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Review

Assessing farm innovations and responses to policies: A review of bio-economic farm models

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Abstract

Bio-economic farm models (BEFMs) are developed to enable assessment of policy changes and technological innovations, for specific categories of farming systems. A rapidly growing number of research projects is using these models and there is increasing interest for application. The paper critically reviews past publications and applications of BEFMs on their strengths and weaknesses in assessing technological innovation and policy changes for farmers and policy makers and highlights key issues that require more attention in the use and methodology of BEFMs. A BEFM is defined as a model that links formulations describing farmers' resource management decisions to formulations that represent current and alternative production possibilities in terms of required inputs to achieve certain outputs, both yield and environmental effects. Mechanistic BEFMs are based on available theory and knowledge of farm processes and these were the focus of our study. Forty-eight applications of mechanistic BEFMs were reviewed as to their incorporation of farmer decision making and agricultural activities, comprehensiveness, model evaluation, and transferability. A clear description of end-use of the BEFM, agricultural activities, model equations and model evaluation are identified as good practices and a research agenda is proposed including the following issues: 1. development of a thorough and consistent procedure for model evaluation; 2. better understanding and modelling of farmer decision making and possible effects of the social milieu; 3. inclusion of several economic and environmental aspects of farming including multifunctionality and 4. development of a generic, modular and easily transferable BEFM.

Keywords: Agriculture; Agricultural systems; Farmer decision making; Mathematical programming; Multi-functional agriculture; Risk

Contents

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1. Introduction

Policy makers and farmers have an interest in making ex-ante assessments of the outcomes of their choices in terms of policy and farm plan (cf. Rossing et al., 1997; Zander and Kächele, 1999; Leeuwis, 1999; EC, 2005). This interest mainly concerns the assessment of socio-economic and environmental performance of farms as a result of innovations, and the assessment of socio-economic and environmental effects of policies on the major categories of farms. Mathematical models based on systems analysis are suited to explore and assess uncertain future states of systems. As expressed by Edwards-Jones and McGregor (1994) "the utility of a series of whole farm models for the European situation would be substantial, particularly in the ex-ante policy assessment and marketing of on-farm technology". Certainly, not only the European situation would benefit from assessments of agricultural innovations or agricultural and environmental policies.

For such assessments research has proposed the use of methods such as Bio-Economic Farm Models (BEFMs), multi-agent systems, environmental risk mapping, life cycle analysis, environmental impact assessment and agri-environmental indicators, which are each briefly reviewed in Payraudeau and Van der Werf (2005). A BEFM is defined as a model that links formulations describing farmers' resource management decisions to formulations that describe current and alternative production possibilities in terms of required inputs to achieve certain outputs and associated externalities. The focus of this article is on BEFMs as they have some clear advantages with respect to the other methods reviewed by Payraudeau and Van der Werf (2005): (i) they are based on an constrained optimization procedure and thereby seem to match the reality of small farmers, striving, with limited resources, to improve their lot (Anderson et al., 1985); (ii) many activities, restrictions and new production techniques with sound technical specifications can be considered simultaneously (Wossink et al., 1992; Ten Berge et al., 2000; Weersink et al., 2004), including linkages between crop and livestock production (Antle and Capalbo, 2001); (iii) the effects of changing parameters, for example prices, can easily be assessed through sensitivity analysis (Wossink et al., 1992), and (iv) they can be used both for short term predictions and long term explorations (Van Ittersum et al., 1998). A BEFM permits the (ex-ante) assessment of technological innovations and policies over a range of different geographic and climatic circumstances. A rapidly growing number of research projects is using these models and there is increasing interest for application (Deybe and Flichman, 1991; Donaldson et al., 1995; Rossing et al., 1997; Louhichi et al., 1999; Vatn et al., 2003; Gibbons et al., 2005; Torkamani, 2005).

The presently available publications and applications of BEFMs can be subdivided in three broad classes based on their purpose: (i.) exploring the suitability of alternative farm configurations and technological innovations, i.e., assessing whether a technology will be viable financially and will have positive environmental effects, for example Abadi Ghadim (2000), usually focused at (groups of) farmers and extensionist; (ii.) predicting or forecasting the effects of changing policies on agriculture, focusing at policymakers or facilitating discussion between multiple groups of stakeholders, for example, Berentsen and Giesen (1994) and Bartolini et al. (2007), and (iii.) efforts to highlight methodological aspects of BEFMs and their improvement; for example Apland (1993), usually targeted at researchers.

Currently many descriptions and applications of BEFMs are being published (cf. Bartolini et al., 2007; Acs et al., in press; Onate et al., in press; Semaan et al., in press). A critical analysis of the methodological strengths and shortcomings of these BEFMs and their applications, as related to ex-ante assessment of farm innovation and policies for farmers, policy makers and other stakeholders is lacking. From such analysis, an overarching research agenda can be derived to help and guide efforts on the third class of purposes mentioned above, i.e., methodological improvement of BEFMs.

The objectives of this article are to critically review past publications and applications of BEFMs as to their strengths and weaknesses in assessing technological innovation and policy changes for farmers and policy makers