Modeling supply and land allocation responses to EU payments

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1. Policy background

Main policy tools of the CAP arable crop regime:

- *Intervention price*: minimum guaranteed price (standard “coupled” tool)
- *Area payments*: crop-specific payments (up to Agenda 2000) based on historical yields and current acreage (“partially decoupled” tools)
- *Set-aside*: supply control tool for large producers
- *MTR single farm payment (SFP)* replacing area payments in 2005 (“statically decoupled” payment)
2. General features of the models

- Econometric models (the statistical properties of the results can be analysed)
- Estimated on individual farm data - FADN (especially important for risk analysis)
- Estimated adopting a flexible functional form to approximate the objective function
- Results are country-specific (FADN sample representative at the country level)
- Difficult to use *per se* for simulations (no demand side: exogenous price changes; no aggregate land constraint; large cross effects..)
3. Deterministic model: structure

► Objective function (Profit max):

\[
\Pi(p^e, w, s, z, a, b, c) \equiv \max_{y, x, s_1, \ldots, s_n} \text{Profit}
\]

\[
\begin{aligned}
& p^e y - wx + \sum_{i=1}^{n_p} a_i s_i + b s_r \\
& \sum_{k=1}^{n} s_k + s_r = s \\
& s_r = \frac{c}{1-c} \sum_{i=1}^{n_p} s_i \\
& (y, x, z, s) \in T
\end{aligned}
\]

► System of equation to be estimated:

\[
y_i(p^e, w, s, z, a, b, c) = \frac{\partial \Pi(.)}{\partial p_i} \quad i = 1, \ldots, n \quad \text{(output supplies)}
\]

\[
x_j(p^e, w, s, z, a, b, c) = -\frac{\partial \Pi(.)}{\partial w_j} \quad j = 1, \ldots, m \quad \text{(input demands)}
\]

\[
s_i(p^e, w, s, z, a, b, c) = \frac{\partial \Pi(.)}{\partial a_i} \quad i = 1, \ldots, n_p \quad \text{(land allocations)}
\]
3. Deterministic model: results

► Short-run (own and cross) elasticities of \((y,x,s)\) with respect to prices, fixed inputs, payments, set-aside rate

► Impact on yields derived endogenously

► Note: in different FADN samples, supply payment elasticities turned out to be positive and statistically significant (evidence of partially coupled payments)
3. Deterministic model: evaluation (a)

► Advantages

- Obtain specific payment parameters
- Estimated equations can be used for policy simulations (with caution) in the context of the pre-MTR regime (i.e.: change in payments)
3. Deterministic model: evaluation (b)

Problems

- Change in intervention prices cannot be properly modeled
- The shift to the SFP cannot be simulated (in a static and deterministic world, it is fully decoupled)
- Price expectations must be modeled properly
- Proper econometric techniques must be adopted to solve some relevant problems (“incomplete” panel data and corner solutions)
4. Uncertainty model: structure

Objective function (Expected utility max):

\[ U(p^e, w, s, z, V_p, W_0, a, b, c) = \max_{y,x,s_1,\ldots,s_n} \left\{ W_0 + p^e y - wx + \sum_{i=1}^{n_p} a_i s_i + bs_r - \frac{\alpha_R}{2} \left( W_0 + p^e y - wx + \sum_{i=1}^{n_p} a_i s_i + bs_r \right) y' V_p y \right\} \]

\[ \sum_{k=1}^{n} s_k + s_r = s \quad s_r = \frac{c}{1-c} \sum_{i=1}^{n_p} s_i \quad (y, x, z, s) \in T \]

System of equation to be estimated:

\[ y_i(p^e, w, s, z, V_p, W_0, a, b, c) = \left( \frac{\partial U(\cdot)}{\partial p_i^e} \right) / \left( \frac{\partial U(\cdot)}{\partial W_0} \right) \quad i = 1, \ldots, n \]

\[ x_j(p^e, w, s, z, V_p, W_0, a, b, c) = -\left( \frac{\partial U(\cdot)}{\partial w_j} \right) / \left( \frac{\partial U(\cdot)}{\partial W_0} \right) \quad j = 1, \ldots, m \]

\[ s_i(p^e, w, s, z, V_p, W_0, a, b, c) = \left( \frac{\partial U(\cdot)}{\partial a_i} \right) / \left( \frac{\partial U(\cdot)}{\partial W_0} \right) \quad i = 1, \ldots, n_p \]
4. Uncertainty model: results

► Short-run (own and cross) elasticities of \((y,x,s)\) with respect to prices, payments, fixed inputs, set-aside rate, \textit{var-cov matrix of output prices, initial wealth}

► Impact on yields derived endogenously

► It is possible to distinguish the relative price/payment effects from the \textit{insurance effects and wealth effects} (Hennessy, 1998)
4. Uncertainty model: evaluation (a)

► Advantages

- Payment parameters are obtained under a more realistic set of assumptions (farmers are risk averse)
- Change in intervention prices can be modeled (impact on expected price and variance-covariance matrix)
- The shift to the SFP can be simulated (setting to 0 the crop-specific payments and adding the discounted value of future payments to farm wealth)
- The absolute and relative size of the risk-related effects can be evaluated
4. Uncertainty model: evaluation (b)

Problems

- No dynamic effect can be evaluated
- Some relevant problems to be solved in measuring price var-cov matrix and farm wealth
4. Uncertainty model: risk results

► Risk neutrality is rejected

► Estimated relative risk aversion coefficients:
  - small farms (<20 ha) 5.53*
  - medium farms (20-40 ha) 0.45*
  - large farms (>40 ha) 0.05
### 4. Uncertainty model: price elasticities

<table>
<thead>
<tr>
<th></th>
<th>Prices</th>
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<tbody>
<tr>
<td></td>
<td>$p_1$</td>
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<tr>
<td><strong>Maize (y1)</strong></td>
<td>0.146*</td>
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<tr>
<td><strong>Durum wheat (y2)</strong></td>
<td>-0.208*</td>
</tr>
<tr>
<td><strong>Other cereals (y3)</strong></td>
<td>-0.260*</td>
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<tr>
<td><strong>Oilseeds (y4)</strong></td>
<td>-0.147*</td>
</tr>
<tr>
<td><strong>Maize acreage (s1)</strong></td>
<td>0.066*</td>
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<tr>
<td><strong>Durum wheat acreage (s2)</strong></td>
<td>-0.081*</td>
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<tr>
<td><strong>Other cereals acreage (s3)</strong></td>
<td>-0.201*</td>
</tr>
<tr>
<td><strong>Oilseeds acreage (s4)</strong></td>
<td>-0.033</td>
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</tbody>
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### 4. Uncertainty model: payment elasticities

<table>
<thead>
<tr>
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<th>Payments</th>
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<tbody>
<tr>
<td></td>
<td>$a1$</td>
</tr>
<tr>
<td><strong>Maize (y1)</strong></td>
<td>0.014*</td>
</tr>
<tr>
<td><strong>Durum wheat (y2)</strong></td>
<td>-0.013*</td>
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<tr>
<td><strong>Other cereals (y3)</strong></td>
<td>-0.014*</td>
</tr>
<tr>
<td><strong>Oilseeds (y4)</strong></td>
<td>-0.019*</td>
</tr>
<tr>
<td><strong>Maize acreage (s1)</strong></td>
<td>0.014*</td>
</tr>
<tr>
<td><strong>Durum wheat acreage (s2)</strong></td>
<td>-0.008*</td>
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<tr>
<td><strong>Other cereals acreage (s3)</strong></td>
<td>-0.012*</td>
</tr>
<tr>
<td><strong>Oilseeds acreage (s4)</strong></td>
<td>-0.007</td>
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</table>
### 4. Uncertainty model: variance and wealth elasticities

<table>
<thead>
<tr>
<th></th>
<th>Variances</th>
<th>Wealth</th>
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<tbody>
<tr>
<td></td>
<td>Var(p1)</td>
<td>Var(p2)</td>
</tr>
<tr>
<td><strong>Maize (y1)</strong></td>
<td>-0.012*</td>
<td>-0.071</td>
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<tr>
<td><strong>Durum wheat (y2)</strong></td>
<td>0.025</td>
<td><strong>0.190</strong>*</td>
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<tr>
<td><strong>Other cereals (y3)</strong></td>
<td>0.040*</td>
<td>-0.052</td>
</tr>
<tr>
<td><strong>Oilseeds (y4)</strong></td>
<td>0.059*</td>
<td>-0.104</td>
</tr>
<tr>
<td><strong>Maize acreage (s1)</strong></td>
<td>-0.001</td>
<td>-0.056</td>
</tr>
<tr>
<td><strong>Durum wheat acreage (s2)</strong></td>
<td>-0.001</td>
<td>0.153*</td>
</tr>
<tr>
<td><strong>Other cereals acreage (s3)</strong></td>
<td>0.03</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Oilseeds acreage (s4)</strong></td>
<td>0.019</td>
<td>-0.029</td>
</tr>
</tbody>
</table>
4. Uncertainty model: decomposition of acreage effects (shift to SFP)
4. Uncertainty model: decomposition of acreage effects by size (Durum wheat)

[Bar chart showing percentage changes in various categories: Average, < 20 ha, 20-40 ha, > 40 ha. The categories are represented by different colors: Total (Red), Relative price (Orange), Relative payment (Blue), Insurance (Yellow), Wealth (Green).]
5. Investment model: structure

- **Objective function (under uncertainty):**
  \[ J(p^e, w, a, b, c, q, k, Z, t, W_0, V_p) = \]
  
  \[ = \max_t \int_t^\infty e^{-rv} U(p^e, w, a, b, c, q, K(v), I(v), Z, v, W_0, V_p) \, dv \]

  \( s.t. \dot{K} = I - \delta K \quad K(t) = k \)

- **System of equation to be estimated:**
  \[ \dot{K}(p^e, w, a, b, c, q, k, z, t, W_0, V_p) = J_{kq}^{-1}(rJ_q + k - J_{tq}) \]
  \[ Y(p^e, w, a, b, c, q, k, z, t, W_0, V_p) = U_{W_0}^{-1}(rJ_{pe} - J_{kp} \dot{K} - J_{tp}) \]
  \[ X(p^e, w, a, b, c, q, k, z, t, W_0, V_p) = U_{W_0}^{-1}(-rJ_w + J_{kw} \dot{K} + J_{tw}) \]
  \[ S(p^e, w, a, b, c, q, k, z, t, W_0, V_p) = U_{W_0}^{-1}(rJ_a - J_{ka} \dot{K} - J_{ta}) \]
5. Investment model: results

- Short-run (own and cross) elasticities of \((y,x,s)\) with respect to prices, payments, fixed inputs, set-aside rate, var-cov matrix, initial wealth, capital rental prices
- Investment demand elasticities with respect to the same set of exogenous variables
- Capital adjustment rates with respect to the long run optimal capital level
- Long run elasticities of output supply, land allocations and all inputs with respect to the same exogenous variables
5. Investment model: evaluation

► Advantages
- The same features (at least in theory) of the uncertainty model (see previous list)
- The dynamic investment effects can be evaluated
- The long run effects can be evaluated

► Problems
- The uncertainty set-up is needed to model the shift to the SFP (under certainty the impact cannot be captured)
- The problem of corner solutions is very important
- The model becomes very difficult to manage empirically
6. Conclusions (a)

- Deterministic model is sufficient to detect the *partially coupled* nature of area payments
- Uncertainty model provides interesting results:
  - The shift to the SFP can be properly modeled
  - Risk neutrality is strongly rejected
  - Risk effects may be relevant (especially the *insurance effects*, while *wealth effects* tend to be small)
  - Cross-crop effects are relevant also for risk behaviour (some crops more attractive because of relative risk patterns)
  - The shift to the SFP will enhance production of “other arable crops”
6. Conclusions (b)

- Uncertainty should be taken into account in more general models (even in a simplified way: see AGLINK)
- Investment results still to come