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Modelling and interpreting the impact of policy and price scenarios on farm-household sustainability: Farming systems vs. result-driven clustering

D. Viaggi [a,*], M. Raggi [b], S. Gomez y Paloma [c]

[a] Department of Agricultural Economics and Engineering, University of Bologna, Viale Fanin, 50, 40127 Bologna, Italy
[b] Department of Statistics, University of Bologna, Via Belle Arti, 41, 40126 Bologna, Italy
[c] European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Edificio Expo, C/Inca Garcilaso 3, 41092 Seville, Spain

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ABSTRACT

The Common Agricultural Policy of the European Union is subject to a continuous process of reform. The objective of this paper is to evaluate the effect of decoupling and related policy and market scenarios, as introduced in the 2003 CAP reform, by way of selected agriculture sustainability indicators and through the aggregation of individual farm-household simulated behaviour. The approach is based on the use of a Net Present Value-maximising dynamic farm-household model. The model is implemented on 80 farm-households to simulate the reaction to scenarios of different agricultural systems in 8 EU countries. The results are measured through three main indicators – represented by farm income, labour use and nitrogen use – evaluated over a period of 14 years. The results of individual farm-households are aggregated first using the concept of farming system and then based on a cluster analysis using the results in different scenarios as discriminant variables. The results show that the CAP as a whole is crucial for the sustainability of farming systems in terms of income and employment, but also provides incentives for higher use of inputs, suggesting a trade-off between social and environmental sustainability concerns. In the range of variation considered, nitrogen and labour use appear much more reactive than income and indicate much higher variability across farms and scenarios. The aggregation by agricultural system denotes rather different behaviour among systems. However, the cluster analysis shows that results appear to be better interpreted by patterns of individual characteristics (location in the plain, structure, asset endowment, labour, etc.) than by country, specialisation or technology.

1. Introduction and objectives

The Common Agricultural Policy (CAP) is a major driver of environmental and social sustainability of agriculture in the European Union (EU). During its development in the second half of the 20th century, the CAP has progressively shifted from price support to area payments, connected to the cultivated area of a limited number of crops. In 2003, the European Commission approved a major reform of the CAP based on the decoupling of payments. Decoupling means that income payments (now called Single Farm Payments – SFP) are detached from the production of specific crops and are conditioned only upon the availability of sufficient eligible land to activate the entitlements owned by the farm. The amount of entitlements owned by each farm is related to the previous (2000–2002) area under payment, while the unitary amount may be related to the previous payment received (historical reference system), or determined on the basis of the regional average payment (regionalised reference system). This approach, which was initiated with EC reg. 1782/2003 and focused mainly on decoupling of cereals, oil and protein crops (COP), was later extended to other sectors. It was confirmed by the Health Check in 2008 and is expected to remain a major cornerstone of the CAP for years to come, likely beyond 2013 (European Commission, 2007, 2010; see also the legal proposals for the post-2013 CAP).

The economic analysis of the effects of policy reforms on the farming sector is an important field in agricultural economics, stimulated by the frequent reforms of agricultural policy, particularly in the EU. As a result of the evolution of the CAP illustrated above, two major policy questions for research in recent years have been: (i) what is the effect of decoupling? and; (ii) how does decoupling combine with policy and market scenarios?

* Corresponding author. Tel.: +39 051 2096114; fax: +39 051 2096105.
E-mail address: davide.viaggi@unibo.it (D. Viaggi).

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Various studies have dealt with the evaluation of such reforms at different levels. At the wider geographical level these studies rely mainly on models characterized by a focus on sector reactions and a much-approximated treatment of the decoupling mechanism. Gohin (2006) provides a review of such impact studies (based on the following models: CAPRI, GOLD, FAPRI, ESIM, AGLINK, GTAP, AGMEMOD) leading mostly to results expressed in terms of total area of production of specific crops. The main estimated effect of the 2003 reform is the reduced production of arable crops and beef. Aggregated model results, however, also indicate that important effects may concern labour choices and the environment (Gohin and Latruffe, 2006; Schmid and Sinabell, 2007). On the other hand, most survey-based studies report little reaction to decoupling on the part of farmers, at least regarding the combination of farm activities (Tranter et al., 2007). They also highlight the need to take into account the complex array of farm choices that make up the various reactions to decoupling, particularly when labour allocation is involved (Serra et al., 2006). Indeed, complexity becomes more important when major changes in the system of incentives are introduced, as is potentially the case for decoupling. An additional issue is that the effects of decoupling will depend on the market context, in particular as agricultural product prices are concerned.

In addition, agricultural activities are carried out under very different environmental conditions (climate, altitude etc.) and different farm specialisations may react differently to policy. Such differentiation can also be detected among farms using different technologies. Among the non-conventional technologies, organic farming has taken on a prominent role in the EU in recent decades, and has been buttressed by a positive perception on the part of consumers. Organic farming tends to have differentiated yields, product prices and costs compared to conventional agriculture, and, as a result, may also be expected to react differently to policy compared to conventional agriculture.

Most of the studies considered do not attempt to account for the overall "sustainability" of farming. In fact, sustainability is now a very widely used concept, yet one that is amenable of different uses and interpretations. The key element in the definition of sustainability is the ability to continue through time (Hansen, 1996). In the context of agriculture, the literature now recognises that this involves at least three dimensions, notably: economic, social and environmental sustainability (e.g. Gómez-Limón and Sanchez-Fernandez, 2010).

The objective of this paper is to evaluate the effect of decoupling and related policy and market scenarios (as introduced in the 2003 CAP reform) by way of selected agriculture sustainability indicators and through the aggregation of simulated results generated by individual farm-household models.

This objective is pursued by simulating farm-household reactions to scenarios through individual dynamic programming models, allowing for an estimation of long-term adaptations and the expression of results by approximating the concept of sustainability through three specific indicators represented respectively by: farm income (as a proxy of economic sustainability), employment (as a proxy of social sustainability) and use of nitrogen fertilisers (as a proxy of environmental sustainability).

In interpreting the results, we address the potential causes of the differentiation in reactions to policy discussed above through two different aggregation strategies: a) classifying individual farm-households according to the concept of farming system (see below); and b) clustering individual farm-households according to their pattern of results in different scenarios.

Our analysis differs from previous studies in four main ways. First, it uses a large set of individual farm-household models (80) rather than representative farm-households or aggregated models. Second, results of individual farm-households expressed by sustainability indicators are aggregated using different and complementary rationales, both by agricultural system, intended as a combination of geographical location, altitude, specialisation and technology (see section 2 for further details) and by result-driven clustering. Third, it uses the farm-household as the decision-making and modelling unit rather than the farm alone. This allows for a consideration of farm investment choices as embedded in the wider issue of household choices and household resource allocation. Fourth, it addresses the issue of long-term sustainability of the adaptation of farms, taking into account structural change and investment through a dynamic model. This enables one to keep track of a wider set of adaptations compared to static models.

This study was developed as a follow up to a previous wider study on investment behaviour involving a survey of 248 farm-households in 8 EU countries (Gallerani et al., 2008). The previous study also provided an estimation of the effects of policy scenarios using multi-criteria household models in a sub-sample of 80 farm-households, which results were also expressed in terms of sustainability indicators. However, the use of multi-criteria analyses tied the results to the objectives of the specific households, and limited the suitability of individual results to be aggregated and used for generalisation. On the contrary, in the present study we use Net Present Value (NPV) maximising models, which allow the estimation of an economically optimal pattern of adaptation and allows for a wider generalisation of the results.

In this paper we focus our attention on the results rather than on the model and methodology, which are illustrated in detail in Gallerani et al. (2008) for the study in its entirety and in Viaggi et al. (2010) for an explanation of the model in its multi-criteria version, with individual farm examples. Compared to such previous studies, this paper is more policy (rather than methodologically) focused, though also addressing a major methodological issue represented by the meaningful aggregation of individual farm-household simulated behaviour and its ability to yield generalised statements that can be meaningfully used in policy evaluation.

The remainder of the paper is organised as follows: in section 2 we develop the methodology adopted in the paper, section 3 illustrates the data and case studies considered, section 4 reports the results, and section 5 provides a discussion and policy implications. The paper concludes with final remarks in section 6.

2. Methodology

2.1. Overview

The methodology adopted in this paper is based on the following steps: a) development of mathematical programming dynamic models of a sample of individual farm-households; b) use of these models for the simulation of selected policy and price scenarios; c) aggregation of the models' results according to two selected criteria: 1) classification of each farm household model into a specific farming system; 2) clustering of farms according to their results in the different scenarios.

2.2. General model specification

In order to simulate the long-term impact of decoupling and other policy and price scenarios on EU farm-households, we use a dynamic household model, based on the NPV approach. The model is the NPV version of the household model presented in Gallerani et al. (2008) and Viaggi et al. (2010). In the current version, which can be considered the most classical approach in investment theory, decision makers are assumed to make choices based on the maximisation of the discounted value of net cash flows generated by a set of choices. The NPV approach is widely used in economic evaluation, e.g. in Cost-Benefit Analysis, and represents the backbone of the methodologies generally used to simulate farm economic intertemporal decision problems, such as investment behaviour (see Gardebroek, 2004, for a generalised investment model). This model has been widely discussed in the literature and a number of derived methodologies are proposed in recent contributions, such as the Real Option approach (Pyndick, 1991), stochastic dynamic programming (Heikkinen and Pietola, 2009) or multi-criteria dynamic decision-making (Wallace and Moss, 2002). In spite of the potential improvements introduced by such derived methodologies, in this paper we use a standard NPV approach for two main reasons. First, it allows to derive simulations yielding an optimal