Evidence from a Time-Changing Regulated Agricultural Market: The Italian Tobacco Industry

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Abstract

Tobacco represents one of the most important crop within the European Common Agriculture Policy (CAP), with a total budget cost of 963 millions euros in 2002 and the highest ratio (6:1) between European financial support and gross saleable production (EC Commission Report, 2003). Nevertheless, the tobacco industry has never been analyzed in details except in the paper by Vernon, Rives, and Naylor (1969) which analyzed the American market. We started analyzing the Italian tobacco industry using fifty years of data and some of the latest economic models used for crops subjected to the European CAP regime. The effects of three different kind of public regulation were examined and interesting empirical evidence is reported. We then did a step further and we proposed a Vector Error Correction approach to take into account the latest developments in econometric estimation techniques together with the main economic determinants highlighted in the first step.

Keywords: Macro models, Micro models, Non-Structural models, Forecasting, Tobacco Industry

JEL classification: G12, G30, G32.

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1 Introduction

The term Tobacco Industry (TI from now on) is used in Vernon et al. (1969) to refer to all activities that allow the production of tobacco, its movement in space and time, and if necessary, its physical transformation, so that it can be made in conformity with consumers tastes and demands. This paper will consider the Italian Tobacco Industry since Italy is the biggest producer of raw tobacco in the European Community (EU Commission, 2003). The expansion of this cultivation dates back as far as the first years of the '50s, when the Italian state monopoly over the TI was introduced, and it was governed by the Administration of State Monopolies (Monital). The Monital ruled by means of inspections on the whole tobacco production, and it was the only one that decided what to produce and how much. In 1970, the EU began a common policy for all its members and the national monopolies were abolished. The changes that have influenced the TI since then are the results of the EU regulations, which had the purpose to protect a class of farmers whose income was mainly determined by the profits coming from tobacco: this kind of income was considered (and partially still is today) very volatile since it may be liable to factors, such as weather conditions, which are not manageable. Moreover, particularly for developed countries like Europe, the gap between agricultural income and other types of income has increased over time.

In order to examine the Italian tobacco market, a unique dataset is used, ranging from 1951 till 2001, which is made up with data collected from Eurostat, INEA, ISTAT, and FAO. This dataset allows us to consider the effects of different European market regulations along an historical path of half a century.

The main features of the Italian (and European in general) tobacco industry can be summarized as follows:

- **During the time period between 1951 and 1971**, tobacco growers decided on production in the Spring based upon the decisions taken by the Administration of State Monopolies. These decisions were usually taken in the first months of the year, no more late than March.

- **During the time period between 1972 and 1992**, tobacco growers awaited for European support prices to be fixed, again in the first months of the new year, just before seeding. The EEC regulation introduced different types of support prices, that were settled on a yearly basis to ensure income stability for farmers and low prices for first transformation manufacturers. The most important was the so-called **Target price**: this was set for every tobacco variety, on the grounds of the current market situation, with the purpose to protect the farmers income and cover all costs sustained during the agricultural-production phase.

- **During the time period between 1993 and 2001**, tobacco growers looked at European prizes to tobacco production. The amount of prizes is announced before seeding, similarly to the previous two cases. In this last EU regime, tobaccos are divided in eight groups of variety, based on the different methods of production and subsequent transformation. The prize is assigned to producers per Kg of tobacco in leaf, with an amount diversified according to the group of variety.

The 1992 reform of the Common Agricultural Policy (CAP) have thus represented a major shift in the way the European Union (EU) provides income support to tobacco farmers.
2 Economic Modelling for Crops under the CAP regime

The most recent empirical literature that examined crops under the European CAP regime basically employed two type of models:

- Structural macro-models to analyze the effect of European CAP reforms on prices and productions. Important examples are the works by Thompson, Herrmann and Gohout (2000) and Thompson, Gohout and Herrmann (2002).

- Micro-based models that explicitly consider risk aversion within the framework of optimizing farms, thus considering price and/or yield variability. This framework, although limited to the price uncertainty component under Constant Absolute Risk Aversion (CARA), has been recently applied by Oude Lansink (1999) to analyze land allocation decisions of Dutch arable crop farms. A step forward was made by Skokai and Moro (2002) who consider Constant Relative Risk Aversion (CRRA) with Italian data.

In order to have a complete picture of the Tobacco Industry, we will consider both these two models.

2.1 A Macro-based model for the Tobacco Industry

We specified a macro structural model of the Italy-Rest of World (ROW) Tobacco market, following Thompson, Gohout and Herrmann (2002, TGH from now on). Being the biggest European producer of tobacco, the small-country assumption can hardly be assumed in this context: therefore, we preferred to consider world prices as endogenous to avoid any endogeneity bias in the subsequent econometric analysis.\footnote{See Greene (2002) for more details about simultaneous equations modelling.}

However, the previous model was modified to accommodate the time changing Italian and European regulations described in the previous section.

As a consequence, the equations modelling the quantity supplied $Q^s$, the export quantity supplied $X^s$ and the Italian domestic price $P^D$, had to consider these different policy regimes. To do that, we introduced two multiplicative dummy variables:

1. $LOG\_TARGET$: this time series is equal to the logarithm of the (average) Target Price per ton for tobacco, within the sample 1972 - 1992, while zero otherwise.

2. $LOG\_PRIZES$: it is equal to the logarithm of the (average) price per ton for tobacco, within the sample 1993 - 2001, while zero otherwise.

We also considered a dummy variables $DSESS$ which is equal to 1 in 1961 and zero otherwise, to model the huge fall in tobacco production that took place in that year. Besides, differently from TGH (2002), we discarded the modelling of the quantity demanded $Q^D$, as it was not included in our dataset and is not a variable of interest for our analysis. A similar choice was made for the import quantity $X^D$ demanded by the rest of the World. Considering market equilibrium, we could write the general model in log-linear form as
follows:

\[
\ln Q^S = c(11) + c(12) \cdot \ln(P^D_t) + c(13) \cdot \ln(Q^S_{t-1}) + c(14) \cdot \ln T + c(15) \cdot DSESS +
\begin{align*}
&+ c(16) \cdot LOG\_TARGET + c(17) \cdot LOG\_PRIZE + \ln u_1 \\
\ln X^S &= c(21) + c(22) \cdot \ln(P^D_t) + c(23) \cdot \ln(Q^S_{t-1}) + c(24) \cdot DSESS +
\begin{align*}
&+ c(25) \cdot LOG\_TARGET + c(26) \cdot LOG\_PRIZE + \ln u_2 \\
\ln P^D &= c(31) + c(32) \cdot \ln(P^W) + c(33) \cdot \ln T + c(34) \cdot DSESS + c(35) \cdot LOG\_TARGET +
\begin{align*}
&+ c(36) \cdot LOG\_PRIZE + \ln u_3 \\
\end{align*}
\] (2.1)

where \(Q^S\) is the quantity supplied in the EU, \(X^S\) is the export quantity supplied by the EU, \(P^D\) is the domestic price in Italy; \(P^W\) is the world price, \(T\) is a linear trend. \(u_i\) are independent (over time, but not instantaneously) normally distributed disturbance variables, i.e.

\[
\ln u_i = N(0, \sigma^2_i), i = 1, \ldots, 3
\] (2.4)

### 2.2 A Micro-based model for the Tobacco Industry

To implement this kind of modelling, we followed closely the theoretical framework introduced by Coyle (1999) and Sckokai and Moro (2002). Sckokai and Moro (2002) used the following utility function \(U(\cdot)\) under non-linear mean-variance risk preferences

\[
U(\cdot) = \bar{W} - \sum_{i=1}^{\alpha R} \frac{1}{\sigma^2_W} \sigma^2_W (2.5)
\]

where \(\bar{W}\) is expected final wealth, which is the sum of non random initial wealth \(W_0\) and random profit \(\pi\), \(\sigma^2_W\) is the variance of wealth and \(\alpha(\cdot)\) is the (non constant) Arrow-Pratt coefficient of absolute risk aversion.

The utility function in (2.5) may take many different specifications, depending on which variables are assumed to be stochastic (only prices, only yields or both) and on the structure of risk preferences.

Sckokai and Moro (2002) considered price uncertainty only, since the policy set-up had nothing to do with yield variability, and Constant Relative Risk Aversion (CRRA) preferences.

Under CRRA, they model \(\alpha(\cdot)\) simply as:

\[
\alpha = \frac{\alpha_R}{\bar{W}} (2.6)
\]

where \(\alpha_R\) is the constant relative risk aversion coefficient: we can easily observe that as wealth increase, the degree of risk aversion decreases.

Sckokai and Moro (2002) extended and adapted Proposition 2 in Coyle (1999) to their specific arable crop regime structure, and assuming that the utility function \(U(\cdot)\) is differentiable, they showed that the following derivative properties holds:

\[
y_i(p^e, w, V_p, r, z, s, c, W_0) = \frac{\partial U(\cdot)}{\partial p^e_i} \frac{\partial U(\cdot)}{\partial W_0} i = 1, \ldots, n (2.7)
\]

\[
x_i(p^e, w, V_p, r, z, s, c, W_0) = -\frac{\partial U(\cdot)}{\partial w_j} \frac{\partial U(\cdot)}{\partial W_0} j = 1, \ldots, m (2.8)
\]

\[
s_i(p^e, w, V_p, r, z, s, c, W_0) = \frac{\partial U(\cdot)}{\partial r_i} \frac{\partial U(\cdot)}{\partial W_0} i = 1, \ldots, n_p (2.9)
\]

---

2This proposition shows the properties of the dual assuming nonlinear mean-variance risk preferences, a general technology with multiple stochastic outputs and uncertainty regarding both output levels and prices.
We considered two variable inputs, labor and other inputs, and the price of the latter is our numeraire in the normalized quadratic utility function. The initial wealth $W_0$ is approximated by the cumulated sum of profits: this choice is quite reasonable since out equation properties, it has a Hessian of constants, such that the curvature properties can hold globally, and it allows negative realization of profits, a possibility which cannot be exploited when working with logarithmic transformations.

Moreover, Sckokai and Moro (2002) used a normalized quadratic function: among its many properties, it has a Hessian of constants, such that the curvature properties can hold globally, and it allows negative realization of profits, a possibility which cannot be exploited when working with logarithmic transformations.

However, we had to consider again the particular features of our tobacco dataset:

- The presence of different European and Italian policy regimes over time, similarly to what we did in the previous macro model;
- Tobacco is a labor intensive crop that cannot be easily replaced by other crops, such as durum wheat. Moreover, the Italian regions which have been allowed to grow this crop, have benefited with strong financial aids. Therefore, differently from Coyle (1999) and Sckokai and Moro(2002), we could not consider a set of alternative outputs $y_i$ (or $Q^S$ to use past notation), but we have to focus on tobacco, only. This because tobacco growers cultivate this crop as much as they can.

We considered two variable inputs, labor and other inputs, and the price of the latter is our numeraire in the normalized quadratic utility function. The initial wealth $W_0$ was approximated by the cumulated sum of profits: this choice is quite reasonable since out dataset starts almost right after World War II.

Therefore, our micro-model for tobacco output $y = Q^S$, labor demand $x_1$ and land allocation $s$ was defined as follows:

\[
\begin{align*}
y &= \{(11) + c(12) \cdot \hat{P}^D/w_2 + c(13) \cdot w_1/w_2 + c(14) \cdot \hat{V}_{pr}/w_2^2 + 
+c(15) \cdot W_0/w_2 + c(16) \cdot TARGET + c(17) \cdot PRIZES + 
+c(18) \cdot DSESS + c(19) \cdot (T)\}/\{\partial U(\cdot)/\partial W_0\} \\
x_1 &= -\{c(21) + c(22) \cdot \hat{P}^D/w_2 + c(23) \cdot w_1/w_2 + c(24) \cdot \hat{V}_{pr}/w_2^2 + 
+c(25) \cdot W_0/w_2 + c(26) \cdot TARGET + c(27) \cdot PRIZES + 
+c(28) \cdot DSESS + c(29) \cdot (T)\}/\{\partial U(\cdot)/\partial W_0\} \\
s &= \{c(31) + c(32) \cdot \hat{P}^D/w_2 + c(33) \cdot w_1/w_2 + c(34) \cdot \hat{V}_{pr}/w_2^2 + 
+c(35) \cdot W_0/w_2 + c(36) \cdot TARGET + c(37) \cdot PRIZES + 
+c(38) \cdot DSESS + c(39) \cdot (T)\}/\{\partial U(\cdot)/\partial W_0\} \\
\partial U(\cdot)/\partial W_0 &= 1 + \frac{c(30)}{2(W)^2} y/\hat{V}_{pr}y
\end{align*}
\]
• $T$ is a linear time trend, while $\hat{P}_D$ and $\hat{V}_{PD}$ are the 1-step ahead forecasts of tobacco price mean and variance, computed by using the Chavas and Holt (1990) methodology, which is the standard procedure in agricultural empirical applications (Coyle 1992 - 1999, Oude Lansink 1999, Sekokai and Moro 2002, to name a few).

• $w_1$ and $w_2$ are the prices of labor and other inputs, respectively.

• $W_0$ is the initial wealth, while $\bar{W} = W_0 + \pi$ is the final wealth, given by the sum of non random initial wealth $W_0$ and random profit $\pi$.

• $TARGET$ is equal to the (average) Target Price per ton for tobacco, within the sample 1972 - 1992, while zero otherwise, while $PRIZES$ is equal to the (average) prize per ton for tobacco, within the sample 1993 - 2001, while zero otherwise. $DSESS$ is a dummy variables which is equal to 1 in 1961 and zero otherwise (similarly to what we did for the macro model).

2.3 The empirical analysis

2.3.1 A Macro-based Model

The model was estimated with the software Eviews 5.1 using 3SLS, where we chose the option to iterate simultaneously over the weighting matrix and coefficient vector. The Eviews estimation output is reported in table(1), while the line graphs of $Q^S$, $X^S$, $P^D$ and $P^W$ are reported in figures (1 - 2).

The empirical analysis showed some interesting results:

• Quantity Supplied $Q^S$: As expected, current domestic prices and lagged quantity strongly influenced current tobacco supply, while the long run supply elasticity was equal to 0.48, which is slightly higher than the 0.30 estimate of Makki, Tweeten and Miranda (1996), and the 0.2 of TGH (2002), for the case of wheat. The trend variable and the dummy variable $LOG\_TARGET$ which is 1 for the time sample 1972-1992 and 0 otherwise (corresponding to the first European regulation), were not significant at the 1% level. The dummy variable corresponding to the current European regulation (1993- 2001) was strongly significant, instead: this clearly highlights that the introduction of the prizes regime reduced the tobacco supplied quantity. The dummy variable $DSESS$ for the outlier in 1961 was significant as expected.

• Export Quantity Supplied $X^S$: the constant, the current domestic prices, the lagged Quantity Supplied $Q^S_{-1}$ and the dummy variable for 1961 were not significant. The dummy variables representing European regulations showed rather high and significant positive signs, instead: this highlights that European policy regimes fostered the cultivation of low quality tobaccos which was not requested by the European demand and therefore have been destined to exports.

• Italian Domestic price $P^D$: The estimated price transmission elasticity $\eta^{PD}$ was rather high (0.70). This is not a surprise, since Target prices as well as prizes were enforced considering the minimum and maximum world prices available at the time policy decisions were taken. Similar considerations hold for the time sample under the Italian Monopoly government. The first European regulation had the effect to increase Italian (and European in general) tobacco prices, while the subsequent
reform had no significant impact, as can be also seen by the line graph in Figure (2). A strong positive trend was found, too.

Figure 1: Line graphs of $Q^S$ and $X^S$ over the time sample 1951-2001

Figure 2: Line graphs of $P^D$ and $P^W$ over the time sample 1951-2001

System: MACRO.MODEL
Estimation Method: Iterative Three Stage Least Squares
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 10 weight matrices, 11 total coef iterations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
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<td>C(11)</td>
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<td>0.627127</td>
<td>4.786048</td>
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<td>C(12)</td>
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<td>4.882842</td>
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<tr>
<td>C(13)</td>
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<td>0.009733</td>
<td>1.421200</td>
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</tr>
</tbody>
</table>

Table 1: 3SLS estimates for the Macro model

We tried to add interaction terms of the type $(P^W \cdot \text{LOG\_TARGET})$, $(P^W \cdot \text{LOG\_PRIZE})$ to the previous equations, but they were not found to be statistically significant as in Thompson, Herrmann and Gohout (2000, 2002).

We report in table 2 the residuals properties resulting from the previous estimated model. We used the Ljung-Box statistic to test the null hypothesis that there was no autocorrela-
tion up to order three in the levels and in the squares. We used the Jarque-Bera statistic, instead, to test whether the residuals were normally distributed.

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<th>Normality</th>
<th>Jarque-Bera (P-value)</th>
<th>Residual01</th>
<th>Residual02</th>
<th>Residual03</th>
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<td>Ljung-Box (P-value)</td>
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<td>0.095</td>
<td>0.000</td>
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</tbody>
</table>

Table 2: Residuals properties Macro model

The previous table presents mixed results: while the equation relative to the quantity supplied $Q^S$ seems to be correctly specified, we observe strong correlation left in the residuals from the equations modelling export supply $X^S$ and prices $P^D$. This must be considered as an alarm bell and caution must be taken when using this model for policy making.

2.3.2 A Micro-based Model

The estimation results of the micro-model is reported in Table (3): we used iterative 3SLS instead of the FIML method, since the latter had problems converging, due to the high non-linear specification. This evidence confirmed similar problems reported by Coyle (1999) and Skokai and Moro (2002).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
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<td>1.567287</td>
<td>-0.527351</td>
<td>0.5990</td>
</tr>
<tr>
<td>C(32)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(33)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(34)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(35)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(36)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(37)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(38)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
<tr>
<td>C(39)</td>
<td>-1.007406</td>
<td>1.711979</td>
<td>-0.588446</td>
<td>0.5575</td>
</tr>
</tbody>
</table>

Table 3: 3SLS estimates for the Micro model
The main results are the followings:

- **Quantity Supplied** $Q^S$: the expected price mean, variance and initial wealth $W_0$ seemed not to have any significant effect on quantity. The price regime in place since 1993 had a negative effect, as well as the dummy variable for 1961. The target price series was not significant, instead. These outcomes were rather similar to what we found when using the macro based model. The price of labor had a positive impact on production, a result similar to Coyle (1999).

- **Labor demand** $x_1$: an increase in salaries $w_1$ decreased the labor demanded, as expected, while an increase in initial wealth $W_0$ increased $x_1$, instead. Moreover, a significant negative trend was found: this can be explained by thinking at improvements in agricultural cultivation techniques that reduce human labor. All other variables were not significant.

- **Land allocation** $s$: Only two variables were found to be significant besides the constant: the price of labor $w_1$ had a positive effect on land allocation, while the prizes regime enforced since 1993 have decreased the total land allocated. An outcome which reflects the current main goal of European policy makers.

The coefficient of relative risk aversion $\alpha_R$ was slightly positive but not significant. Besides, we could test the hypothesis concerning the degree of absolute risk aversion by using (2.14) and equations (19) in Coyle (1999):

\[
\frac{\partial U(\cdot)}{\partial W_0} > 1, \text{ under decreasing absolute risk aversion (DARA)} \\
\frac{\partial U(\cdot)}{\partial W_0} = 1, \text{ under constant absolute risk aversion (CARA)} \\
\frac{\partial U(\cdot)}{\partial W_0} < 1, \text{ under increasing absolute risk aversion (IARA)}
\]

The null hypothesis that the sample mean of (2.14) equals 1 was not rejected with a p-value of 30%.

These results highlight that the degree of protection in Italian (and European in general) tobacco industry has been rather high so far, so that the risk component does not seem to be significant. The full effects of recent reforms will probably change this evidence. The residuals of the micro model showed mixed results, even though slightly better than the previous macro-based model: the normality assumption was rejected in all cases while some correlation was left in the residuals of the price of labor equation (see Table 4).

<table>
<thead>
<tr>
<th>NORMALITY</th>
<th>Jarque-Bera (P-value)</th>
<th>RESID01</th>
<th>RESID02</th>
<th>RESID03</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO-</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-1)</td>
<td>0.024</td>
<td>0.000</td>
</tr>
<tr>
<td>CORRELATION</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-2)</td>
<td>0.650</td>
<td>0.012</td>
</tr>
<tr>
<td>LEVELS</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-3)</td>
<td>0.239</td>
<td>0.043</td>
</tr>
<tr>
<td>AUTO-</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-1)</td>
<td>0.350</td>
<td>0.008</td>
</tr>
<tr>
<td>CORRELATION</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-2)</td>
<td>0.235</td>
<td>0.008</td>
</tr>
<tr>
<td>SQUARES</td>
<td>Ljung-Box (P-value)</td>
<td>Lag (-3)</td>
<td>0.517</td>
<td>0.642</td>
</tr>
</tbody>
</table>

Table 4: Residuals properties Micro model

3 The negative sign of $c(23)$ becomes positive once you consider the minus sign in front the demand equation.
3 A Vector Error Correction Approach

The previous approaches clearly highlighted how the European policy regimes based on target prices fostered the cultivation of low quality tobaccos which were destined to exports, thus determining a heavy burden for the EC agricultural budget. However, the introduction of the prizes regime since 1993 has reduced the tobacco supplied quantity as well as the total land allocated for tobacco production.

While the previous modelling was very helpful to get interesting insights within the tobacco industry, some remarks have to be done:

• *Macro-based models* of the type we’ve seen in the previous pages have helped to shed some light on agricultural economics, by focusing the attention on the effects of government restrictions and market liberalization schemes. However, the lack of any reference to farmers’ degree of risk aversion as well as to any measure of supply and price volatility, makes the previous modelling rather limited.

• *Micro-based models* explicitly consider risk aversion within the framework of optimizing farms, thus considering price and/or yield variability. However, the highly nonlinear specification of these models makes them difficult to estimate and therefore limits their possible use as well as their extensions. Besides what we’ve seen so far, it’s surely meaningful to observe that Coyle(1999) himself avoided estimating the complex nonlinear model under CRRA he theoretically described, but considered the empirical analysis of a mean-variance model with CARA preferences and output uncertainty, only. Moreover, the use of adaptive expectations for calculating expected prices and variance-covariance matrices, make the previous analysis rather rough. It is a well known fact in economics that this kind of modelling is a poor measure of prices expectations and variability.

• Both these two kind of models do not take into account the past developments in econometric modelling for non-stationary series with common trends, such as the Vector Error Correction models\(^4\).

A recent paper by Roche and McQuinn (2003) is the first work to show how a Vector Error Correction (VEC) model can be successfully implemented to model the joint evolution of agricultural prices.

Particularly, they used a VEC model together with a multivariate Generalized Auto-Regressive Conditional Heteroscedasticity model (VEC-MGARCH) to investigate the effect of British grain prices on their Irish equivalents. They found that their model was able to explain the main features of Irish grain prices dynamics and produced superior forecasts compared to the standard Chavas and Holt(1990) methodology, which we used in the previous section within the micro-based model. However, Roche and McQuinn (2003) used this approach for modelling agricultural prices only.

Making a step forward, we employed a trivariate VEC to model the joint dynamics of *Italian prices*, *World prices* and *Italian production*. This model outperformed the previous macro and micro based models in terms of both residuals properties and forecasting performances. We did not use a MGARCH model since the second moments can be considered constant with no harm.

\(^4\)See Greene (2002) for more details.
By using standard trace tests, we decided to consider 1 cointegration relationship only, with unrestricted constants. Besides, we did not consider the time trend within the long run relationship, since it was found not significant after proper statistical analysis. Based on the findings of section 2 and following Roche and McQuinn (2003), the conditional means of Italian domestic prices $P^D$, supplied quantity $Q^S$ and World prices $P^W$ could be specified as follows:

$$
\Delta \ln Q^S_t = \alpha^Q (\ln Q^S_{t-1} - \beta_1 - \beta_2 \ln P^D_{t-1} - \beta_3 \ln P^W_{t-1}) + \sum_{i=1}^{m_i} \delta_i^Q \Delta \ln P^D_{t-i} + \\
+ \sum_{i=1}^{m_i} \delta_i^Q \Delta \ln P^W_{t-i} + \sum_{i=1}^{m_i} \gamma_i^Q \Delta \ln Q^S_{t-i} + \\
+ \phi^Q LOG\_TARGET + \lambda^Q LOG\_PRIZES + \rho^Q DSESS + u_t^Q
$$

$$
\Delta \ln P^D_t = \alpha^P (\ln Q^S_{t-1} - \beta_1 - \beta_2 \ln P^D_{t-1} - \beta_3 \ln P^W_{t-1}) + \sum_{i=1}^{m_i} \delta_i^P \Delta \ln P^D_{t-i} + \\
+ \sum_{i=1}^{m_i} \delta_i^P \Delta \ln P^W_{t-i} + \sum_{i=1}^{m_i} \gamma_i^P \Delta \ln Q^S_{t-i} + \\
+ \phi^P LOG\_TARGET + \lambda^P LOG\_PRIZES + \rho^P DSESS + u_t^P
$$

$$
\Delta \ln P^W_t = \alpha^W (\ln Q^S_{t-1} - \beta_1 - \beta_2 \ln P^D_{t-1} - \beta_3 \ln P^W_{t-1}) + \sum_{i=1}^{m_i} \delta_i^W \Delta \ln P^D_{t-i} + \\
+ \sum_{i=1}^{m_i} \delta_i^W \Delta \ln P^W_{t-i} + \sum_{i=1}^{m_i} \gamma_i^W \Delta \ln Q^S_{t-i} + \\
+ \phi^W LOG\_TARGET + \lambda^W LOG\_PRIZES + \rho^W DSESS + u_t^W
$$

$$
\begin{bmatrix}
  u_t^Q \\
  u_t^P \\
  u_t^W
\end{bmatrix} = \mathbf{u}_t \sim MN(0, \Sigma) \tag{3.1}
$$

where $LOG\_TARGET$, $LOG\_PRIZES$ and $DSESS$ are previously defined time series and dummy variables, while $m_i$ is the number of lagged growth variables that are added as explanatory variables in the VEC model. Similarly to Roche and McQuinn (2003), $m_i$ was determined by using a combination of minimizing the Bayesian (or Schwartz) Information Criterion and ensuring that the residuals are white noise: we found $m_i = 2$ to be the best choice.

### 3.1 The Empirical Analysis

The restricted model where restrictions on the cointegrating vector $\beta$ and the adjustment coefficients $\alpha_i$ are imposed, is reported in Table 5.
Cointegration Restrictions:
B(1,1)=1, B(1,3)=0, A(3,1)=0, A(2,1)=0
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):
Chi-square(3) 5.917749
Probability 0.115681

Cointegrating Eq:
CointEq1
LOG(QS(-1)) 1.000000
LOG(PW(-1)) -0.333772
LOG(PD(-1)) -0.696867
C -6.696867

Log likelihood 140.3891

Error Correction:
D(LOG(QS)) 0.000000
D(LOG(PW)) 0.000000
D(LOG(PD)) 0.000000

CointEq1 -0.622894
D(LOG(QS)) 0.056117
D(LOG(PW)) -0.068009
D(LOG(PD)) -0.006811

LOG(TARGET) 0.008976
LOG_PRIZES -0.006881

Cointegrating Eq. CointEq1
<table>
<thead>
<tr>
<th>LOG(QS(-1))</th>
<th>LOG(PW(-1))</th>
<th>LOG(PD(-1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>-0.333772</td>
<td>-0.696867</td>
</tr>
</tbody>
</table>

Table 5: Restricted VEC model estimates

The main results can be summarized as follows:

• The (restricted) estimated long-run relationship, with std. errors in brackets, was

\[
\ln Q_t^S = 6.69 + 0.33 \ln P_t^W
\]

which implies that the long run elasticity with world prices was equal to 0.33. This result is more in line with the estimated elasticity found for other crops, than the previous value of 0.48 estimated with the macro model.

• The cointegrating error term CointEq1 was significant for the production \( Q^S \) and with the right sign (between -1 and 0) : this highlights that the system is mean reverting towards the long run relationship.
• The restrictions on $\beta_i$ and $\alpha_i$ were not rejected. This implies that the error correction term did not have any influence on prices.

• Lagged $\Delta \ln P_D$ and $\Delta \ln P_W$ were significant and positive for both Italian and World price, showing some degree of persistence. Lagged $\Delta \ln Q_S^i$ were not significant, instead.

• The dummy variables $DSESS$ was significant at the 5% level for both Italian price and production, showing that in 1961 there was a big fall in production, with a contemporaneous increase in prices. No significant effect on $P_W$ was found.

• The series $LOG\_TARGET$ was significant at the 5% level and positive for both $P_D$ and $Q^S$: this points out that the first European regulation (in force between 1972 and 1992) had the effect to increase both prices and production. No significant effect on $P_W$ was found, instead.

• The series variables $LOG\_PRIZES$ was significant and negative for $Q^S$, meaning that the second European regulation decreased production by cutting the strong financial incentives to tobacco growers, thus confirming previous findings with micro and macro models.

<table>
<thead>
<tr>
<th>NORMALITY</th>
<th>Jarque-Bera (P-value)</th>
<th>RESID01</th>
<th>RESID02</th>
<th>RESID03</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CORRELATION</td>
<td>Ljung- Box (P-value)</td>
<td>0.878</td>
<td>0.192</td>
<td>0.470</td>
</tr>
<tr>
<td></td>
<td>Lag (-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEVE L</td>
<td>Ljung- Box (P-value)</td>
<td>0.988</td>
<td>0.427</td>
<td>0.677</td>
</tr>
<tr>
<td></td>
<td>Lag (-2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTO-</td>
<td>Ljung- Box (P-value)</td>
<td>0.828</td>
<td>0.410</td>
<td>0.854</td>
</tr>
<tr>
<td>CORRELATION</td>
<td>Lag (-3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQUARES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ljung- Box (P-value)</td>
<td>0.770</td>
<td>0.795</td>
<td>0.502</td>
</tr>
<tr>
<td></td>
<td>Lag (-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ljung- Box (P-value)</td>
<td>0.215</td>
<td>0.513</td>
<td>0.715</td>
</tr>
<tr>
<td></td>
<td>Lag (-2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ljung- Box (P-value)</td>
<td>0.272</td>
<td>0.298</td>
<td>0.610</td>
</tr>
<tr>
<td></td>
<td>Lag (-3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Residuals properties VEC model

The VEC model residuals, differently from the previous macro and micro-based models, showed nice statistical properties: the levels and the squares were not autocorrelated and were normally distributed. Moreover, (unreported) multivariate autocorrelation and normality tests included in Eviews confirmed this outcome as well.

4 A Forecasting Exercise

In order to compare the goodness of our approach to previous modelling, we performed 1-step ahead forecasts, where we considered the quantity supplied $Q^S$ and the domestic price $P_D$ as variables to forecast.

The first estimation sample was given by the first 43 observations ranging from 1951 till 1994. Then, 1-year ahead forecasts were estimated and the estimation sample was augmented to include one more observation. This procedure was iterated until all years, but the last one, were included in the estimation sample. We decided to consider in the first sample also the years 1993 and 1994 because we wanted to examine the effect of the second European regulation, too.

Besides, we computed the Root Mean Square Error and the Mean Absolute Percentage Errors, as forecast error statistics to compare the forecasts delivered by the three models. We used the Eviews Model object to compute the forecasts. The results are reported below:
<table>
<thead>
<tr>
<th>Year</th>
<th>QUANTITY</th>
<th>Macro model</th>
<th>Micro model</th>
<th>VEC</th>
<th>PRICE</th>
<th>Macro model</th>
<th>Micro model</th>
<th>VEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>124,492</td>
<td>119,332</td>
<td>125,404</td>
<td>124,371</td>
<td>5,291,000</td>
<td>7,311,325</td>
<td>4,919,768</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>130,590</td>
<td>121,859</td>
<td>106,872</td>
<td>128,846</td>
<td>4,833,000</td>
<td>4,955,265</td>
<td>3,353,449</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>130,513</td>
<td>127,701</td>
<td>103,581</td>
<td>128,569</td>
<td>4,640,000</td>
<td>5,520,318</td>
<td>6,393,992</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>132,509</td>
<td>126,293</td>
<td>133,774</td>
<td>131,714</td>
<td>4,316,987</td>
<td>5,161,977</td>
<td>4,646,833</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>129,937</td>
<td>123,781</td>
<td>114,647</td>
<td>136,264</td>
<td>5,270,216</td>
<td>4,764,313</td>
<td>5,236,738</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>130,487</td>
<td>122,413</td>
<td>119,071</td>
<td>131,122</td>
<td>5,270,216</td>
<td>4,764,313</td>
<td>5,236,738</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RMSE</td>
<td>3483</td>
<td>15909</td>
<td>2732</td>
<td>605066</td>
<td>1346438</td>
<td>450582</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAPE</td>
<td>2.39%</td>
<td>9.94%</td>
<td>1.50%</td>
<td>10.94%</td>
<td>25.46%</td>
<td>7.78%</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Real Values and Forecasts of $Q^S$ and $P^D$, for the Macro model, Micro model and the VEC model

It is possible to observe that the forecasts of the quantity supplied $Q^S$ for the macro model were rather precise, while the forecasts of Italian domestic prices $P^D$ were rather poor, instead, with a MAPE higher than 10%. This outcome was not a surprise, since we previously saw that for the macro model the equation modelling $Q^S$ was the only one with nice residuals properties.

As for the Micro model, the forecast error statistics were the worst among the three classes of models, while the VEC model produced the most precise forecasts, showing the smallest RMSE and MAPE.

![Figure 3: Line graphs of $Q^S$ and $P^D$ and their forecasts (Macro model)](image1)

![Figure 4: Line graphs of $Q^S$ and $P^D$ and their forecasts (Micro model)](image2)
4.1 Testing for Superior Predictive Ability

Hansen (2005) proposed a Superior Predictive Ability (SPA) test, which compares the performances of two or more forecasting models. The forecasts are evaluated using a prespecified loss function like the MAE and the RMSE, and the best forecast model is the model that produces the smallest expected loss. The SPA tests for the best standardized forecasting performance relative to a benchmark model, and the null hypothesis is that none of the competing models is better than the benchmark.

Let $L(Y_t; \hat{Y}_t)$ denote the loss if one had made the prediction, $\hat{Y}_t$, when the realized value turned out to be $Y_t$. The performance of model $k$ relative to the benchmark model (at time $t$), can be defined as:

$$X_k(t) = L(Y_t, \hat{Y}_0t) - L(Y_t, \hat{Y}_{kt}), \quad k = 1, \ldots, l; \quad t = 1, \ldots, n.$$  

The question of interest is whether any of the models $k = 1, \ldots, l$ are better than the benchmark model. To analyze this question Hansen (2005) formulates the testable hypothesis that the benchmark model is the best forecasting model. This hypothesis can be expressed parametrically as

$$\mu_k = E[X_k(t)] \leq 0, \quad k = 1, \ldots, l.$$  

For notational convenience, Hansen (2005) defines an $l$-dimensional vector $\mu$ by

$$\mu = \begin{pmatrix} \mu_1 \\ \vdots \\ \mu_l \end{pmatrix} = E \begin{pmatrix} X_1(t) \\ \vdots \\ X_l(t) \end{pmatrix}.$$  

Since a positive value of $\mu_k$ corresponds to model $k$ being better than the benchmark, Hansen (2005) wants to test the hypothesis $H_0 : \mu_k \leq 0$ for $k = 1, \ldots, l$. Therefore, the equivalent vector formulation is

$$H_0 : \mu \leq 0$$  

One way to test this hypothesis is to consider the test statistic

$$T_{sm} = \max_k \frac{n^{1/2} \bar{X}_k}{\hat{\sigma}_k}$$  

where

$$\bar{X}_k = \frac{1}{n} \sum_{t=1}^n X_k(t), \quad \hat{\sigma}_k^2 = \text{var}(n^{1/2} \bar{X}_k).$$
The latter is estimated by using the bootstrap method. The superscript "sm" refers to standardized maximum. Under the regularity condition, Hansen (2005) shows that

\[ T_{sn}^{sm} = \max_k \frac{\hat{X}_k}{\hat{\sigma}_k} \max_k \frac{\mu_k}{\sigma_k} \]

which is greater than zero if and only if \( \mu_k > 0 \) for some \( k \). So one can test \( H_0 \) using the test statistic \( T_{sn}^{sm} \). The only remaining problem is to derive the distribution of \( T_{sn}^{sm} \) under the assumption of a true null hypothesis. Testing multiple inequalities is more complicated than testing equalities (or a single inequality) because the distribution is not unique under the null hypothesis. Nevertheless, a consistent estimate of the p-value can be obtained by using a bootstrap procedure, as well as an upper and a lower bound.

<table>
<thead>
<tr>
<th>BENCHMARK Model</th>
<th>RMSE</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower P-value</td>
<td>Consistent P-value</td>
</tr>
<tr>
<td>Macro model</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Micro model</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Non-structural model (VEC)</td>
<td>0.64</td>
<td>0.64</td>
</tr>
</tbody>
</table>

**Table 8: Hansen’s SPA test: Quantity \( Q^S \)**

<table>
<thead>
<tr>
<th>BENCHMARK Model</th>
<th>RMSE</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower P-value</td>
<td>Consistent P-value</td>
</tr>
<tr>
<td>Macro model</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Micro model</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Non-structural model (VEC)</td>
<td>0.49</td>
<td>0.49</td>
</tr>
</tbody>
</table>

**Table 9: Hansen’s SPA test: Quantity \( Q^S \)**

The p-values for the SPA tests are presented in Table 8-9 and indicate that the VEC model produced superior forecasts at the 1% significance level in almost all the cases. This result did not depend on whether loss functions using either mean squared error or mean absolute error were employed. On the other hand, neither the macro model nor the micro model were able to outperform the VEC model.

### 5 Conclusions

The goal of this paper was that of analyzing the Italian Tobacco Industry using different approaches along an historical path of half a century.

The empirical analysis highlighted how the European policy regimes based on support prices increased the cultivation of low quality tobaccos which were destined to exports, with high costs for the EU agricultural budget. However, the introduction of the prizes regime since 1993 has reduced the tobacco supplied quantity as well as the total land allocated, by cutting the strong financial incentives to tobacco farmers. We found out that the estimated price transmission elasticity between Word prices and Italian prices to be rather high, despite of the enforced Italian and European regulation.

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5 The authors would like to thank Peter Hansen for supplying the Ox code that calculates the SPA test statistics and associated p-values.
The micro based modelling showed a significant negative trend in labor demand that can be explained by thinking at improvements in agricultural cultivation techniques. Moreover, the degree of protection in Italian (and European in general) tobacco industry resulted to be rather high so far, so that the risk component is not significant. However, the full effects of recent reforms will probably change this evidence.

Finally, we have proposed a VEC approach to take into account recent econometric techniques together with the economic determinants found in the previous analysis. This kind of modelling outperformed the previous ones in terms of both residuals properties and forecasting performances. This approach can be of help not only to policy makers, given the current hot debate in the EU about CAP budget cuts, but also to old and new firms in the tobacco industry, such as biotech firms for pharmaceutical uses.

References