Indirect effects of French biofuel policies on pesticide demand: an econometric analysis

Basak Bayramoglu* Raja Chakir†‡

June 23, 2010

Abstract

In this study, we use an individual panel data approach to measure the indirect effect of biofuel policies in France. Our model tests the hypothesis that an increase in rapeseed prices increases pesticide demand, rapeseed being the principal feedstock for the production of biodiesel in France. We take the case of farms observed from 1993 to 2006 in the French Department of Meuse. Indeed, our findings reveal that a 1% increase in the price of rapeseed increases pesticide demand by 0.122%. Using the estimated value of the demand elasticity of the pesticide with respect to rapeseed prices, and following the 50% increase in the price of rapeseed observed between 2007 and 2008 in France, this would induce an increase of 6.1% in the use of pesticides in the Department of Meuse. These results could contribute to the ongoing debate over the potential adverse effects of the development of biofuels on the environment.

Keywords: Pesticide demand, rapeseed price, biofuel policies, panel data model.

JEL codes: Q12, C33.

*UMR Economie-Publique, INRA-AgroParisTech, France. email: basak.bayramoglu@grignon.inra.fr
†UMR Economie-Publique, INRA-AgroParisTech, France. email: raja.chakir@grignon.inra.fr
‡We thank the Centre de Gestion et d’Economie Rurale de la Meuse/CER for providing the data and Jean-Pierre Butault, Nathalie Delame and Guy Millet for their helpful comments and suggestions. We also thank the participants of the Agricultural Economics Society (AES) Conference, Dublin (March 2009) and the seminar of the POPSY Project, Paris (September 2009) for comments. We would also like to thank S. Tanis-Plant for fruitful discussions and editorial advice in English. Supports from the POPSY-ANR-08-12-STRAT project funded by the French National Research Agency, and the AgFoodTrade project funded under the 7th Framework Programme for Research and Development, DG-Research, European Commission, are acknowledged. The views expressed in this paper are the sole responsibility of the authors and do not necessarily reflect those of the Commission.
1 Introduction

In recent years, there have been various measures to promote the development of biofuels in the European Union. Directive 2003/30/CE of the European Commission asks that by 2010 biofuels represent 5.75% of all fuels used by the transport sector. The Proposition of Directive on Renewable Energies of 23th January 2008 (2008/0016 (COD)) makes mandatory that biofuels represent 10% of all transport fuel by 2020, for each Member State. France established more ambitious targets: 7% of biofuel is to be incorporated in transport fuels by 2010 and 10% by 2015. In France, biodiesel reaches a larger market than ethanol. In 2006, the consumption of biodiesel was 630,000 t, whereas that of corn based ethanol was 230,000 t. In addition, French biofuel production units benefit from partial tax credits on the "internal tax on consumption". In 2006, the level of the tax credit for biodiesel (EMHV) was 25 euros/hl (Guindé et al. (2007)). These incentives have increased the production of biodiesel, and in turn could explain some of the rise in the price of rapeseed used as a raw material for biodiesel production in France.

As regards rapeseed price dynamics in France, the 2007-2008 period displayed a substantial increase up to 500 euros/t. This period of high crop prices was not specific to France and has been observed overall the cereals world markets. To investigate the driving forces behind this worldwide increase in food prices, Abbott et al. (2008) reviewed 25 studies and identified three principal factors: global changes in the production and consumption of key commodities, the depreciation of the dollar, and increased interest in biofuels to cope with depleting fossil-fuel resources. The first two factors are conjectural variations that could explain changes in food prices, whereas the latter one relates to policies aimed to encourage the use and production of biofuels. For the two-year period 2006-2008, Baier et al. (2009) estimated that the increase in worldwide biofuel production induced an increase in corn, soybean, and rapeseed oil prices by 27, 21 and 18 percentage points respectively.\(^1\)

The context of high crop prices could incite farmers to change their agricultural practices including pesticide use.\(^2\) It is well known that the use of pesticides in agriculture increases crop yield and prevents risks related to crop production.\(^3\) However, it could also have some potential effects on the environment such as ground and surface water pollution as well as biodiversity loss, not to mention any effects on human health problems. The concern is that certain levels of pesticide residues in food and feed could be dangerous for human health. The regulation of pesticide residues has therefore been placed on the agenda of the European Union.\(^4\) Indeed, the European Commission has set Maximum Residue Levels (hereafter denoted as MRLs). As of 1

---

\(^1\)They found, however, that biofuel production in the same period explained only 12 percent of the rise in global food prices, measured by the IMF food price index.

\(^2\)For a general survey on pesticide economics see Sexton et al. (2007), for a review of empirical evidence in the economics of pesticide use, see Fernandez-Cornejo et al. (1998), and finally for a survey in French on the environmental impacts of pesticide use see the report Expertise Scientifique Collective INRA-Cemagref (2005).

\(^3\)Cooper and Dobson (2007) discuss the benefits of the use of pesticides in agriculture. Edwards-Jones (2008) criticizes their method of accounting these benefits in that it does not include a comparison of the costs and benefits of each pest control method.

\(^4\)For more information, see http://ec.europa.eu/food/plant/protection/pesticides/explanation_pesticide_residues.pdf.
September 2008, a new legislation (Regulation (EC) No 396/2005) undertakes the harmonization of MRLs throughout the European Union. This new regulation may be restrictive in the case of France which is the fourth consumer of pesticides in Europe, having consumed 5.1 kg of active materials per hectare of arable land in 2004. Meanwhile, for 2006, the IFEN (French Institute for the Environment) has reported that 37% of surface water has a low quality in terms of pesticides. This increases up to 48% when measurements are taken at pesticide hot points.

The question of how crop prices could affect the farmers’ production decisions was the subject of very large theoretical and empirical literature. Using a mono-product model with a constant-returns-to-scale production technology, Mahé et Rainelli (1987) showed that price support programs induced an increase in the intensification level defined as the ratio of chemical inputs on land. In the same vein, Carpentier et al. (1998) highlighted, in a mono-product model with a supermodular production function, that price support programs increased both the intensive and extensive margins of production. The overall effect is the rise in the use of chemical inputs.

These changes in intensive and extensive margins of production following the increase in crop prices also hold for biofuel crops. Nelson and Robertson (2008) have argued that higher prices for biofuel crops would first incite farmers to intensify the cultivation of these crops while also inciting them to convert some land area to biofuel crops. As concerns cropping intensification, Lankoski and Ollikainen (2009), using an integrated economic-ecological model, have estimated that to enlarge biofuel support policy to incorporate the 2007 US Energy Act, the EU Bioenergy Directive and second generation biofuels would lower the use of fertilizers and herbicides in Finland, as well as decrease its CO2-eq emissions. Nehring et al. (2008), using an econometric model, have estimated a significant increase in quality-adjusted fertilizer use in the United States, following the increase in biofuel production. The data was gathered at the state-level for a cross section approach of the period from 1986 to 2006. As concerns the extensive margin, Secchi and Babcock (2007), using the Environmental Policy Integrated Climate (EPIC) model, have estimated that high corn prices in the United States will bring under production more environmentally sensitive lands, with associated negative environmental effects in terms of soil erosion, nutrient loss, and carbon sequestration.

In this study, we estimate an econometric model, based on an individual panel sample of farms observed from 1993 to 2006 in the Department Meuse in France, to evaluate the indirect effect of biofuel policies. More specifically, we test the hypothesis that there is an increase in pesticide demand when rapeseed prices increase, rapeseed being the principal feedstock for the production of biodiesel in France. The current paper contributes to the existing literature on the effects of biofuel development on cropping intensification by estimating in a microeconometric model the relationship between the level of rapeseed prices and the pesticide demand. We equally investigate the magnitude of this demand. Using the estimated value of the demand elasticity of the pesticide with respect to rapeseed prices, we then simulate the effects of the recent French

---

5 For more details, see Expertise scientifique collective INRA - Cemagref(2005), chapter 2.
6 Source: www.ifen.fr
biodiesel policy on the use of pesticides. Compared to studies using purely cross-sectional data, our panel data model contains far more information than single cross-sections and thus allows for an increased precision in estimation.

This paper is organized as follows. In Section 2, we present the empirical model. In Section 3, the description of the data and estimation results are presented. In Section 4, to conclude, we discuss how our estimates could contribute to the ongoing debate over the potential adverse effects of the development of biofuels on the environment.

2 The empirical model

We assume the farm as a competitive multiproduct firm with a fixed amount of total land. We also assume that the production technologies are interdependent only through the land constraint. We follow here the model proposed by Chambers and Just (1989) for the estimation of an input non-joint technology with allocatable fixed factors. To obtain optimal land allocation as well as crop supply and variable input demands, we characterize the producer decision in two stages. In the first stage, we derive the optimal land allocation across crops by maximizing total profit subject to the land constraint. In the second stage, given the optimal land allocation, we derive crop supply and variable input demands by applying standard duality results from the crop-specific profit function.

We define the profit function for crop $c$ as:

$$\pi_c(p_c, w, l_c^*) = \max \{x_c'y_c - wx_c \text{ s.t } y_c = f_c(x_c, l_c^*)\}$$ (1)

where $x_c$ is the vector of variable inputs, $p$ is the price of crop $c$, $y_c$ is the output, $w$ is the vector of input prices and $l_c^*$ is the optimal land allocation to crop $c$.

Variable input demands follow from applying Hotelling’s lemma to the crop specific profit function (1):

$$x_{ck}(p_c, w, l_c^*) = - \frac{\partial \pi_c(p_c, w, l_c^*)}{\partial w_k} \quad k = 1, ..., K \text{ and } c = 1, ..., M,$$ (2)

where $x_{ck}$ is the optimal demand for input $k$ and crop $c$.

To investigate the pesticide demand in terms of rapeseed price changes, we adopted the reduced form approach as presented in Miranowski (1980) and Burrows (1983). Miranowski (1980) estimated the effects of pest management information detained by farmers and the energy prices on the share of corn acres treated with pesticides. The information was gleaned from cross sectional data for ten USDA agricultural regions which were pooled for 1966, 1971 and 1976. On the one hand, estimation results show that rising fuel prices implied an increase in the demand for both corn insect and weed control treatments. On the other hand, when the value of the variable used as a proxy for the availability of improved information on alternative pest control techniques increased, the demand for insecticide and herbicide use decreased. Burrows (1983) estimated the effect of the integrated pest management (IPM) on the cotton pesticide
use in California’s San Joaquin Valley. Both the single equation and a system of simultaneous
equations were estimated on individual data from 1970 to 1974. Both estimation results confirm
the hypothesis that the adoption of IPM would significantly reduce pesticides expenditures.

According to equation 2, the reduced form of the derived demand model for pesticide treat-
ment of rapeseed is defined as:

\[
\ln(pesticide_{it}) = cte + \beta_1 \cdot \ln(rapeprice_{it-1}) + \beta_2 \cdot \ln(rapearea_{it}) \\
+ \beta_3 \cdot \ln(pestprice_{it}) + \mu_i + \varepsilon_{it}
\] (3)

where \(\beta_k\) (\(k = 1, ..., 4\)) are parameters to be estimated, \(\mu_i\) are individual farm effects and \(\varepsilon_{it}\) are errors terms that are assumed iid, \(i = 1, ..., N\) is individual subscript and \(t = 1, ..., T_i\) is time subscript.

We choose a log-log specification for the pesticide demand equation in order to directly obtain
the estimates of the elasticity of the pesticide demand with respect to prices. Here, parameters
\(\beta's\) represent the elasticity of the pesticide demand with respect to exogenous variables: rapeseed
price (\(\beta_1\)), cultivated rapeseed area (\(\beta_2\)) and pesticide price (\(\beta_3\)). A lagged term is used for
rapeseed price. This corresponds to the usual assumption of adaptative expectations for an
agent. As suggested by equation 2, we also include the log of rapeseed area (\(\ln(rapearea_{it})\))
as an explanatory variable. Finally, dummy variables corresponding to different years of the
data set are introduced in Equation 3. These dummy variables capture all the omitted variables
which depend on time and which can affect pesticide demand, such as changing agricultural
regulations or varying meteorological events.

The dependent variable pesticide is specified as pesticide demand per hectare (ha). This
variable is constructed by dividing total expenditures of farmers for pesticides by the price of
pesticides pestprice. The price of pesticides is calculated as follows. First of all, we calculate the
volume of herbicides by dividing herbicide expenditures by a national annual index of herbicide
price. We do the same for fungicides, insecticides, and growth regulators. Then we sum up all
these volumes to obtain the total pesticide volume. Finally, we divide total pesticide expendi-
tures by the total pesticide volume to obtain the price of pesticides. The rapeprice variable is
calculated by dividing the rapeseed production in Euros by the production of rapeseed in kg.

3 Data description and Estimation results

3.1 Data description

The study is conducted on a sample of French farmers from the Department of Meuse. Our data
are provided by the Departmental Management Centre (Centre de Gestion de la Meuse).

First of all, let us describe the main characteristics of agricultural production in the Depart-
ment of Meuse. Agricultural land in Meuse represents 54% of the overall area: 36% is arable
land and the remaining 18% is grasslands. Both cereal production and oil crop production cover
81% of the arable land. In terms of production and cultivated area in 2006, both alimentary rapeseed and energy rapeseed represented approximately 3% of France (metropolitan). In terms of cultivated area, Meuse ranked 15th out of 96 Department of France. The Eure-Loire Department ranked first, representing 5% of all rapeseed production and cultivated area of France (metropolitan).

Our sample is an unbalanced panel of rapeseed farmers observed between 1993 and 2006. Our data set allows us to sort out this choice because it contains detailed information for numerous crops according to inputs: quantity of fertilizers (N, P, K), fertilizer expenditures, seed expenditures, total pesticide expenditures, herbicides expenditures, fungicides expenditures, insecticides expenditures, and growth regulator expenditures. Table 1 represents descriptive statistics on our sample observed between 1993 and 2006: rapeseed price, cultivated rapeseed area\(^7\), pesticide demand per ha, and pesticide price.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>rapeprice</td>
<td>Rapeseed price in Euros/kg</td>
<td>0.198</td>
<td>0.031</td>
<td>0.021</td>
<td>1.184</td>
</tr>
<tr>
<td>rapeseed area</td>
<td>Rapeseed area in are</td>
<td>2751.117</td>
<td>2204.765</td>
<td>10</td>
<td>23280</td>
</tr>
<tr>
<td>pesticide</td>
<td>Pesticide demand per ha</td>
<td>1.671</td>
<td>0.468</td>
<td>0</td>
<td>7.34</td>
</tr>
<tr>
<td>pestprice</td>
<td>Pesticide price</td>
<td>1.218</td>
<td>0.181</td>
<td>0.961</td>
<td>8.4811</td>
</tr>
</tbody>
</table>

### 3.2 Estimation results

We suspect that the log of rapeseed area (\(\ln(\text{rapeseed area}_{it})\)) is endogenous since it may be correlated with the error term. In order to decide whether it is necessary to use instrumental variable estimation methods to deal with endogeneity, we use the Davidson and MacKinnon (1993) exogeneity test to check for the endogeneity of the log of rapeseed area. An instrumental variables estimate of the pesticide demand is computed, using log of rapeseed area as potentially endogenous variable, instrumented by the lagged of the log of rapeseed area\(^8\). The test is applied, and indicates that the null hypothesis of exogeneity cannot be rejected (\(P-value = 0.6535\)).

Since our sample consists of panel data, we have to choose between a random effect and a fixed effect specification. To this end, we used the Hausman test to evaluate the null hypothesis: the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. The Hausman test results show a \(\chi^2(14) = 54.42\) with a \(P-value = 0.0000\) that suggests that the null hypothesis be rejected and that the fixed effects model results be retained. This result also suggests that the individual effects do appear to be correlated with the explanatory variables.

We have tested for heteroskedasticity and autocorrelation of errors. Using standard error estimates which ignore heteroskedasticity and serial autocorrelation in errors would lead to

\(^7\)The value presented is in "are" which is a french measure of area. It is equal to 0.025 acres.

\(^8\)The regression output is not reported here but could be provided upon request.
invalid statistical inference because it would be based on biased estimates of standard errors. We have used the test proposed by Wooldridge (2002) for autocorrelation in panel-data. The test results suggest to reject the null hypothesis of "no first-order autocorrelation" at 1% significance level ($P = 0.0000$). We have used methods which produce heteroscedasticity consistent standard errors that are also robust to temporal dependence (Wooldridge (2002)). Estimation results of the fixed and random effects models are presented in Table 2.

The results presented in Table 2 are consistent with our intuitive beliefs, confirming that farmers tend to use more pesticides in a context of high crop prices. Indeed, given our data set, our empirical results suggest that a 1% increase in rapeseed price will increase pesticide demand by 0.122%.

This estimate of the pesticide demand with respect to rapeseed price appears to be within the range of the estimates that can be found in the literature of production economics. The below mentioned estimates are obtained through models which consider the pesticide as a standard yield-increasing input, such as fertilizers. Moro and Sckokai (1999) estimate, using normalized quadratic profit functions, the elasticity estimates of seeds and chemicals together with respect to crop prices and to area payments in the context of the 1992 CAP reform. The information is from farm-level data for a northern region in Italy from 1993 to 1995. The elasticity estimates with respect to crop prices are negative for maize, other cereals, and oilseeds, but positive for other field crops (namely 0.063, with a standard error of 0.139). Williams and Shumway (2000) estimate the effects of the NAFTA trade agreement on the use of pesticides in the United States and Mexico. Estimations are carried out on aggregate multiple-input multiple-output production model. They are applied to time series between 1966 and 1991. The U.S. elasticity estimates of pesticides with respect to crop prices are negative for food grains, but positive for other field crops (namely 0.461, with a standard error of 0.158) and for feed (namely 0.063, with a standard error of 0.019).

Our results also show that the rapeseed area is significantly and positively correlated to pesticide demand. Our empirical results suggest that a 1% increase in rapeseed area will increase pesticide demand by 0.955% in our sample. Moreover, our findings show that the price of pesticides is significantly and negatively linked to pesticide demand. The estimates of the own-price elasticity of pesticides are rarely found in the literature, because this input is usually aggregated with chemical fertilizers. Few estimates concern the U.S. and the Netherlands. Our results indicate an estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718). Our estimate is within the estimates provided by the literature, which range from (-1.2) to (-0.1). For instance, Williams and Shumway (2000), in a time-series model, provide a low estimate of the own-price elasticity of pesticides of (-0.718).
elasticity of pesticides for the United States, namely (-0.247) with a standard error of (0.053). Our higher estimate can be explained by our estimation method based on panel data which implicitly takes into account the dynamics over time. Therefore, our estimate of the own-price elasticity of pesticides could be considered as a long-term one.

Finally, our estimation results show that most of the dummy variables included in the model are significant. This means that there are some omitted variables that depend on time and have an effect on pesticide demand such as agricultural regulation changes or meteorological events that could occur during the given period.

4 Summary and conclusions

In this study, we have estimated an econometric model, based on an individual panel sample of farms observed from 1993 to 2006 in the Department Meuse in France. We have tested the hypothesis that an increase in rapeseed prices increases pesticide demand, rapeseed being the principal feedstock for the production of biodiesel in France. We have equally investigated the magnitude of this demand. Our findings reveal that a 1% increase in the price of rapeseed increases pesticide demand by 0.122%. This elasticity estimate allows us to simulate the change in pesticide demand following the 50% increase in the price of rapeseed observed between 2007 and 2008 in France. Given the estimated elasticity of 0.122%, this would induce a 6.1% increase in the use of pesticides in the Department of Meuse.

This assessment of the increased use of pesticides due to the rise in rapeseed price between 2007 and 2008 is a first step toward understanding potential local environmental problems in the area under study. Since biofuel policy which promotes the development of biofuels is one of the most important factors triggering this price increase, it appears to be implicated in the deterioration of environmental conditions in Meuse. Some of these potential environmental effects include ground and surface water contamination due to the increase in pesticide use. Given that these pollution problems are cumulative and not completely reversible, the potential environmental effects of biofuel development will persist.

Our empirical results therefore lead us to question the current European Union (EU) environmental policy. On the one hand, the EU promotes the development of biofuels through various Directives. These measures contribute to an increase of biofuel crop prices which, in the framework of our model, provoke an increase in pesticide demand. One the other hand, the EU implements strict pesticide residue levels in food and feed. These two different policies have clearly conflicting effects on the use of pesticides in at least France.

This study could be extended in several ways. We plan to carry out estimations of the demand for chemical fertilizers (especially nitrogen) in order to estimate their elasticity with respect to the price of rapeseed. Future research could also apply the same analysis to other major crops in the given data base which include wheat and barley.
References


Table 2: Estimation results of the FE and RE models of pesticides demand

<table>
<thead>
<tr>
<th></th>
<th>FE</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln(pestprice_{it})$</td>
<td>-0.718***</td>
<td>-0.671***</td>
</tr>
<tr>
<td></td>
<td>(-12.14)</td>
<td>(-12.39)</td>
</tr>
<tr>
<td>$\ln(rapeprice_{it-1})$</td>
<td>0.122***</td>
<td>0.123***</td>
</tr>
<tr>
<td></td>
<td>(3.77)</td>
<td>(4.33)</td>
</tr>
<tr>
<td>$\ln(rapearea_{it})$</td>
<td>0.955***</td>
<td>0.981***</td>
</tr>
<tr>
<td></td>
<td>(78.68)</td>
<td>(127.90)</td>
</tr>
<tr>
<td>ann4</td>
<td>0.0231**</td>
<td>0.0307**</td>
</tr>
<tr>
<td></td>
<td>(1.58)</td>
<td>(2.27)</td>
</tr>
<tr>
<td>ann5</td>
<td>0.132***</td>
<td>0.131***</td>
</tr>
<tr>
<td></td>
<td>(8.82)</td>
<td>(9.53)</td>
</tr>
<tr>
<td>ann6</td>
<td>0.0921***</td>
<td>0.0904***</td>
</tr>
<tr>
<td></td>
<td>(6.21)</td>
<td>(6.77)</td>
</tr>
<tr>
<td>ann7</td>
<td>0.172***</td>
<td>0.168***</td>
</tr>
<tr>
<td></td>
<td>(11.33)</td>
<td>(12.51)</td>
</tr>
<tr>
<td>ann8</td>
<td>0.176***</td>
<td>0.172***</td>
</tr>
<tr>
<td></td>
<td>(12.61)</td>
<td>(13.76)</td>
</tr>
<tr>
<td>ann9</td>
<td>0.196***</td>
<td>0.193***</td>
</tr>
<tr>
<td></td>
<td>(12.31)</td>
<td>(13.41)</td>
</tr>
<tr>
<td>ann10</td>
<td>0.186***</td>
<td>0.187***</td>
</tr>
<tr>
<td></td>
<td>(11.77)</td>
<td>(13.09)</td>
</tr>
<tr>
<td>ann11</td>
<td>0.171***</td>
<td>0.173***</td>
</tr>
<tr>
<td></td>
<td>(11.50)</td>
<td>(12.70)</td>
</tr>
<tr>
<td>ann13</td>
<td>0.151***</td>
<td>0.156***</td>
</tr>
<tr>
<td></td>
<td>(6.86)</td>
<td>(7.74)</td>
</tr>
<tr>
<td>ann14</td>
<td>0.162***</td>
<td>0.168***</td>
</tr>
<tr>
<td></td>
<td>(10.86)</td>
<td>(12.24)</td>
</tr>
<tr>
<td>ann15</td>
<td>0.247***</td>
<td>0.250***</td>
</tr>
<tr>
<td></td>
<td>(15.70)</td>
<td>(17.27)</td>
</tr>
<tr>
<td>cons</td>
<td>0.839***</td>
<td>0.630***</td>
</tr>
<tr>
<td></td>
<td>(7.95)</td>
<td>(8.21)</td>
</tr>
<tr>
<td>$\sigma_u$</td>
<td>0.248</td>
<td>0.210</td>
</tr>
<tr>
<td>$\sigma_e$</td>
<td>0.207</td>
<td>0.207</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.589</td>
<td>0.508</td>
</tr>
<tr>
<td>$N$</td>
<td>5441</td>
<td>5441</td>
</tr>
<tr>
<td>$R^2$ Within</td>
<td>0.776</td>
<td>0.775</td>
</tr>
</tbody>
</table>

$t$ statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$