Agricultural policy uncertainty and anticipatory firm level adjustments

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Volatility in agricultural investment remains a puzzle. This paper investigates the extent to which an active agricultural policy can be the source of such volatility. Specifically, it addresses how policy uncertainty, where the political process creates parameter uncertainty and noise about the precise timing of a reform, influences investment at the farm level. The motivation for the analysis is the ongoing round of multilateral trade negotiations under the WTO and the recent history of the OECD countries, where far reaching agricultural policy reforms have been preceded by prolonged negotiations, public debates and parliamentary processes. The specific question raised concerns the incentive effects originating from the uncertainty related to the reformation of blue box subsidies. The blue box is an exemption from the rule within the WTO that all subsidies linked to production must be reduced or kept at a minimal level. The blue box includes payments directly linked to acreage or animal numbers. Although, the blue box is a permanent provision in the Agriculture Agreement, these support instruments is likely going to be the ones most challenged in the new WTO-round (Blandford; Josling and Tangermann). The issue is not whether changes in the blue box provisions will take place, but how long time it will take to reach an agreement and how much additional support reduction will be possible.

Uncertainty about agricultural policy support linked to the capital stock is a relevant feature of the decision making process in the farm firm since future policy support influences today’s investment. A retroperspective glance at recent reforms of agricultural policy reforms undertaken gives that changes can be either rather sweeping or appear as frequent, small changes in support parameters. The recurrent changes characterizing the CAP, recently provided by the Agenda 2000 reform exemplifies the latter type. In order to accurately model the effect of uncertainty it is crucial to identify which type of reform (sweeping or frequent) that are at hand. This paper develops a dynamic stochastic model of the capital employment explicitly taking into account linked support payments
when the proposed policy is expected to be in existence for a long time span. This part of the paper extends the tax-policy model of Alvarez, Kanniainen and Södersten (AKS) to include the effects of public policy uncertainty on the stock of real capital. The basic idea behind the model developed is that the future change in linked support is viewed as a shift in the control problem. After the reform have been implemented the world is deterministic since the new policy support is expected to stay unchanged. Prior to the reform, the farm operator updates conditional probabilities of the reform time and support level so that the problem may be solved by ordinary techniques and linked to the post-reform period. It is shown that the announcement of a reform creates anticipatory effects upon the incentives to invest and that these effects are reinforced by uncertainty when there exists expectations of a reduction in support levels. Adhering to the stochastic modeling approach in the AKS paper also provides a mean of separating the impact of parameter uncertainty from the effects of timing uncertainty. This separation is not possible with conventional models of stochastic control.

In the second part of the paper the incentive effects originating from a reduction of the European acreage payments system is illustrated. The difference in the cost of land between the pre-reform regime and the post-reform regime is analyzed using Beta-distributions to represent different cases of size and timing uncertainty. This part of the paper contributes to the existing uncertainty literature by revealing the combined effects upon the investment incentives from both size and timing uncertainty and the ambiguous effect originating from a simultaneous increase in the two forms of uncertainty. The final section concludes.
The Model

The starting point of the conceptual model is a farm operator who is informed that there will be an agricultural policy reform in the future and that the post-reform system is going to be in existence for a long time span. Public intervention is introduced through the exogenous support instrument $\omega(s)$ linked to and proportionate in the stock of capital. Let $t^*$ denote the date of the regime shift in public policy. Both the timing and the size of the anticipated reform are assumed to be unknown and stochastic. It is, however, assumed that the farm operator views the expected size and timing of the reform as independent events. The argument for this could for instance be that the believes of the farmer with respect to the magnitude of the reform does not hinges upon the time of implementation.

The operator is assumed to have a well defined and continuous probability density function (pdf) for the timing of the reform over the time interval between $d$ and $u$ given by $g;[d, u] \rightarrow \mathbb{R}_+$, with an associated continuous cumulative probability distribution function (cdf) $G;[d, u] \rightarrow [0,1]$. In addition, the farmer has formed believes of the size of the reform given by the pdf over the support parameter interval $h;[a, b] \rightarrow \mathbb{R}_+$ with a corresponding cdf $H$.

The aggregated capital stock $K$ of the productive enterprise is characterized by exponential decay at the rate $\delta$ and follows the dynamics $\dot{K}(t) = I(t) - \delta K(t)$ with the initial value given. To ensure the fulfillment of the transversality condition, $\lim_{t \to \infty} \mu_K e^{-\gamma t} = 0$ where $\mu_K$ represents the shadow value of the capital stock, it is assumed the production function of the farm firm is concave, has constant returns to scale properties and satisfies the standard Inada conditions (Inada). It is also assumed that the farm operator faces no restrictions to adjust the variable input factors of the productive enterprise so the net farm income per unit of time, is defined as

$$D(s, \omega) = (1 - \tau) \left[ p \int \frac{f(k)}{k} (w / p) K(s) + \omega(s) K(s) - p \phi(I(s)) \right] - qI(s)$$

(1)
where \( f_k() \) is the marginal product of capital, \( p \) is output price, \( w \) is the price of variable inputs, \( \phi \) is a strictly convex adjustment cost function, \( I(t) \) investments, \( \tau \) is the tax rate and \( q \) is the price of capital. \( s \) represents time.

Prior to the reform \((t < t^*)\), the farm operator faces the problem of determining the optimal investment policy \( I(t) \) to maximize the value \( V \) of the productive enterprise, assuming he knows the form of its post-reform value for all possible realizations of \( \omega \) and \( t^* \). The dynamic stochastic adjustment problem is

\[
V(K(t)) = \max_{I(t)} E_{I_t,\omega^*} \int_t^{t^*} e^{-r(s-t)} D(s,\omega_t) ds + E_{I_t,\omega^*} \left[ e^{-r(t^*-t)} V(K(t^*)) \right]
\]

(2)

where \( r \) represents the opportunity rate of return on equity required by the owner of the agricultural firm net of the effective marginal tax rate on equity.

If the farm operator updates his information in a standard way (Alvarez, Kanniainen and Södersten) according to the conditional density

\[
P[t^* \in ds \mid t^* > t] = \left( g(s) ds / 1 - G(t) \right) \cdot 1_{[t,u]}(s),
\]

where \( 1_{[t,u]}(s) \) is the indicator function on the set \([t,u]\), then following (Alvarez, Kanniainen, Södersten; Dasgupta and Heal, 1979, 1974; Nickell), this stochastic problem can be transformed into an ordinary deterministic control problem linking the optimal programs in the pre-reform and the post-reform regimes

\[
V(K(t)) = \max_{I(t)} \int_t^u e^{-r(s-t)} \left[ D(K(s), I(s)) \frac{1 - G(s)}{1 - G(t)} + V^*(K(s)) \frac{g(s)}{1 - G(t)} \right] ds
\]

(3)

The first term in the bracketed part of (3) represents the contribution to the value of the productive enterprise from net farm earnings prior to the reform. This part is weighted by the probability that the reform has not taken place. The second term \( V^*(. \) in the bracketed term
in (3) represents the post-reform value of the productive enterprise at the unknown time $t^*$ and is weighted by the probability of a reform in the near future.

To analyze the investment behavior consider first the post-reform regime (i.e. $t > t^*$). The choice of investment in this regime is deterministic since the implemented reform is assumed to be in practice for a sufficiently long time. The non-maximized value of the productive enterprise is given by the net present value of future net farm earnings as

$$
\hat{V}(K(t), I(t)) = \int_t^\infty e^{-r(s-t)} \left[ (1 - \tau) \left( p f_k \frac{w}{p} K(s) + \omega_2 K(s) - p \phi(I(s)) \right) - q I(s) \right] ds
$$

(4)

where $\omega_2$ represents the post-reform value of the support instrument. Applying now the capital accumulation identity (Alvarez, Kanniainen, Södersten, p. 25)

$$
K(s) = K(t) e^{-\delta(s-t)} + \int_t^s e^{-\delta(s-y)} I(y) dy
$$

(5)

under the condition that $s \geq t$, $y \geq t$ and $s \geq y$ and introducing for the sake of compactness the mappings

$$
\alpha = \frac{(1 - \tau) p f_k \frac{w}{p}}{r + \delta}
$$

(6)

$$
\beta(\omega_2) = \frac{(1 - \tau) \omega_2}{r + \delta}
$$

(7)

imply that (4) may be rewritten as

$$
\hat{V}(K(t), I(t)) = \left( \alpha + \beta(\omega_2) \right) K(t) + \int_t^\infty e^{-r(s-t)} \left[ (\alpha + \beta(\omega_2) - q) I(s) - (1 - \tau) p \phi(I(s)) \right] ds
$$

(4')

The economic interpretation of (4') is now clear. The value of the productive enterprise consists of two parts. The first part originates from the current stock of capital employed
and consists of the tax adjusted net present value of the marginal revenue product (6) and
the present value of the support instrument per unit of capital (7). The second part of the
firm value is given by the present value of the cash flow from the future investment program.
It is worth noting that in spite of the assumed constant returns in production the productive
enterprise is of bounded size. This boundness is due to the monotonic convex adjustment
cost which gives that this model leads to the flexible accelerator model of net investment
introduced by Eisner and Strotz.

The optimal constant investment behavior \( \tilde{I} \) in the post-reform regime is obtained
from the integral in (4'). The principles of optimality requires that the productive enterprise
equates the marginal adjustment cost to the present value net return on the marginal unit of
capital. Hence,

\[
\frac{\alpha + \beta(\omega - q)}{(1 - \tau)p} = \phi'(I(s)) \iff I(s) = \tilde{I} = \phi^{-1}\left(\frac{\alpha + \beta(\omega - q)}{(1 - \tau)p}\right)
\]

(8)

for all \( s \geq t^* \). Since the value of the productive enterprise at the date \( t^* \) \( V^*(K(t)) \) is
defined by adhering to the optimal control from \( t^* \) and onwards value the value is

\[
V^*(K(t)) = \sup_{I(t)} \tilde{V}(K(t), I(t)) = (\alpha + \beta(\omega - q))K(t) + \frac{(\alpha + \beta(\omega - q)\tilde{I} - (1 - \tau)p\phi(\tilde{I})}{r}
\]

(9)

Consider now the pre-reform regime (i.e. \( t < t^* \)) where uncertainty prevails with
respect to the timing of the reform as well as with respect to the value of the support
parameter in the post-reform regime. For any potential realization of \( t^* \), the non-maximized
value of the productive enterprise is

\[
\tilde{V}(K(t), I(t), t^*) = \int_t^{t^*} e^{-\tau(s - t)} \left\{ \left[ (1 - \tau)(p f_k(w/p)K(s) + \omega K(s) - p\phi(I(s))) \right] - qI(s) \right\} ds
\]
\[ + e^{-r(t_\tau-t')} \left\{ (\alpha + \beta(\omega_2))K(t^*) + \frac{(\alpha + \beta(\omega_2) - q)\hat{I} - (1 - \tau)p\phi(\hat{I})}{r} \right\} \].

(10)

Applying again the capital accumulation equation (5) and changing the order of integration over the triangular area in the two dimensional plane given by \( y \in \mathbb{R}_+: t \leq y \leq t^* \), \( s \in \mathbb{R}_+: y \leq s \leq t^* \) and then taking conditional expectations on \( \hat{V}(K(t), I(t), t^*) \) with respect to the timing of the reform as well as expectations with respect to the post-reform support parameter yields that the value of the productive enterprise is

\[
\hat{V}(K(t), I(t)) = \left[ \alpha + \beta(\omega_2) + \left( E[\beta(\omega_2)] - \beta(\omega_2) \right) E_{t<t^*} \left[ e^{-\hat{\delta}((t_\tau-t'))} \right] \right] K(t)
\]

\[
+ E_{t<t^*} \left[ e^{-\hat{\delta}((t_\tau-t'))} \left( \alpha + \beta(\omega_2) - q \right) \hat{I} - (1 - \tau)p\phi(\hat{I}) \right] \frac{1}{r}
\]

\[
+ \int_t^{u} e^{-r(s-t')} \left[ \alpha + \beta(\omega_2) + \left( E[\beta(\omega_2)] - \beta(\omega_2) \right) E_{t<t^*} \left[ e^{-\hat{\delta}((s-t')} \right] - q \right] I(s) - (1 - \tau)p\phi(I(s)) \frac{1 - G(s)}{1 - G(t)} ds.
\]

(11)

The economic interpretation is similar to (4'). \( E_{t<t^*} \) is the expectation operator representing the expectation of the timing of the reform conditional upon that the reform has not been implemented by time \( t \). \( E[\beta(\omega_2)] \) represents the pre-reform expectation of the value of the support parameter in the post-reform regime. The first term on the right hand side of (11) then reflects the contribution to the value of the farm enterprise from currently employed capital. In comparison to (4') this term now involves the expected value of the change in the support instrument. The rest of (11) reflects the value of future investments. This value is separated into two parts. The first part represent the expected value of investments
undertaken in the post-reform period \([t^*, \infty]\) while the second part, that is the integral in (11), represents the expected value of the investment program during the pre-reform period \([t, t^*)\). Then if the farm operator is risk neutral the principles of optimality now requires that the marginal adjustment cost is to be equated to the expectation of the present value net return on the marginal unit of capital. Note that since the integral in (11) is state-independent with respect to the current as well as the future capital stock, \(t>0\), \(s\) is arbitrary and that the optimality criterion has to be expressed in current value terms, the optimal non-constant investment behavior is on \((0, t^*)\)

$$I(t) = \phi^{-1}\left(\frac{\alpha + \beta(\omega_1) + \left(E[\beta(\omega_2)] - \beta(\omega_1)\right) E_{t<\tau}\left[e^{-(r+\delta)(t-s)}\right] - q}{(1-\tau)p}\right).$$

(12)

Inspection of (12) and (8) reveals that the investment behavior differs between the pre- and post-reform regimes. This is due to that future support payments will be made to presently employed capital. In the pre-reform regime currently held expectations about the timing and magnitude of the reform will therefore affect investment at the firm level. This effect is absent in the post-reform regime when the farm operators are confronted with an assumed stable policy. This finding motivates the separation of farm level investment into a short-run perspective (the pre-reform regime) and a long-run perspective. In the following section the analysis will concentrate on the incentive effects in the long-run and short-run originating from policy uncertainty.
Incentive effects

The solution of the neoclassical capital accumulation problem defines the implicit rental value of capital services supplied by the firm to itself. This rental value is the price chargeable for capital services provided by the capital stock when managed in accordance with maximizing profits. According to the seminal definition given by Miller & Modigliani the “cost of capital” is the minimum yield that an investment in real assets must offer to be worthwhile undertaking from the point of view of the owners of the firm. The underpinning is that the cost of capital is identical with the implicit rental price. In fact, both Hall and Jorgenson and Miller & Modigliani showed that under conditions of perfect capital market using the cost of capital as the discount rate when evaluating prospective investment is equivalent to maximizing the utility of the owners of the firm. The approach taken is this section follows the later development in the capital accumulation theory initiated by the work of King. Hence, the cost of capital concept derived defines the minimum yield required by a rational investor in order to be indifferent between investment alternatives in- and outside the existing farm enterprise. Functioning as such a discount rate governing the acceptance of investment also defines the role for the cost of capital as an incentive mechanism.

To analyze the incentive effects originating from an uncertainty over an agricultural policy reform a distinction has to be made between the long-run incentives and the short-run incentives.

The long-run cost of capital is obtained from (4’). According to the assumed dynamics of the stock of real capital the steady-state level of gross investment is \( I^* = \delta K^* \).

Inserting this relationship into (4’) and optimizing with respect to \( K^* \) yields that

\[
\frac{\partial \hat{V}(K(t), I(t))}{\partial K^*} = \left[ \alpha + \beta (\omega(t)) - q - (1 - \tau) p \phi'(\delta K^*) \right] \frac{\delta}{r} = 0. \quad (13)
\]
Hence, a sufficient condition for optimal employment of capital in steady-state necessitates either a non-depreciable capital stock or that the bracketed term in the numerator of (13), representing the marginal value of an additional capital unit, is zero valued. The cost of capital is derived out of this latter requirement. Developing the bracketed term in (13) defines

\[ p \left[ f_k \left( \frac{w}{p} \right) - \left( r + \delta \right) \phi' \left( \delta K^* \right) \right] = \frac{1}{1 - \tau} \left( r + \delta \right) - \omega(t) \]  

(14)

as the long-term cost of capital. Expression (14) differs from the standard Hall-Jorgenson cost of capital formulation in two respects. First, the full marginal return to capital includes an increase in current adjustment costs per unit of investment. Second, the marginal return includes a reduction originating from the policy support.

In deriving this incentive effect a further distinction has to be made between the pre-reform and the post-reform long-term cost of capital measure in the sense that the farm operator has either not yet entered the region of uncertainty (i.e. \( t < d \)) or is in a situation where this region has been left (i.e. \( t > u \)). In the case of \( t < d \), the long-term measure of the cost of capital must be based on the pre-reform support instrument \( \omega_1 \) while if the uncertainty region has been left the appropriate support instrument to use is \( \omega_2 \).

The short-run (pre-reform) cost of capital is derived from (11). Differentiating with respect to \( I(t) \) yields

\[ p \left[ f_k \left( \frac{w}{p} \right) - \left( r + \delta \right) \phi' \left( \delta K^* \right) \right] = \frac{1}{1 - \tau} \left( r + \delta \right) - \omega_1 - \left( E[\omega_2] - \omega_1 \right) E_{t < r} \left[ e^{-\left( r + \delta \right) (t^* - t)} \right]. \]  

(15)
It is straightforward to observe that the pre-reform cost of capital measure differs from the pre-reform long-term cost of capital measure only by the second term on the right-hand side of (15). This term reveals the impact upon the cost of capital of an expected reformation of coupled agricultural policy support and are in the following referred to as the anticipatory effect. Clearly, this anticipatory effect may be further decomposed into two parts. The first part corresponds to the expectation of future support levels vis-à-vis current support levels \( E[w_2] - \omega_1 \). There are two cases depending on the sign of this expectation. If the farm operator expects that the post-reform level of support is lower than the pre-reform level, the cost of capital is higher in the short-run than in the long-run and thus creating a disincentive for investment. On the opposite, if the farm operator expects an increase in the support levels the short-run cost of capital is lower than the long-run cost of capital. The second part of the anticipatory effect originates from timing uncertainty by the generated uncertainty with respect to the accurate discounting horizon. The effect of uncertainty regarding the magnitude and timing of the reform can now be stated.

**Proposition 1** (incentive effects of policy uncertainty). In the meaning of Hartman: A mean preserving increase in timing uncertainty, in the sense that while the mean of the distribution remains unaltered the variance (if it exists) increases, will increase current investment if \( E[w_2] - \omega_1 \) is positive and decrease current investment if \( E[w_2] - \omega_1 \) is negative. A mean preserving increase in support parameter uncertainty has no incentive effects.

Proof: The support instrument \( \omega(s) \) is linear in the stock of real capital by assumption and therefore both convex and concave. The exponential function \( e^{-(r+\delta)(u-t)} \) is clearly convex for non-negative values of \( (u-t) \) so the conditional form of Jensen’s inequality gives
\[
(E[\omega_2] - \omega_1) \mathbb{E}_{\tau \in \mathcal{R}} \left[ e^{-(r+\delta)(\tau' - \tau)} \left| \begin{array}{c} \geq \mu \end{array} \right. \right] \begin{array}{c} \leq \mu \end{array} \left( E[\omega_2] - \omega_1 \right) e^{-(r+\delta)(\tau' - \tau)} \Leftarrow (E[\omega_2] - \omega_1) \begin{array}{c} \geq \mu \end{array} \begin{array}{c} \leq \mu \end{array} 0
\]

for any distribution function.

**Numerical illustration of anticipatory adjustments to policy uncertainty**

Within the blue box policy instruments, a reform of the European acreage payments system will be illustrated. The illustration is based on Swedish figures by availability and starts with support levels as given by the implemented Agenda 2000 reform and extends without loss of generality to reflect the effect of blue box policy uncertainty in Europe as a hole. Acreage payments are based on the current support level of 63 ECU/ton and is the single most important support instrument in Swedish agriculture, amounting to 46 per cent out of the total support in 1999 (Statistics Sweden, 1999a). For a representative farm of 109 hectares in the most productive areas of Sweden the total direct support for crops then corresponds to 10.8 percent on an annual basis out of the total market value of farm land (Ds 1998:70; Statistics Sweden, 1999b). This will be used as a measure of the current support parameter \( \omega_1 \). The real tax adjusted discount factor of the farm operator \( r \) was assumed to be 8 percent while the tax rate on net farm earnings was assumed to equal 51 percent.

In order to clarify the impact on investment incentives the numerical illustration is divided into three steps. First, timing uncertainty is analyzed while assuming that the change the support parameter is known with certainty. In the second step, parameter uncertainty is analyzed while assuming that the reform date is known. Finally, the effects of simultaneous parameter and timing uncertainty are illustrated. Common to all steps are that the Beta probability function was used to assess the impact of uncertainty. This is motivated by its
mathematical tractability allowing for linear transformation over intervals and the flexibility in modeling skewness in the density function. The Beta function also includes the uniform distribution, used by Alvarez, Kanniainen and Södersten to illustrate timing uncertainty, as a special case.

Illustration of timing uncertainty

The question of interest here is how uncertainty over the timing of a thorough reformation of support linked to the current capital stock affects investment decisions in the pre-reform period. Crucial in analyzing the effects of timing uncertainty is the length of the interval over which the farmer finds the reform likely to occur. The previous Uruguay-round of WTO extended over 8 years and this is also the assumed length of the timing uncertainty period in this illustration. The sensitivity of this assumption will be shown below. The next crucial step is when in time the uncertainty region starts. Since the peace clause in the Agricultural Agreement expires in year 2003 and year 2000 is assumed to be the base year, the uncertainty region was chosen to be \([3,11]\).

Four cases of timing uncertainty are then considered. The probability density function associated with each case are depicted in Figure 1. Case 1 represents a situation where the farmer expects the reform date to be in year 5. Case 2 represents an expected reform at date 7. Case 3 has year 7 as the expected reform date but differs from case 2 by having a larger standard deviation. That is to say that the farmer is less certain about a reform at year 7. Case 3 will be used to analyze the impact of a mean preserving spread of the timing uncertainty. In case 4 the farmer is more certain that the reform will occur late in the region with an expected reform at year 9. Furthermore, the density functions for the
cases 1, 2 and 4 have the same standard deviation (=1/8) while the standard deviation in case 3 was set at 1/6. In order to isolate the incentive effects from timing uncertainty the cost of land was calculated with eq. (15) for two farm operators, using a post-reform support parameter $\omega_2$ set at 5.4 percent (i.e. a reduction in support by 50 percent). For each case illustrated one of the farmers is fully informed about the appropriate reform date while the other farmer is uninformed. The difference in cost of land between the uninformed and the informed farmer thus measures the impact of timing uncertainty. The results are displayed in Table 1 together with the long-term pre- and post-reform cost of land, calculated by eq.(14).

![Figure 1. Probability density functions corresponding to each case of the expected reform date.](image)
Table 1. Long-term pre-reform cost of land, short-term cost of land corresponding to each case of timing uncertainty and long-term post-reform cost of land. (percentages).

<table>
<thead>
<tr>
<th>Time</th>
<th>Case 1 informed</th>
<th>Case 2 informed</th>
<th>Case 3 informed</th>
<th>Case 4 informed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.091463</td>
<td>0.091577</td>
<td>0.086111</td>
<td>0.086209</td>
</tr>
<tr>
<td>1</td>
<td>0.094477</td>
<td>0.094601</td>
<td>0.08868</td>
<td>0.088787</td>
</tr>
<tr>
<td>2</td>
<td>0.097743</td>
<td>0.097877</td>
<td>0.091463</td>
<td>0.091579</td>
</tr>
<tr>
<td>3</td>
<td>0.101281</td>
<td>0.101426</td>
<td>0.094477</td>
<td>0.094603</td>
</tr>
<tr>
<td>4</td>
<td>0.105114</td>
<td>0.100378</td>
<td>0.097743</td>
<td>0.097876</td>
</tr>
<tr>
<td>5</td>
<td>0.109265</td>
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<td>0.101281</td>
<td>0.101238</td>
</tr>
<tr>
<td>6</td>
<td>0.105114</td>
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<td>0.103083</td>
<td>0.097743</td>
</tr>
<tr>
<td>7</td>
<td>0.109265</td>
<td>0.10593</td>
<td>0.104832</td>
<td>0.101281</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>0.105114</td>
<td>0.103902</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>0.109265</td>
<td>0.106206</td>
</tr>
</tbody>
</table>

Long-term pre-reform cost of land = 0.055265

Long-term post-reform cost of land = 0.109265

It is clear by comparing the long-term pre- and post-reform cost of land that a reduction of policy support linked to the capital stock has strong effects upon the investment incentives at the farm level. Another way of viewing the results is in term of the implicit land rent required by the land owner to himself or from a leaseholder in order to satisfy the required rate of return on land. A reduction of the policy support parameter should then increase the long-term land rent through the increase of the required rate of return.

The short-term cost of land captures the investment incentive following the announcement of a reform reducing acreage payments. The immediate result is an increase of the cost of land so that the short-term cost is higher than the long-term pre-reform level. This finding, equal to the informed as well as the uninformed farm operator, implicates that the announcement triggers anticipatory adjustments in investment and/or in land rents. A comparison between the four cases considered gives that this anticipatory effect is higher the
closer to the current date in the interval of uncertainty the reform is expected (or known).

Equal to all cases is that the short-term pre-reform cost of land of the informed farm operator gradually adjust so that it equals the post-reform level at the date of the reform.

Although the uninformed farm operator also experiences an increase in the short-term cost of land over the pre-reform period, the lack of information about the actual reform date creates a higher anticipatory effect as compared to the informed farm operator. Thus, initially the short-term pre-reform cost of land is higher for the uninformed farmer. When approaching the expected reform date the situation is reversed so that the short-term cost is lower for the uniformed operator. This shift is explained by the continuous reassessment of information about the expected reform date that starts when the uninformed farm operator enters the region of uncertainty. Close to the expected reform date the uninformed operator still have believes of a reform at a later date, the occurring reform therefore appears as a surprise. The result is an over-investment by the uninformed farmer as compared to the informed farmer. At the end of the uncertainty interval the short-term cost of land equals the long-term post-reform cost of land. This holds for all cases considered in this illustration. It should be noted that the formation of believes about the timing of the reform is important in determining the difference in short-term costs between the uninformed and the informed operator. The difference is most negative close to the expected reform date when the density function is more skewed to the left (case 1) and less negative when skewed to the right.

Case 3 illustrates the impact of a mean-preserving spread in the uncertainty around the expected reform year 7. The short-term cost of land is in this case initially higher as compared to the uniformed farm operator in case 2, inducing a lower investment incentive.
and/or higher land rents. After year 4 the situation is reversed so that case 3 reveals a lower
cost of land as compared to case 2. In line with Proposition 1 it is found that a mean
preserving increase in timing uncertainty induces higher anticipatory adjustment effects and
makes the farm operator to more likely to misapprehend the reform date.

To analyze the sensitivity of the results illustrated, the short-term cost of land was
first calculated for case 1 and 4 by increasing the standard deviation of the pdf, secondly by
using the narrower interval of uncertainty \([4,10]\) in case 2, and thirdly by using a higher
discount rate.

In a first attempt to reveal the impact of higher timing uncertainty simulations were
performed with a mean preserving spread in the pdf for case 1 and 4. However, the Beta
function then becomes U-shaped when the interval of uncertainty is remained fixed with very
high anticipatory effect in the beginning, low in the middle, and again high levels at the end of
the uncertainty region since either the \(\alpha\)-parameter or the \(\beta\)-parameter of the Beta
distribution has to be \(<1\) in order to preserve the mean. Although this property of the Beta
function possesses no analytical difficulties, the economic consequences becomes less
appealing, implicating a corresponding U-shaped short-term cost of land development.
Increasing the standard deviation from 1/8 to 1/6 is therefore given the interpretation that the
farm operator becomes less certain with respect to the anticipated reform date. The
expected reform date thereby becomes year 6.2 and year 7.8 in case 1 and 4, respectively.
In case 1 this gives that the value of the anticipatory term in (15) decreases due to that a
larger part of the probability mass is placed on later dates within the region of uncertainty
and therefore more affected by discounting. Hence, the short-term cost of land decreases by
increasing uncertainty. On the contrary, if the farm operator becomes less certain of the
reform date in case 4, the anticipatory term in (15) increases. Increasing uncertainty then reduces the investment incentives in this case.

The ceteris paribus effect of the alternative interval is to increase the anticipatory effect with the short-term cost of land amounting to 8.6166 percent for the uniformed farm operator at \( t=0 \) and to 10.6734 percent at the expected reform year 7. This means that a shorter interval will trigger smaller initial adjustment in investment and instead larger adjustments later in the region of uncertainty.

The ceteris paribus effect of using a higher discount rate is to decrease the anticipatory effect, thus creating lower incentives to adjust to the proposed policy. This effect is due to the convexity of the discount factor.

The impact of timing uncertainty revealed in this illustration appears inconclusive with the recent results of Alvarez, Kanniainen and Södersten. for corporate firms, but are not. Their short-term cost of capital is initially lower for the uninformed firm vis à vis the informed firm and then reversing so that the uniformed firm reveals a higher short-term cost at the expected reform date. The difference in effect of timing uncertainty is due to that they are considering a reduction in the tax rate which stimulates investment. According to Proposition 1, our result would have been similar to the result by Alvarez, Kanniainen and Södersten if farm operators would have had reasons to expect an increase in the support parameter instead of a reduction.

**Illustration of parameter uncertainty**

The question of interest here is how uncertainty with respect to the reduction in the support parameter in a thorough reformation of support linked to the current capital stock affects
investment decisions in the pre-reform period. As is clear from (15), a lower value of the post-support parameter increases the anticipatory adjustment. Based on the idea that looking at a future reform, farm operators “would frame the possibilities in terms of the extremes” (Duffy, p. 147), three cases are then considered in illustrating the impact of uncertainty. Case 1 assumes a belief of the farm operator for a post-reform support parameter value of 2.7 percent out of the market value of land on an annual basis with a standard deviation of 1/8. Case 2 illustrates a mean-preserving spread to a standard deviation of 1/6. Finally, case 3 represent a situation where the farm operator becomes less certain of an extreme reduction in the support parameter. Case 3 has the same standard deviation as case 2 but with an expected mean of 4 percent. The Beta probability density function associated with each case are shown in Figure 2.

![Figure 2. The Beta probability density function associated with three cases of parameter uncertainty.](image)
The numerical simulation of a mean preserving increase in the parameter uncertainty confirms that the anticipatory adjustment term in (15) is unaffected and therefore leaves the investment incentives unchanged. Case 3 is of more interest. Suppose that the farm operator initially frames the low extremes and then becomes less certain of the expected value. When the Beta function is skewed to the left such an increase in the standard deviation of the density function will increases the expected mean and act to reduce the anticipatory adjustment term in (15). This increase in uncertainty will therefore reduce the short-term cost of land. If the farm operator initially has expectations that are skewed to the right and then becomes less certain of the post-reform parameter the opposite result is obtained. The expected mean decreases resulting in an increase in the short-term cost of land.

**Simultaneous increase in support parameter and timing uncertainty**

Given the cases considered there exist \((2 \cdot 3)\) combinations of simultaneous increases in support parameter and timing uncertainty. Initially, the farm operator may expect the post-reform support parameter to be either a low extreme or a high extreme on the interval \([0, \omega]\). In addition, the farm operator may expect the reform date to be either early, in the middle or late on the interval of uncertainty \([3,11]\). The increase in uncertainty was modeled by increasing the standard deviation in each combination from 1/8 to 1/6 for each support parameter level and expected reform date, respectively. Table 2 summarizes the effect on the short-term cost of land.

The effect of a simultaneous increase in uncertainty on the short-term cost of land is found ambiguous. The incentive effects of higher uncertainty in the two symmetrical combinations (low support parameter, early expected reform) and (high support parameter,
late expected reform) and in the combination (high support parameter, mean preserving expected reform) are however reinforcing with an unambiguous reduction (increase) of the short-term cost of land. The incentive effects associated with higher support parameter and timing uncertainty in the asymmetrical combinations (low support parameter, late expected reform date) and (high support parameter, early expected reform date) are counteracting. An equal increase in uncertainty results in a larger effect on the expected support parameter as compared to the expected date of the reform. The increase (decrease) in the expected post-reform value of the support parameter therefore outweighs the effect of an earlier (later) expected reform date. The same mechanism applies to the combinations (low support parameter, mean preserving expected reform date). Although a mean preserving increase in timing uncertainty increases the anticipatory term in (15), this is outweighed by the reduction of the difference $E[\omega_2] - \omega_1$ caused by the less certainty of framing a low extreme post-reform support parameter.
Table 2. Causality and impact on the short-term pre-reform cost of land by a simultaneous increase in support parameter and timing uncertainty.

<table>
<thead>
<tr>
<th>Initial level of expectation of post-reform support level</th>
<th>Initial expectation of about the timing of the reform</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>$\sigma (t *) \uparrow \Rightarrow E[t *] \uparrow$</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>High</td>
<td>$\sigma (\omega_2) \uparrow \Rightarrow E[\omega_2] \uparrow$</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
</tr>
</tbody>
</table>

Notes: $\uparrow (\downarrow)$ means increase (decrease). $\sigma(\cdot)$ symbolises the standard deviation.

Conclusions

The results emerging from this study shows the existence of anticipatory adjustments in current investment by the announcement of agricultural policy programs linked to the capital stock of the farm firm. Closed form solutions for the implied adjustment prior to the reform are provided by the wedge between the short-run (pre-reform) cost of capital and the long-run (pre-reform) cost of capital. In addition, it is shown that the anticipatory adjustment effect consists of two complementary mechanisms, the pure expectation effect and the uncertainty effect. When confronted with a reduction in support levels farm operators
immediately embarks a gradual adjustment process with incentives to slow down investment. If instead a policy reform with an increase in support level is proposed farm operator faces an adjustment with higher investment incentives.

The model developed allows for a separation between uncertainty over the timing of the reform and uncertainty with respect to the size of the support instrument. The applicability of the model was demonstrated through a numerical analysis of the cost of land in a reformation of the European acreage payments system. The question then arises to what extent agricultural policy uncertainty is harmful to investment.

By numerical methods it was shown that a firm commitment to a more stable date of the reform is less harmful because of the reduction of uncertainty. The distorting effect of timing uncertainty is higher the closer to the current date the reform is expected. Lack of information also creates an inefficient capital employment by making farm operators to over invest at the reform date. This inefficiency is found reinforced by higher timing uncertainty which makes farm operator more likely to misapprehend the reform date.

The effect of uncertainty over the post-reform level of the parameter measuring the level of linked support where found dependent upon the initial believes of farm operators. When the post-reform parameter is expected to be a low extreme on the interval of uncertainty, increasing uncertainty reduces the anticipatory adjustment. If, however, the post-reform parameter initially is expected to be a high extreme, increasing uncertainty increases the anticipatory adjustment with a further decrease in investment.

Finally, it was found that increasing parameter uncertainty outweighs the effects of a simultaneous equal increase in timing uncertainty in the cost of land measure. The implication is that an increase in the noise around the outcome of multilateral trade negotiations with
respect to the acceptable support linked to the capital stock has surprisingly volatile and ambiguous effects on farm level investment. In order to be as less harmful as possible to the allocation of capital, policy makers should therefore strive to reveal information of proposed reforms, especially concerning the support levels, as accurately as possible.

The outcome of this study has implications for the dynamics of land rents and should therefore be of relevance in the evolution of land values. Future research is warranted on this issue, especially in incorporating the effects of inflation and risk aversion of the farm operators to the model developed. Risk attitudes was considered in an early stage of this paper but not incorporated since it is not clear if there exists an analytical solution. Another interesting field for future research would be to investigate to what extent the obtained results hold up empirically.

References


Dasgupta, P. S. and Heal, G. M. “The optimal depletion of exhaustible resources”.


