Introduction: Farmer's adaptation to environmental changes

Sophie Drogué, Florence Jacquet et Julie Subervie

Revue d'Études en Agriculture et Environnement / Volume 95 / Issue 01 / March 2014, pp 3 - 11
DOI: 10.4074/S1966960714011011, Published online: 07 May 2014

Introduction: Farmer's adaptation to environmental changes

Sophie DROGUÉ, Florence JACQUET*, Julie SUBERVIE**

* INRA, UMR 1110 MOISA, F-34000 Montpellier, France
e-mail: julie.subervie@supagro.inra.fr

This special issue of the *Review in Agriculture and Environment Studies* presents several relevant research findings from the *Ecoprod* workshop entitled Adaptation Practices and Adoption of New Technologies, organized in Montpellier in September 2012. This workshop topic was selected based on the observation that modern farm management is undergoing significant changes in order to cope with emerging challenges to agricultural production. First, the evolution of the global marketplace has important implications for the production processes and technologies implemented by farmers.

Beyond these contextual differences, in developed as in developing countries alike, farmers also face choices concerning not only what they should produce, but also how they should do so. These choices entail a consideration of the techniques that lead to sustainable, environmentally friendly, and energy- and resource-efficient production, keeping in mind that in many countries, and particularly in developing ones, productivity levels must be increased or at least maintained.

In France and in Europe, recent developments in public policies also serve as one of the primary incentives for changing agricultural practices. Environmental and energy policies such as the latest revisions made to the Common Agricultural Policy (CAP) provide a new framework for agricultural regulations. These policies address the provision of both agricultural (food and non-food) and environmental goods. This trend is evidenced in policies that aim to reduce the use of chemical inputs in agricultural production processes (*e.g.* the Water Framework Directive, the Ecophyto 2018 plan, the Framework Directive on sustainable use of pesticides, the agri-environmental measures of the CAP). These developments raise important issues regarding the choice of farming systems (*e.g.* agro-ecology, ecologically intensive agriculture) which could help to achieve these new objectives, as well as the institutional schemes best suited to facilitate farmers' success in addressing these new challenges.

In developing countries, price increases on world markets and fears of food shortages have made the need for increasing agricultural productivity

a central concern. In these countries, however, production processes take place in a context of observable ecosystem fragility and natural resource scarcity, and these palpable realities contribute to an innate consideration of sustainability in cultural and agricultural practices. Furthermore, climate change raises specific issues regarding the adoption of new plant varieties, the modification of cropping calendars, and the implementation of new irrigation practices.

The challenge for the economist in studying these changes is to account for the diversity of farmers' behavioural responses. This diversity can be explained by the specific context of the farmer (including, for example, degree of integration in social and technical networks and ability to access information and advice), individual farmer characteristics (including level of education, cognitive abilities, etc.), as well as the farmer's individual preferences such as risk aversion. Taking diversity into account is essential in order to understand how and why a new technology is adopted or to contribute to the development of new public policies which may encourage farmer behaviour in one direction or another. Taking the individual heterogeneity of farmers into account will be a major component of future research in production economics.

Understanding the economics of the farm: new research issues

As stressed by Chavas *et al.* (2010), agricultural economics benefited greatly from advances in economics, including refinements in economic theory as well as empirical methods. For decades, the literature in agricultural economics has focused on the reasons why productivity levels are so different across farms (Syverson, 2011). Now that there is a growing consensus that emissions of greenhouse gases due to human activity will lead to higher temperatures and increased precipitation, new research issues surrounding farming systems' adaptability to the changing climate have emerged. At the same time, the environmental impacts of intensive agricultural systems have become an important aspect in the evaluation of their overall performance. The fact that these systems have a variety of harmful impacts on humans, animals and the environment is of increasing concern to policy makers. In developed countries, public policies recommend the reduction of chemical inputs to production and encourage farmers to adopt environmental-friendly practices. In Europe, such practices exemplify the current "greening" trend in agricultural policy. These changing contexts raise new research questions for agricultural economists. At least three of these questions are relevant for this special issue: estimating the effects of climate change on agriculture, assessing farming system adaptability to the changing climate and economic context, and estimating farmers' willingness to adopt agri-environmental schemes.

Estimating the effects of climate change on agriculture

Because temperature and precipitation are direct inputs in agricultural production, agriculture has been the focus of much of the existing research on climate impacts. Dell *et al.* (2013) stress the progress made in estimating the likely impacts of climate on agriculture. Starting from the production function approach (Adams, 1989; Kaiser *et al.*, 1993; Adams *et al.*, 1995), economic research has evolved toward the cross-sectional hedonic approach in models that take into account land use changes and the adoption of new crops when the temperature changes (Mendelsohn *et al.*, 1994). Deschênes and Greenstone (2007, 2012) later provided an important methodological contribution by estimating panel data models in order to control for unobserved determinants of agricultural productivity that are correlated with climate. Many other studies have followed, generally finding that adverse weather shocks like higher temperatures and lower rainfall have negative impacts on agricultural output in developing countries.

Assessing farming system adaptability to the changing climate and economic context

Climate change can be considered economically akin to a technology shock, the potentially negative effects of which can be mitigated by appropriately adaptating the production function. Specific ways in which farmers can adapt include changing input use and altering cropping calendars. They may also adapt by selecting or diversifying crops, or purchasing crop insurance for losses caused by climate change (Bradshaw *et al.*, 2004). The assessment of the sustainability of adaptation strategies must take into account the interactions and feedbacks between crop growth, resource availability, and economic drivers at the farm scale. This requires the use of models that simulate farmer decision rules in order to investigate possible adaptation strategies to environmental changes (Thomas, 2013). Economists have thus developed models which link agricultural production with environmental impacts (called "integrated hydrologic-agronomic-economic models" or "bio-economic farm models"), which aim to aid policy makers by simulating various policy *scenarii* (Lacroix and Thomas, 2011; Bamière *et al.*, 2011; Jacquet *et al.*, 2011, among others). In a recent review, van Wijk *et al.* (2012) conclude that enough techniques exist for integrated assessments of farm systems in relation to climate change, adaptation, and mitigation, but that these techniques have not yet been combined in a way that is meaningful to farm-level decision makers.

Although some adaptation solutions are available, farmers' willingness to adopt new practices remains uncertain. Even when the future damage costs associated with climate change impacts appear large enough to nudge farmers to pre-emptively adapt their practices to the changing context, the adoption of these new practices may require significant investment. In

developing countries in particular, rapid adaptation is unlikely when access to information and capital is limited: poor smallholders cannot be expected, nor can they afford, to change cropping systems when large opportunity costs exist or when production risks and market variability are significant (de Pinto *et al.*, 2013). Field experiments have been designed to shed light on the complexity of farmers' adoption of new technologies and practices and of climate-related adaptation decisions. In this special issue, Karen Macours reviews some of the challenges related to understanding the constraints to agricultural productivity improvements in developing countries and provides a useful illustration using an example from a randomized evaluation of a development program in Nicaragua.

Estimating farmers' willingness to participate in agri-environmental schemes

There are a variety of external rewards systems, such as payments for ecosystem services, that are likely to nudge farmers to provide ecosystem services (Chabé-Ferret and Subervie, 2013). However, the provision of such services is embedded in a complex social, economic and institutional context (Broch *et al.*, 2013). Thus, the factors that influence farmers' decisions regarding agricultural practices and the adoption of alternative techniques are related to individual preferences as well as the social, economic and technical context of the farms (Nave *et al.*, 2013). Recent papers have tackled the adoption issue directly by estimating farmers' willingness to participate in agri-environmental schemes (Christensen *et al.*, 2011; Broch *et al.*, 2013). They have placed a considerable focus on the role of farmers' individual preferences in farm management decisions and have employed a wide range of econometric techniques in order to account for this in their analyses.

Key research findings

This special issue reflects on several new research issues in production economics and farm management, focusing on the agroecological and socioeconomic heterogeneity of farms. The articles herein were selected from the *EcoProd* workshop held in Montpellier, France, for inclusion in this special issue. Together, the selected articles address the issue of farmers' adaptation to environmental changes in light of their individual preferences. Their key findings are summarized below.

For Macours, a farmer's adoption of new technologies and response to climate change in developing countries is complex. Facing this complexity is a real challenge for the economist who aims at understanding and explaining the agricultural adoption and adaptation decisions in developing countries. She argues that the complexity in addressing this issue stems from i) the need to take market imperfections into account, ii) the dynamic nature of the adoption

decision, iii) the impact of climate change. She illustrates her arguments with the evaluation of a randomized safety net program in Nicaragua. This program provided selected farmers in Nicaragua regular cash transfers under certain conditions. In a first treatment, the cash transfer was conditional on an improvement in the quality and quantity of nutritional intake of all household members. In a second treatment, the cash transfer was accompanied with a vocational training scholarship. In the third treatment, a cash transfer was provided with a productive grant. Fieldwork revealed two key findings. The author observed a consumption shift to fruits and vegetables, which was accompanied by a corresponding shift in fruit and vegetable production. She also observed that subsistence crops were not necessarily given up, despite the risks associated with growing them. It was determined that this was because these crops (maize and beans) are linked to cultural and gender identity; hence, even if they were aware of the riskiness of these activities, farmers continued to invest in these crops without making adjustments. This case of maize and beans is illustrative of the complexity of farmers' decisions in a complex world. Moreover, the third treatment revealed that interventions targeting non-agricultural income sources were effective in facilitating climate change adaptation. The grant and training interventions helped households to start new non-agricultural activities and adopt a more diversified income *portfolio*. In doing so, it increased farmers *ex ante* risk management and made them less vulnerable to shocks, even after the end of the program. This article clearly illustrates that heterogeneity governs farmers' decisions, whether in response to a climatic or institutional shock, or to adopt new techniques. This applies not only in developed countries but also, and probably particularly, in developing countries.

Chakir and Hardelin investigate the factors affecting the demand for hail insurance and explore the potential relation with pesticide use for a sample of French farmers observed between 1993 and 2004. They address the issue of farmers' heterogeneity through a panel data model, which allows them to capture individual farmer effects and follow the evolution of farmers' choices over a long period of time. Their results show that hail insurance demand is positively and significantly related to pesticide use, providing empirical support for the interdependence of technical choices and insurance decisions. Although the magnitude of this effect remains small, this suggests that reforms that aim at facilitating access to insurance may have positive, albeit modest, effects on pesticide use. Moreover, their results show that CAP subsidies have a statistically significant negative influence on insurance demand and, in turn, on pesticide use. This suggests that decreasing the CAP subsidy would increase farmers' propensities to pay for risk management instruments.

Lefebvre *et al.* analyse the discrepancy between intention and behaviour in farmers' land investment decisions. They use the results of two surveys on 165 farms in 5 EU countries carried out in 2006 and 2009. It is important to note that two major events occurred during the 2006-2009 period: the

implementation of the CAP decoupling reform of 2003 and the global economic crisis. A main finding of this research is that even though farmers do exhibit several common features, heterogeneity ultimately governs intention and behaviour in farmers' land investment decisions. Two models are used to model farmers' intentions and investment behaviour. A first probit model explains the probability of stating an intention to invest in land between the two dates. A second probit model explains the realized investments in the same period. Farm size and country are the only two common explanatory variables to emerge in both models. Other variables are significant in explaining either intentions or behaviour, but not both. The main variable explaining stated intention is the debt-asset *ratio*, while uncertainty regarding succession and total income are significant determinants of actual investment behaviours. The authors conclude that their results do not enable them to confirm that heterogeneity is a key feature of farmers' responses to a new institutional environment.

The article by Letort and Temesgen shows that environmental regulations can sometimes enhance farmland competition. They illustrate this in their paper with the case of the French region *Bretagne*, where urban pressure on farmland associated with environmental regulations creates a heterogeneous zoning of farmland prices. In this region, several environmental regulations have been implemented with the aim of reducing agricultural nitrate runoff and the resulting water pollution. The authors examine three cases of pollution regulations based on a farmer profit maximization problem: (i) a compulsory regulation is introduced via a constraint on nitrogen which is a factor in the production function; (ii) a voluntary adoption of the environmental regulation for which adopting farmers receive a financial compensation, modelled as a subsidy added to the profit function; (iii) a compulsory regulation that farmers are compensated for by receiving a subsidy. In the first case, the farmer profit decreases due to lower nitrogen use; in the second case, farmers are incentivized to participate in the environmental program if the subsidy is greater than the loss of profit; in the third case, the heterogeneity of farmers determines their over- or under-compensation according to their respective subsidy levels and loss in profits. The possibility of compensation when a regulation is implemented will have an impact on the farmland price, as this price depends in part on the future gains or losses of the land. Using an econometric spatial hedonic pricing model, the authors examine the determinants of farmland price heterogeneity in Bretagne. This research shows that when studying farmer responses to a new institutional environment, the challenge for the analyst is adequately accounting for the complexity that is introduced in this new context. The case of Bretagne typically illustrates the need to take into account not only the intrinsic heterogeneity of farmers when studying their adoption or adaptation behaviour, but also the heterogeneity of the frame within which they behave. In *Bretagne*, the *a priori* simple implementation of an environmental regulation aiming at reducing nitrates leads to a complex zoning with significant variation in farmland prices.

Kuhfuss, Préget, and Thoyer examine how to improve the appeal of agri-environmental schemes in France by conducting a choice experiment from a sample of 317 farmers in the Languedoc-Roussillon region. This study aims to estimate wine-growers' preferences for subsidy schemes that would limit the use of herbicides. In their empirical framework, heterogeneity is modelled by incorporating the interaction terms of case-specific variables with alternative-specific attributes. They use a latent class model which derives heterogeneity from different classes, each having its own parameters. Their results indicate that farmers are willing to trade off the size of the subsidy for less restrictive scheme requirements and that the amount of the subsidy they are willing to trade off varies with specific scheme requirements, suggesting which features are most important for successful policy design. Moreover, they investigate the effect of introducing a collective dimension in the contracts. This collective dimension relies on a monetary "bonus" paid to each farmer who signs a contract, provided that the proportion of land collectively enrolled in the agri-environmental scheme reaches a predefined threshold. The results show that, despite a high level of heterogeneity among wine-growers, respondents exhibit a preference for contracts that include this collective bonus. These results suggest that the presence of a bonus in the contracts terms could enhance farmers' participation in schemes that limit the use of herbicides. The high value given to this bonus by the respondents is consistent with the hypothesis that farmers are more willing to engage in environmental efforts when their neighbours also do so.

Together, the papers presented in this special issue take into account heterogeneity in farmers' behaviours and in the environmental contexts of decision-making. This appears to be particularly relevant in addressing the emerging issues that face agricultural economists today: adaptation to climate change, the adoption of new technologies, and participation in agri-environmental schemes to provide ecosystem services. The research findings described herein illustrate the need for continuing to explore new avenues of research that accommodate for heterogeneity, such as behavioural economics studies that address issues related to cognitive skills and non-cognitive behavioural traits (aspirations, attitudes, time and risk preferences, *etc.*), as well as methodological approaches such as field experiments and randomized evaluation.

References

Adams R., Fleming R., Chang C.-C., McCarl B. and Rosenzweig C. (1995) A reassessment of the economic effects of global climate change on US agriculture, *Climatic Change 30*(2), 147-167.

Adams R. M. (1989), Global climate change and agriculture: An economic perspective, *American Journal of Agricultural Economics 71*(5), 1272-1279.

Bamière L., Havlík P., Jacquet F., Lherm M., Millet G. and Bretagnolle V. (2011) Farming system modelling for agri-environmental policy

design: The case of a spatially non-aggregated allocation of conservation measures, *Ecological Economics 70*(5), 891-899.

Bradshaw B., Dolan H. and Smit B. (2004) Farm-level adaptation to climatic variability and change: Crop diversification in the Canadian prairies, *Climatic Change 67*(1), 119-141.

Broch S. W., Strange N., Jacobsen J. B. and Wilson K. A. (2013) Farmers' willingness to provide ecosystem services and effects of their spatial distribution, *Ecological Economics 92*, 78-86.

Chabé-Ferret S. and Subervie J. (2013) How much green for the buck? Estimating additional and windfall effects of French agro-environmental schemes by DID-matching, *Journal of Environmental Economics and Management 65*(1), 12-27.

Chavas J.-P., Chambers R. G. and Pope R. D. (2010) Production economics and farm management: a century of contributions, *American Journal of Agricultural Economics 92*(2), 356-375.

Christensen T., Pedersen A. B., Nielsen H. O., Mørkbak M. R., Hasler B. and Denver S. (2011) Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones: A choice experiment study, *Ecological Economics 70*(8), 1558-1564.

Dell M., Jones B. F. and Olken B. A. (2013) *What do we learn from the weather? The new climate-economy literature*, Working paper n°19578, National Bureau of Economic Research, 70 p.

Deschênes O. and Greenstone M. (2012) The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather: Reply, *American Economic Review 102*(7), 3761-3773.

Deschênes O. and Greenstone M. (2007) The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather, *American Economic Review 97*(1), 354-385.

Jacquet F., Butault J.-P. and Guichard L. (2011) An economic analysis of the possibility of reducing pesticides in French field crops, *Ecological Economics 70*(9), 1638-1648.

Kaiser H. M., Riha S. J., Wilks D. S., Rossiter D. G. and Sampath R. (1993) A farm-level analysis of economic and agronomic impacts of gradual climate warming, *American Journal of Agricultural Economics 75*(2), 387-398.

Lacroix A. and Thomas A. (2011) Estimating the environmental impact of land and production decisions with multivariate selection rules and panel data, *American Journal of Agricultural Economics 93*(3), 784-802.

Mendelsohn R., Nordhaus W. D. and Shaw D. (1994) The impact of global warming on agriculture: A Ricardian analysis, *American Economic Review 84*(4), 753-771.

Nave S., Jacquet F. and Jeuffroy M.-H. (2013) Why wheat farmers could reduce chemical inputs: evidence from social, economic, and agronomic analysis, *Agronomy for Sustainable Development 33*(4), 795-807.

De Pinto A. D., Robertson R. D. and Obiri B. D. (2013) Adoption of climate change mitigation practices by risk-averse farmers in the Ashanti Region, Ghana, *Ecological Economics 86*, 47-54.

Syverson C. (2011) What determines productivity?, *Journal of Economic Literature 49*(2), 326-365.

Thomas A. (2013) Linking farm-level models with environmental impact models, In: *Farm level modelling of CAP: a methodological overview*, JRC Scientific and Policy Reports n°79969, Langrell S. (ed.), Sevilla, Spain, 53-60.

van Wijk M., Rufino M., Enahoro D., Parsons D., Silvestri S., Valdivia R. and Herrero M. (2012) *A review on farm household modelling with a focus on climate change adaptation and mitigation*, Working Paper No. 20, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark, 118 p.