Some Simple Analytics of Target Prices and Land Values

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Some Simple Analytics of Target Prices and Land Values

Abstract
Because land is a crucial factor of production in the U.S. agricultural sector, land prices have an impact on a wide range of participants in the world economy. Land prices have a direct impact on farmers’ abilities to begin, operate, and expand their enterprises. Consumers worldwide are affected indirectly by land values because the cost of land services will partly determine the supply of farm commodities. Taxing authorities are directly affected by land value changes because property values are used as the basis for property tax assessment.

Disciplines
Agribusiness | Business Administration, Management, and Operations | Statistical Models | Taxation

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SOME SIMPLE ANALYTICS

OF

TARGET PRICES AND LAND VALUES

Duane G. Harris

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Because land is a crucial factor of production in the U.S. agricultural sector, land prices have an impact on a wide range of participants in the world economy. Land prices have a direct impact on farmers' abilities to begin, operate, and expand their enterprises. Consumers worldwide are affected indirectly by land values because the cost of land services will partly determine the supply of farm commodities. Taxing authorities are directly affected by land value changes because property values are used as the basis for property tax assessment.

Prior studies have identified some of the important factors in the determination of land values. In addition to such factors as farm income, farm enlargement, and expected capital gains, many studies have documented the influence of government farm programs on land values. For example, Reynolds and Timmons found, by using 1933-1965 aggregate U.S. data, that payments made through government farm programs were indeed capitalized into farmland value. Boxley and Anderson summarized various studies that show positive values for tobacco allotments. And Hedrick documented that benefits of the peanut program were capitalized into land values in North Carolina.

With the adoption of the Agriculture and Consumer Protection Act of 1973, however, the thrust of farm programs in the United States was changed. Programs to restrict supply were replaced with ones to promote production. Policies to stabilize commodity prices were
replaced by a new policy of target prices. Although it is not clear
that future farm programs will take the form of the 1973 Act, general
interest in the inflation indexing of economic variables likely
will cause some form of target-price policies to be considered seri-
ously in the future.

Unfortunately, because of our limited experience with target-
price policies, it is not possible to empirically document or project
the impact of target prices on land values. It is possible, however,
to develop and illustrate some of the potential important relationships
between target-price policies and land values. The purpose of this
paper is to present such conceptual relationships.

In the next section a theoretical model of land value determi-
nation is developed to incorporate target prices. Then, the model
is illustrated for different assumptions about the implementation of
target-price policy. Finally a summary and some conclusions of the
study are presented.
A Model of Target Prices and Land Values

General Framework

Assume a simplified world in which there is one commodity produced from land in time-period $t$. Also assume that the future level of production $Q_t$ is certain and constant. If the farmer sells the commodity at random price $P_t$ and incurs the certain cost of production (exclusive of land cost) $C_t$, then the farmer's net return to land can be written as

\[ R_t = P_t Q_t - C_t \]

where price uncertainty constitutes the only source of risk and causes net return to be a random variable. The expected level of net return is thus given by

\[ E(R_t) = E(P_t) Q_t - C_t \]

and the variability of return is given by

\[ \sigma^2_{R_t} = Q_t^2 \sigma^2_{P_t} \]

If it is furthermore assumed that the expected probability distribution for future prices is constant so that the expected value and variability will be the same in all future time periods, then the value of farmland $V_t$ is given by the standard simple valuation formula:

\[ V_t = \frac{E(R_t)}{k} \]
where $k$ is the capitalization rate given by

\begin{equation}
(5) \quad k = a + b \sigma_R^2
\end{equation}

In Equation (5), the coefficient $a$ represents the risk free rate and $b$ is the unit increase in $k$ brought about by a change in risk as measured by $\sigma_R^2$. Any factor that causes expected return to increase will increase land value. Any factor that causes variability (risk) to increase will increase the capitalization rate and thus decrease land value. \footnote{3} \\

**Target-Price Mechanism**

Suppose now that a target price $T_t$, as a matter of policy, is automatically implemented as a function of the per-unit cost of production of the commodity. \footnote{4} Specifically, let

\begin{equation}
(6) \quad T_t = \frac{\gamma_C C_t + \gamma_L L_t}{Q_t}
\end{equation}

where $C_t/Q_t$ represents the per-unit operating cost and $L_t/Q_t$ the per-unit land cost of production. The parameters $\gamma_C$ and $\gamma_L$ are policy decision variables used to establish the proportion of operating and land charges that will be recaptured via the target price per unit of the commodity.

If it is also assumed that

\begin{equation}
(7) \quad C_t = \delta C_{t-1}
\end{equation}

and

\begin{equation}
(8) \quad L_t = \lambda \nu_{t-1}
\end{equation}

then Equation (6) can be rewritten as
Equation (7) defines current operating costs as proportional to last-period operating costs where δ represents the value (1+c) and c is the rate of growth (decline) in operating costs. Equation (8) establishes total land charges as a return on last-period land value where λ is the rate of return. The parameter λ is a policy decision variable that is established as the allowable rate of return on farmland that can be considered as a land charge for target-price purposes.

**Price Expectations and Land Values**

To identify the expected returns and capitalization rate necessary for the determination of land value, it is necessary to postulate a subjective probability distribution for commodity prices. Suppose, to keep the analysis simple, that the distribution is uniform, ranging from the target price $T_t$ as the lower bound to $U_t$, the upper bound (Figure 1). Furthermore, assume that once the target price is established by the policy authority, farmers expect that policy to prevail forever. If the policy authority changes the target price, farmers revise their expectations but again believe that the new target price will prevail forever. Thus, at any given time, farmers are basing the valuation of land on an expected distribution of returns that is constant over all future years.\(^5\)

Also assume that if the target price is changed, the mean of the distribution will be shifted, but the variance will remain unchanged. For example, if the target price is increased by x units,
Figure 1: Subjective Probability Distribution of Commodity Prices
the upper bound of the distribution will also be increased by x units. 6/

Note that the upper bound of the distribution $U_t$ can be defined as the sum of the lower bound $T_t$ and the range $R^G_t$. From (9), then

$$U_t = \frac{Y_{C^t}^{\delta t-1} + Y_{L^t}^{\lambda V t-1}}{Q_t} + R^G_t$$

Thus, the first two moments of the uniform distribution give expected price and variance of price as

$$E(P_t) = \frac{T_t + U_t}{2} = \frac{1}{2} \left[ R^G_t + \frac{2(Y_{C^t}^{\delta t-1} + Y_{L^t}^{\lambda V t-1})}{Q_t} \right]$$

$$\sigma^2 = \frac{(U_t - T_t)^2}{12} = \frac{R^G_t^2}{12}$$

Substituting (11) and (12) into (2) and (3) gives expected return and risk as

$$E(R_t) = \frac{1}{2} \left[ R^G_t + \frac{2(Y_{C^t}^{\delta t-1} + Y_{L^t}^{\lambda V t-1})}{Q_t} \right] Q_t - C_t$$

$$\sigma^2_R = \frac{Q_t^2 R^G_t^2}{12}$$

Finally, substituting (14) into (5) and then (13) and (5) into (4) gives land value as

$$V_t = \frac{1}{2} \left[ R^G_t Q_t + \frac{2(Y_{C^t}^{\delta t-1} + Y_{L^t}^{\lambda V t-1})}{Q_t} \right] - \delta C_{t-1}$$

$$a + b \frac{Q_t^2 R^G_t^2}{12}$$
By rearranging Equation (15), the valuation formulation is given as a linear, first-order difference equation

\[
V_t = \frac{12\nu_t\lambda}{12a + bQ_t^2\rho t} V_{t-1} + \frac{6\rho tQ_t + 12\delta_C(t-1)(\nu_C - 1)}{12a + bQ_t^2\rho t}
\]

or

\[
V_t = \left(\frac{\nu_t\lambda}{k}\right) V_{t-1} = \frac{\lambda tQ_t + \delta C(t-1)(\nu_C - 1)}{k}
\]

The solution value for Equation (17) is given by

\[
V_t = (V_0 - \phi)(\phi)^t + \phi
\]

where

\[
\phi = \frac{\lambda tQ_t + \delta C(t-1)(\nu_C - 1)}{k - \nu_L\lambda}
\]

\[
\phi = \frac{\nu_L\lambda}{k}
\]

and where \( V_0 \) is some initial land value.

**Policy Prescriptions and Land Values**

The time path of land values is crucially related to the sizes of the policy parameters in the model. The general form of the time path is dependent on the size of \( \phi \) in Equation (18). But because \( \phi = \nu_L\lambda/k \), the path is determined by the relationship between the effective return on land allowed by policy (\( \nu_L\lambda \)) and the market capitalization rate on
land \((k)\). If policymakers guarantee nothing above operating costs \((\nu_L^\lambda = 0)\), the time path of land values will be constant. If policymakers allow an effective rate of return less than the market rate \((0 < \nu_L^\lambda < k)\), the time path will be nonoscillatory and damped. If policymakers set policy parameters such that the effective rate of return on land is greater than the market capitalization rate \((\nu_L^\lambda > k)\), then the time path will be nonoscillatory and explosive (Figure 2).

Both the value maximum and the rate at which land values approach that maximum will be influenced by target-price policy decisions. Although \(\phi\) is a function of both \(\nu_C\) and \(\nu_L\), \(\phi\) is a function only of \(\nu_L\). So, changes in the proportion of operating costs covered by the target price will affect the maximum that land values achieve over time. Changes in the proportion of land charges that are covered by the target price will affect the land value maximum and the rate at which land values approach that maximum.

More specifically, the impact of changes in policy parameters on the time path of land values can be evaluated using comparative dynamics (Gandolfo, pp. 359-360). By differentiating totally the solution function [Equation (18)] with respect to \(\nu_C\), \(\nu_L\), \(\lambda\), and \(\delta\), the influence of policy parameters and exogenous factors can be discerned. The following comparative dynamic results are obtained:

\[
\frac{dV_t}{d\nu_C} = \frac{\delta C_t - 1}{k - \nu_L^\lambda} \left[ 1 - \left( \frac{\nu_L^\lambda}{k} \right)^t \right] > 0
\]
Figure 2: Time Path of Land Values
An increase in the proportion of operating costs covered by the target price \( (\psi_C) \) \textit{ceteris paribus} will result in higher land values at every point in time. Increases in either the allowed rate of return on land \((\lambda)\) or the proportion of land charges covered by the target price \( (\psi_L) \) \textit{ceteris paribus} will lead to ambiguous results without numerical specification of the parameters in the model. An increase in the rate of inflation of operating costs \((\delta)\) \textit{ceteris paribus} will everywhere increase land values if more than 100 percent of operating costs are covered by the target price \( (\psi_C > 1) \). If exactly 100 percent of operating costs are covered \( (\psi_C = 1) \), an increase in \( \delta \) \textit{ceteris paribus} will result in no change in land values. If operating costs are not fully covered \( (\psi_C < 1) \), an increase in \( \delta \) \textit{ceteris paribus} will lead to lower land values at every point along the time path.
Numerical Example

Although an examination of Equation (18) provides qualitative information about the time path of land values in a target-price world, explicit specification of the parameters and variables in the model is necessary to assess the quantitative impact of farm-policy changes. Suppose the model is evaluated for a cash-grain situation in which corn is the single commodity produced. Furthermore, assume that the following parameter and variable values are reasonable for the cash-grain example:

\[ Q_t = 100 \text{ bu./acre} \]
\[ c_{t-1} = 150 \text{ /acre} \]
\[ \delta = 1.00 \]
\[ V_0 = 1667 \text{ /acre} \]
\[ RG_t = 2.00 \text{ /bu.} \]
\[ a = 0.02667 \]
\[ b = 0.00001 \]

Also, assume that the policy parameters initially are set as follows:

\[ \lambda = 0.09 \]
\[ \nu_C = 1.00 \]
\[ \nu_L = 0.00 \]

In this setting, the initial target price \( T_0 \), will be $1.50/bu., so the farmers' subjective probability distribution for corn prices will range from $1.50/bu. to $3.50/bu. with an expected value of $2.50/bu. The capitalization rate \( k \) will be 0.06. Policymakers
are assumed to allow a return on land $\lambda$ equal to .09—a long term average of mortgage rates on farm real estate loans. Furthermore, the target-price policy is established by covering 100 percent ($\gamma_C = 1.00$) of operating costs and zero percent ($\gamma_L = 0.00$) of land charges. It is assumed that operating costs will be constant over all future periods. The time path of land values for this scenario is shown in Column 2 of Table 1. Land values remain constant at $1667/acre, and the target price is constant at $1.50/bu.

If policymakers decide to set the target price formula to recapture a portion of land costs ($\gamma_L > 0$), however, the path of land values will increase over time. Solution values for the model for selected values of $\gamma_L$ greater than zero are shown in Columns 3-8 of Table 1 and in Figure 3. Note that the equilibrium value for land increases from $1667/acre to $6665/acre as $\gamma_L$ is changed from 0.00 to 0.50. Thus, the greater the proportion of land charges that policymakers allow to be recaptured through the target price, the larger will be the long-run equilibrium price of land. In other words, any guaranteed return to land—above and beyond operating costs—will be capitalized into the price of land. An increase in the value of land will necessitate an increase in the target price, which will increase the expected returns to land which will increase land value, which will require a further increase in the target price, and so on.

In this numerical example, as long as $\gamma_L \lambda < .06$, land values will increase at a decreasing rate over time. With $\lambda = .09$, however, if $\gamma_L > .667$, land values will explode—values will increase at an increasing rate. An illustration of exploding land value is given in Column 10.
Table 1: Target Prices and Land Values for Selected Policy Schemes

<table>
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<tr>
<th>$T_t$</th>
<th>$V_t$</th>
<th>$Y_L = 0.50$</th>
<th>$V_t$</th>
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$T_t =$ Time period; $Y_L =$ Proportion of nonland costs covered by target price; $V_t =$ Target price per bushel; $V_L =$ Land value per acre of land costs covered by target price.
Figure 3: Policy Schemes and Land Values

Land Value

$8000

$6000

$4000

$1667

\( \gamma_L = 0.70 \)

\( \gamma_L = 0.50 \)

\( \gamma_L = 0.30 \)

\( \gamma_L = 0.10 \)

\( \gamma_L = 0.00 \)

Time Periods
of Table 1 and in Figure 3. In that instance, \( \gamma_L = .70 \) and thus 
\[ \gamma_L \lambda = .063 \] which is greater than the market capitalization rate of 
\( \lambda = .06. \)

Table 2 presents the dollar and percentage changes in land values over time for each of the policy schemes. For example, Row 5 shows that after five years, land values will have increased \$294/acre or 17.64 percent for \( \gamma_L = .10. \) Over that same time interval, land values will have increased \$3812/acre or 228.67 percent if \( \gamma_L \) is set at .50. Thus, the particular scheme used to implement a target-price policy could have substantial impact on the future path of land values.

Also, the potential social cost of the different schemes could differ substantially. For the first year of policy implementation, the difference between the required target prices for the \( \gamma_L = .00 \) case and the \( \gamma_L = .50 \) case is \$.75/bu. (Table 1). By year five, that target price differential increases to \$2.29/bu. At their equilibrium levels, the difference in target prices is \$3.00/bu.
Table 2: Cumulative Land Value Changes for Selected Policy Schemes

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\( t \) = Time period; \( \gamma_C \) = Proportion of nonland costs covered by target price; \( \gamma_L \) = Proportion of land costs covered by target price; $ = Dollar change in land value per acre over \( t \) time periods; % = Percentage change in land value per acre over \( t \) time periods.
Summary and Conclusions

The purpose of this paper is to develop and illustrate some relationships between cost-indexed target-price policies and land values. A simple theoretical model of land valuation is developed in the context of a single commodity, price-uncertain world where farm policy is conducted in a general target-price framework. Policymakers are allowed to control the percentage of nonland operating costs and the percentage of land costs covered by the target price.

If the policy authorities establish a target-price formula that recaptures all nonland operating costs but no return on land, the time path of land values will be level or constant. Thus, implementation of that type of policy would have a once-and-for-all impact on land values—raising them to a new equilibrium level.

If, however, policymakers allow a portion of the rate of return on land to be included in the target-price formula, land values will increase over time and approach an equilibrium value greater than for the situation in which no land costs are included in the target price. Both the level of the new equilibrium and the rate at which land values approach that equilibrium are affected by the proportion of land charges included in the target-price formula. In the extreme case, if policymakers inadvertently allow an effective return on land greater than the market capitalization rate, land values will explode.

Thus, it is likely that the particular scheme used to implement a general cost-indexed target-price policy will be crucial to the
resulting impact on future land values and also to the possible social cost of the farm program for years in which actual commodity price falls below the target price. It is unreasonable to expect that policymakers would allow an explosive mechanism to track very far into the future. Implementation of a policy that guaranteed a rate of return on land greater than the market capitalization rate, however, could have substantial impact on land values before the policy parameters could be adjusted.

Of course, the model was developed under many simplifying assumptions which, when relaxed, might alter the conclusions of the analysis. Without doubt, quantitative results would be changed, but it is likely that the qualitative implications of the model would remain intact. Also, the time paths of land values were developed in a ceteris paribus context where only policy variables were allowed to change. In the real world many other factors besides farm policy affect land values, so the time path of land values will not likely follow the track of those generated by the model. But hopefully, if nothing else, this analysis demonstrates the potential importance of the selection of an appropriate scheme for the implementation of well-intentioned social and policy goals.
1. For example, escalator clauses in labor contracts, automatic inflation adjustments in retirement and pension plans, and inflation-indexed bonds all represent inflation indexing mechanisms.

2. The analysis is confined to an examination of the impact of cost-indexed target prices on land values. No evaluation is made of the impact of target-price policy on stability of commodity prices or on income support in the farm sector.

3. The valuation formula in Equation (4) could be modified to accommodate net returns that grow at a constant rate g over time. In that case \( V = \frac{E(R)}{r} \) where \( r = (k - g) \). In such a model, expected returns would grow over time, but the variability of returns would remain constant such that the capitalization rate would be constant over time.

4. The target price mechanism can be interpreted to encompass either target prices or support prices. The crucial assumption is that the mechanism establishes a price floor which is automatically adjusted as production costs change.
5. The expected distribution of returns with target prices will remain unchanged even in times of increased supply and depressed market prices. Thus, even though the supply of land services may not be perfectly inelastic, the target price will guarantee that expectations will not change concerning the annual net return to farmland.

6. This assumption is necessary to conform to the assumption that the capitalization rate is constant over all time periods.

7. For purposes of numerical analysis, the model was modified by assuming that the upper limit on the probability distribution of prices $U_t$ was constant. In that situation, as the target price $T_t$ is increased, the expected value of the distribution increases and the variance decreases as the range is narrowed. Consequently, the capitalization rate declines each time the target price is increased. The qualitative results of the model remain unchanged. The quantitative results are more extreme, however, because land values are increased by both increases in expected returns and decreases in the capitalization rate.
REFERENCES


