Economic Impacts of the Conservation Reserve Program:

A General Equilibrium Framework

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Abstract

This article uses a general equilibrium framework and econometric analyses to examine economic wide impacts of the Conservation Reserves Program. It determines direct and indirect factors which affect the economic efficiency of the program and shows their magnitudes. It shows that the interaction between the program and the tax system causes indirect efficiency costs but the interaction between the program and the agricultural support subsidies generate economic gains. The program has the potential to distort the labor market and cause efficiency losses form this channel. However the analytical model shows that trade can reduce social costs of the policy because a part of the burden of the policy can be passed on to foreign consumers of crop products through the world market. The numerical results show that at the current level of acreage reduction (34 millions acres), the marginal cost of spending one more dollar on the program is about $1.9 for the US economy. In addition, the numerical results illustrate that the program has the potential to generate different and significant unintended economic impacts. For example, depending on the parameters of the model, the program can raise the prices of land up to 10.6%, generate up to 20% land conversion, and raise the demand for nitrogen fertilizer up to 4.2% at the current level of acreage reduction. Finally, the empirical regression results demonstrate that the program has affected the production behavior of the crop industry significantly. In particular, the program has increased the demand for fertilizer and labor and has decreased the demand for land and capital.

Keywords: land retirement, slippage effect, efficiency cost, agricultural pollution, tax system

Introduction

Acreage reduction programs have played a major role in the US agricultural policy in the past 73 years, at least from the passage of the Agricultural Adjustment Acts of 1933 and 1938 (Ericksen and Collins, 1985). Prior to 1986, acreage reduction programs have been mainly used to control and reduce crop production based on the short term contracts. The Conservation Title of the 1985 Food Security changed this pattern and allowed the government to retire environmentally sensitive croplands based on the long term contracts (10 to 15 years). The Conservation Reserve Program (CRP), which has been established under this act, has begun retiring cropland in 1986. This program has retired about 34 million acres of cropland shortly after its beginning and continued to set aside the same acres of cropland from production thereafter[1].

Figure 1 shows the history of retired acres during 1955 to 2004. This figure shows that unlike other acreage reduction programs, which retired land with a high degree of dispersion over time, the CRP has persistently retired about 34 million acres of land during its presence. This program which extensively targets land use in agriculture over time has the potential to affect resource allocation in the whole economy and particularly in agriculture. This paper aims to estimate the overall efficiency costs of this program regardless of its environmental impacts and examine its long term economic impacts on the demand for the main agricultural inputs including labor, land, capital, and fertilizer.

The economic efficiency of the acreage reduction programs and their economic and environmental consequences are important subjects that have been addressed frequently in the literature. The efficiency of alternative targeting instrument for selecting the land to be retired and the cost-effectiveness of retired acreages (in terms of forgone production and environmental gains) are two major issues that have been discussed extensively in the literature. Many papers

[1] Retired acres under other acreage reduction programs (such as the Soil Bank Program and the Acreage Reduction Program) were returned to crop production during the period of 1986-1995.

investigate determinants of the cost effectiveness of land retirement and provide estimates of their magnitudes. For example, three recent papers in this field are Feng el al. (2005); Kirwan, Lubowski, and Roberts (2005); and Yang, Khanna and Farnsworth (2005).

In this field some papers demonstrate that the acreage reduction programs, in particular the CRP, have some unintended impacts which may reduce their efficiency (For example see Hoang, Babcock, and Foster (1993) and Wu 2000)). They mainly address the slippage effects of land retirement. Slippage effects arise for two main reasons: an increase in the use of non-land inputs and the diversion of less productive land to crop production. For example, Wu (2000) shows that for each one hundred acres of cropland retired under the CRP twenty acres of non-cropland were converted to cropland in the central United States. In a recent article Roberts and Bucholtz (2005) question the reliability of Wu's empirical findings. However, their work provides an evidence for the land conversion (Wu, 2005)

Previous papers which study economic impacts of the acreage reduction programs typically apply partial equilibrium frameworks in their analyses and ignore general equilibrium impacts of these programs. The CRP is a large program that can affect the whole economy from different directions. The government finances this program from the distortionary income taxes ($1.8 billion per year). This can adversely affect the economic efficiency through the tax system. This program has the potential to affect prices of agricultural inputs and outputs and affect the farmers' behavior. For example, when nitrogen and land are substitute inputs, the CRP can encourage farmers to apply more nitrogen (and other inputs). An increase in applied nitrogen may adversely affect the water quality which in turn imposes indirect cost on the economy. In addition, more demand for non-land inputs (such as fertilizer, capital, and labor) restricts resources available in production of other goods and services which in turn reduces welfare. The CRP has the potential to raise prices, in particular prices of crop products, which consequently reduces welfare of consumers. The CRP may also reduce incentives to work and raise inefficiency in labor market.

The CRP has positive and welfare improving impacts as well. It raises prices of crop products and therefore reduces the need for the commodity price support subsidies. This can generate economic gains through the tax system. Furthermore, since the US is a large exporter of crop products, the CRP can raise the prices of these commodities in the world market (Sumner, 2003). This can generate economic gains for the US economy. In addition to these economic benefits, the CRP reduces soil erosion, provides wildlife habitat, and improves water quality.

This paper investigates long run economic impacts of the CRP program at a macro level for the US economy regardless of its *environmental consequences*. It first examines the economy-wide impacts of the program by developing a stylized analytical and numerical general equilibrium model. The general equilibrium model is built on the theory of environmental regulation in the second best setting setting[2]. In particular, the model is an extension of Taheripour, Khanna, and Nelson (2006). The model first examines unintended impacts of the CRP and their determinants and then measures their magnitudes. Finally, the paper applies an econometric analysis to seek empirical evidence for unintended impacts and study impacts of the program on the demand for the main agricultural inputs at a macro level. The econometric analysis follows Ray (1988) and sheds light on the impacts of the CRP on the economic parameters associated with the crop production at an aggregate level.

Section 2 presents the analytical general equilibrium model and determines factors that affect efficiency costs of an incremental increase in retired land. Section 3 describes the numerical model and calibration process. Section 4 contains results of the numerical model. Section 5 demonstrates the regression analysis followed by the conclusion in Section 6.

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[2] Throughout this article, the term “second best” refers to a setting with prior distortionary income and commodity taxes/subsidies.

The Analytical Model

Consider an open economy with one representative consumer, two producers, and a regulator. Each producer produces only one final good. Hence, there are two final goods: *X* and *Y*. Here *X* represents a homogeneous crop product and *Y* stands for other goods and services. Output of these goods and their prices are indicated with O_X, O_Y, p_X, and p_Y, respectively. The resources used in production of both goods are labor, land, and capital. Endowments of these resources are $\overline{L}$, $\overline{R}$, and $\overline{K}$, and they are fixed. Land and capital are fully employed. However, the consumer consumes some part of the labor endowment as leisure, *l*. The wage rate, *w*, is selected as the numeraire. Prices of land and capital are r_R and r_K. The crop producer uses nitrogen fertilizer in its production process as well. The economy imports nitrogen fertilizer, N_X, at a constant price[3] of p_N and exports some part of its crop product, *x*, at the price of p_X. Domestic markets are all competitive and agents are price takers. We assume free trade with no tariffs. The demand for exports, $x(p_X)$, is downward sloping, with a constant price elasticity of ε_x. The balance of trade, *Z*, can be positive or negative and is defined as follows:

(1) $$Z = p_X x(p_X) + p_N N_X$$

The consumer derives utility from consumption of goods, leisure, and foreign reserves. The utility function is given by:

(2) $$U = u(C_X, C_Y, l) + \varphi(Z).$$

Here C_X and C_Y show domestic consumption of *X* and *Y*, respectively. In the utility function $l = \overline{L} - L$ is leisure and *L* is labor supply. We assume that *u(.)* is increasing in all arguments and is quasi-concave and that $\varphi(Z)$ is increasing in *Z* and weakly concave. The representative consumer takes *Z* as given. We consider reserves as an opportunity to import other goods from

[3] We will incorporate the elasticity of supply of nitrogen in the world market in the numerical model.

the world market. Alternatively, we can interpret reserves as a public asset/debt. The consumer supplies labor, land, and capital and receives a lump sum transfer, G, from the government. The consumer budget constraint is:

(3) $p_X C_X + p_Y C_Y = (1-t_L)L + Q$.

Where $Q = (1-t_R)r_R \bar{R} + (1-t_K)r_K \bar{K} - Z + G$ represents consumer's non-labor incomes. Here t_L, t_R, and t_K are flat tax rates on labor, land, and capital incomes. The following demands for goods, supply of labor and indirect utility function, V, can be derived from utility maximization:

(4) $C_X = X(p_X, p_Y, (1-t_L), Q)$,

(5) $C_Y = Y(p_X, p_Y, (1-t_L), Q)$,

(6) $L = L(p_X, p_Y, (1-t_L), Q)$,

(7) $V = v(p_X, p_Y, (1-t_L), Q) + \varphi(Z)$.

Production functions represent constant returns to scale (CRS) and are represented by:

(8) $O_X = X(L_X, R_X, K_X, N_X)$,

(9) $O_Y = Y(L_Y, R_Y, K_Y)$.

Since production functions exhibit CRS, the marginal and average cost functions are equal to each other. In addition, because markets are competitive, prices of goods equal marginal costs in the absence of price support subsidies. These assumptions imply:

(10) $MC_X = MC_X(r_R, r_K, p_N) = p_X$,

(11) $MC_Y = MC_Y(r_K, r_R) = p_Y$.

Here, MC_X and MC_Y represent marginal costs of X and Y, respectively. Competitive markets and CRS technologies impose zero profits in both sectors. In equilibrium, the supply of X must equal its domestic demand plus exports and the supply of Y must equal its domestic price. That is:

(12) $O_X = C_X + x(p_X)$,

(13) $O_Y = C_Y$.

Furthermore, market clearing conditions for the primary inputs and nitrogen should be satisfied.

In this economy, the government has several functions. It supports crop production through a subsidy per unit of output, S_o, and retires land, R_G, to protect environment. The government also taxes incomes and pays a lump-sum transfer, G, to the consumer. The government is committed to a certain level of real lump-sum transfer. Therefore, it adjusts G with changes in the prices of consumption goods. In equilibrium government revenues must equal government expenditures. That is:

(14) $t_L L + N_{LTR} = S_o X + r_R R_G + G$,

here $N_{LTR} = t_R r_R \bar{R} + t_K r_K \bar{K}$ and N_{LTR} stands for non-labor tax revenues. Since the government supports production of crop through a subsidy per unit of output, the consumer price of each unit of X is:

(15) $p_X = MC_X(r_R, r_K, p_N) - S_o$.

To express results succinctly, we define the partial equilibrium marginal costs of public funds (MCPF) from the labor tax as:

(16) $MCPF = \tau = (1 + M)$, where $M = -t_L(\partial L / \partial t_L)/(L + t_L(\partial L / \partial t_L))$

We also define the partial equilibrium marginal excess burden (MEB) of the labor tax as:

(17) $MEB = \tau' = -t_L(\partial L^C / \partial t_L)/(L + t_L(\partial L / \partial t_L))$.

Here superscript C indicates compensated derivative of labor supply with respect to the labor tax. These measures are basically distinguishing between the compensated and uncompensated labor supply elasticities. We define elasticity of labor supply with respect to non-labor income by $\varepsilon_{LQ} = (dL/dQ)(Q/L)$. Following the literature we assume that $\varepsilon_{LQ} < 0$. We denote the share of lump-sum transfer in total income as:

(18) $S_G = G/((1-t_L)L+Q)$.

Finally, we define λ as the consumer's marginal utility of income.

To examine direct and indirect welfare impacts of an incremental increase in R_G we first totally differentiate the utility function with respect to this variable. Then we define components of this equation through different steps. In these steps we use equations (1) through (15) to trace welfare impacts of the policy from all markets. In this process we apply definitions (16) through (18), the Slutsky equation, and Shepard's lemma to shrink the final result into compact components[4]. Note that in this derivation, it is assumed that t_R and t_K are constant. Equation (19) shows the final result, where each positive component represents a positive change in the welfare and vice versa.

(19)
$$\frac{1}{\lambda}\frac{du}{dR_G} = \underbrace{-\left(p_X\frac{\partial X}{\partial R_X} - S_o(-\frac{dX}{dR_G})\right)}_{\text{Primary Retirment Effect}} \underbrace{+\left((1-\varepsilon_x)\frac{dp_X}{dR_G}x + (\frac{d\varphi}{\lambda \cdot dZ}-1)\frac{dZ}{dR_G} - p_X\frac{dx}{dR_G}\right)}_{\text{Primary Trade Effect}}$$
$$\underbrace{-(\tau-1)\left(\left(r_R + R_G\frac{dr_R}{dR_G}\right) - \left(\frac{dN_{LTR}}{dR_G} + S_o(-\frac{dX}{dR_G})\right)\right)}_{\text{Reverse Revenue Recycling Effect}}$$
$$\underbrace{+\tau t_L\varepsilon_{LQ}\left(\frac{L}{Q}\right)\left(\bar{R}(1-t_R)\frac{dr_R}{dt_N} + \bar{K}(1-t_K)\frac{dr_K}{dt_N} - \frac{dZ}{dt_N}\right)}_{\text{Non-Labor Income Effect}}$$
$$\underbrace{-\sum_{J=X,Y}\left(\tau t_L\left(-\frac{\partial L}{\partial p_J}\right) + \tau'(C_J)s_G\right)\frac{dp_J}{dR_G}}_{\text{Land Retirment and Labor Tax Interaction Effect}}.$$

The first component which is labeled *primary retirement effect* is equal to the value of marginal product of land minus total saving in agricultural subsidies due to the reduction in *X*.

[4] Detailed derivation is available from the author on request.

This is the opportunity cost of retired land regardless of other impacts of the policy on the economy.

The second component which is labeled *primary trade effect* measures impacts of the policy through the trade channel. The first subcomponent of the trade effect measures changes in the export value of crop product due to an increase in R_G . An increase in retired land has the potential to restrict supply of crop product. Therefore, when the price elasticity of demand for crop product in the world market, ε_x , is less than one this term is positive. In this case an increase in R_G decreases export volume of crop product but increases its export value. The second subcomponent of the trade effect measures changes in the utility of reserves due to an increase in R_G . The sign of this effect depends on two terms: dZ/dR_G and $\frac{d\varphi}{\lambda dZ}$. The first term shows direction of change in the reserves due to an increase in R_G and the second term represents the ratio of the marginal utility of reserves over the marginal utility of income. An increase in retired land may either increase or decrease the reserves. When land and nitrogen fertilizer are complement, an increase in R_G would reduce the demand for nitrogen which in turn raises the reserves, recall that $\varepsilon_x < 1$. However, when these two inputs are substitutable then and increase in R_G would increase the demand for nitrogen fertilizer which can lead to a reduction in reserves. The econometric results presented below and previous work in this field indicate that at a macro level land and nitrogen are substitutable (for example see Hertel, Stiegert, and Vroomen 1996). In the rest of this section we assume that land and nitrogen are substitutable. We now turn to the term $\frac{d\varphi}{\lambda dZ}$. When the marginal utility of reserves is equal to the marginal utility of income this term is equal to one and as the result the second subcomponent of the trade effect will be vanished. However, when these marginal values are different then the second component will be materialized. One can expect $\frac{d\varphi}{\lambda dZ} > 1$ when the economy is faced with a trade deficit and $\frac{d\varphi}{\lambda dZ} < 1$ when there exist a trade surplus. In conclusion, the second subcomponent is positive and welfare improving when the marginal value of reserves is larger enough and $\frac{dZ}{dR_G} > 0$. Finally, the last subcomponent of the trade effect measures an increase in utility due to diverted exports to domestic consumption. In inclusion, when $\varepsilon_x \leq 1$, $d\varphi / dZ$ is large enough, and $dZ / dR_G > 0$ the trade effect offsets some part of the primary retirement costs.

The third component which is labeled *reverse revenue recycling effect* is a welfare reducing item and measures efficiency costs of additional labor tax that is needed to finance the policy. This effect is equal to the marginal cost of public funds minus one times the net change in government expenditures due to an increase in R_G. In one hand the government raises the labor tax rate to pay rental value of retired acres to their owners. This imposes some efficiency costs to the economy. On the other hand the policy raises the non-labor tax revenues, mainly due to an increase in the price of land. In addition, as mentioned earlier, the policy reduces the needs for agricultural subsidies. These two items eliminate some burdens of labor tax that is needed to finance the policy.

The fourth component which is labeled *non-labor income effect* reflects the impacts of the policy on the labor supply due to changes in the consumer's non-labor income. The non-labor income effect is a negative and welfare reducing item as well. An increase in R_G elevates the prices of land and capital which accordingly raises consumers' income from these resources and discourages labor supply.

Finally, the fifth component which is labeled *land retirement and labor tax interaction effect* reflecting the efficiency costs due to interaction between changes in the prices of goods and the labor tax rate. An increase in R_G increases prices of both goods which in turns reduces the real wage and discourages labor supply. The interaction effect captures the efficiency costs of reduction in real wage. This effect has two major subcomponents. The first subcomponent (when $J=X$) is the interaction effect due to changes in the price of crop products. The second subcomponent (when $J=Y$) is the tax interaction effect due to changes in the price of the other good.

The Numerical Model

The above analytical analysis shows that an incremental increase in retired acres imposes several primary and secondary efficiency costs to the economy and it affects economic variables in several directions. This section develops a numerical model to measure the overall efficiency costs of retiring large portions of acres and gauge their corresponding impacts on the economy.

The numerical model follows the analytical model and depicts the US economy at a macro level. The representative consumer derives utility from goods and leisure according to the following two-level constant elasticity of substitution utility function:

(20) $U = \left(\alpha_l l^{\rho_U} + (1-\alpha_l)(C)^{\rho_U}\right)^{\frac{1}{\rho_U}} + \varphi Z$, where $C = \left(\alpha_X C_X^{\rho_C} + (1-\alpha_X)C_Y^{\rho_C}\right)^{\frac{1}{\rho_C}}$.

In this utility function $\rho_U = (\sigma_U - 1)/\sigma_U$, $\rho_C = (\sigma_C - 1)/\sigma_C$, σ_u is the elasticity of substitution between leisure and consumption goods, σ_C is the elasticity of substitution between the two consumption goods, α_l and α_X are distribution parameters and φ indicates marginal utility of the reserve.

We model production processes with two-level production functions introduced by Sato (1967) and widely used in literature (for example see Binswanger 1974; Kawagoe, Otsuka, and Hayami 1985; Thirtle 1985; Abler and Shortle 1992). This type of production function provides a simple and convenient way to build up constant elasticity of substitution (CES) production functions with more than two factors of production. In a two-level production function, first, production is a function of two composite inputs: which are called mechanical and biological inputs. Second, production of each composite input is a function of two inputs. The biological input is a function of land and fertilizer and the mechanical input is a function of capital and labor. The production functions are written as:

(21) $$O_i = \gamma_{ii} \left\{ \alpha_{ii} B_i^{\rho_{ii}} + (1-\alpha_{ii}) M_i^{\rho_{ii}} \right\}^{\frac{1}{\rho_{ii}}},$$ for i=X and Y,

(22) $$B_i = \gamma_{Bi} \left\{ \alpha_{Bi} R_i^{\rho_{Bi}} + (1-\alpha_{Bi}) N_i^{\rho_{Bi}} \right\}^{\frac{1}{\rho_{Bi}}},$$ for i=X and Y,

(23) $$M_i = \gamma_{Mi} \left\{ \alpha_{Mi} L_i^{\rho_{Mi}} + (1-\alpha_{Mi}) K_i^{\rho_{Mi}} \right\}^{\frac{1}{\rho_{Mi}}},$$ for i=X and Y.

Here O_i, B_i, and M_i represent outputs of final goods, composite biological inputs, and mechanical inputs, respectively. In these production functions α's and γ's are distribution and adjustment parameters, $\rho_{ii} = (\sigma_{ii} - 1)/\sigma_{ii}$, $\rho_{Bi} = (\sigma_{Bi} - 1)/\sigma_{Bi}$, $\rho_{Mi} = (\sigma_{Mi} - 1)/\sigma_{Mi}$, and σ_{ii} are the elasticities of substitution between the biological and the mechanical inputs, σ_{Bi} are the elasticities of substitution between land and nitrogen and σ_{Mi} are the elasticities of substitution between labor and capital. It is assumed that production of Y does not need nitrogen. This implies that $\alpha_{BY} = 1$ which in turn implies $B_Y = \gamma_{BY} R_Y$.

Data

Table 1 depicts the US economy in 2002. In this table, the US economy is divided into two sectors: a sector which produces crop products and a sector which provides other goods and services. In addition to the benchmark data, some parameters are taken from the literature. The uncompensated labor supply elasticity of $e_L = 0.15$ is taken from Goulder et al. (1999). The price elasticity of $e_{p_Y} = 1.0$ is assigned to the demand of the clean good based on the work of

Kyer and Maggs (1997). Their work indicates that the price elasticity of aggregate demand for the US economy was around 1.0 during the time period of 1965-90. This value is adopted because the clean good approximately represents an aggregate demand for the US economy. Based on the Database for Trade Liberalization Studies (Sullivan et al. 1989), the price elasticity of $e_{p_X} = 0.5$ is assigned to the domestic demand of the dirty good. This number represents an inelastic demand for crop products. Furthermore, we assume that the elasticity of demand for crop products in the world market is equal to $\varepsilon_x = 0.9$. These elasticities are used to calibrate parameters of the utility function. To incorporate the supply of nitrogen into the model, it is assumed that the supply of nitrogen is increasing in its price. To measure sensitivity of results to the price elasticity of supply of the nitrogen, the model is solved for three different values of this elasticity. The selected elasticities are: ($\varepsilon_{SN} = 0.5$, $\varepsilon_{SN} = 1.0$, and $\varepsilon_{SN} = \infty$). Finally, elasticities of substitution in the production functions are taken from Balisteri et al. (2002) and Horan et al. (2002), and Hertel et al. (1996). They are shown in table 2. We also do sensitivity analyses to check how results change due to changes in the selected parameters.

Efficiency Costs and Unintended Impacts

To evaluate the efficiency costs an *equivalent variation* measure (*EV*) with the following extended definition[5] is calculated for each target of acreage withdrawal:

(24) $$EV = e(p^0, u^0) - e(p^0, u^1),\ u^0 = v(p^0, m^0) \text{ and } u^1 = v(p^1, m^1).$$

Here $e(\ ,\ )$ and $v(\ ,\ )$ stand for the expenditure and indirect utility functions, p^0 and p^1 represent vectors of prices (including prices of inputs) in the absence and presence of land retirement, and m^0 and m^1 indicate wealth in the absence and presence of land retirement, respectively. In this definition, wealth includes all types of income, leisure, and trade reserves. This definition

[5] This definition is designed based on the question 3.I.12 of Mas-Collel, Whinston, and Green (1995).

captures changes in both the prices and wealth. In this definition, a positive amount of *EV* represents welfare loss. The numerical model is calibrated and then solved for several consecutive targets of acreage reduction (from 3 to 75 million acres) using Mathematica.[6]

Efficiency costs

Results for three values of the elasticities of supply of nitrogen fertilizer ($\varepsilon_{SN} = 0.5$, $\varepsilon_{SN} = 1.0$, and $\varepsilon_{SN} = \infty$) have been reported in table 3. Four figures for each of these elasticities have been presented in this table: total, average, and marginal costs for each level of acreage reduction and the marginal cost of public expenditures (MCPE) associated with that level. The total costs gauge reduction in welfare in terms of *EV* due to the designated level of land retirement. The average costs show welfare lost per acre of the retired land and the marginal costs represent welfare lost of the last units of the retired land. Finally, the last figures, MCPE, compare the marginal costs with the amount paid per acre of the retired land by the government in 2002. The MCPE measure the unaccounted social costs of government land retirement payments.

Table 3 shows that for each level of the retired land, costs are decreasing in the elasticity of supply of nitrogen fertilizer. For example, the first acre of the retired land costs the economy \$83.2, \$80.8, and \$74.3 when $\varepsilon_{SN} = 0.5$, $\varepsilon_{SN} = 1.0$, and $\varepsilon_{SN} = \infty$, respectively. In the rest of this section we focus on the results for the unit elasticity of nitrogen supply, $\varepsilon_{SN} = 1.0$, to be neutral with respect to this parameter.

Table 3 illustrates that costs grow with the level of acreage reduction. For example, the first and the last retired acres cost the economy \$80.8 and \$110.1. These figures are 1.5 and 2.1 times of the money that the government has paid for each acre of retired land in 2002. The

[6] To evaluate the precision of the calibration process and measure the simulation capability of the calibrated model, the status quo is simulated first. The simulation of the status quo shows negligible differences (usually less than one percent) between real data and their simulation figures.

federal government has paid about $1.7 billion to withdraw 33 million acres of land from production, approximately $52 per acre of land.

Table 3 reveals that the total social costs of retiring 33 million acres of land is about $2.9 billion for the US economy, about $88.8 per acre. The marginal cost of public expenditures for this level of land retirement is about $1.8. This means that the last dollar paid by the government for the CRP program costs the economy $1.8. This umber reflects the marginal cost of the CRP at the current level of acreage reduction. If the government decides to retire more land (for example to sequester carbon in the soil) costs will grow rapidly. For example, retiring 75 million acres of land (twice the current retired land) will cost the economy $7.2 billion, about $96.3 per acre. At this level of land retirement the MCPE will be $2.1

Unintended impacts

Numerical results reveal that land retirement largely affects the prices of land and crop products and it has minor and negligible impacts (but positive) on the prices of capital and other goods. Table 4 shows impacts of acreage reduction on the prices of land and the price of the homogeneous crop product for the three values of the elasticity of supply of nitrogen fertilizer. This table illustrates that when the supply of nitrogen is more inelastic, land retirement generates stronger price impacts. For example, when the supply of nitrogen is very inelastic ($\varepsilon_{SN} = 0.5$), retiring 33 million acres of land raises the prices of land and the crop product by 10.6% and 4.1%, respectively. Corresponding figures for a perfect elastic supply of nitrogen ($\varepsilon_{SN} = \infty$) are 9.3% and 3.3%, respectively. Furthermore, a careful review of table 4 reveals that the price impacts (change in the price of land and crop products) of land retirement grow exponentially with the amount of retired acres.

The price impacts of land retirement have the potential to affect both consumers and producers behaviors. In one hand, an increase in the price of land forces crop producers to apply more labor, capital, and nitrogen fertilizer per unit of output. On the other hand, an increase in the price of crop products encourages consumers to reduce their demand for crop products which in turn forces farmers to reduce supply of crop products. In the rest of this section we examine the impacts of land retirement on the demand for inputs and supply of crop products. Table 5 illustrates some of these effects for the three values of the elasticities of supply of nitrogen.

Table 5 illustrates that the aggregate demand for nitrogen fertilizer grows with the quantity of retired acreages. As explained earlier land retirement significantly raises the price of land compare to the prices of other inputs. This encourages crop producers to apply more nitrogen per unit of output. This eventually leads to an increase in the aggregate demand for nitrogen fertilizer. For example, table 5 shows that when the supply of nitrogen fertilizer is perfectly elastic ($\varepsilon_{SN} = \infty$), retiring 33 million acres of land raises the aggregate demand for nitrogen fertilizer by 4.2%. The corresponding figure for an inelastic supply of nitrogen fertilizer ($\varepsilon_{SN} = 0.5$) is equal to 1.5%. Notice that applied labor and capital per unit of output grow with the level of acreage reduction but their aggregate demand fall slightly due to the reduction in the crop production.

Table 5 illustrates that land retirement has the potential to transfer non-cropland to crop production. For example, when the supply of nitrogen fertilizer is very elastic, retiring 33 million acres of land generates a land slippage effect of 18.9%. This means that at this size of acreage reduction, for each 100 acres retired, about 18.9 acres of non-cropland would be converted to cropland (this number is very close to the reported figure by Wu, 2000). Table 5 shows that the size of slippage effect increases with the amount of retired acres and decreases with the elasticity of supply of nitrogen fertilizer. However, these factors do not affect the size of the land slippage effect very much.

Table 5 also shows that land retirement has a relatively weak impact on the crop production. For example, when the supply of nitrogen fertilizer is very elastic, retiring 33 million acres of land reduces the supply of crop products by 1.8%. The corresponding figure for a perfectly inelastic supply of nitrogen is about 2.3%. This means that land retirement restricts the supply of crop products moderately. This is because of using more non-land inputs per unit of output in crop production and because of the existence of the land slippage effect.

Sensitivity Analysis

To test impacts of alternative parameterizations on the simulation results, three more sets of parameters are tested. In the first set, the elasticity of labor supply is reduced from 0.15 to 0.11. This affects calibrated parameters of the utility function. In the second set, the elasticity of substitution between land and nitrogen fertilizer in production of the dirty good is reduced from 1.25 to 0.75. This affects the calibrated parameters in sector *X*. In the third set, two more values for the elasticity of demand for exports of the crop product, $\varepsilon_x = 1$ and $\varepsilon_x = 1.1$, are tested.

In short, a reduction in the elasticity of labor supply (from 0.15 to 0.11) reduces the efficiency costs but not significantly. A reduction in the elasticity of substitution between land and nitrogen fertilizer (from 1.25 to 0.75) makes substitution between nitrogen and land difficult and raises the efficiency costs and generates more slippage effect. Finally, results are slightly sensitive to the elasticity of demand for exports of the crop product. The efficiency costs grow with higher elasticities of demand for exports.

Econometric Analysis

This section applies regression analyses to explore impacts of the CRP on the demand for agricultural inputs and investigates structural change in the production parameters in the crop industry due to the CRP. To develop an econometric model consistent with the rest of this paper it is assumed that crop production at the macro level is a function of four inputs: labor, land, capital, and fertilizer (including all chemical inputs). Then it is assumed that the crop industry minimizes costs of production. Under these assumptions the structure of the production function can be studied empirically using a cost function. A useful and flexible functional form that has been frequently used in defining cost functions is the translog form. For example, Ray (1982) has estimated a two-output-five-input translog cost function for the US agricultural industry for the period of 1939-77. The translog cost function of Ray (1982) is modified in the current paper to study the US crop industry in the period of 1984-2004. According to Ray (1982), the following one-output-four-input translog cost function along with the corresponding input share equations have been defined and used in the current paper:

$$\ln C = \alpha_0 + \alpha_X \ln X + \frac{1}{2}\gamma_{XX} (\ln X)^2 + \sum_i \lambda_i D \ln P_i + \sum_i \alpha_i \ln P_i$$
$$+ \sum_i \gamma_{Xi} \ln X \ln P_i + \frac{1}{2}\sum_i \sum_J \gamma_{ij} \ln P_i P_J + hT$$

$$S_i = \alpha_i + \lambda_i D + \gamma_{Xi} \ln X + \sum_j \gamma_{ij} \ln P_J \qquad \text{For } i = L, K, R, N \text{ and } j = L, K, R, N.$$

Here C represents the annual cost of crop industry, X stands for annual crop production, D is a dummy variable that represents presence of the CRP, S_i shows cost share of input i, P_i represents price of input i, and T is an annual index of time. The full system (i.e. the cost function and the share equations jointly) is estimated under the following restrictions to impose homogeneity of degree one in input prices:

$$\sum_i \alpha_i = 1, \quad \sum_i \lambda_i = 0, \quad \sum_i \gamma_{xi} = 0, \quad \sum_i \gamma_{ij} = \sum_j \gamma_{ij} = \sum_i \sum_j \gamma_{ij} = 0.$$

Notice that in this system $\gamma_{ij} = \gamma_{ji}$. Using these restrictions, the full system has been transferred to a modified translog system. In the modified system the price of labor has been selected as the numeraire. The Zellner's Seemingly Unrelated method has been applied to estimate the modified translog system.

Data

The following variables have been collected for the period of 1984-2004: C, index of crop production expenses; X, index of crop production; P_L, index of wage rate paid by farmers; P_N, fertilizer (including chemicals) price index: P_R, index of rental rate of land: P_K, price index of other inputs. The cost share variables are calculated using the crop industry expenses on labor, land, capital, and fertilizer (including all chemicals). The data has been taken from the Agricultural Statistics reports (1984 to 2004).

The dummy variable associated with the CRP has been defined based on the net acreage reduction during the sample period. The CRP program began enrolling farmland in 1986. However, the net retired acres during the period of 1984-96 were negative, because retired acres under other acreage reduction programs were gradually returned to production during this period. For this reason, the value of the dummy variable is zero in the period of 1984-96 and is one thereafter.

Empirical Results

A cost function should satisfy homogeneity, monotonicity, and convexity conditions. The homogeneity constraints were imposed throughout the estimation process. The estimated cost function is monotonic because it generates positive fitted share at every observation. Finally, the cost function is quasi concave in input prices because its Hessian matrix is negative semi definite at every observation. Therefore, the estimated cost function represents a well behaved production function. The Durbin-Watson test is preformed for each equation of the full system to test for autocorrelation. There was no sign of autocorrelation. The estimated parameters are reported in table 6. This table indicates that those parameters which demonstrate structural change in the cost and share equations (i.e. λ_K , λ_R , λ_N , and λ_L) are all statistically significant (at least at 5%

level of significance). The signs of these parameters show that the CRP has had negative impacts on the demands for capital and land and positive impacts on the demands for nitrogen and labor.

It is straightforward to derive significant economic parameters such as elasticities of substitutions between inputs and the price elasticities from the estimated cost function parameters. The Allen partial elasticity of substitution is frequently used in the literature to determine whether pairs of inputs are substitutes or complements. In a translog cost function, the Allen partial elasticities of substitution between inputs *i* and *j*, σ_{ij}^{A} , can be obtained from the following formula:

$$\sigma_{ij}^{A} = \frac{\hat{\gamma}_{ij} + \hat{S}_i \hat{S}_j}{\hat{S}_i \hat{S}_j},$$

When $\sigma_{ij}^{A} > 0$ inputs j and i are net substitutes and when $\sigma_{ij}^{A} < 0$ they are net complements. Note that $\sigma_{ij}^{A} = \sigma_{ji}^{A}$, this means the Allen elasticity of substitution has symmetry attribute. In a translog cost function the own and cross price elasticities of demands for inputs also can be derived from the following formulas, respectively:

$$\varepsilon_i = \frac{\hat{\gamma}_{ii} + \hat{S}_i (\hat{S}_i - 1)}{\hat{S}_i},$$

$$\varepsilon_{ij} = \frac{\hat{\gamma}_{ij} + \hat{S}_i \hat{S}_j}{\hat{S}_i}.$$

Here ε_{iJ} represent the cross price elasticity of demand for input *i* with respect to the price of input *j* and ε_{ii} stands for the own price elasticity of demand for input *i*. The scale economy is another significant economic parameter that can be derived from the estimated cost function parameters. Following Christensen and Green (1976) the scale economy is calculated from the following formula:

$SEC = 1 - \partial \ln C / \partial \ln X$.

The pairwise Allen elasticities of substitution are computed and reported in table 7 for selected years. The table indicates that capital and labor; capital and nitrogen; and land and nitrogen were substitute during the sample period. Table 7 shows that capital and land were substitute at the beginning of the period but they became compliment at the end of period. Table 7 also indicates that land and labor and nitrogen and labor were compliment during the sample period. In general, elasticities of substitution have changed over the sample period, in particular after 1996. This confirms a structural change in crop production due to the CRP.

The computed own price elasticities are reported in table 8 for the selected years. This table shows that demand for inputs were relatively inelastic with respect to their own prices during the sample period. The own price elasticities of capital and nitrogen were fluctuating around - 0.5 and -0.69, respectively. The own price elasticity of land has drastically decreased (in absolute terms) from -.17 to -.02 over the sample period. In contrast, the own price elasticity of labor has significantly increased (in absolute terms) from -0.33 to -0.46 in the same period. The computed values of the scale economy are also reported in table 8 for the selected years. These figures were very close to 1 during the sample period. Finally, the computed cross price elasticities are reported in table 9 for the selected years. This sign of these elasticities are consistent with the signs of elasticities of substitutions.

Conclusion

The CRP program which extensively and consistently retires cropland can generate significant direct and indirect economic consequences. It raises government expenditure and causes efficiency costs through the tax system. In addition, it acts as an implicit tax which reduces consumers' real income and generates welfare losses. Since the program has the potential to raise the prices of crop products in the world market it may generate some gains from the trade channel. At the current level of land retirement the program costs the US economy around $2.9 billion dollars. The cost of program can grow exponentially if the government decided to retire more cropland. For example, retiring 75 million acres of cropland may cost the economy up to $7.5 billion. The program has the potential to affect the demand for agricultural inputs, in particular demand for nitrogen and generate considerable amount of land conversion. The econometric results confirm these effects.

Table 1. Benchmark Data (in millions of 2002 dollars except as otherwise noted)

Description	*Dirty Good*	*Clean Good*	*Total*
Value added at the producer price	87718	8908190	8995908
Subsidy (the price support)	9513	0	9513
Value added at the consumer price	78205	8908190	8986395
Export (payments for fertilizer)	15168	0	15168
Consumption at the consumer price	63037	8908190	8971228
Consumption at the producer price	70705	8908190	8978896
Leisure	0	0	2871434
Labor income	20894	5139655	5160549
Land income	27462	9912	37373
Capital income	24194	3758624	3782818
Land (million acres)	341	1222	1563
Homogenized land (million acres)	1148	415	1563
Capital stock	585325	22827675	23413000
Homogenized capital	149744	23263256	23413000
Fertilizer (nitrogen content in million metric tons)	12		12
Mechanical inputs	45089	8898279	8943367
Biological inputs	42629	9912	52541
Marginal income tax rate (percent)			40
Government expenditures (G)			1595427

Source: These figures are mainly obtained from the 2002 US input output table, USDA reports, and the 2002 statistical abstract of the United States.

Table 2. Selected Parameters

Description of Parameter	*Value*	*Source*
Uncompensated labor supply elasticity	0.15	Goulder (1999)
Uncompensated price elasticity of demand for the dirty good	0.5	Steven et al. (2003)
Uncompensated price elasticity of demand for the clean good	1.0	Kyer and Maggs (1997)
Elasticity of substitution between the biological and the mechanical inputs in production of X	0.5	Horan et al. (2002)
Elasticity of substitution between land and nitrogen fertilizer in production of X	1.25	Hertel et al. (1996) and Horan et al. (2002)
Elasticity of substitution between labor and capital in production of X	0.585	Balisteri et al. (2002)
Elasticity of substitution between the biological and the mechanical inputs in production of Y	0.5	Horan et al. (2002)
Elasticity of substitution between labor and capital in production of Y	0.951	Balisteri et al. (2002)

Table 3. Efficiency costs of acreage reduction for the US economy

Retired Acreages (Million Acres)	$\varepsilon_{SN=0.5}$				$\varepsilon_{SN=1.0}$			
	Total (Million dollars)	Average (Dollar)	Marginal (Dollar)	MCPE* (Dollar)	Total (Million dollars)	Average (Dollar)	Marginal (Dollar)	MCPE* (Dollar)
3	249	83.2	83.2	1.6	242	80.8	80.8	1.5
6	515	85.8	88.5	1.7	499	83.1	85.4	1.6
9	783	87.0	89.4	1.7	757	84.2	86.3	1.6
12	1055	87.9	90.4	1.7	1019	84.9	87.2	1.7
15	1329	88.6	91.4	1.7	1283	85.5	88.1	1.7
18	1606	89.2	92.3	1.8	1550	86.1	89.0	1.7
21	1886	89.8	93.3	1.8	1820	86.7	90.0	1.7
24	2169	90.4	94.3	1.8	2093	87.2	90.9	1.7
27	2455	90.9	95.4	1.8	2368	87.7	91.9	1.7
30	2744	91.5	96.4	1.8	2647	88.2	92.9	1.8
33	3036	92.0	97.5	1.9	2929	88.8	93.9	1.8
36	3332	92.6	98.6	1.9	3214	89.3	94.9	1.8
39	3631	93.1	99.7	1.9	3501	89.8	96.0	1.8
42	3934	93.7	100.8	1.9	3793	90.3	97.0	1.8
45	4239	94.2	101.9	1.9	4087	90.8	98.1	1.9
48	4549	94.8	103.1	2.0	4385	91.3	99.2	1.9
51	4862	95.3	104.3	2.0	4686	91.9	100.3	1.9
54	5178	95.9	105.5	2.0	4990	92.4	101.5	1.9
57	5498	96.5	106.7	2.0	5298	92.9	102.6	1.9
60	5822	97.0	108.0	2.1	5609	93.5	103.8	2.0
63	6150	97.6	109.3	2.1	5925	94.0	105.0	2.0
66	6482	98.2	110.6	2.1	6243	94.6	106.3	2.0
69	6817	98.8	111.9	2.1	6566	95.2	107.5	2.0
72	7157	99.4	113.2	2.2	6892	95.7	108.8	2.1
75	7501	100.0	114.6	2.2	7222	96.3	110.1	2.1

*The marginal cost of public expenditures on land retirement

Table 3. Continued

Retired Acreages (Million Acres)	$\varepsilon_{SN=\infty}$			
	Total (Million dollars)	Average (Dollar)	Marginal (Dollar)	MCPE* (Dollar)
3	223	74.3	74.3	1.4
6	453	75.5	76.7	1.5
9	685	76.1	77.4	1.5
12	920	76.6	78.2	1.5
15	1157	77.1	78.9	1.5
18	1396	77.5	79.7	1.5
21	1637	78.0	80.5	1.5
24	1881	78.4	81.3	1.5
27	2128	78.8	82.1	1.6
30	2377	79.2	83.0	1.6
33	2628	79.6	83.8	1.6
36	2882	80.1	84.7	1.6
39	3139	80.5	85.6	1.6
42	3398	80.9	86.4	1.6
45	3660	81.3	87.4	1.7
48	3925	81.8	88.3	1.7
51	4193	82.2	89.2	1.7
54	4463	82.7	90.2	1.7
57	4737	83.1	91.1	1.7
60	5013	83.5	92.1	1.7
63	5292	84.0	93.1	1.8
66	5575	84.5	94.2	1.8
69	5860	84.9	95.2	1.8
72	6149	85.4	96.3	1.8
75	6441	85.9	97.3	1.8

*The marginal cost of public expenditures on land retirement

Table 4. Price impacts of acreage reduction (in percentage change compare to $R_G=0$)

Retired Acreages (Million Acres)	$\varepsilon_{SN=0.5}$		$\varepsilon_{SN=1.0}$		$\varepsilon_{SN=\infty}$	
	Price of Land	Price of Crops	Price of Land	Price of Crops	Price of Land	Price of Crops
3	0.8	0.3	0.8	0.3	0.8	0.3
6	1.7	0.7	1.7	0.7	1.6	0.6
9	2.7	1.1	2.6	1.0	2.5	0.8
12	3.6	1.4	3.5	1.3	3.3	1.1
15	4.6	1.8	4.5	1.7	4.2	1.4
18	5.5	2.2	5.4	2.1	5.1	1.7
21	6.5	2.6	6.4	2.4	6.0	2.0
24	7.5	2.9	7.4	2.8	6.9	2.3
27	8.5	3.3	8.4	3.2	7.9	2.7
30	9.6	3.7	9.4	3.5	8.8	3.0
33	10.6	4.1	10.4	3.9	9.8	3.3
36	11.7	4.5	11.4	4.3	10.8	3.6
39	12.8	5.0	12.5	4.7	11.8	3.9
42	13.9	5.4	13.6	5.1	12.8	4.2
45	15.0	5.8	14.7	5.5	13.8	4.6
48	16.1	6.2	15.8	5.9	14.8	4.9
51	17.3	6.6	16.9	6.3	15.9	5.2
54	18.4	7.1	18.1	6.7	17.0	5.6
57	19.6	7.5	19.2	7.1	18.1	5.9
60	20.8	8.0	20.4	7.5	19.2	6.3
63	22.1	8.4	21.6	7.9	20.3	6.6
66	23.3	8.9	22.8	8.4	21.4	6.9
69	24.6	9.3	24.1	8.8	22.6	7.3
72	25.9	9.8	25.4	9.2	23.8	7.7
75	27.2	10.3	26.6	9.7	25.0	8.0

Table 5. Unintended impacts of acreage reduction (in percentage change compare to $R_G=0$ except as otherwise noted)

Retired Acreages (Million Acres)	$\varepsilon_{SN=0.5}$			$\varepsilon_{SN=1.0}$			$\varepsilon_{SN=\infty}$		
	Demand for Nitrogen	Land Slippage Effect†	Supply of Crop Product	Demand for Nitrogen	Land Slippage Effect†	Supply of Crop Product	Demand for Nitrogen	Land Slippage Effect†	Supply of Crop Product
3	0.1	18.6	-0.2	0.2	18.3	-0.2	0.3	17.5	-0.2
6	0.2	19.5	-0.4	0.4	19.1	-0.4	0.7	18.2	-0.4
9	0.4	19.8	-0.6	0.6	19.4	-0.6	1.0	18.4	-0.5
12	0.5	19.9	-0.8	0.8	19.6	-0.8	1.4	18.5	-0.7
15	0.7	20.0	-1.0	1.0	19.7	-1.0	1.8	18.6	-0.8
18	0.8	20.1	-1.2	1.2	19.7	-1.2	2.2	18.7	-1.0
21	0.9	20.2	-1.4	1.4	19.8	-1.4	2.6	18.7	-1.2
24	1.1	20.2	-1.6	1.6	19.8	-1.6	3.0	18.8	-1.3
27	1.2	20.3	-1.9	1.8	19.9	-1.8	3.4	18.8	-1.5
30	1.4	20.3	-2.1	2.0	19.9	-2.0	3.8	18.8	-1.7
33	1.5	20.3	-2.3	2.2	19.9	-2.2	4.2	18.9	-1.8
36	1.7	20.3	-2.5	2.4	20.0	-2.3	4.6	18.9	-2.0
39	1.8	20.4	-2.7	2.6	20.0	-2.5	5.0	18.9	-2.2
42	1.9	20.4	-2.9	2.9	20.0	-2.7	5.5	18.9	-2.3
45	2.1	20.4	-3.1	3.1	20.0	-2.9	5.9	19.0	-2.5
48	2.2	20.4	-3.3	3.3	20.1	-3.1	6.3	19.0	-2.7
51	2.4	20.5	-3.5	3.5	20.1	-3.4	6.7	19.0	-2.8
54	2.6	20.5	-3.8	3.7	20.1	-3.6	7.2	19.0	-3.0
57	2.7	20.5	-4.0	4.0	20.1	-3.8	7.6	19.1	-3.2
60	2.9	20.5	-4.2	4.2	20.2	-4.0	8.1	19.1	-3.3
63	3.0	20.6	-4.4	4.4	20.2	-4.2	8.5	19.1	-3.5
66	3.2	20.6	-4.6	4.7	20.2	-4.4	9.0	19.1	-3.7
69	3.3	20.6	-4.8	4.9	20.2	-4.6	9.4	19.1	-3.9
72	3.5	20.6	-5.1	5.1	20.2	-4.8	9.9	19.2	-4.0
75	3.7	20.6	-5.3	5.4	20.3	-5.0	10.4	19.2	-4.2

† Converted acres from non-crop to crop production as a percent of retired acres.

Table 6. Estimated coefficients of the translog cost function

Parameter	Value	Standard Error	t Value	P>|z|
λ_K	-0.0179	0.0061	-2.9500	0.0030
λ_R	-0.0145	0.0044	-3.3300	0.0010
λ_N	0.0146	0.0061	2.3900	0.0170
λ_L	0.0178	0.0049	3.6600	0.0000
α_X	-0.0109	0.0090	-1.2100	0.2250
γ_{XX}	-0.1081	0.0469	-2.3100	0.0210
α_K	0.5544	0.0047	116.8900	0.0000
α_R	0.1554	0.0022	71.8400	0.0000
α_N	0.1595	0.0032	49.2100	0.0000
α_L	0.1308	0.0039	33.7769	0.0000
γ_{KK}	-0.0253	0.0552	-0.4600	0.6460
γ_{RR}	0.1105	0.0186	5.9300	0.0000
γ_{NN}	0.0236	0.0394	0.6000	0.5500
γ_{LL}	0.0622	0.0215	2.9000	0.0040
γ_{KR}	-0.0722	0.0255	-2.8300	0.0050
γ_{KN}	0.0371	0.0392	0.9500	0.3440
γ_{RN}	0.0119	0.0215	0.5500	0.5820
γ_{KL}	0.0605	0.0252	2.4000	0.0160
γ_{RL}	-0.0502	0.0122	-4.1000	0.0000
γ_{NL}	-0.0725	0.0168	-4.3200	0.0000
γ_{XK}	-0.0334	0.0362	-0.9200	0.3560
γ_{XR}	-0.0047	0.0163	-0.2900	0.7720
γ_{XN}	0.0378	0.0241	1.5700	0.1170
γ_{XL}	0.0003	0.0287	0.0100	0.9910
h	0.0003	0.0001	2.4800	0.0130
α_0	-0.0003	0.0014	-0.2000	0.8400

Table 7. Allen elasticities of substitution between pairs of inputs (selected years)

Year	σ_{KL}	σ_{KR}	σ_{KN}	σ_{RN}	σ_{RL}	σ_{NL}
1984	1.983	0.217	1.397	1.422	-1.708	-2.870
1990	1.812	0.144	1.421	1.493	-1.467	-2.414
1996	1.834	0.136	1.399	1.433	-1.348	-2.054
2000	1.684	-0.026	1.418	1.574	-1.431	-1.791
2004	1.667	-0.055	1.421	1.604	-1.478	-1.787

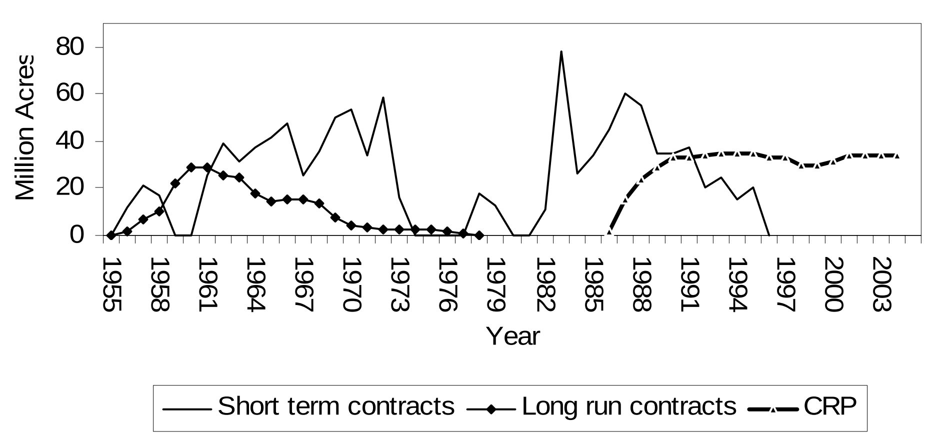
Table 8. Own price elasticities of demand for inputs and scale economies (elected years)

Year	Own Price Elasticities				Economies of Scale
	ε_K	ε_R	ε_N	ε_L	
1984	-0.49	-0.17	-0.69	-0.33	0.99
1990	-0.49	-0.12	-0.69	-0.40	1.00
1996	-0.52	-0.14	-0.69	-0.41	1.01
2000	-0.50	-0.01	-0.69	-0.45	1.02
2004	-0.49	0.02	-0.69	-0.46	1.02

Table 9. Cross price elasticities of demand for inputs (selected years)

Year	ε_{KL}	ε_{LK}	ε_{KR}	ε_{RK}	ε_{KN}	ε_{NK}	ε_{RL}	ε_{LR}	ε_{RN}	ε_{NR}	ε_{NL}	ε_{LN}
1984	0.22	1.10	0.04	0.12	0.24	0.77	-0.19	-0.28	0.24	0.24	-0.32	-0.48
1990	0.24	1.01	0.02	0.08	0.23	0.79	-0.20	-0.22	0.24	0.23	-0.32	-0.38
1996	0.25	0.98	0.02	0.07	0.24	0.75	-0.18	-0.21	0.25	0.22	-0.28	-0.36
2000	0.27	0.93	0.00	-0.01	0.23	0.78	-0.23	-0.18	0.25	0.20	-0.29	-0.29
2004	0.27	0.92	-0.01	-0.03	0.23	0.79	-0.24	-0.18	0.25	0.20	-0.29	-0.28

Figure 1. Hostory of Acreage Reduction 1955-2004



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