Alternative subsidy scenarios for different agricultural practices: 
A sustainability assessment using fuzzy multi-criteria analysis

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Summary

The recent Common Agricultural Policy reform (CAP14) at the European level links the granting of aid to farmers to adhering to environmentally-friendly farming practices. It therefore becomes important to assess the overall effectiveness of such a policy by taking into account different economic and environmental criteria. In this work, an ex ante assessment of different agricultural policy scenarios in Italy is undertaken at the national level, through the adoption of a fuzzy multi-criteria analysis approach, to account for the different economic and environmental aspects (indicators) of each scenario. Italian agricultural holdings were divided into homogeneous groups (according to farm typology, location, and environment), in order to determine the most preferable scenario for each group. Results are extremely heterogeneous across the macro areas, the farm typologies, and the climatic zones, and it is not possible to determine a ‘good-for-all’ scenario. However, we can observe that when all indicators are assigned an equal weight and also when environmental indicators are assigned a higher weight, the preferred scenario for the majority of groups is the alternative scenario where a tax of 30% on pesticides is added to the CAP14. On the other side, when economic indicators have a higher weight, the situation of subsidies preceding CAP14 (base subsidies and environmental subsidies, with no differentiation among conventional and organic farming) seems to be the ‘best’ scenario for all groups, with one exception.

Keywords: multi-criteria analysis, sustainability, agricultural subsidies, environment, organic agriculture

JEL Classification codes: C02; C65; D81; Q15; Q18
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1. INTRODUCTION

Climate change and agriculture are interrelated processes, where climate change affects the production capacity of agriculture, and agriculture contributes to greenhouse gas (GHG) emissions through land use and livestock raising practices. According to the European Environment Agency, agriculture is the second main source of GHG emissions (after the energy sector), accounting for 10% of total EU-27 emissions in 2011 (EEA, 2013).

In a policy document prepared for the United Nations Conference on Sustainable Development held in June 2012 in Rio de Janeiro, the Food and Agriculture Organization called for a sustainable food production in order to decrease hunger and malnutrition, by promoting a ‘more with less’ approach (FAO, 2013). The identification of an overall sustainable farming technique integrating economic, social and environmental aspects is not straightforward because of critical trade-offs between profit maximization, environment conservation, and equitable social development. At the same time, agricultural policies at the European level are evolving towards a closer link between agricultural support and the achievement of environmental objectives (see the new Common Agricultural Policy, CAP14), but it is difficult to predict the overall effectiveness of a policy when several economic and environmental criteria need to be taken into account.

In this work, an ex ante assessment of different policy scenarios in Italy is undertaken at the national level, through the adoption of a fuzzy multi-criteria analysis approach, in order to account for the various economic and environmental aspects of each scenario. Italian agricultural holdings were divided into homogeneous groups (according to farm typology, location, and environment) in order to determine the most preferable scenario for each group.

This paper is organised as follows. The next section will describe the methodological approach adopted, together with an illustration of the data used and how they were obtained. Results of the assessment are then shown in Section 3, and final considerations and points for discussion are given in the fourth section.

2. METHODOLOGY AND DATA

Multi-criteria analysis (MCA) allows for the assessment of various alternatives according to a series of multiple and even conflicting criteria. Such criteria can be quantitative and qualitative. On this regard, MCA overcomes the main limitation of the mostly used approach for impact assessment, cost-benefit analysis (CBA), where all criteria need to be monetized. The extension of MCA to consider fuzzy measurement
allows to accompany impact evaluations with an indication of uncertainty. MCA is being extensively and successfully used as a support tool to decision making in the environmental policy area since a few decades, for its ability to deal with trade-offs between social, environmental, and economic impacts, and with the uncertainty and measurement problems that are present in environmental policy analysis (see Huang et al., 2011, for a review). More recently, various MCA techniques are also being used for modelling agricultural decision-making (see Romero and Rehman, 2003, and Hayashi, 2000, for comprehensive references).

For this work, a fuzzy MCA procedure, called Scryer, has been applied, which was originally developed for the ex ante impact assessment of food safety regulatory proposals (Mazzocchi et al., 2013).

Basically, the starting point of Scryer is an impact matrix having, on one axis, different policy scenarios or policy options (‘alternatives’), and, on the other axis, the various indicators (‘criteria’) by which such scenarios are to be evaluated. Inside the matrix, measurements of all scenarios with respect to each indicator (evaluation criterion) are given. Those indicators do not need to be expressed in monetary terms (as happens in CBA) but may have different measurement units and also be represented in qualitative terms. Each (qualitative or quantitative) estimate in the matrix (i.e. estimate of each combination of indicator and scenario) is accompanied by a measure of uncertainty, which is the peculiarity of the fuzzy extension of MCA methods (see e.g. Meyer and Roubens, 2005). In order to explain the fuzzy concept, let us make a simple and rough example. Consider the comparison of two policy scenarios, A and B. The fuzzy approach considers all comparison outcomes (e.g. ‘A is better than B’, ‘B is better than A’, ‘A and B are similar’) with different grades of ‘fuzziness’ (e.g. ‘A is better than B’ is much more credible than ‘B is better than A’). In other words, the dominance of a policy scenario is associated with a credibility measure (which can be paralleled with a probability level for precise stochastic estimates). The required indicators of credibility result as a combination of (1) the degree of dominance of a policy scenario versus another (pairwise comparison) for each individual criterion; and (2) the degree of uncertainty (fuzziness) in the measurement. Individual criterion assessments and pairwise comparisons are then aggregated to produce a ranking of policy scenarios.

An additional characteristic of Scryer is the possibility to assign different weights to each criterion, in order to account for different preferences (for example, the decision maker may assign a higher weight to environmental indicators and a lower weight to economic indicators, or the other way round). This allows an explicit recognition of subjectivity of the assessment, which is unavoidable when dealing with ex ante evaluation of various alternatives.

Scryer is based on a comparison algorithm of the alternatives, performed according to the following steps:

- pairwise comparison of alternatives according to each criterion using preference relations
- aggregation of all criteria
- ranking of alternatives

The final output of Scryer is a couple of indexes (‘best scenario’ and ‘worst scenario’ indexes) which can be interpreted as the degree of membership to the statements ‘this scenario is the best one’ and ‘this scenario is the worst one’, respectively.

Data used in the analysis refer to a sample of agricultural holdings (conventional agriculture) from the Italian Farm Accountancy Data Network (FADN) database1 for the year 2007 (Romano and Scardera, 2008).

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1 Called RICA (‘Rete di Informazione Contabile Agricola’). 
Sampled farms were firstly subject to a simulation analysis, based on a mathematical linear programming model approach (Vitali et al., 2012a), in order to estimate all 15 economic, social, and environmental indicators that were considered as the ‘criteria’ for the multi-criteria analysis.

The environmental indicators considered are the following:

1. vulnerability (exposure to climate change)
2. GHG emissions
3. GHG emissions related to consumption products (fertilizers, pesticides, fuels)
4. crop intensity
5. ‘naturality’
6. landscape biodiversity
7. soil erodibility
8. average quantity of used pesticides

The social indicator is:
9. average amount of work

The economic indicators are the following:
10. ratio of gross production to the amount of work
11. yearly average net income per hectare
12. total public support
13. ratio of purchased fertilizers to requested fertilizers
14. average used fuels
15. ratio of purchased feed to requested feed

The simulation analysis identified the most profitable farming technique for each policy scenario. The policy scenarios considered for the multi-criteria analysis, i.e. the alternative solutions which needs to be assessed according to the defined criteria, are the following:

1. BAU, i.e. the current situation of subsidies (base subsidies and environmental subsidies, with no differentiation among conventional and organic farming)
2. CAP14, i.e. base subsidy for all farms, and greening subsidy for all organic farms and those farms with at least 7% of natural land
3. CAP14+FITO, i.e. CAP14 plus an additional tax of 30% on pesticides (not for products used in organic agriculture)

The farming techniques considered were as following:

4. conventional
5. organic
6. ‘greening’ (i.e. conventional technique with some limitations on the farm land use, compensated by a higher level of subsidies; this latter technique is only available for the CAP14 and CAP14+FITO scenarios).

Italian farms were grouped according to 3 different perspectives (Vitali et al., 2012b):

7. geographic (5 macro areas):
   a. north-west
   b. north-east
   c. centre
   d. south
e. isles

8. agronomic (6 most frequent farm typologies):
   a. sem
   b. arb
   c. arb+sem
   d. sem+zoo
   e. sem+zoo+nat
   f. arb+nat

9. climatic (6 most frequent environments combining climate and slope).
   Scryer was performed for each of the above groups.

   Therefore, for each group, the impact matrix for the MCA has, on one axis, the 3 policy scenarios (the ‘alternatives’), and, on the other axis, the 15 indicators (the ‘criteria’) by which such scenarios are to be evaluated. Inside the matrix, measurements of all 3 scenarios with respect to each indicator (evaluation criterion) are provided by the simulation analysis. Each measurement is accompanied by the standard error of the mean, representing the precision of the estimate, and, consequently, it can be considered as a measure of uncertainty.

   For each group, results are given according to 3 different weightings of criteria:
   1. all indicators are assigned an equal weight
   2. economic indicators are assigned a 10-times higher weight than the other indicators
   3. environmental indicators are assigned a 10-times higher weight than the other indicators.

3. RESULTS

   Results are shown in Table 1. They are extremely heterogeneous across the macro areas, the farm typologies, and the climatic zones, and it is not possible to determine a ‘good-for-all’ scenario. However, some general comments can be given. When all indicators are assigned an equal weight and when environmental indicators are assigned a higher weight, CAP14+FITO is the preferred scenario for the majority of groups, and BAU has higher chances to be the ‘worst’ scenario. Results are generally stronger with the ‘environmental’ weighting than with ‘equal’ weighting. On the other side, when economic indicators have a higher weight, BAU seems to be the ‘best’ scenario for all groups, with one exception (Central macro area), and CAP14 has the highest frequency for the worst scenario index. Such results suggest that CAP14 is an ‘intermediate’ scenario that distances itself from CAP14+FITO more than expected.
### Table 1. Results of the MCA analysis

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Source: own elaboration
4. CONCLUSIONS

On a methodological point of view, given the high variability of the farms contributing to the values of the indicators for each group, doubts can be raised on the choice of MCA as the appropriate method of analysis. On the other side, MCA gives the opportunity to calibrate weights and see how results change, and to include an indication of the uncertainty of the estimates. In addition, in a few cases, Scryer reported a zero index for one or two scenarios, and the reasons need to be further investigated, but it could be possibly due to an extreme uncertainty of the estimates.

As far as policy analysis is concerned, a point for discussion could be the appropriateness of the identified scenarios, and the possibility to consider additional scenarios.

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