate surplus amounts to

$$W(\cdot) = \int_\Theta S^c(\theta, \cdot) I_\Theta dG(\theta) + \int_\Theta S^f(\theta, \cdot) \left(1 - I_\Theta\right) dG(\theta) \quad (1)$$

There are no externalities or market power effects in our model, so we may invoke the first fundamental welfare theorem to assert that this measure of aggregate surplus is maximized in market equilibrium.

With feeder production cost per acre at κ^f, let feeder productivity for the most productive operator be $m(\theta)$, an increasing function, or $m(\theta) \geq 0$. Let the decline in productivity be given by function $A[\cdot]$ and, tentatively, write $S^f(\theta, \cdot) = m(\theta)A[x]p^f - \kappa^f$. Here, x is the fraction of acres in pasture. The larger the fraction of land in pasture, the smaller should be productivity at the margin because less-productive operators will be drawn in at the margin. If only low productivity acres enter pasture then we may specify the measure of low productivity acres $G(\cdot)$ as the argument in $A[x]$. For the state of Iowa, only a small fraction of very low productivity land is cropped while only a low fraction of very high productivity land is grazed. This is because corn and soybean seed, materials, and annual cultivation costs are high so that a critical threshold crop yield must be obtained, while perennial grass and hay production is less costly.

Now as $m(\theta)$ is increasing in θ the value of $A[x]$ should be largest at the land quality level where there is indifference between the use the acre is put to, which we label $\hat{\theta}$. In line with the above we may write the θ-dependent value of productivity as

$$A[x(\theta)] = A\left[\int_{\theta}^{\hat{\theta}} dG(s)\right], \quad A[0] = 1; \tag{2}$$

so that $A\left[G(\hat{\theta}) - G(\theta)\right]$ decreases as θ decreases toward 0. The fully specified feeder cattle surplus function is

$$S^f(\theta, \hat{\theta}) = m(\theta)A\left[\int_{\theta}^{\hat{\theta}} dG(s)\right]p^f - \kappa^f. \tag{3}$$

To interpret, if more acres are drawn into pasture (i.e., $\hat{\theta}$ rises) then the value of $\int_{\theta}^{\hat{\theta}} dG(s)$ rises, the value of $A\left[G(\hat{\theta}) - G(\theta)\right]$ falls, and economic surplus on land with attribute θ should fall. This is because operators less suited to feeder cattle production have been drawn into the sector.

Notice that

$$\begin{aligned} \frac{dS^f(\theta,\hat{\theta})}{d\theta} &= m_{\theta}(\theta)A\left[\int_{\theta}^{\hat{\theta}} dG(s)\right]p^f - m(\theta)A'\left[\int_{\theta}^{\hat{\theta}} dG(s)\right]g(\theta)p^f > 0; \\ \frac{dS^f(\theta,\hat{\theta})}{d\hat{\theta}} &= m(\theta)A'\left[\int_{\theta}^{\hat{\theta}} dG(s)\right]g(\hat{\theta})p^f < 0; \end{aligned} \tag{4}$$

with $A'[\cdot]$ as the derivative of $A[\cdot]$ with respect to the value of its integral argument. The first derivative in (4) is positive in part because better land quality should generate a larger surplus in and of itself. This explains the first right-hand term in the derivative. The second right-hand term in the first equation arises because better operators match with that land. The effect of an increase in the threshold type on surplus for any given land quality in pasture is due to the fact that when $\hat{\theta}$ rises then better operators are drawn away from renting pastureland not at the margin.

To see why better operators operate better land in our model, consider when $\theta = \theta^h$ for fraction δ of land at issue and $\theta = \theta^l < \theta^h$ for the remainder. Now $m(\theta^h)A(\delta) + m(\theta^l)A(1) - m(\theta^h)A(1) - m(\theta^l)A(\delta) = [m(\theta^h) - m(\theta^l)][A(\delta) - A(1)] > 0$. If better land is not allocated to more efficient operators then surplus is not maximized and the market could do better by facilitating the switch. Complementarity between operator skills and land quality ensures there is matching in the sense of Becker (1973). Note that this feature of the model is not at all necessary for our analysis. But realism requires that we model heterogeneity in operator efficiency so that we do need some approach to matching operators with land.

Turning to cropland, let cropping cost per acre be κ^c and let feeder productivity for the most productive operator be $n(\theta)$, increasing in θ. For crops, let the decline in productivity be given by function $B[y]$ and write $S^c(\theta, p^c) = n(\theta)B[y]p^c - \kappa^c$. Here, y is the fraction of cropped acres where, as with pasture, the larger the fraction, the smaller should be productivity at the margin. Since only high-productivity acres enter cropping, we may specify the measure of high-productivity acres $\bar{G}(\cdot) = 1 - G(\cdot)$ as the argument in $B[\cdot]$. Similar to (2), write

$$B[\cdot] = B\left[\int_\theta^1 dG(s)\right], \quad B[0] = 1; \tag{5}$$

so that when $\theta = 1$ then $B[\bar{G}(\theta)] = 1$ and $B[\bar{G}(\theta)]$ decreases as θ decreases toward $\hat{\theta}$. The fully specified crop operation surplus function is

$$S^c(\theta) = n(\theta)B\left[\int_\theta^1 dG(s)\right]p^c - \kappa^c \tag{6}$$

where $\hat{\theta}$ does not matter in this case. This is because there is no acreage re-matching, with growers as the best growers always renting the $\theta = 1$ land.

Total surplus expression (1) simplifies to

$$\begin{aligned} W(\hat{\theta}) &= \int_{\hat{\theta}}^1 \left(n(\theta)B\left[\int_\theta^1 dG(s)\right]p^c - \kappa^c\right) dG(\theta) \\ &\quad + \int_0^{\hat{\theta}} \left(m(\theta)A\left[\int_\theta^{\hat{\theta}} dG(s)\right]p^f - \kappa^f\right) dG(\theta), \end{aligned} \tag{7}$$

with optimality derivative

$$\begin{aligned} W_{\hat{\theta}}(\hat{\theta}) &= -S^c(\hat{\theta})g(\hat{\theta}) + S^f(\hat{\theta}, \hat{\theta})g(\hat{\theta}) + T(\hat{\theta})g(\hat{\theta}) = 0; \\ S^c(\hat{\theta}) &= n(\theta)B\left[\int_{\hat{\theta}}^1 dG(s)\right]p^c - \kappa^c > 0; \quad S^f(\hat{\theta}, \hat{\theta}) = m(\hat{\theta})p^f - \kappa^f > 0; \\ T(\hat{\theta}) &= p^f \int_0^{\hat{\theta}} m(\theta)A'\left[\int_\theta^{\hat{\theta}} dG(s)\right] dG(\theta) < 0; \end{aligned} \tag{8}$$

and the second-order concavity condition is assumed. The optimality condition may be rewritten as

$$S^c(\theta) = S^f(\hat{\theta}, \hat{\theta}) + T(\hat{\theta}). \tag{9}$$

Here, $S^c(\theta)$ is surplus on cropland at the extensive margin and $S^f(\hat{\theta}, \hat{\theta})$ is that on pastureland at the extensive margin. Expression $T(\hat{\theta})$ represents the (intensive margin) effect of an increase in threshold $\hat{\theta}$ on feeder surplus due to operator heterogeneity and, more specifically, to the market mechanisms allowing for advantage to be taken of this heterogeneity.

The average economic surplus for pastureland (i.e., the aggregate divided by the fraction of land in pasture) is

$$\bar{S}^f(\hat{\theta}) = \frac{p^f \int_0^{\hat{\theta}} A \left[\int_\theta^{\hat{\theta}} dG(s) \right] dG(\theta)}{G(\hat{\theta})} - \kappa^f. \tag{10}$$

This formula is consistent with the survey data we will study, in which the survey asks for typical rents on land under a given use and not for rent on land of a given quality.

Differentiate with respect to p^c to obtain

$$\frac{d\bar{S}^f(\hat{\theta})}{dp^c} = \frac{\{S^f(\hat{\theta}, \hat{\theta}) + T(\hat{\theta}) - \bar{S}^f(\hat{\theta})\}}{G(\hat{\theta})} g(\hat{\theta}) \frac{d\hat{\theta}}{dp^c}. \tag{11}$$

Now differentiation of equation (9) ensures that

$$\frac{d\hat{\theta}}{dp^c} = -\frac{n(\hat{\theta}) B \left[\int_{\hat{\theta}}^1 dG(s) \right]}{S^c_{\hat{\theta}}(\hat{\theta}) - S^f_{\hat{\theta}}(\hat{\theta}, \hat{\theta}) - T_{\hat{\theta}}(\hat{\theta})} < 0; \tag{12}$$

since $S^c_{\hat{\theta}}(\hat{\theta}) - S^f_{\hat{\theta}}(\hat{\theta},\hat{\theta}) - T_{\hat{\theta}}(\hat{\theta}) > 0$ in light of welfare function concavity.[2] If $d\hat{\theta}/dp^c < 0$ then

$$\frac{d\bar{S}^f(\hat{\theta})}{dp^c} \overset{\text{sign}}{=} -\big\{S^f(\hat{\theta},\hat{\theta}) + T(\hat{\theta}) - \bar{S}^f(\theta,\hat{\theta})\big\}, \tag{13}$$

where $dS^f(\theta,\hat{\theta})/d\theta > 0$ in equation (4) implies $S^f(\hat{\theta},\hat{\theta}) > \bar{S}^f(\theta,\hat{\theta})$. This is because the average over $\theta \in [0,\hat{\theta}]$ of a function that is increasing in θ must be smaller than the function when evaluated at $\theta \in \hat{\theta}$. In addition, (8) has $T(\hat{\theta}) < 0$.

Thus there are two effects. Both are premised on the assumption that an increase in crop prices reduces the amount of pastureland, or $d\hat{\theta}/dp^c < 0$. Observation $S^f(\hat{\theta},\hat{\theta}) > \bar{S}^f(\theta,\hat{\theta})$ is a supply-side effect. It has that an increase in crop prices increases the amount of cropped land, draws from better land, reduces average pastureland quality, and so reduces average pastureland rent. Observation $T(\hat{\theta}) < 0$ is a demand-side effect. It has that when the amount of pastureland decreases there is more demand for the remaining pastureland from those most committed to feeder cattle production. On this account, average surplus on pastureland should increase. Whether this demand-side effect outweighs the supply-side effect is an empirical matter.

Rents Data and Preliminary Analysis

In this study, we used annual survey data of farmland cash rental rates collected by Iowa State University Extension over the period 1994-2008 (Iowa State University Extension, 1994-2008). The survey is sent each year to over 3,000 landowners, tenants, farm managers, lenders and educators who are knowledgeable about cash rental rates for farmland in their county. Respondents are asked to state what they think a typical cash rental rate in a specific county (or counties) is for land devoted to various crops. No other county-level land rent survey of its kind has been collected consistently for this length of time in the United States.

[2] See the appendix for consideration of second-order conditions.

The survey collects typical cash rental rates for (a) farmland with relatively high soil quality devoted to row crop production, including corn and soybeans; and (b) lower-quality farmland used for forage crops. For the sake of brevity in presentation, we refer to land under row crops as cropped land and all other land (including that under hay) as non-cropped land. Non-cropped land is subdivided into the following categories: alfalfa hay, grass hay, improved permanent pasture, and unimproved permanent pasture. Hay land is assumed to have an existing stand of hay, that is, the renter does not have to pay the initial costs of establishing the hay crop. The establishment costs would be presumed to be capitalized into the rental rate. Some alfalfa and grass may be harvested as haylage (green) rather than dry hay, but that was assumed to have no effect on the rental rate. Improved pasture was assumed to have been renovated or reseeded in recent years, to contain some legume species, and to be regularly fertilized. Unimproved pasture was assumed to be on old stands of mostly grass, with little or no maintenance. By far the most common use of pastureland is to graze beef cows and young cattle and, to a lesser extent, dairy cattle and sheep.

The data from the survey are collected by county. However, the response rate for hay and pasture rental rates is too low for many counties to report average values (fewer than five responses). Each year the data are aggregated into 12 geographical areas, containing 7 to 10 counties each. The counties included in the 12 data reporting areas can be found in Figure 1. The county-level cropland cash rental rates are averaged over counties in each area.

Figure 2 presents the historical deflated cash rental rates for five types of farmland in area 1 over the period 1994-2008. All cash rental rates data are deflated by Indexes of Prices Paid by Farmers in the sample period, which are obtained from the USDA Annual Prices Summary (1994-2008).[3] The deflated rents for each type of farmland did not vary much until 2007. Averaged over farmland in all areas, cash rental rates for 2007-2008 increased by 11% compared

[3]The data are obtained from http://usda.mannlib.cornell.edu/MannUsda/, last visited 9/28/2008.

with the level for 1994-2006. While cropped land cash rental rates increased by only 3% in real terms over the year 2007-2008, the rates of increase for alfalfa hay, grass hay, improved pasture, and unimproved pasture farmland are much higher at 13%, 9%, 13%, and 16%, respectively.

Figure 3 shows the log of real cash rental rates in area 1 for five types of farmland included in this study. It indicates that cash rental rates of non-cropped farmland exhibit higher variation than those of cropland. This may be due in part to noisier information on non-cropped farmland because these markets are not as active as cropped land rental markets. Figure 4 presents cash rents of non-cropped farmland relative to those of cropped land. Unimproved permanent pastureland has the lowest cash rental rates, while alfalfa hay land has the highest rents. All relative rent series show a slight increase over the sample period.

Before exploring the major issues, we conduct a simple regression analysis on the rents data to understand the basic relationship. This preliminary estimate should be viewed as motivation for further investigation in this study. OLS regression results of rents of non-cropped farmland on cropped land cash rental rates and time are summarized in Table 1. The results indicate that, on average, for a 1% change in cropped land cash rental rates, cash rents increase by 0.77%, 0.66%, 1.91%, and 1.95% for improved pastureland, permanent pastureland, alfalfa hay, and grass hay land. All responses to cropped land rent are positive and statistically significant. Only the cash rents for permanent pastureland show a significant time trend.

While changes of cash rents for non-cropped farmland are in the same direction as those of cropland, they differ in magnitude. Hayland, closest in quality to cropland, demonstrates sensitivity beyond unit elasticity, while the sensitivity of pastureland is less than 1. This makes some intuitive sense. The state has comparatively little land under hay, which is bulky and costly to transport. As some of the land under hay enters into row crop production, hay land rents may increase markedly in the face of local hay scarcity.

Empirical Analysis

In this section, we justify the linkage between crop prices and the amount of cropped land by analyzing the effect of product market prices on shares of cropped land in total farmland. Expected corn and soybean prices, hay and feeder cattle prices, and the soil quality index are considered to be important factors to explain changes of cropped land shares. Then, employing a panel data regression model, we further analyze the determinants of cash rental rates for four types of non-cropped farmland. To determine the contributing factors of cash rental rates for non-cropped farmland, we consider the following explanatory variables: expected corn, soybean, and feeder cattle prices; population density; non-cropland soil quality; and proportion of non-cropland in each data reporting area. We first discuss each of the chosen explanatory variables and its relationship to the dependent variables.

Feeder Cattle Price: In Iowa, pastureland rental agreements are typically renegotiated and renewed in the fall of each year. Higher feeder cattle prices may induce higher demand for pastureland and put downward pressure on cropland shares. Feeder cattle are the major output of rented pastureland and are typically marketed around November. The expected market prices for feeder cattle should be important in the determination of pastureland rents. As previously assumed, tenant farmers use futures prices to formulate their price expectations when entering rental contracts. The expected prices are represented by average December settlement prices of futures contracts expiring in November the following year over the period 1994-2008.

Corn and Soybean Prices: Harvest-time corn and soybean price expectations influence farmers' planting and land allocation decisions, which are typically formulated in April each year. Corn and soybeans are major alternative feed sources for feeder cattle production. These prices are also likely the main way by which biofuel expansion affects non-cropped farmland rental markets. As with feeder cattle, we use the prices on the harvest-time futures contract traded on the Chicago Board of Trade (CBOT) to proxy the expected corn and soybean prices. In this case, they are averaged over the average daily settlement prices of December (November) futures contracts of corn (soybeans) with expiration of December (November) the following year.

Population Density: Alternative farmland uses such as urban expansion, recreational purposes, and other non-farming motives may put upward pressure on farmland cash rental rates. Du, Hennessy, and Edwards (2007) find that cropped land cash rents are significantly higher for counties closer to big metropolitan areas. Livanis et al. (2006) describe and empirically confirm important impacts of urban sprawl on farmland values. Recreational demand will be affected by scenic endowments, hunting possibilities, and the spatial distribution of income and access, among other factors. To simplify, we consider that the influence of alternative land uses should increase with population size in the corresponding area. We use each area's population density, measured by population per square mile, to capture this effect. The population and area data are obtained from the U.S. Census of 2000.[4]

Cropped land and non-cropped land CSR: Farmland soil quality is another important factor in farmers' production decisions. The county average corn suitability rating (CSR) index is employed in this study to reflect soil quality of all land. It is a farmland productivity index ranging from 0 to 100 with the higher number indicating higher land productivity. Index values are obtained from Iowa State University Extension (1994-2008).

We calculate the acreage-weighted CSR for cropped land in each data reporting area as follows:[5] (a) sort farmland acreage in each county by CSR index of each soil type in descending order; (b) find the cropped land cutoff point by matching the accumulated acres to actual crop planting acreage; (c) calculate county-weighted average CSR indices for cropped farmland; (d) calculate weighted average area CSR indices for cropped farmland in each area. The calculation

[4]The data are obtained from http://www.census.gov/main/www/cen2000.html, last visited 9/28/08.

[5]We obtain similar and consistent results when using other general soil quality indices such as the average slope and land capability class (LCC) calculated from the National Resource Inventory (NRI) database.

of average CSR for non-cropped land is similar to that of cropped land. Although the CSR index is intended to measure row-crop productivity, the attributes underlying high-quality cropland are also good for forage crops.

Proportion of non-cropped farmland: Previously we found that demand for forage land should affect how the corn market influences rent for lower-quality land. So the supply of non-cropped farmland is another important factor in determining rental prices. For example, if a large amount of pastureland is available in a given area and few farmers demand extra pasture, rents should tend to be low. Likewise, if there is little pasture acreage for rent but many farmers demand extra pasture, rents may be bid higher. We use the proportion of non-cropped farmland in total farmland as reported in U.S. Census of Agriculture (2002) to capture the relative availability of non-cropped farmland.

It is worth mentioning that the hay price is not included in regression analyses in this study. Hay prices in May each year, obtained from USDA's Agricultural Price Annual Summary over the sample period, is studied to explain their exclusion from regressions. Figure 5 presents the deflated prices and production of three types of hay, including all hay, alfalfa hay, and other hay, in Iowa over the period 1980-2007. While production levels are stable in the sample period, especially after 1990, hay prices vary much more. Applying a cumulative periodogram white noise test on the deflated hay price series of 1990-2007, we get a Bartlett Kolmogorov-Smirnov (BKS) test statistic of 0.34 with a P-value of 0.9998 (Fuller, 1995). We fail to reject the null hypothesis of white noise. The result means that the reported hay price is noisy and hard to explain by local production. Demand should evolve gradually as local livestock sectors expand or contract, so that demand side events are unlikely to be the cause either. Supply variability at the margin from more drought-prone areas just west of Iowa may be a cause for seemingly excess price volatility.

Change of cropped land shares

In the theoretical model, we assume that an increase in crop prices should reduce the amount of non-cropped land. Because annual acreage data on non-cropped land are not available, we turn to justifying the assumption that higher crop prices increase the amount of cropped land given the fixed amount of total farmland. Cropped land shares are calculated as the shares of corn and soybean planted acres in total farmland for each county over the period 1980-2007. The planting acreage data are downloaded from the National Agricultural Statistics Service (NASS) website.[6]

Cropped land shares among neighboring counties are correlated, possibly because of similar weather and soil quality conditions. To correct for the cross-sectional correlations, we apply the Feasible Generalized Least Squares (FGLS) estimator in the panel data setting (Greene, 2003, p. 322). The estimation results, which are presented in Table 2, show that an increase in corn price induces farmland to shift from other crops such as forage crops to row crop production. The negative coefficient on expected soybean price is mainly due to multicollinearity between corn and soybean prices. The estimation result for corn price only included in Table 2 indicates a significant and positive effect on cropland shares. We notice that the signs for feeder cattle are unexpectedly positive, which requires further investigation.

Determinants of cash rental rates of non-cropped farmland

For illustration, average cash rental rates for improved pastureland of 12 areas in 2008 are shown in Figure 6. Prices are highest in areas 1, 5, and 6, where there is a large feedlot industry, and also in areas 4 and 9 with a large milk production industry. It is lowest in area 2, which concentrates on row crop and hog production.

All price and price-related variables are deflated by Indexes of Prices Paid by Farmers over

[6] The data are obtained from www.nass.usda.gov.

the sample period. Three panel unit root tests are applied on the four deflated cash rental rates time series to ensure the stationarity property of the cash rent time series and so the appropriateness of using level data in regression analysis. The tests include the Levin-Lin-Chu test (Levin, Lin, and Chu, 2002; LLC hereafter), Im-Pesaran-Shin test (Im, Pesaran, and Shin, 2003; IPS hereafter), and Pesaran's CADF test (Pesaran, 2007). The tests results, shown in Table 3, indicate that the rent series on all four non-cropped farmland rent series are stationary.

The panel data regression is based on the data set of 12 reporting areas over the period 1994 through 2008. The cash rental data are characterized by spatial and serial autocorrelations. The correct estimation procedure involves explicitly incorporating spatial and temporal autocorrelation and regional heterogeneity. We expect the cash rental rates data to be positively correlated over space mainly because of the geographic configuration of the 12 data reporting areas. Temporal autocorrelation is possible because landowners and tenant farmers usually prefer formal or informal longer-term rental agreements. Pastureland and hay land involve capital investments, including liming and seeding, that need to be recouped over several years. So tenant farmers and landowners may not respond to market changes annually (Yoder et al., 2008).

Pesaran's CD test (2004) and Friedman's non-parametric test (1937) for cross-sectional dependence are applied on the panel data set of all four types of non-crop farmland rents. The test results are presented in Table 4; all tests strongly reject the null hypotheses of no cross-sectional dependence, at least at the 5% significance level. In addition, Wooldridge's test for autocorrelation in panel data (2002, p. 282) provides a significant F statistic, confirming the existence of serial autocorrelation.

Individual heterogeneity is taken into account using the random effects estimator. The χ^2 statistic for Hausman's specification test of fixed/random effect estimators is calculated as 4.3 with $P > \chi^2 = 0.12$ (Greene, 2003, p. 301). So we fail to reject the null hypothesis that the heterogeneity is uncorrelated with the regressors. This means that we can assume the random effects estimator is consistent and asymptotically efficient. Thus, we conclude that the random effect panel data model incorporating spatial and serial correlations is appropriate for our study.

The random effects panel data model is written as

$$Y_{it} = X_{it}^{'}\beta + \varepsilon_{it} \quad \text{for} \quad i = 1, ..., N, t = 1, ..., T. \tag{14}$$

which can be stacked as

$$Y_t = X_t^{'}\beta + \varepsilon_t \quad t = 1, ..., T$$

where the dimensions of the including variables are $Y_t = [N \times 1]$, $X_t = [N \times k]$, and $\varepsilon_t = [N \times 1]$. Vector β has dimension $k \times 1$ and represents the estimated coefficients for k explanatory variables. Vector Y_t denotes cash rental rates for non-cropped farmland over areas $i \in 1, ..., N$ in year t, while X_t are the variables discussed above. Disturbance term ε_t can be expressed as follows to explicitly take into account spatial and serial correlations:

$$\begin{aligned} \varepsilon_t &= \delta W \varepsilon_t + \nu_t, \\ \nu_t &= \rho \nu_{t-1} + e_t. \end{aligned} \tag{15}$$

Vectors ε_t, ν_t, and e_t all have the same dimensions, $[N \times 1]$. Parameter δ is the spatial autocorrelation coefficient and ρ denotes the temporal autocorrelation coefficient. Error e_{it} is assumed to be independently and identically distributed as $N(0, \sigma^2)$. The matrix W is the spatial contiguity matrix having dimensions $[N \times N]$. Basically, the matrix is a square table with cells of one or zero to indicate whether the areas mentioned in the rows and columns are contiguous or not. Reviewing Figure 1, the value of one indicates that the two areas have a common border and hence are contiguous. The diagonal elements of W are all zero. Following the concentrated maximum likelihood estimation procedure in Elhorst (2008), the estimated coefficient vectors β for the four types of non-cropped farmland are reported in Table 5.

In the four sets of regression results, spatial and temporal autocorrelation coefficients are statistically significant at the 1% significance level. The temporal autocorrelation coefficients are estimated to be from 0.59 to 0.74, while spatial autocorrelation coefficients are in the range of 0.21 to 0.29. The sets of regression results for hay land, including alfalfa hay and grass hay land, are quite different from those for pastureland, including improved and unimproved pastureland. Almost all independent variables included in pastureland regressions are statistically significant to explain the rental price variation, while only corn price and non-cropped CSR are marginally significant in the hay land regressions. This is also indicated by the comparatively low values for the first two columns of Table 5. As we mentioned before, this may be because of the noisy nature of the rental price information of hay land.

We now focus on the improved pastureland. It is sufficiently distinct from land under row crops but is of greater commercial relevance than unimproved pasture. Table 6 presents regression results on improved pastureland cash rents under different model specifications, which involve excluding the soybean price and making alternative assumptions on the model specification autocorrelation structure. All results are consistent with the original model specification shown in Column 1 of Table 6, demonstrating robustness in the regressions. In the results, the expected corn price has a significant positive effect on cash rental prices, which further verifies our main hypothesis in this study that increasing biofuel demand for corn pushes up not only the cropped land cash rents as found in Du, Hennessy, and Edwards (2007), but also the rents for other non-cropped farmland.

The negative sign of the soybean price may result from the high correlation between corn and soybean prices. For the regressions excluding soybean price in Column 2 of Table 6, the coefficient of the corn price remains significantly positive. As hypothesized, the expected feeder cattle price is found to increase significantly the pastureland rents. Share of non-cropped land in a given area is another important contributing factor to explain variations in the cash rental rates. A higher proportion of non-cropped land as identified by Census of Agriculture imposes downward pressure on land rental prices.[7] The results also indicate that competition from alternative uses of pastureland nudges up land rent slightly. This effect is indicated by the population density variable, which is estimated to be small and only marginally significant at the 10% level.

Conclusion

This study has investigated the comparative relationships between cropped land and non-cropped land cash rents through theoretical and empirical analyses. In the theoretical model, the possible linkage is identified as a substitution relationship between lands of different innate fertilities. A higher corn price induces land use conversion from non-cropped land to corn production, reducing the number of acres used for hay and pasture. Demand from feeder cattle production also pushes up non-cropped land cash rental rates. This issue is further investigated in the empirical analysis, including estimates of foraged land rent sensitivities to cropped land rents and a panel data regression model. The empirics find that (a) a higher corn price does lead to an increase in the cash rental prices for non-cropped farmland, and the increase can be elastic with respect to rents for cropped land; (b) a higher corn price does induce a higher share of cropped land; (c) besides corn and soybean prices, other determinants of non-cropped land cash rental rates include the expected feeder cattle price, population density, soil quality, and the proportion of non-cropped farmland.

Current ethanol policy can be viewed as the equilibrium outcome from political pressures

[7] The proportion of non-cropped farmland is probably endogenous and correlated with the determinants of non-cropped land cash rental rates.

brought to bear by interested parties, including corn growers and livestock producers. While farmers who buy corn to feed their livestock lose from current ethanol policies, this study indicates that tenant farmers who rent non-cropped land for grazing are also harmed through increasing cash rental rates. On the one hand, higher feed prices should depress the market price of feeder cattle leaving the cow-calf sector. On the other hand, non-farming owners of lower quality land gain from the policies. The overall effect on cow-calf operators who own their land is unclear, as their incomes are subject to two opposing forces.

There are several possible further extensions to this study, and we mention two. Higher returns to corn production likely encourage Conservation Reserve Program (CRP) acres to re-enter crop production at contract expiration. However, not all CRP acres are prime cropped land, and these acres could be used for hay or pasture. But low-grade land may be used to produce cellulosic ethanol as feedstock for second-generation ethanol production. Were it to occur on a large scale, cropping for cellulosic ethanol would create a more direct demand for non-prime farmland, would likely put upward pressure on their rents, and may place downward pressure on prime farmland rates. So the long-run equilibrium effect of ethanol policy on lower-grade land is as yet unclear.

There is a literature on the political economy of pass-through for government subsidies (e.g., Lence and Mishra, 2003; Roberts, Kirwan, and Hopkins, 2003). Conventional wisdom based on Ricardian rent theory suggests that landowners, who are often stylized as the owners of the most limiting resource, should have the bargaining power to ensure that they receive all benefits. But econometric analysis has identified imperfect pass-through for government subsidies. Historically, it is fair to say that farm policies have not been directed at lower-grade land. Whether land under hay and pasture, which have not been subsidized crops, have actually benefited from government payments through substitution effects is an open question.

Appendix

Derivatives are

$$\begin{aligned} S^c_{\hat{\theta}}(\hat{\theta}) &= n_\theta(\hat{\theta})B\left[\int_{\hat{\theta}}^1 dG(s)\right]p^c - n(\hat{\theta})B'\left[\int_{\hat{\theta}}^1 dG(s)\right]g(\hat{\theta})p^c > 0; \\ S^f_{\hat{\theta}}(\hat{\theta},\hat{\theta}) &= m_\theta(\hat{\theta})p^f > 0; \\ T_{\hat{\theta}}(\hat{\theta}) &= m(\hat{\theta})A'[0]g(\hat{\theta})p^f + p^f g(\hat{\theta})\int_0^{\hat{\theta}} m(\theta)A''\left[\int_\theta^{\hat{\theta}} dG(s)\right]dG(\theta). \end{aligned}$$

Thus, the sign of $S^c_{\hat{\theta}}(\hat{\theta}) - S^f_{\hat{\theta}}(\hat{\theta},\hat{\theta}) - T_{\hat{\theta}}(\hat{\theta})$ is not certain without further structural assumptions.

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Table 1. OLS Regression of Non-cropped on Cropped Land Rents

	Log(cropped land rents)	Time	R^2
Log(alfalfa hay land rents)	1.92***	-0.00066	0.5067
	(13.48)	(-0.49)	
Log(grass hay land rents)	1.96***	-0.0013	0.4943
	(13.21)	(-0.90)	
Log(improved pastureland rents)	0.76***	0.001	0.3478
	(9.60)	(1.37)	
Log(permanent pastureland rents)	0.63***	0.0028***	0.2055
	(6.64)	(3.15)	

Note: Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively. t values are in the parentheses.

Table 2. Panel FGLS Regression Results for Cropped Land Shares

	with soybean price	without soybean price
Expected corn price	0.027***	0.023***
	(10.17)	(2.89)
Expected soybean price	-0.056***	—
	(-4.53)	
Expected feeder cattle price	0.0019***	0.0023***
	(21.26)	(6.64)
CSR	0.0062***	0.0062***
	(116.63)	(115.40)
Constant	0.036***	-0.014*
	(2.85)	(-1.42)

Note: Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively. z values are in the parentheses.

Table 3. Panel Unit Root Tests for Deflated Cash Rental Rates

Test	Alfalfa hay	Grass hay	Improved pasture	Unimproved pasture
LLC	-9.229***	-9.774***	-7.699***	-8.987***
IPS	-2.448***	-2.544***	-2.295***	-2.424***
CADF	-3.624***	-3.210***	-2.880***	-2.954***

Note: Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively.

Table 4. Tests for Cross-sectional Dependence in Panel Data Model

Test	Alfalfa hay	Grass hay	Improved pasture	Unimproved pasture
Pesaran's CD test	1.986***	1.623***	3.319***	5.216***
Friedman's test	25.108***	17.667***	24.283***	40.550***

Note: Rows with Pesaran's CD test and Friedman's test report the t values for the cross-sectional dependence tests. Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively. The null hypothesis of no cross-sectional dependence is rejected if the test statistic is significant.

Table 5. Panel Regression Results

	Alfalfa hay	Grass hay	Improved pasture	Unimproved pasture
Corn price	14.59**	8.04	9.36***	3.23*
	(2.43)	(1.53)	(3.86)	(1.67)
Soybean price	-3.18	-2.21	-2.10***	-0.51
	(-1.29)	(-1.03)	(-2.24)	(-0.67)
Feeder cattle price	0.05	0.12	0.16***	0.10***
	(0.50)	(1.25)	(3.64)	(2.84)
Population density	0.027	0.04	0.028*	0.025**
	(0.51)	(0.88)	(1.92)	(2.30)
Non-cropped land CSR	-1.02*	-0.83	-0.52***	-0.37***
	(-1.71)	(-1.58)	(-3.34)	(-3.07)
% of non-cropped land	-34.67	-23.91	-14.62***	-11.33***
	(1.60)	(-1.26)	(-3.05)	(-2.84)
Constant	108.55***	82.99***	38.24***	30.48***
	(3.66)	(3.20)	(4.59)	(4.61)
Temporal auto.	0.74***	0.74***	0.59***	0.60***
	(25.18)	(24.83)	(9.88)	(10.53)
Spatial auto.	0.26***	0.26***	0.21***	0.29***
	(24.61)	(24.26)	(2.23)	(3.32)
R^2	0.7005	0.6402	0.8567	0.8176

Note: Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively.

Table 6. Panel Regression Results of Cash Rents on Improved Pastureland

	Results in Table 5	without soybean price	with spatial autocorrelation only	without spatial and temporal autocorrelations
Corn price	9.36***	5.19***	5.17**	4.87**
	(3.86)	(3.36)	(2.08)	(2.12)
Soybean price	-2.10***	—	-1.43*	-1.32**
	(-2.24)		(-1.90)	(-2.07)
Feeder cattle price	0.16***	0.14***	0.13***	0.10***
	(3.64)	(3.33)	(2.87)	(3.20)
Population density	0.028*	0.027*	0.03	0.031
	(1.92)	(1.83)	(1.41)	(1.15)
Non-cropped land CSR	-0.52***	-0.51***	-0.54***	-0.54***
	(-3.34)	(-3.19)	(-2.46)	(0.27)
% of non-cropped land	-14.62***	-14.07***	-16.77***	-16.75***
	(-3.05)	(-2.74)	(-3.02)	(-2.48)
Constant	38.24***	37.33***	47.20***	47.86***
	(4.59)	(4.31)	(4.51)	(4.05)
Temporal auto.	0.59***	0.60***	—	—
	(9.88)	(9.93)		
Spatial auto.	0.21***	0.24***	0.19**	—
	(2.23)	(2.63)	(1.87)	
R^2	0.8567	0.8427	0.8230	0.3116

Note: Single(*), double (**), and triple (***) asterisks denote significance at the 0.10, 0.05, 0.01 levels, respectively.

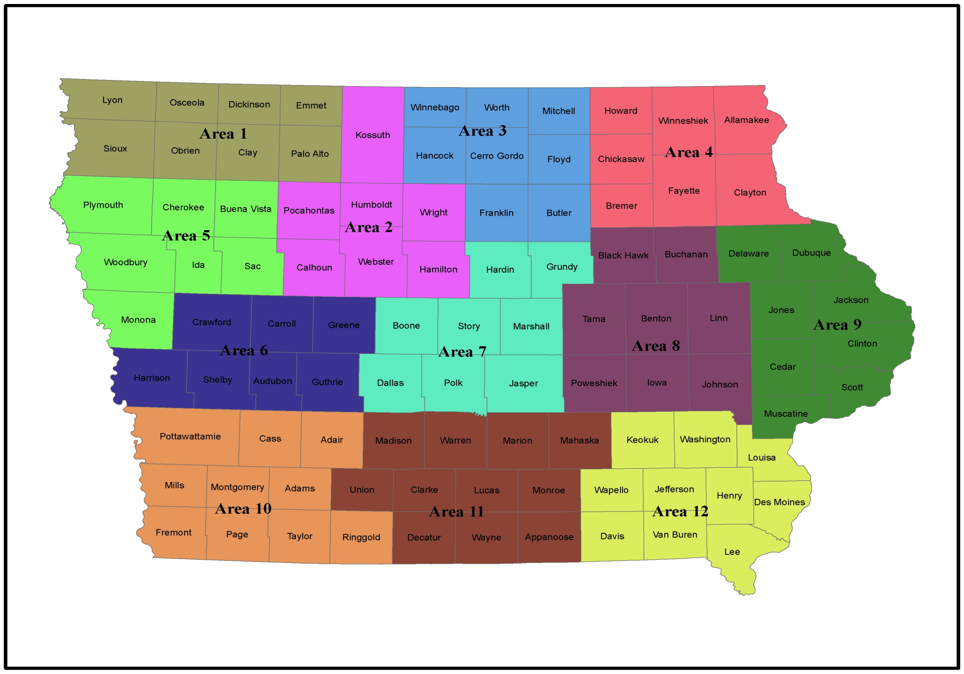

Figure 1. Rent Data Reporting Areas in Iowa

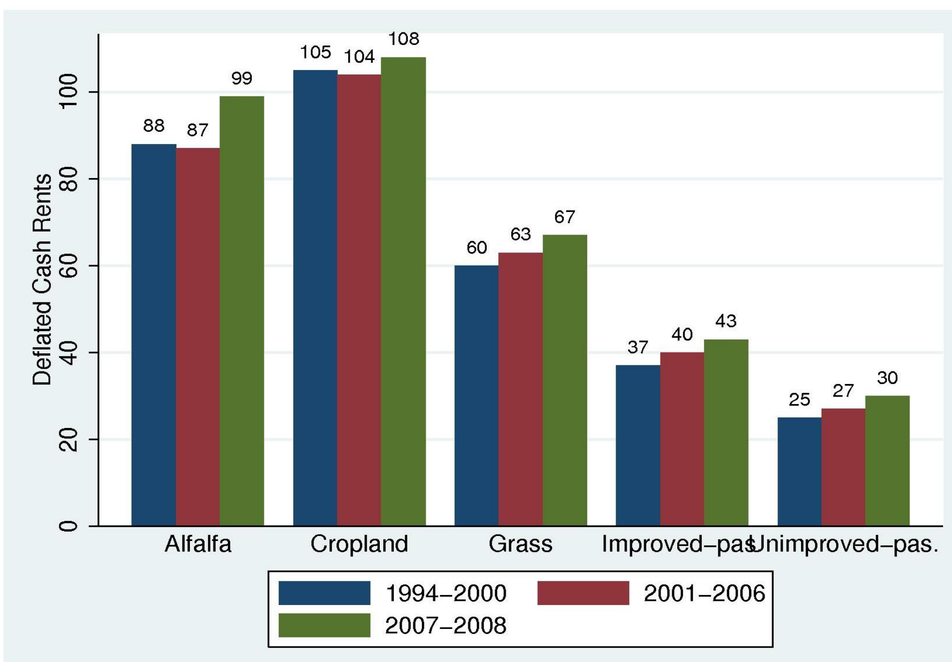

Figure 2. Average Historical Deflated Cash Rental Rates, 1994-2008

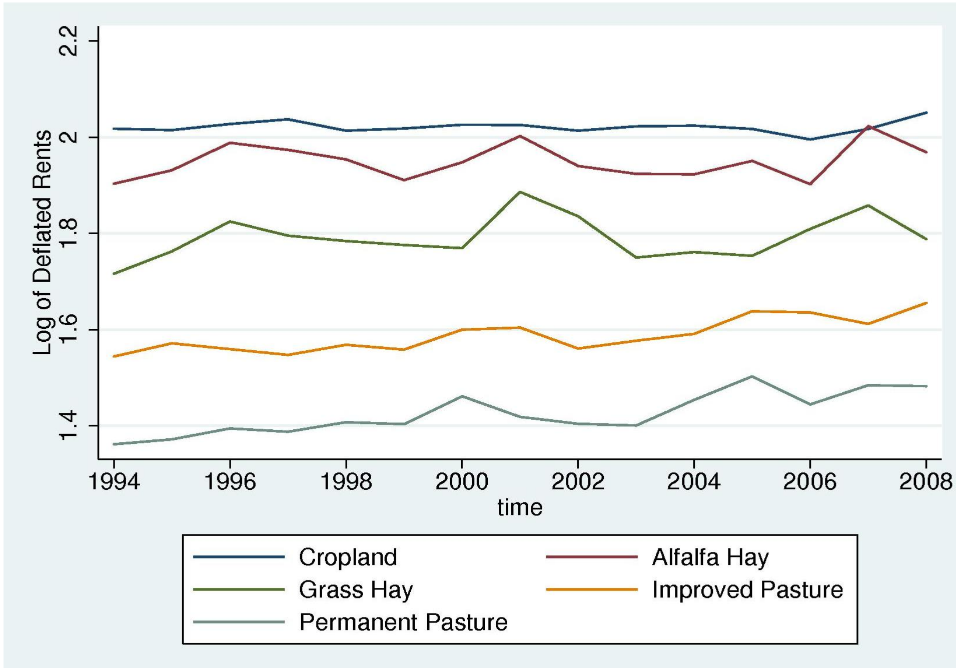

Figure 3. Log of Deflated Cash Rental Rates of Area 1, 1994-2008

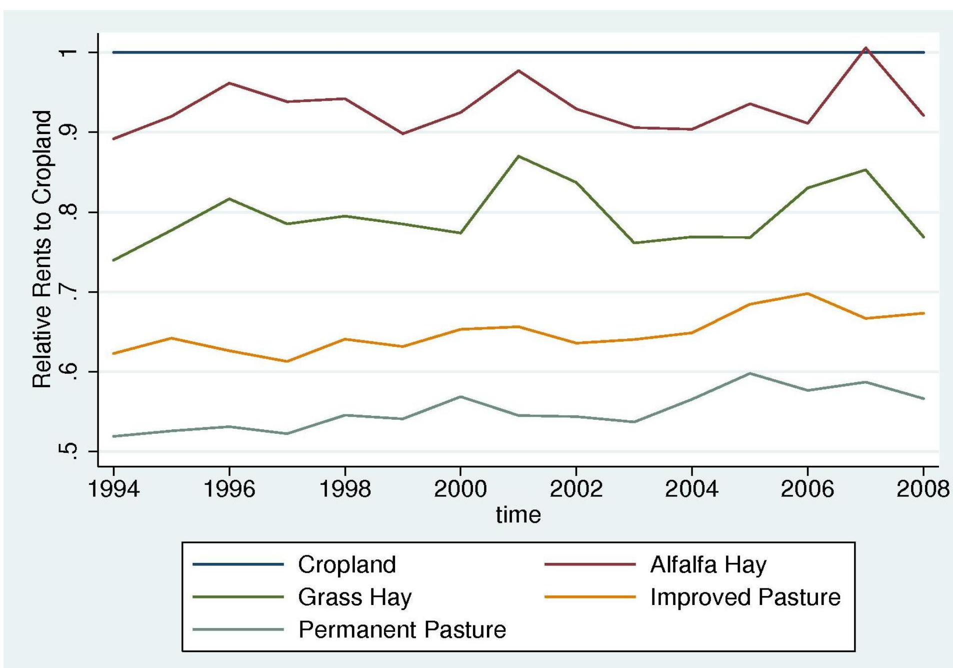

Figure 4. Relative Cash Rents of Non-cropped to Cropped Farmland

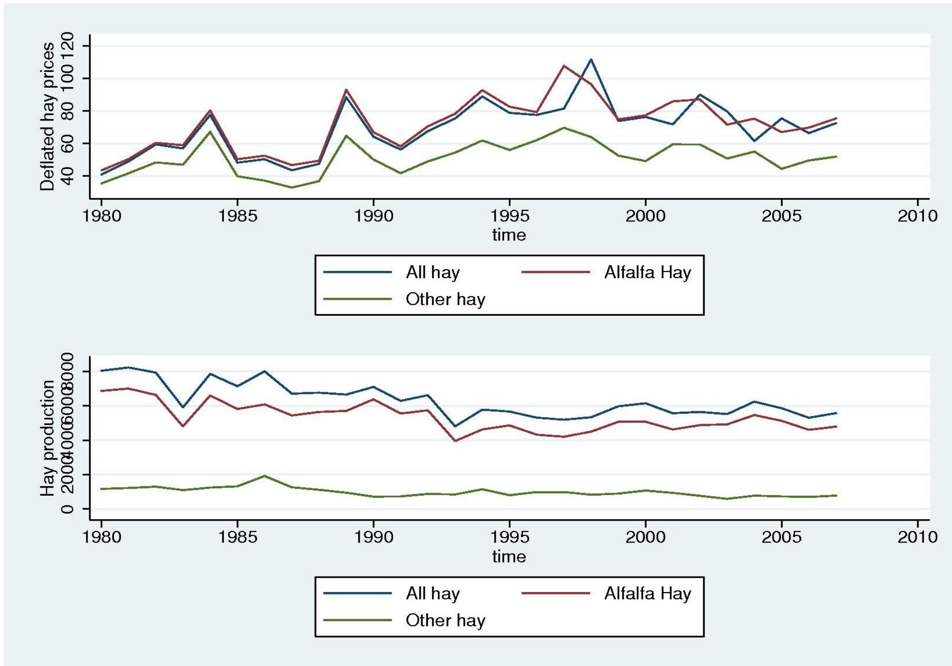

Figure 5. Deflated Hay Prices and Production in Iowa, 1980-2007

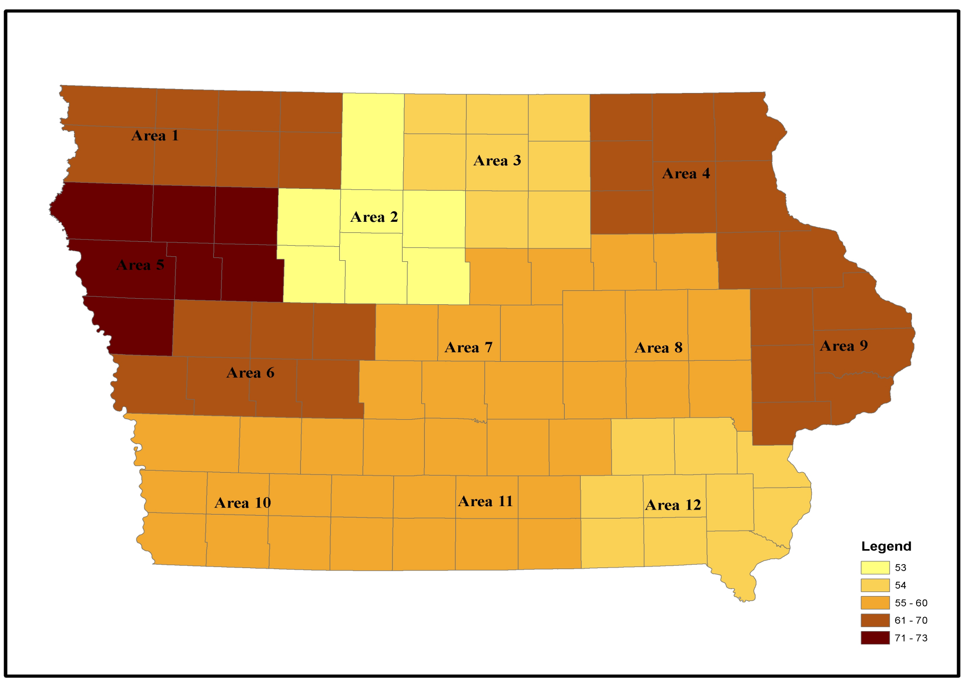

Figure 6. Cash Rental Rates for Improved Pastureland, 2008