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The impact of high crop prices on the use of agro-chemical inputs in France: A structural econometric analysis☆

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ABSTRACT

World crop prices increased dramatically during the period 2006–2009. In this context of high crop prices, farmers may tend to increase the amount of agro-chemical inputs they use in order to increase yield and manage risks related to crop production. These practices could, however, have potentially adverse environmental effects in terms of loss of biodiversity and increased water and air pollution. This study uses a structural econometric model to measure the effects of crop prices on demand for agro-chemical inputs and land allocation. We study individual farms observed in the period 2006–2009 in the French *Département de la Meuse*. We estimate a multi-output profit function using farm-level panel data. Our results show that an increase in the rapeseed price, which is the principal feedstock for the production of biodiesel in France, has a positive and significant effect on demand for agro-chemical inputs. Higher rapeseed prices also induce an expansion in the land area allocated to rapeseed at the expense of barley and set-aside. These results suggest that changes in the rapeseed price, partly driven by biofuel policies, induce changes in demand for chemicals and land allocation which may have potentially adverse effects on the environment.

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1. Introduction

World crop prices increased dramatically in 2007. For example, in France during the period 2006–2010, the rapeseed price increased by 60%, going from € 261 up to € 416 per ton. This period of high crop prices was not limited to France; it was observed in all world cereal markets. Three principal factors have been identified as the drivers of this worldwide increase in food prices: rising demand from emerging markets for key commodities, dollar depreciation, and biofuel policies (Abbott et al., 2009). The first two factors are cyclical variations; the last relates to policies encouraging production and use of biofuels. According to Baier et al. (2009), for the period 2006–2008, the increase in world biofuel production induced increases in corn, soybean, and rapeseed prices by 27%, 21% and 18% respectively.

High crop prices can encourage farmers to change their agricultural practices, which in turn may induce potential adverse effects for the environment. For instance, it has been shown that higher crop prices due to the biofuel production lead to nitrogen runoff and water pollution problems (Secchi et al., 2011; Langpap and Wu, 2011), induce losses in biodiversity (Secchi et al., 2007), and exacerbate the climate change problem due to greenhouse gas (GHG) emissions from land-use changes (Searchinger et al., 2008). The objective of this study is to measure how increased crop prices affect demand for agro-chemical inputs among French farmers. More specifically we test the hypothesis that an increase in crop prices increases demand for chemical inputs (fertilizers and pesticides). We estimate a multi-output profit function based on a panel of individual farms in France observed from 2006 to 2009. Using the estimated value of the demand elasticity of pesticides and fertilizers with respect to the rapeseed price, rapeseed being the principal

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feedstock for biodiesel production in France, we simulate the effects of European Union (hereafter denoted as EU) biofuel policy on the use of agro-chemical inputs. These estimates provide a basis for discussion of a policy instrument, namely a fertilizer tax, in France to limit the use of fertilizers which may affect surface water and groundwater quality.

France is particularly appropriate for analysing demand for agro-chemicals because water pollution by nitrates and pesticides, mainly due to agricultural and livestock production, is a major issue there. France is the world's third largest user of pesticides and the seventh largest consumer of fertilizers. In September 2014 the European Court of Justice ruled that France had failed to fulfill its obligation to comply with the EU Water Framework Directive. After its previous judgments of March 2001 (too many nitrates in Brittany catchments) and June 2013 (incomplete designation of "vulnerable" areas of water pollution by nitrates), the decision of September 2014 was thus the third time the European Court had ruled against France. On this occasion it was censured for the insufficient measures taken.

The EU Water Framework Directive specifies the objective of good or very good surface water quality by 2015 for all member states. In France in 2013, only 48.2% of surface water resources are in a good situation regarding the chemical status. The situation is better for groundwater resources as 67% of them are in a good situation in 2013. The main causes of the bad status of the remaining 32.8% of groundwater resources are nitrate pollution (17% of water resources) and pesticide pollution (15.8% of water resources) (Katell and Michon, 2015).

The French Ministry of Agriculture recently implemented the Ecophyto Plan aimed at reducing agricultural pesticide use by 50% by 2018. Environmental taxes on sales of pesticides ("*redevances pour pollutions diffuses*") have been introduced in order to achieve this objective. The tax rate varies depending on the type of phytosanitary product: it is € 2 per kg for environmentally-harmful organic substances, € 0.90 per kg for mineral substances, and € 5.10 per kg for toxic substances. Despite the extent of nitrogen pollution, there is no tax on fertilizers in France.

The paper is organized as follows. Section 2 provides a brief overview of the literature on the estimation of multi-output models and the literature on the environmental impacts of biofuel production. Section 3 presents the empirical model and the estimation method. Section 4 discusses the data, and the estimation results. We provide a simulation exercise to assess the impact of alternative crop price scenarios, found in the literature, on the use of agro-chemical inputs, and discuss a policy instrument to limit their use. Section 5 concludes by discussing how our estimates could contribute to the ongoing debate on the potential adverse effects of biofuel development on the environment.

2. Literature

Our paper is related to two strands in the literature. The first strand deals with the estimation of multi-output models to measure how crop prices affect farmers' production decisions. Multi-output models are able to take into account cross-price elasticities between different products (see, among others, Moro and Sckokai, 1999; Williams and Shumway, 2000; Arnade and Kelch, 2007; Fezzi and Bateman, 2011; Lacroix and Thomas, 2011; Laukkanen and Nauges, 2014). Arnade and Kelch (2007) propose a method to estimate individual crop areas and output responses to a change in prices, by including in the estimations shadow price equations for each crop area allocation. The estimation method is applied to aggregate data for the state of Iowa during the period 1960–1999. Lacroix and Thomas (2011) estimate a multi-output model for a panel of French farmers during 1995–2001. They incorporate a crop-selection mechanism which allows them to control for the influence of crop rotation on land use and output decisions. The study most closely related to ours is Laukkanen and Nauges (2014) which estimates a multi-output profit function in order to assess the effects of agri-environmental payments on agro-chemical inputs and land-use decisions. The estimations are based on a sample of individual Finnish grain farmers over the period 1996–2005. The estimation results show modest reductions in fertilizer use in response to agri-environmental payments, which however increase the area allocated to grain and reduce the area of set-aside land. The authors combine these estimates with environmental production functions in order to assess the damage costs associated with nutrient pollution.

The second strand in the literature focuses on changes in intensive and extensive margins of production following an increase in energy crop prices. The adverse environmental effects due to higher crop prices could come either from changes in the intensive margin of production, through the increased use of agro-chemical inputs, or from changes in the extensive margin of production through land-use changes. In relation to cropping intensification, Louhichi and Valin (2012) estimate that for France higher rapeseed prices driven by EU biofuel policies will increase by 2020 pesticide use by 5% and N_2O emissions by 2.5%. Lankoski and Ollikainen (2011) show in the case of Finland that biodiesel based on rapeseed and ethanol produced from wheat and barley lead to nitrogen and phosphorus runoff. For the extensive margin, Hausman (2012) estimates the impact of sugarcane and soybean prices on acreage conversion in Brazil. High corn prices in the United States (hereafter denoted as US) are estimated to induce nitrate runoff, nitrate percolation, and soil water erosion (Langpap and Wu, 2011), and to have adverse effects on water quality (Secchi et al., 2011). Langpap and Wu (2011) estimate the environmental impacts of higher commodity prices driven by ethanol mandates in the US, by combining economic and physical models. The economic models provide information on the changes in crop mix and land use allocation (cropland vs. noncropland). These estimated changes are then used to evaluate local environmental impacts such as nitrate runoff, nitrate percolation, and soil water erosion. Following a $3 increase in the corn price in the Corn Belt and Lake States, fertilizer use is estimated to increase by 18% and 18.7%, and pesticide use by 23.1% and 27.5% respectively. With regard to the climate change problem, Timilsina and Mevel (2013) forecast the impacts of worldwide biofuel mandate policies on the extent of GHG emissions triggered by land-use changes.

To the best of our knowledge, there has been no econometric assessment of the effects of crop prices on cropping intensification and land allocation decisions for the case of France in the recent context of high agricultural commodity prices, partly driven by biofuel policies. Our study aims to fill this gap and to shed some light on this question. The structural econometric approach presented below, allows us systematically to estimate the effects of crop prices on both cropping intensification and land allocation decisions.

3. The empirical model

We consider a risk-neutral farmer who uses K variable inputs and one fixed but allocatable factor (land) to produce C different crops, where: c is the crop index, $c = 1, \ldots, C$; p_c is the price of crop c; y_c is the output level of crop c; x is a K vector of variable inputs;

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