New developments in agricultural policy modelling and consequences for managing the policy analysis systems

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Abstract

Last decade, the importance of multifunctionality and environmental issues in agricultural policies has been growing. This shift in scope of agricultural policy instruments implies an adjustment of the conventional ex-ante policy analysis systems. New requirements on input and output parameters will be needed. The objective of this paper is to show how the input/output management can be improved. Focus is on how the information management by the system can enhance the policy analysis and decision making and facilitate information flow and social support from the stakeholder debate.

1. Introduction

The agricultural sector is changing, so are also the arguments for, and instruments of, public intervention. With environmental and sustainability concerns entering the public debate, new types of policy instruments emerged. The importance of multifunctionality and environmental issues has been growing under the pressure of international trade liberalisation. The price and production linked intervention decreased and were partly replaced by direct income and rural development support, production rights and other instruments. These new policy instruments imply more specific responses at farm level. Moreover, this shift in policy instruments broadens the range of stakeholders committed to the policy debate: as in the last decades farmers and their unions were the main stakeholders, this latter group is now enlarged with other stakeholders with different perspectives and motives.

The change in scope of agricultural policy instruments means that conventional policy analysis systems should be adjusted. Policy analysis systems, or decision support systems, and more specific model-driven systems are characterised by a model core for simulation, embedded in a shell that supplies the adequate input, and converts and translates the results to transparent information. In an accompanying article, Buysse et al. (2006) show the importance of enlarging the modelling core with various programming techniques, in order to cope with new aspects of policy-making. The objective of this paper is to show how the input/output management can be improved. Focus is on how the management of information by the system can enhance the policy analysis and decision making.

Starting from a general framework of model-based policy analysis systems (section 2), three ways for managing new input requirements are discussed (section 3). Section 4 describes new requirements of output management. In section 5, some reflections are made on how the input/output management, in particular the interactions between input and output, can be organised. The new requirements of input/output management are demonstrated and illustrated in section 6. Finally, section 7 concludes.

2. Policy impact analysis

2.1. Shift towards more farm and location specificity

The outcome of a policy depends on how the farmers react to their policy-influenced decision-making environment. Because policy alternatives cannot be tested in a laboratory, possible outcomes and impacts have to be simulated or analysed, using models, before (ex ante), during (mid term) or after (ex post) policy action. These models may be normative or positive, depending on whether they use empirical information on the reactions of farmers.

Figure 1 brings a simplified illustration of the multi-stakeholder system that has to be considered when modelling agri-environmental and rural policies. As long as price and market policies prevail, impact models could mainly concentrate on supply and demand analysis and equilibrium estimation at regional or national level. In this kind of models, individual farm reactions are mostly ignored because models are interested in average reactions. By doing this, however, effects on structural change are often ignored.

With the introduction of voluntary measures, however, policy impact will mainly depend on the farmers' reaction to new signals. Agri-environmental and multifunctionality measures are targeted to very specific farm conditions, often linked to local conditions (Tanaka and Wu, 2004). Even when the policy is organised at a supra national level, outcomes highly differ according to farm type and farm localisation.

The overall impact of such policies will therefore depend on both the impact per unit (e.g. income effect per hectare, biodiversity increase per hectare) and the uptake of policies. This uptake depends on the farm conditions and the farmer's attitude and behaviour. The more local and farm specific the interventions are, the more modelling farm level attitude and behaviour becomes important (the bold arrow in Figure 1).

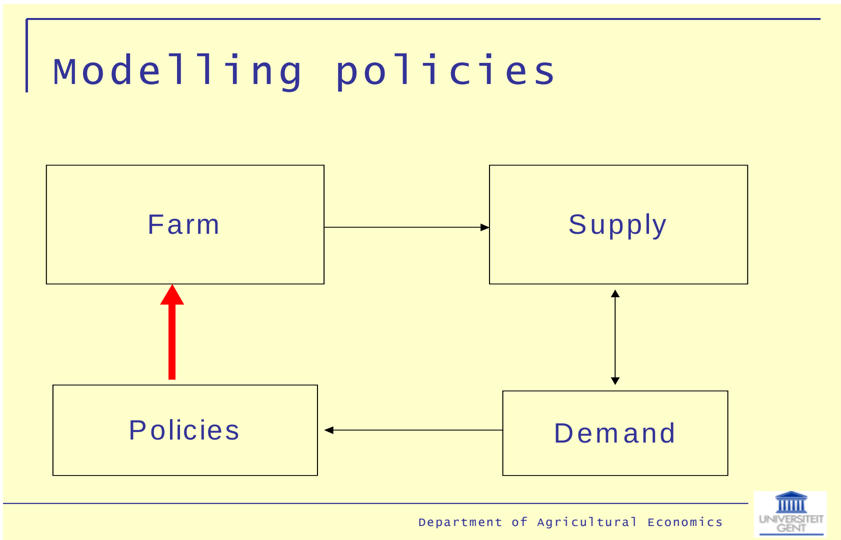


Figure 1. Modelling policies: a simplified illustration of the multi-stakeholder system.

Because of this farm-specific approach, more and more information supply is needed for the model. Nevertheless, simulating the farmers' behaviour is not only integrating all detailed information. A good practice of an ex ante policy analysis system depends on the choice of the specific information.

The shift from supply and demand analysis at national level towards simulation of farmers' behaviour also entails that more attention needs to be paid to analyse and validate the outcomes of ex ante policy analysis systems.

2.2. Implications for the organisation of policy support and information flow.

The information flow with respect to policy analysis will drastically change. Not only the above-mentioned farm and location specificity and the tight dependence of policy outcomes on farmers' behaviour are main reasons behind this, also the broader sustainability and multifunctionality scope of policy objectives implies a much larger engagement of other stakeholders. At least the broader scope of goals has to be made explicit in order to allow for the corporate governance balancing of various interests. A mere one-way communication of policy alternatives will not suffice anymore. Similar to unfolding stakeholders engagement in business practices (see e.g. Andriof & Waddock, 2002), policy makers (and their supporting analysis system) will need to take new and strategic relationships into account. This will extra challenges in the organisation of policy-making linked information flow.

Multiple goals emerging from the diversity of stakeholders are not the only changing factor in the policy analysis system. Given the specificity and diversity of multifunctionality in agrosystems, it will be hardly possible for the policy analyst to foresee a reasonable set of eligible solutions. Contrarily to conventional market and price policies, where the policy possibilities set is rather limited (e.g. alternative intervention prices), new policies directions will depend on creative new ideas and broad social support of policy proposals. Both can be extracted from adequate stakeholder engagement. Summarising, engaged input from stakeholders may concern:

- Priority alternative problem definitions
- Making individual and communal goals explicit
- Supplying creative ideas for enlarging the possibilities set

- Helping to construct and to consolidate priorities

On the other hand, also the policy analyst, or researcher, behind the policy support system has to become a part of the stakeholder involvement process. Already from a mere economist's point of view, and embedded in a rather conventional policy analysis framework, Pannell (2004) emphasised engagement with the process of policy formation.

3. Managing new requirements on input of policy analysis systems

Data supply for more conventional policy analysis systems is mostly generated by extracting information from farm level data bases (FADN, National Statistics,…). Other technical information can be estimated by econometrics or, given the ill posed nature, with techniques like maximum entropy, maximum entropy Leuven estimator, etc. (Paris & Howitt 1998, Paris 2001). For simulating agri-environmental and multifunctionality measures or new activities, however, there is a more prominent lack of farm level data on these issues. Although there is no doubt that part of these data will become accessible through extending conventional databases (e.g. with agri-environmental key figures), additional knowledge will always be needed to enrich the model with necessary parameters. In the conventional way of modelling, this information is retrieved from researchers with different, mainly technical-agronomical, disciplines. For the sake of agri-environmental and multifunctional simulation, other ways of retrieving extra information is needed. Given the multi-stakeholder involvement, this information retrieval can even be organised in a transdisciplinary way.

In this section various aspects of enriching the input information are given. First, through exploiting the joint production of by-products and side-effects, multifunctionality and environmental issues can be linked to the traditional production processes for which conventional data bases are available.

Secondly, normative models can be enriched with extra expert knowledge, or, thirdly, merged with estimations of expected reaction of attitude models.

3.1. Incorporating the joint externality production

Multifunctionality and environmental issues are the result of joint production (Romstad et al., 2000). Most production processes entail by-products and side-effects, which cannot be freely disposed, or, in other words, are weak disposable. Weak disposability is linked to congestion and implicitly refers to the notion of ambivalent joint production, which is the possibility that an output may have a positive value in one circumstance and a negative value in another (Freshwater and Jia, 2004). In the case of undesirable outputs, weak disposability means that the reduction of the by-product can only be achieved by simultaneously reducing some desirable outputs and/or resource-using abatement (Färe et al., 1993). Analogously, we can think of positive externalities that only can get produced when there is a simultaneous agricultural production.

Joint production is a rather physical concept, disposability refers more to productive economic analysis. As long as their disposability is free, the joint production of non-wanted outputs is no problem. Only when disposability becomes weak, e.g. costly disposal after environmental regulations, then the bad joint product becomes a problem. These principles can also be transposed to positive externalities. As long as the primary agricultural production remains profitable, landscape amenities can be supplied for free. The moment the primary production ceases to be profitable, e.g. in marginal mountainous areas, then the supply of amenities need to be sustained by extra payments.

Wossink et al. (2001) treat two other aspects of the joint production of by-products: non-separability and heterogeneity. Separability means that the production of by-products and the pollution abatement are treated as separate processes. This is a mere emission-oriented approach and inherent to end-of-pipe technologies. Non-separability allows considering abatement options (or avoidance options) within the production process itself. Non-separability and heterogeneity are features that are mostly linked to the non-point source emission and pollution control. Although Wossink et al. (2001) worked out non-separability and heterogeneity for pollution control, some of these principles can be extrapolated to amenities' stimulation. For example, a farmer can make specific input-output decisions in harmony with local production conditions that favour biodiversity.

For agricultural production and pollution control modelling, it becomes a challenge to integrate non-separability, heterogeneity and ambivalent joint production in sector models. This must allow reconstructing the three stages of the marginal abatement cost curve (Hill et al., 1999): first, avoidance of pollution through efficiency improvement, second substitution of inputs or production processes, and third a redesign through output reduction or the use of emission reduction technologies. Again these findings concerning emission and pollution control can be extrapolated to positive externalities. Given the non-separability, heterogeneity and ambivalent jointness of amenities, one can imagine that their marginal provision cost curve is also multi-staged.

3.2. Introducing expert knowledge through normativity

Exploiting expert knowledge is another way to introduce extra information in models for policy analysis. As little data are available, policy analysis models will inevitably rely on normative mathematical programming techniques. This can be illustrated with the case of conversion to organic farming. In that case, not only technical but also attitude factors (risk, transaction costs,...) play an important role. A normative approach allows easily for changes in factor costs (such as higher seed and fodder costs), in investment costs (such as for mechanical weed control and new housing systems) or for changes in the crop rotation, lower yield levels, higher labour requirements,… (Kerselaers et al., 2005). By introducing the constraints of the new system that is modelled (e.g. in case of the organic farming system, the limits on livestock density and the minimum rotation and feed requirements) as well as predicted changes in prices and in premiums the expected effects of switching to the new system can be predicted with the model.

3.3. Estimation of expected reaction

A major disadvantage of normative models is that they don't take into account the behaviour with respect to the new policy measures or new activities. Even in the above mentioned case of expert-supported modelling, simulations showed that, under Belgian conditions, about half of the concerned farmers would face a successful conversion to organic farming. This is much more than the actually observed conversion behaviour. Attitude estimates derived from inquiries on similar farms (De Cock & Calus, 2005) that these might be, when combined with the economic potentiality estimates, a good explanator of observed conversion rate.

Although not done in the cited research, the above-mentioned example shows that merging the normative models with attitude models could be another way to tackle the problem of modelling voluntary shift into new farming systems. Attitude models try to estimate the expected reaction of farmers to policy incentives, based on information to be gathered from e.g. surveys. Well accepted as survey format is the Willingness-To-Accept (WTA) format (Vanslembrouck et al, 2002). Farmers are confronted with a policy or allocation choice that reduces their income. The WTA question, then, tries to estimate the compensation farmers are willing in order to accept the shift. The response can then be linked to structural characteristics of the respondent or his situation (e.g., the location or size of the farm, the age or education of the respondent), information that can then be linked to attenuate the influence of these variables in the normative model.

4. New requirements of output management

In general, with conventional policy analysis systems there is no major need for structuring output results. As the need for extra information increases with new policy developments, more and more output can be used for refining the system. The system itself will be used to verify whether the estimation of specific parameters is robust or not. As a consequence, data input and data output become more and more tied up.

One of the most applied techniques to test and refine the system is sensitivity analysis. Besides refining and testing models, sensitivity analysis can be used for a wide range of purposes, which are classified by Pannell (1997) in four groups: development of recommendations, communication, understanding, model development. It has no doubt, that as the need for extra information increases, the importance of sensitivity analysis will increase as well. This emphasises the need for a more structured output generation.

For example, information that is linked to a switch to a new farming system is not so easy to model like changes in labour requirements or possiblities for introducing new activities. This can be solved by combining scenario and sensitivity analysis and by adequately organising the model runs and result reports. By using such an approach, assumptions on e.g. the flexibility of farmers to adjust their farm management plan can be analysed. In order to keep prediction realistic, expert knowledge of e.g. farm advisers can be used to assess the plausibility of farm changes (Kerselaers *et al*., 2005).

However, sensitivity analysis has its limitations. More specifically to policy analysis systems where interactions between farms are fundamental, sensitivity analysis often occurs in unsystematically and unstructured way, by only varying some parameters (Kleijnen et al. 2003). The 'one-at-a-time' approach excludes possible interactions between input parameters, i.e. whether the effect of one factor depends on the level of one or more parameters. In this case, more structured output generation does not offer more insight in the model. This 'one-at-a-time' approach can be a too crude simplification of the underlying model (Vonk Noordegraaf et al. 2002). The statistical techniques of Design of Experiments (DOE) and metamodelling can provide a methodology to analyse model outputs systematically by taking parameter interactions into account.

5. Organising interactive processes in I/O management

In the previous two chapters was stated that extra information as such does not guarantee a better performance of models. Structuring of parameter interactions becomes indispensable. Moreover, since a larger engagement of other stakeholders in the policy analysis process is expected, a more interdisciplinary approach is needed instead of the more common multi-disciplinarity, where different disciplines cope the same problem by investigating one aspect in the perspective of their proper discipline. In order to capture the new policy modelling problems a holistic approach is preferred.

It will be important that the policy analyst is highly interactive and co-operative with those stakeholders who show a sufficient engagement with the problem solving process. A high interaction and co-operation, operationalised through showing prototype model simulations, can help to canalise transdisciplinarly emerged knowledge as extra information to the modelling system. This implies a high interaction of input and output management in the policy analysis system.

This interactive approach in gathering extra information also induces the need for an easy adaptation of the conceptual model. Experiences with the elaboration of operational environmental modules to be incorporated in policy analysis models showed that a lack of flexibility was the origin of not regularly adapting a model to new insights (Vervaet et al., 2006). Model-independent agri-environmental indicator modules facilitate the adaptation of models to new insights.

An example of attempting to facilitate the input/output management in a more systematic way is the MicroWave concept, described by Wolfert et al. (2005). Although it is mainly developed with the aim to improve the continuity and communication between model builders, it can also serve to enhance the more interdisciplinary approach. The strength of this framework is that it reduces the model and data to a generic form, which enhances the accessibility for external experts.

6. Illustrations

In this section, two illustrations of new requirements of policy analysis systems are given: first, the estimation of the economic potential for conversion to organic farming (Kerselaers *et al*., 2005) and second, the effects of proposed EU sugar policy reforms (Buysse *et al*., 2004).

The first started with three discriminatory scenarios: a pessimistic, optimistic and business-as-usual scenario. Scenario outcomes are discrete points in an n-dimensional space of influencing factors, on which sensitivity analyses on the most dominant underlying assumptions can be grafted. Nowadays technology is not limiting for performing and managing huge number of computer runs. Figure 2 shows the impact of a crop yield parameterisation on the income increase during and after conversion, superposed on the discrete scenario outcomes (indicated with arrows). This combination of model runs allows for highlighting the impacts of one particular assumption, here crop yield, in the overall scenario assumption set. For example, crop yield has a minor impact with the pessimistic scenario assumption set, but a major one in the BAU and optimistic scenario.

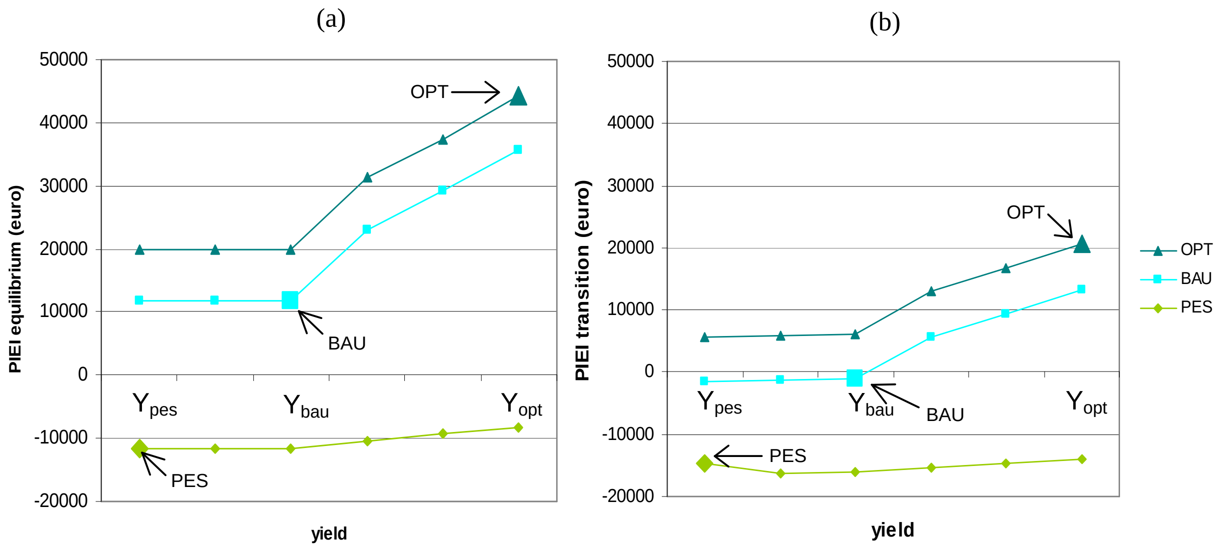


Figure 2. Impact of crop yield assumptions on the potential increase of earned income
(a), after conversion to organic farming
(b), during the conversion period

Six crop yield assumptions are used: Y_{pes}, Y_{bau}, Y_{opt} and three intermediates

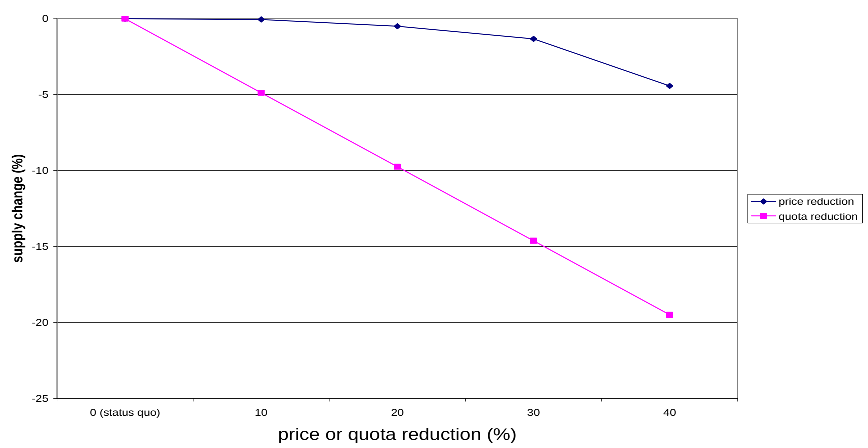
A similar approach is followed to analyse the EU sugar reform proposals of 2005, which are a recombination of four policy instruments:

- reduction of sugar beet prices;
- reduction of production quota;

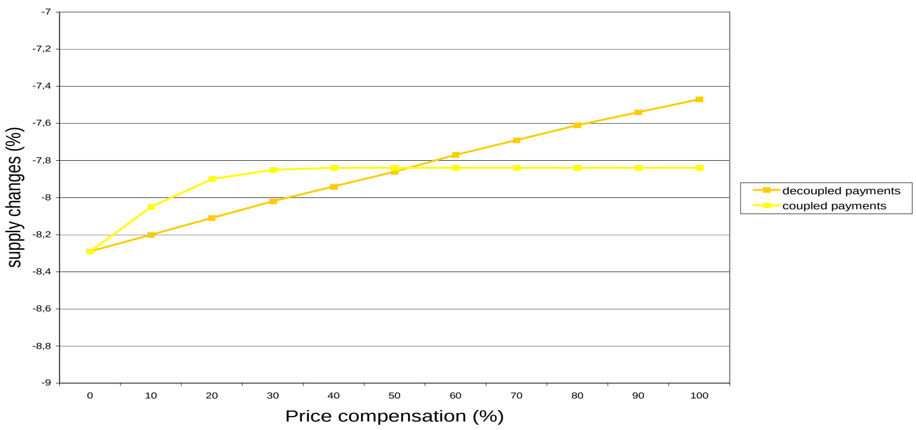
- compensation of the price decline;
- coupling or decoupling of compensation.

Simulations were run by Gams Simulation Environment (GSE) (Dol, 2005), a software developed as a graphical user interface for running independently diverse policy analysis systems. Already a limited number of changes in each of the above given four policy instruments lead to a combinatorial high number of policy options that cannot be analysed in the commonly applied discrete way. Different from the previous case, parameterisation is done on policy instruments instead of scenario elements. Figure 3a shows the impact of declining sugar beet prices and production quota on sugar beet supply. The response curve shows a linear response to quota reduction. The response to price is non linear and show a lower elasticity. Figure 5b shows the impact of income compensation and of the discrete coupling-decoupling choice. The response curves are clearly different. In the case of decoupled income compensation, the response on supply remains linear. In the other case, the effect of increasing compensation attenuates asymptotically.

Besides the (aggregated) optimisation at farm level, maximising farm income, a multidimensional response plane over all combinations of the 4 policy instruments could show what is the optimal policy mix. The more policy instruments are involved, the more difficult it becomes to determine the best policy mix from separate response curves. When finding the best policy mix, next to the private-economic optima also social optima would be detected. Moreover, as agri-environmental and multifunctional issues come into prominence, an optimal policy mix derived for example from the aggregated minimised pollution level can be used for policy analysis as well. Nevertheless, although GSE has the merit to automatically store all simulation runs and it is independent of the underlying core model, it is not yet able to optimise the policy mix. This stressed the need for software that can handle this multiple optimisation.



(a)



(b)

Figure 3. Sugar reform impacts on sugar beet supply:

(a) effects of proportional decrease in price and quota

(b) effects of income compensation , decoupled or not

7. Conclusions

The new developments in agricultural policies imply that policy analysis systems will become more complex. In order to keep pace with these new policy needs, a vast range of innovative research needs to be developed. An overall conclusion of this paper is therefore that the need for effective policy analysis triggers two interrelated development lines:

Operational, as more information and different kinds of information is necessary, there is a need for with a strong management of input and output. The frontier between input and output management, however, becomes a thin line. Exploring the interaction between input and output is essential to test, understand and communicate new policy instruments.

Organisational: more attention should be paid to inter and transdisciplinarity and engagement between modellers, field expertise, policy makers and other stakeholders during modelling and simulation. There is a need for organisational systems that facilitate the input/output management and information flow in a more systemic way.

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