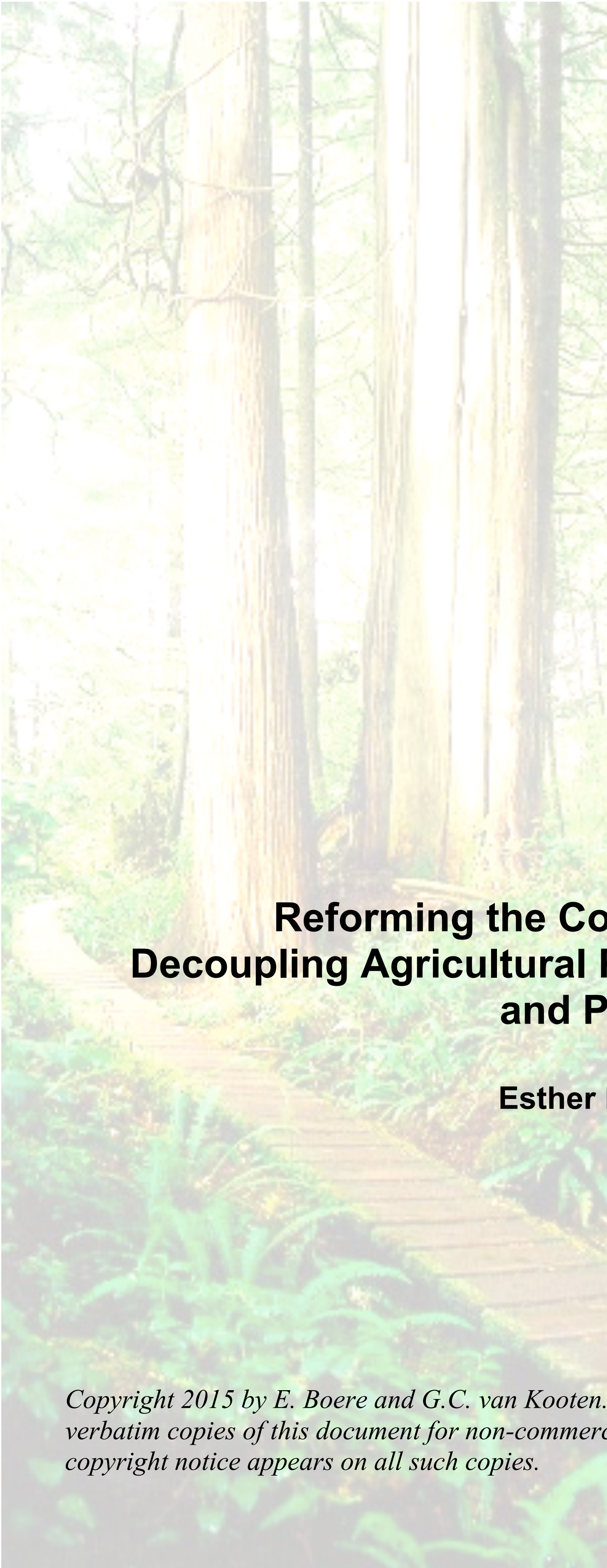

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Reforming the Common Agricultural Policy: Decoupling Agricultural Payments from Production and Promoting the Environment

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Reforming the Common Agricultural Policy: Decoupling Agricultural Payments from Production and Promoting the Environment

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Abstract

In this paper, we analyze the potential impact on producers' land-use decisions in moving from support payments based on entitlements to a single farm payment (SFP). Further, we then consider a single farm payment with a greening component as part of the 2013 CAP reform. Using data for representative crop farms of different sizes in the Netherlands, we develop a farm-level crop allocation model that is calibrated using positive mathematical programming. We use a two-step calibration method to determine a nonlinear cost function and farm-specific risk aversion coefficients. Not unexpectedly, we find that the 2013 CAP reforms will cause farmers to shift away from crops previously eligible for payments, with the initial shift under the SFP enhanced by the move towards SFP combined with green payment.

Key words: Agricultural policy and CAP reform; mathematical programming; agricultural business risk management

JEL classifications: Q14, Q18, Q17, G22

1. INTRODUCTION

Europe's Common Agricultural Policy (CAP) has increasingly focused on liberalizing markets by decoupling payments from production, and linking them to the provision of environmental services. The 1992 MacSharry reform laid the foundation for the transition from market protection and price support policies to a direct income payment system. Products receiving price support, such as cereals, oilseeds, tobacco, milk, beef and lamb, saw a reduction in levels of protection, with producers receiving direct payments in return. This transition was reinforced by the reforms that followed: Agenda 2000, the 2003 Mid-Term Review (Fischler reform), the 2008 Health Check, and, more recently, the 2013 CAP reform. Direct payments can therefore be seen as the embodiment of the move away from support measures for specific products towards less market-distorting agricultural support where subsidies are paid directly to farmers, conditional upon certain practices but decoupled from production. An important step in this direction was the 2003 Mid-Term Review that gradually introduced the Single Payment Scheme (SPS) between January 2005 and January 2007. Direct payments were decoupled from production but linked to eligible farmland, although coupling elements were retained in some programs, notably dairy, cereals, sugar beets and starch potatoes.

Under the 2003 reforms, countries could choose (1) an approach where entitlements depended on farm-specific historical reference amounts, (2) an approach where entitlements depended on the region's outcomes for establishing a reference margin, or (3) a hybrid of the historic and regional approaches (European Commission, 2014). While the European Commission expressed a preference for the regional model, the majority of countries opted for the historical one. Under the historic approach, only lands growing specific crops were considered eligible for fixed payments (€/ha) that varied by crop based on historic 2000-2002 yields; additionally, payments depended on cross-compliance measures linked to environmental standards (Helming et al., 2010). Because payments were based on farm-specific entitlements, their size differed significantly by type of farm and across farms (Helming and Peerlings, 2014).

When subsidies are completely decoupled from production, one would expect the levels of output with and without subsidies to be equal (Hennessy, 1998). However, production decisions may be affected indirectly because flat-rate payments based on historic reference amounts result in an *insurance effect*, because it provides an effective lower bound on a producer's income, and a *wealth effect*, because it increases a farmer's wealth and thereby reduces her level of risk aversion (Finger and Lehmann, 2012; Hennessy, 1998). Decoupled payments do not affect price variability and thus are not expected to have an insurance effect. Wealth effects, on the other hand, are likely to be small and producer specific, although some evidence suggests the wealth effect could still have a slight impact on crop choices (Sckokai and Moro, 2009; Koundouri et al., 2009). Wealth effects only occur under the assumption of decreasing absolute risk aversion, where the farmer becomes less risk-averse with an increasing expected payoff. Since the payoff would need to be quite large to have a significant impact on wealth in any one year, we assume that a farmer's risk-aversion is unaffected by the expected change in wealth as a result of her crop allocation choices.

Besides potential insurance and wealth effects, there is an extensive literature evaluating the other effects that the decoupled payments of the 2003 Mid-Term Review had on farmers' decisions (for a review see Bhaskar and Beghin, 2009). These include impacts on investment decisions caused by increased access to credit (Sckokai and Moro, 2009), changes in on- and off-farm labour allocations (Key and Roberts, 2009; Hennessy and Thorne, 2005), changes to inputs or other activities that would increase output (Hauser et al*.*, 2004), increased land and rental prices (Brady et al., 2009), and, related to prices, competition for land between agricultural markets (Gohin, 2006). On a broader scale, direct payments impacted land abandonment and biodiversity (Brady et al., 2009; Mosnier et al., 2009; Baskar and Beghin, 2009; Key and Roberts, 2009), affected prices/markets (Balkhausen et al., 2008; Gohin, 2006), and led to the distortion of subsidies on production (Dewbre et al., 2001; Burfisher and Hopkins, 2003). Except for the effect of decoupled payments on land prices, the impacts of all these effects tend to be rather small (Hennessy and Thorne, 2005; Sckokai and Moro, 2009; Koundouri et al., 2009; Key and Roberts, 2009), certainly in comparison to other support mechanisms (Dewbre et al., 2001; Burfisher and Hopkins, 2003). However, most changes were analysed at the national or large-region scale and not at the farm level, leading to general instead of farm-specific statements about land-use change.

The CAP reform of 2013 introduced a single farm payment (SFP) that would eventually provide the same level of support to every hectare of agricultural land within a region, independent of the type of farm or crop grown – it is a flat rate payment. In addition, producers can be compensated for providing public goods in the form of environmentally-friendly farming practices – a so-called greening component that is added to the new SFP (SFP&GP) if farmers are in compliance (European Commission, 2014). The most important restriction imposed by the greening component is a set-aside requirement referred to as the Ecological Focus Area (EFA). Estimates for the Netherlands indicate that some 12,500 farms with a total area of 670,000 hectares have to apply EFA measures to meet the greening criteria, implying 33,500 hectares of EFA (Bron et al., 2014).

The objective of the current research is to analyse the farm-specific effect that the different payment mechanisms, including the single farm payment and green payment (GP), have on land use (crop allocation) decisions. In essence, we compare the direct payment reforms on cropping decisions using the Netherlands as a case study. For the Netherlands, it is expected that the SFP will lead to a lower level of income support and an increase in income uncertainty (Helming and Peerlings, 2014). Thus, we investigate if, and under what circumstances, this implies enhanced greening practices for farms of different sizes.

We begin our analysis in the next section with a description of our crop allocation model, which employs representative farms of various sizes, followed in section 3 by a summary of the Dutch data employed in this application and how the data are used to calibrate our model using PMP. Our simulation results comparing historic, SFP and SFP&GP follow in section 4. Our conclusions ensue.

2. FARM-LEVEL CROP ALLOCATION MODELS

In deciding how to allocate her land among different uses, the agricultural producer takes into account government support payments. Three stages in the reform of direct payments for the Netherlands are indicated in Table 1. Before 2006, payments were linked to crops, leading to payments up to €9,560 for an average arable farm. Then the Mid-Term Review led to a significant but not total shift to decoupled direct payments starting in 2006. Finally, beginning 2015 direct payments were fully decoupled and are now linked to greening criteria. Our purpose is to determine the potential effect that these three stages have on the way the farmer allocates her land to various crop activities. We do this using a farm-level crop allocation model for representative Dutch arable farms of different sizes.

We assume that the producer selects the crops to plant in a way that addresses two conflicting objectives: the farmer seeks to maximize expected net returns from her land-use decision while minimizing the variance of returns. For example, the objective might be to maximize expected utility using a mean-variance approach where the expected net return is adjusted for risk. In that case, risk is defined as the variance in net returns associated with the crop portfolio multiplied by the Arrow-Pratt absolute risk aversion coefficient (discussed below). Further, we calibrate the model using positive mathematical programming (PMP) (Howitt, 1995).

Table 1: Amount and type of payments for an average arable farm in the Netherlands

Type of support	Year	Coupled payments (€)	Direct payments (€)	Size of average arable farm (ha)
CP	2001	5,340		50.7
CP	2002	7,180		51.1
CP	2003	7,900		52.7
CP	2004	9,560		53.2
CP	2005	9,310		55.1
SPS	2006	2,390	17,390	55.2
SPS	2007	2,750	18,270	57.6
SPS	2008	3,130	20,150	58.7
SPS	2009	2,840	21,880	59.4
SPS	2010	2,940	23,090	59.1
SPS	2011	3,170	24,750	59.4
SPS	2012		29,210	59.5
SFP	2013			

Source: LEI (2014a)

We begin by constructing a base farm-level crop allocation model that includes a direct payment (€/ha) based on historic entitlements that are assumed to be in place until 2012 (first stage). Then we discuss how we calibrate our crop allocation model using PMP. Finally, we describe how the model needs to be modified to take into account flat-rate direct payments (second stage) and, subsequently, direct payments that include an option for higher payments by meeting certain greening requirements (third stage). In Table 1, these are referred to as CP, SPS and SFP, respectively.

2.1 Base Model and Flat-Rate Payments

For the average arable farm in the Netherlands, the crops previously eligible to receive payments were wheat, barley and sugar beets. A farmer received the subsidy as long as her eligible land is planted to one of the eligible crops, independent of the precise distribution of crops within the eligible set (RVO, 2015). In our model and based on payments as of 2006, we employ the fixed crop-specific direct payments provided in Table 2. Sugar beets are still coupled and subject to a quota regime. Therefore, only wheat and barley can be freely allocated within the eligible hectares to receive payments. For reasons of simplicity, we model the payments in Table 2 as if they were crop-specific.

Table 2: Fixed crop-specific payment based on historic 2000-2002 yields

Crop	Payment (€/ha)
Wheat	377.5
Barley	377.5
seed potato	0
edible potato	0
sugar beet	687.0
Onions	0

Source: Hermans *et al.* (2006)

Expected income and its variance are affected by the subsidies agricultural producers receive. We assume that farmers maximize their gross margins (defined as the difference between crop revenue and identifiable variable costs), while accounting for risk in their production decisions; thus, in the current context, an arable farmer with a fixed amount of land and facing exogenous input and output prices seeks to maximize her expected utility by allocating land to various uses. Expected utility is determined by the expected overall gross margin, the variance-covariance matrix of gross margins, and the Arrow-Pratt measure of absolute risk aversion (denoted φ). The allocation problem can be specified as:

(1) $$\text{Maximize } U = \sum_{k=1}^{K} E[R_k] - \tfrac{1}{2}\,\varphi\,\sigma^2$$

Subject to:

(2) $$R_{k,t} = [p_{k,t}\, y_{k,t} - c_k(w) + SPS_k]\, x_k, \forall\, k$$

(3) $$\sigma^2 = \sum_{k=1}^{K}\sum_{i=1}^{K}\left[x_k \times CV(R_k, R_i) \times x_i\right]$$

(4) $$CV(R_k, R_i) = \frac{1}{T}\sum_{t=1}^{T}\left(R_{k,t} - E[R_k]\right)\left(R_{i,t} - E[R_i]\right), \forall k, i$$

(5) $$E[R_k] = \frac{1}{T}\sum_{t=1}^{T} R_{k,t}, \forall k$$

(6) $$\sum_{k=1}^{K} x_k \leq \overline{X}$$

where U refers to the representative farmer's utility; $\sum E[R_k]$ is the expected total gross margin from crop production; $\varphi = -U''(w)/U'(w)$, where $U(w)$ is specified as an exponential utility function of wealth w;[1] σ^2 is the risk associated with the total crop portfolio; $p_{k,t}$ and $y_{k,t}$ represent, respectively, the output price and yield for crop k in period t; SPS_k is the historic refrence payment (€/ha) for crop k; and $c_k(w)$ is the per unit-area variable cost of producing crop k as a function of exogenously-determined input prices w. $CV(R_k,R_i)$ refers to the covariance matrix, where R_i and R_k refer to the respective realized gross margins to crops i and k, and $E[R_k]$ is the farmer's expected overall gross margin (€/ha) from planting crop k; there are K crops that can be planted in any period; x_k denotes the number of hectares allocated to produce crop k; and $\overline{X}$ represents the total area (ha) the farmer allocates to crop production. Finally, T refers to the number of past years used to generate the expected gross margins and the variance-covariance matrix.

Equations (2) through (5) are accounting identities. Equation (2) calculates the gross margin accruing to each crop in each period given the allocation of land to crops, which is endogenously chosen in the model. SPS_k is included in (2) because we model payments based on entitlements as payments varying by crop. Equation (3) specifies the risk associated with the total crop portfolio, while equation (4) provides the variance-covariance matrix. Based on historic data, equation (5) calculates the expected (mean) revenue that accrues to each crop and is used in each of our model simulations. An additional constraint (6) restricts the

[1] This implies constant absolute risk aversion (CARA) as discussed below. Notice that some authors specify utility as a function of consumption or income rather than wealth, but this can be confusing in the current context as explained in the next section (compare Freund, 1956; McCarl and Bessler, 1989; Petsakos and Rozakis, 2011).

farmer's cultivated area to that which is available. In each period, the producer must decide how to allocate her $\overline{X}$ hectares among the K different crops so as to maximize utility.

2.2 Model Calibration

The PMP procedure for calibrating a model in which the objective is simply to maximize the gross margin from allocating a fixed amount of cropland to a variety of crops is now well known (Howitt 1995, 2005). The calibration procedure is first to maximize E[R], as given in equation (5), where R_k is a linear function, subject to (2), (3), (4) and (6) plus added calibration constraints (discussed below). Notice that, at this stage, linearity implies that $c_k(w)=c_k$, where c_k is the (fixed) average cost of producing crop k (€/ha); it is this average cost that is the only cost component commonly available to the researcher.

Using the 1st-stage PMP results, the linear objective function is then adjusted to include nonlinear terms (Heckelei et al., 2012). Nonlinearities might arise, for example, as a result of unobserved differences in soil quality, topography or to account for other physical attributes of the land such as crop rotation, as well as anticipated government programs, labour availability, et cetera. These unobserved attributes result in increasing marginal costs as more of a particular crop is planted on a farm (Howitt, 1995). Upon taking these factors into account, a smooth supply response can be detected, and continuous changes in land use responses can be identified by changing the (exogenous) policy variables, avoiding over-specialisation and unrealistic responses in land uses (Röhm and Dabbert, 2003).

The PMP method is somewhat more complicated when the objective is to maximize expected utility rather than the total expected gross margin. In that case, one should also calibrate the absolute risk aversion parameter. Petsakos and Rozakis (2011, 2015) provide a more complete model in which observed plantings and a covariance matrix of gross margins are needed to calibrate the crop-allocation model. Rather than assuming an exponential utility function which leads to a constant absolute risk aversion (CARA) parameter, Petsakos and

Rozakis (2015) assume a logarithmic function and thus a decreasing absolute risk aversion (DARA) coefficient that is a concave function of wealth. Specification of an initial level of wealth is required so that DARA changes in response to the farmer's cropping choices. In their application, the authors choose an initial level of wealth given by the single farm payment. However, this is more suited to the situation where the level of initial wealth is larger than that given by SFP, primarily because a producer's total wealth is not likely to change dramatically from one crop year to the next, making a normal wealth distribution more likely; if wealth is set equal to SFP, small changes in annual returns will have too great an impact on wealth. Producers face different kinds of uncertainty and increased output price volatility caused by the EU's shift towards SFP does not necessarily imply changes in the level and variance of income (Pennings et al., 2010; Moschini and Hennessy, 2001). Perceived risk may therefore depend more on the person rather than changes in wealth. As a result, and to allow comparison of the degree of risk aversion among farmers, we characterize the farmer's risk aversion by CARA rather than DARA. In this paper, we assume different farmers with varying degrees of risk aversion. In order to do so, an exponential utility function and normal distribution of wealth are required.

A method for specifying the CARA parameter φ is nonetheless still required. In the current application, we vary φ for the small, medium and large representative producers in an iterative fashion in order to come close to duplicating the observed crop allocation (see Jeder et al., 2011).[2] We begin with the standard PMP approach identified in Howitt (2005) that starts by introducing the following calibration constraints:

(7) $x_k \leq x_k^o + \varepsilon_k, \forall k,$

where the superscript denotes observed land use and ε_k are small perturbations required to

[2] This is discussed in more detail in section 3.3 below.

avoid degeneracy of the shadow prices. The calibration constraints put an upper limit on simulated land-use allocations. Since it is not possible to infer the crop specific costs as functions of input prices, cost functions $c_k(w)$ are replaced by observed average variable costs in (2). More specifically, we assume that $c_k(w)=c_k(x_k)=c_k^o$ (€/ha), or a farm-specific value set to the observed average cost of producing crop k. Thus, the cost of planting, tending and harvesting crop k is now assumed to be a function of how much land is allocated to that crop.

In the second step, the dual values associated with the calibration constraints are used to parameterize a nonlinear cost or production function; in this case a quadratic cost function is specified. The revenue function (2) becomes a function of land use as follows:[3]

(8) $$R_k(x_k) = p_k y_k - c(x_k) = p_k y_k - (\alpha_k x_k + \tfrac{1}{2}\beta_k x_k^2) + SPS_k\, x_k,$$

with $c(x_k) = \alpha_k\, x_k + \tfrac{1}{2}\beta_k\, x_k^2$ an assumed quadratic cost function. Now, for each crop, the shadow price λ_k is simply the difference between the marginal (MC_k) and average (AC_k) costs:

(9) $$\lambda_k = MC_k - AC_k = (\alpha_k + \beta_k x_k) - (\alpha_k + \tfrac{1}{2}\beta_k x_k) = \tfrac{1}{2}\beta_k x_k.$$

Given observed values for yields, crop prices, average per ha production costs and the allocation of farmland to various crops, it is possible to derive α_k and β_k from the shadow prices λ_k determined in the first step:

(10) $$\beta_k = 2\lambda_k / x_k^o \text{ and } \alpha_k = c_k^o - \lambda_k - SPS_k.$$

In the third step, the calibration constraints are removed; i.e. $c(x_k)=c_k^o$ is replaced by $c(x_k)$, and φ is varied until it exactly duplicates observed land allocation. Given the parameterized objective function and the farm-specific value for φ, it is now possible to simulate changes to the policy variables. The revised revenue equation used in place of equation (2) is:

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[3] The subscript t has been dropped as we calibrate the model to land uses observed in our base year.

(11) $$\sum_{k=1}^{K} R_k = \sum_{k=1}^{K} \left[p_k y_k - (\alpha_k + 0.5\beta_k x_k) + SPS_k \right] x_k \ .$$

3. DESCRIPTION OF THE MODEL FARMS

In this section, we first examine the data and then present the results of the PMP analysis using a trade-off function that gradually increases the risk-aversion coefficient for the representative crop farms of different sizes under payments based on entitlements.

3.1 Data and Descriptive Statistics

Our study focuses on representative arable farms of different sizes in the Netherlands that have a mixed crop portfolio. We use the Farm Accountancy Data Network (FADN) to select representative small, medium and large farm sizes. For each of our representative farms, farm specific land allocations, prices, yields and costs are reported in Table 3. Because the FADN employs a representative sample of farms, it was not possible to gather historic data per representative farm. Thus, we took a sample of farms within the farm size classes to establish historic prices, yields and costs for the three representative farms.

Farm specific data from the FADN (LEI, 2014b) for the period 2000 through 2012 were used to measure annual variations in prices, yields and costs. Variable costs were calculated by crop per hectare and include costs of seed, pesticide, fertilizer, energy and other costs for crop activities. Given available yield and price data, net revenues were calculated for all cropping activities. A summary of net revenues and their variances for 2012 is also found in Table 3. By employing information from the PMP calibration, we establish farm plans for each of the representative farms to use for simulating different scenarios for direct payments as part of the CAP reform.

Table 3: Land allocations, yields, prices, costs and revenues and their variance for the small, medium and large farm.

Crop	Observed ha	Yield (100 kg/ha)	Price (€/100 kg)	Variable cost (€/ha)	Gross margin (€/ha) [a]	Variance gross margin (€/ha)
SMALL						
wheat	10.45	78.4	22.91	911.59	884	390,468
barley	5.06	63.08	22.54	564.34	858	125,037
potato	10.55	387.09	17.29	2,174.90	4,519	1,561,499
sugar	8.15	773.61	6.07	1,160.29	3,539	354,382
Onion	5.72	748.5	11.51	2,388.67	6,223	7,926,375
Total	**39.93**					
MEDIUM						
Wheat	19.31	86.1	24.23	647.25	1,439	131,076
Barley	10.8	75.45	23.62	489.11	1,293	107,267
Potato	12.68	424.94	18.87	2,357.02	5,660	2,255,007
Sugar	8.83	803.63	6.22	1,080.62	3,920	350,510
Onion	7.79	629.73	11.62	2,184.60	5,131	8,203,962
Total	**59.41**					
LARGE						
Wheat	35.02	88.6	23.63	593.23	1,500	126,251
Barley	14.97	73.52	24.96	387.34	1,448	109,852
Potato	26.37	455.72	18.94	2,253.42	6,379	1,740,431
Sugar	17.08	794.51	6.39	993.48	4,083	447,065
Onion	13.09	579.3	10.98	2,227.38	4,133	6,841,132
Total	**106.53**					

Source: Farm Accountancy Data Network (LEI, 2014b)

[a] Farmers initially receive payments based on entitlements which have not yet been included.

3.2 PMP calibration

To model our various scenarios, we develop a mathematical programming model in GAMS (Rosenthal, 2008). We begin by maximizing the overall gross returns subject to technical and observed land-use calibration constraints of the representative farms (Table 3). The gross margin is calculated for each crop as price × yield minus variable cost using the data in the table. In Table 4 we provide the estimated slope coefficients, but only for four PMP activities as barley continues as a non-marginal (linear) activity for all farm sizes as its calibration constraint was not binding (λ_b=0).

Table 4: Calibrated slope (β) coefficient for the small, medium and large farms

Crop	Small	Medium	Large
Wheat	27.07	145.93	52.67
Barley	0	0	0
Potatoes	3656.63	3991.08	4552.7
Sugar beets	2681.14	2934.44	2945.22
Onions	5365.31	3462.34	2308.11

For barley, outside information is needed to distinguish between average and marginal cost. Following Howitt (2005, pp.88-91), we employ the elasticity of land supply with respect to output price: $\eta_s = (\partial q/\partial p)\ (p/q) = (\partial x_b/\partial MC_b)\ (p_b/x_b^o)$, where x_b^o is the observed land in barley and p_b is the output price for barley. Recall from (9) that $MC_k = \alpha_k+\beta_k x_k$, so $\partial MC_b/\partial x_b = \beta_b = p_b/(\eta_s \times x_b^o)$. Now define an adjustment at x_b^o that is added to the LP average cost to obtain a nonlinear cost function: $Adj = MC - AC = ½\ \beta_b\ x_b^o = p_b/2\eta_s$. If the adjustment applies to the marginal activity – the activity whose calibration constraint is not binding – then the PMP values for the non-marginal activities (whose calibration constraints are binding) must also change as follows:

(12) $\hat{\lambda}_k = \lambda_k + Adj.$

The choice of value for the elasticity of land supply for the non-marginal activity differs between studies, even for the same crops (Jongeneel, 2000; Sahlhofer, 2000; Helming, 2005; Helming and Peerlings, 2014). Following Salhofer (2000), who indicates that elasticities of land supply must be between 0 and 1, and based on a previous study using the same period and study area, we choose $\eta_s = 0.174$ for barley with respect to land (Boere et al., 2015). The farm-specific results for $\hat{\lambda}_k$, α_k and β_k that are obtained after re-calibration of the PMP model are presented in Table 5.

Table 5: Shadow prices and PMP calibrated marginal cost functions for the average farm, with one remaining non-PMP calibrated land use[a]

	Small			Medium			Large		
Crop	λ	α	β	λ	α	β	λ	α	β
Wheat	4113	-3201	787	5267	-4620	545	5326	-4733	304
Barley	4086	-3521	1616	5121	-4632	949	5273	-4886	705
Potatoes	7742	-5567	1468	9112	-6755	1437	9826	-7572	745
Sugar beets	6767	-5607	1660	8056	-6975	1824	8218	-7225	962
Onions	9451	-7062	3304	8583	-6399	2203	7581	-5354	1158

[a] Recall that $MC_k = \alpha_k + \beta_k x_k$, where λ_k is the shadow price of the calibration equation for crop *k* determined from GAMS and α_k and β_k are derived using equation (11). In doing so, SPS was added to α_k and then used to calculate β. The shadow price for total land use is the shadow price found for the total land use constraint. Values are in €/ha.

3.3 Revenue-Variance Trade-offs under Varying Levels of Risk-Aversion

Next, we construct a frontier based on the model described above where we vary the level of the risk coefficient from very low to very high values, each time finding the related revenue and variance of revenue. The resulting frontiers for the representative small, medium and large farms are shown in Figure 1, but with risk measured as standard deviation. If the farmer has a very low risk-aversion coefficient, and focuses primarily on maximizing revenue, she is at the upper right of her frontier. If the farmer places much more emphasis on minimizing risk, she is at the bottom left of her frontier. The total difference in potential revenue between these two points is less than 1%, 9% and 4% for the small, medium and large farms, respectively, indicating that a very small reduction in income leads to a relatively large increase in the risk coefficient. The corresponding optimal planting strategies change gradually as the risk coefficient changes, as indicated in Figure 2 below.

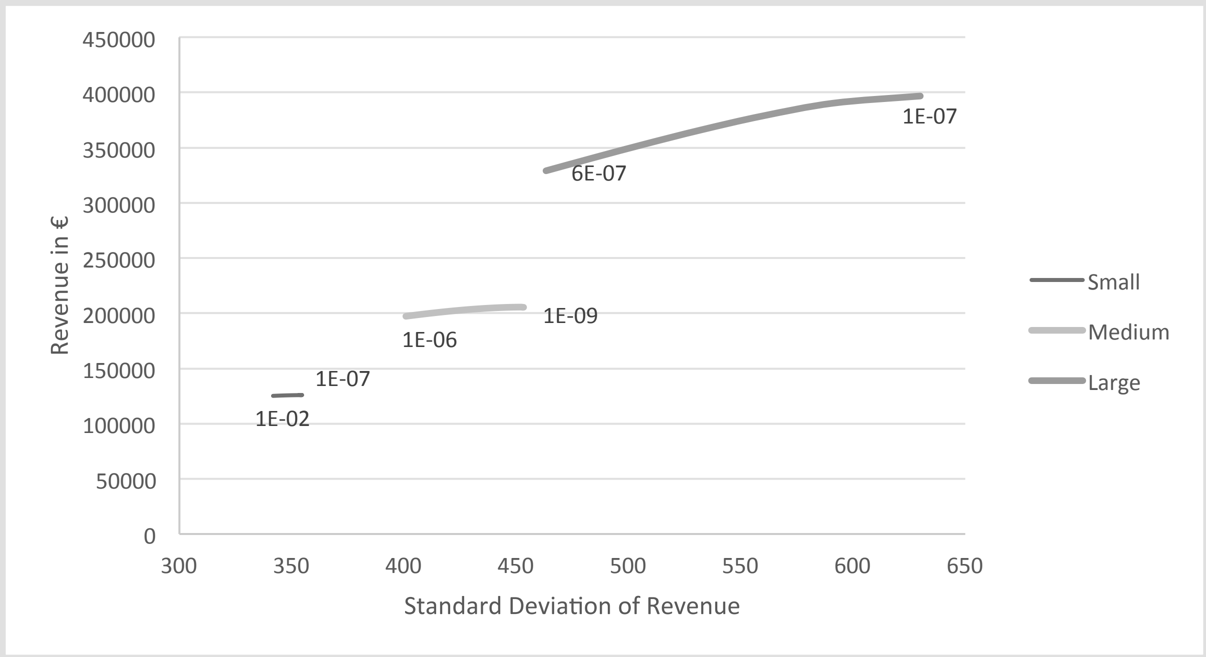

Figure 1: Trade-off between Revenue and Standard Deviation at given levels of risk aversion for representative small, medium and large farms

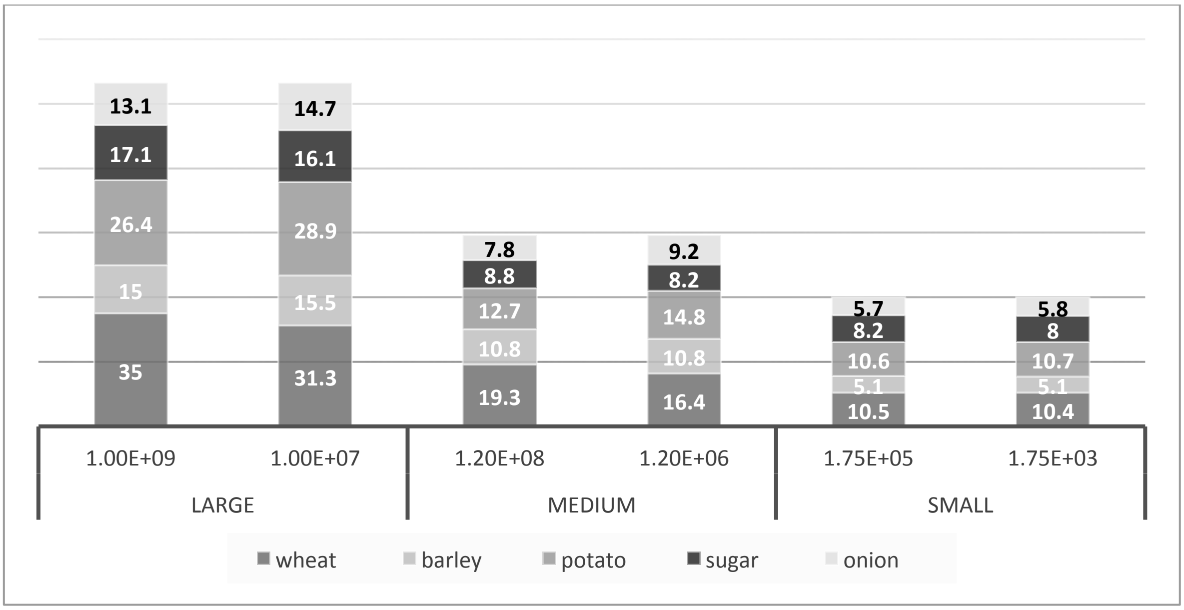

Figure 2: Changes in land use: Comparison of a producer's objective of maximizing revenue and minimizing variance for a small, medium and large farms (ha)

If we knew a producer's utility function (or aversion to risk), we would be able to identify the optimal allocation of land to various crops. In step 3 of the PMP model, we calibrate the risk coefficient by iteratively increasing the value of φ to the point where it begins to impact the calibrated (observed) crop allocation. The objective function in equation

(1) then includes calibrated costs in E[R_k] and the maximum possible value for φ that still retains the observed land allocation. For small, medium and large farms, we find respective values of 17.5×10^{-6}, 0.012×10^{-6} and 0.001×10^{-6} for the absolute risk aversion coefficient. The risk aversion coefficient of the small farm is much larger than that of the medium and large farms, whereas the risk aversion coefficient differs to a much lesser extent between the medium and the large farm. The differences in coefficients are as expected. The risk aversion coefficient of a small producer is greater than that of a large producer, suggesting that the absolute risk aversion coefficient does indeed decline with increasing wealth.[4] In their seminal paper, McCarl and Bessler (1989) suggested an upper bound on φ might be as follows: $\varphi \leq 5/\sigma_R$, where σ_R is the standard deviation of gross margin. Using data for an average farm of 60 ha and the associated allocation of crops (with 1/3 of the land planted to wheat), and based on yield and price data for 2000-2012, we find $\varphi = 0.00009$ as the upper bound. The values for the small, medium and large farms are all well below this threshold.

Moving away from values of φ that still retain the observed land allocation towards larger values of φ will result in a change in land allocation. As an agricultural producer becomes increasingly risk averse, the primary change in land use is away from wheat and sugar beets towards potatoes and onions, and this is true for each of the three representative farms, as can be seen from Figure 2. The relative increase in potatoes and onions compared with wheat and sugar beets is largest for the medium farm, then for the large farm, and finally for the small farm.

[4] Because our 'calculation' of the risk coefficient follows the PMP calibration, the actual value of farmers' risk aversion coefficients is likely different from that estimated here because the calibration method may account for some risk considerations. Nonetheless, along with the calibrated cost functions, the risk coefficients we use enable us to duplicate the observed land uses for each farm size almost exactly.

4. SINGLE FARM AND GREEN PAYMENT

As the CAP changes, payments based on historic entitlements are to evolve into a per-hectare, flat-rate payment that is invariant to crop choice – the Single Farm Payment (SFP). Previously, entitlements were based on the cultivation of specific crops in the reference period (Table 2). In the scenarios that follow, we first assume a shift from direct payments tied to crop choice to direct payments independent of crop choice, and then from direct payments independent of crop choice to direct payments with a greening component. In all cases, our objective is to determine impacts on income and land use decisions.

4.1 Single Farm and Greening Payment Scenario

As part of the 2013 reforms starting in 2015, all producers in the Netherlands will receive a new entitlement based on the size of their operation, which amounts to about €270 per hectare (Dutch Government, 2014).[5] In addition, 30% of a nation's agricultural support budget is to be reserved for environmentally friendly practices (European Commission, 2014). For the Netherlands, this implies an additional payment of some €120 per hectare if the producer meets certain greening requirements (Dutch Government, 2014). An arable producer with more than 30 hectares of land must meet three basic practices to qualify for the green payment (RVO, 2015).

1. The producer must maintain permanent grassland, defined as land that has been in pasture for at least five years. In practice, arable farms in the Netherlands only keep 'permanent' grassland if the land is not suited to cultivation, which implies that the farmer's opportunity costs associated with this land are lower than for other cropland. Although grassland is integral to many crop rotation systems, it is generally not held in that state for more than five years. Hence, we do not address this greening option here,

[5] Note that the SFP based on the payments in Table 1 and the observed land allocation for the average farm (see Table 3 below) would be €282.60 per ha.

focusing instead on the other greening criteria. At a national level, permanent grassland is not allowed to drop below 95% of its 2012 reference level; since we focus on the individual farmer, this objective is also not addressed here.

2. The producer must diversify her crop portfolio. For farms with at least 30 hectares of cropland, this requires that the producer must (1) cultivate at least three crops, with (2) the largest crop planted to no more than 75% of the land and (3) the largest two crops accounting for no more than 95% of land in cultivation.
3. At least 5% of cropped land must be set-aside for purposes such as field margins and buffer strips that are eligible as part of the ecological focus area (EFA). From 2017 this may increase to 7% (European Commission, 2014).

The exact interpretation of the three basic practices is likely to vary by country, especially concerning the EFA. We assume that farmers have to set-aside 5% of their agricultural land independent of any positive or negative compensation to the area set aside, and that they must satisfy the diversification criteria in order to be eligible for a green payment.[6]

If the farmer meets the crop diversification and set-aside EFA criteria, the SFP will be €390/ha (= €270/ha + €120/ha). In the future, however, farmers might be penalized (witness a reduction in basic payments) if the greening criteria are not met; in essence, the producer would only receive green payments if she complies with crop diversification requirements and satisfies the EFA. To take these conditions and payments into account in our model, the revised revenue equation (2) is written as:

(13) $R_{k,t} = [p_{k,t}\, y_{k,t} - c_k(w) + SFP + \delta\, GP]\, x_k,\ \forall\, k.$

[6] Because the green payment applies to all cropland, it would seem that farmers would always seek to qualify for it. To determine whether it would actually be beneficial for the farmer to qualify, it will be necessary to include these three constraints along with an ‘if condition’ in the programming model that we develop below.

where *SFP* and *GP* were defined earlier, and δ is a binary variable indicating whether the EFA requirement is satisfied (δ=1). In addition, the following three constraints are need to model the greening requirements:

(14) $$x_k \leq 0.75\left(\overline{X} - x_{efa}\right),$$

(15) $$x_k + x_i \leq 0.95\left(\overline{X} - x_{efa}\right),\ \forall\ x_k \neq x_i, \text{ and}$$

(16) $$x_{efa} \geq 0.05\,\overline{X},$$

where x_{efa} refers to the area set-aside as part of the ecological focus area. The third crop diversification requirement, cultivating at least three crops, is automatically satisfied via equations (12) and (14), because the largest two crops cannot account for more than 95% of total cultivated area, and the farmer wants to maximize risk-adjusted revenue. Objective (1) is now maximized subject to equations (3)-(6), (12) instead of (2) or (11), and (13)-(15), while retaining the PMP-calibrated cost function and values of the absolute risk aversion coefficient of the base scenario.

4.2 Simulating the effect of a Single Farm and Greening Payment

As explained in section 2, we first simulate a move from direct payments tied to crop choice and then to direct payments that are independent of crop choice. We then simulate a move from direct payments independent of crop choice to direct payments including greening payments. We simulate the results for farms of different sizes with land-use allocations as displayed in Table 3. First, rather than the payments based on entitlements indicated in Table 1, we now assume that our representative farmers are paid €270/ha, independent of whether they comply with the greening criteria. For the simulations, we assume that changes can only be made to the crop allocation and not to the cropping intensity (e.g., greater use of fertilizer). The land use allocations under different policy scenarios for farms of different sizes are provided in Table 6.

When moving from payments based on historic reference amounts to the single farm payment without greening criteria, only small changes in land allocation are observed and only for medium and large farms (Table 6). For the medium and large farms this leads to a slight decrease in the area allocated to wheat, barley and sugar beet and a slight increase in the area allocated to potatoes and onions. This is as expected, because it indicates a move away from those crops that were eligible for entitlements, towards crops that were not eligible (see Table 1). The largest increase, albeit still very limited, is observed for onions (about 2%), but area planted to potatoes also increases by about 1.6% for both medium and large farms. The largest decrease (2.2%) is observed for sugar beets, the crop where a quota regime is still present.

Table 6: Land use allocation under different policy scenarios for farms of different sizes[a]

	Small			Medium			Large		
Crop	Base	SFP	GP	Base	SFP	GP	Base	SFP	GP
wheat	10.45	10.45	9.72	19.31	19.21	18.02	35.02	34.81	32.61
barley	5.06	5.06	4.70	10.80	10.74	10.05	14.97	14.88	13.92
potato	10.55	10.55	10.16	12.68	12.90	12.45	26.37	26.79	25.89
sugar	8.15	8.15	7.80	8.83	8.63	8.28	17.08	16.69	16.00
onion	5.72	5.72	5.55	7.79	7.94	7.64	13.09	13.36	12.78
EFA			2.00			2.97			5.33
Total	39.93	39.93	39.93	59.41	59.41	59.41	106.53	106.53	106.53

[a] SFP represents the 2013 EU-CAP reform flat-rate or single farm payment of €270/ha and a potential green payment of €120/ha. GP represents the crop allocation if the farmer adopts greening practices.

The move from a SFP to one that includes a GP is more profound. In absolute terms, a decrease in land allocation is observed for all crops. Naturally, this is linked to the 5% set-aside which is required to be eligible for green payments. However, some crops experience larger relative decreases than others. A further move away from wheat and barley towards sugar beet, potatoes and onions is observed. The relative shift is about equal between farm sizes, with a slightly larger change for small farms. The crop-diversity requirement of the green component does not have any effect on the farmer's land allocation because crop diversity was already a common practice among producers of all sizes, a conclusion reached by Mosnier et al. (2009) as well.

If a farmer is concerned only with revenue, the shift from payments based on historic entitlements towards SFP, and from SFP towards SFP with GP, would make her worse off (Table 9). However, the shift from SFP towards SFP with GP leads to an increase in gross revenue between 7.8% and 8.5%. When accounting for risk however, GP may lead to larger benefits for the farmer in terms of a larger level of utility. Hence, the additional GP income generated is likely to offset the income lost by setting aside 5% of the land; that is, the opportunity costs of setting aside farmland are lower than the GP compensation.

Table 7: Changes in gross revenue under different policy scenarios for farms of different sizes.

	Small			Medium			Large		
Crop	Base	SFP	GP	Base	SFP	GP	Base	SFP	GP
wheat	13,183	12,066	15,181	35,077	33,376	39,314	78,970	62,745	73,609
barley	6,252	5,701	7,213	18,041	17,088	20,465	32,979	26,029	30,699
potato	47,675	50,506	52,773	71,769	74,472	77,403	168,214	173,908	179,852
sugar	32,772	31,027	32,887	39,965	37,726	39,849	87,723	75,791	79,904
onion	35,596	37,163	38,292	39,970	41,609	43,460	54,101	56,740	60,101
EFA	0	0	779	0	0	1,158	0	0	2,077
Total	135,478	136,463	147,125	204,823	204,271	221,649	421,988	395,213	426,242

The small changes in land allocation we find are in line with the estimated impact of partial decoupling under the 2003 Mid-Term Review; most authors found that it had at most only a modest impact on crop allocation decisions (Helming and Peerlings, 2014; Mosnier et al., 2009; Sckokai and Moro, 2009). Where there was a change, the effects were as predicted – a reallocation of land use away from crop activities that did not receive direct payments under the historical reference scenario, namely, reduced plantings of potatoes and onions.

For the 2013 reforms, we find shifts of a similar magnitude, but then in the opposite direction as incentives no longer disadvantage the planting of these crops. In addition, we find that the introduction of a single flat-rate payment (SFP) along with GP leads to a further relative decline in the area cultivated to cereals. This corresponds with previous research at a regional scale (Balkhausen et al., 2008; Koundouri et al., 2009; Solazzo et al., 2014). The fact that changes are small may also be explained by crop rotation requirements that are inherently incorporated in the PMP calibration.

With respect to the specific greening component measures, diversification measures do not influence a farmer's crop allocation decisions due to crop rotation schemes, while environmental set-aside requirements do substantially alter farm income and the farm plan. For farms of all sizes, the hypothesized green payment of €120/ha appears to compensate for lower revenues caused by set-aside of land, confirming results by Solazzo et al. (2014). The EFA requirements will lead to a relatively larger use of the most profitable crops, hence reducing the amount of land devoted to cereals and sugar beets. Furthermore, grassland and set-aside land benefit from the CAP reform, reducing the area allocated to crop cultivation. Taking into account the possibility for land that is not cultivated is therefore of importance in modelling the 2013 CAP-reform (Balkhausen et al., 2008).

5. CONCLUSION AND DISCUSSION

Coupled support has slowly been replaced by support linked to land-entitlements with limited coupling, and, finally, to support that is decoupled from the choice of crop activities, with more emphasis on environment-friendly practices (Helming et al., 2010). The objective of this paper was to analyse different forms of direct payments, including green payments, in terms of their effects on land use (cropping) decisions. More specifically, we analysed if, and under what circumstances, this implies a shift towards more ecologically-sensitive land-use practices for farms of different sizes. Thus, we compared single (flat-rate) farm payments with and without a greening incentive, as described in the December, 2013 agreement on CAP reform, with the payment system based on historic entitlements. To do so, we developed a mathematical programming model that was calibrated using positive mathematical programming, and maximized utility of different representative producers by selecting various crop (land-use) allocations.

The change from payments based on entitlements to flat rate payments is both crop and farm specific, as also determined by Sckokai and Moro (2009) using econometric analysis. The policy shift is crop specific because previously ineligible crops are now included in the agricultural support scheme. The changes are farm specific because responses to changes in EU farm policies depend on a farmer's utility, with more risk-averse farmers unlikely to modify their cropping decisions and less risk-averse ones more willing to reallocate land among crops. This has been shown by tracing back farm-specific risk coefficients that differ significantly across farm sizes, and thus potentially wealth. Moreover, in the case of a policy change, less risk-averse farmers (owning larger farms) make larger changes to land allocation than more risk-averse ones (with smaller farms).

We assumed farm-specific, constant absolute risk aversion coefficient. This implied that we did not account for wealth effects, where the producer is more willing to plant crops with higher, but riskier returns when her expected gross margin was larger. Instead, we focused on risk-aversion that is inherent to the farm itself. Hence, the change from a historic to a flat-rate payment affects the shadow price of land for some types of farmers more than others, which in turn affects the producer's crop allocation. However, the shift from cereals to potatoes may also be explained as a wealth effect, where the increasing effect of direct payments on income makes producers less averse towards production risk, leading to alterations in the crop portfolio (Koundouri et al., 2009; Sckokai and Moro, 2006; Burfisher and Hopkins, 2003).

Because of the complex and uncertain nature of the direct payments, we had to assume that entitlements, though not entirely crop specific, were based on the land allocated to cultivated crops eligible for payments in a certain reference period. Hence, our model might overestimate the crop-specific effects. In addition, while the rules and regulations of the new direct payment system are determined at the EU level, their interpretation is country specific, which might make our results less applicable more generally. Finally, research into the biodiversity aspects of crop cultivation is necessary to investigate to what extent the increased shift towards potatoes and onions and away from cereals might offset the ecological benefits obtained from the ecological focus area. Despite these uncertainties, however, the effects on crop strategies found here are likely to remain.

REFERENCES

Balkhausen, O., Banse, M., and Grethe, H. (2008). Modelling CAP Decoupling in the EU: A Comparison of Selected Simulation Models and Results. *Journal of Agricultural Economics* 59(1): 57-71.

Bhaskar, A. and Beghin, J.C. (2009). How Coupled are Decoupled Farm Payments? A Review of the Evidence. *Journal of Agricultural and Resource Economics* 34(1): 130-153.

Boere, E., Peerlings, J., Reinhard, S., Kuhlman, T., and Heijman, W. (2015). Effects of output price volatility on agricultural land-use change. *New Medit* (3). Forthcoming.

Brady, M., Kellermann, K., Sahrbacher, C., and Jelinek, L. (2009). Impacts of Decoupled Agricultural Support on Farm Structure, Biodiversity and Landscape Mosaic: Some EU Results. *Journal of Agricultural Economics* 60: 563-585.

Bron, J.C., Engwerda, J. and Vermaas, M. (2014). Gewasteelt kan in focusgebied. Keuze beperkt bij vergroening. *De boerderij*. June 11, 2014: 8-11.

Burfisher, M.E., and Hopkins, J. (2003). Decoupled Payments: Household Income Transfers in Contemporary U.S. Agriculture. Agriculture Economic Report No. 882. Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture.

Dewbre, J., Anton, J. and Thompson, W. (2001). The transfer efficiency and trade effects of direct payments. *American Journal of Agricultural Economics* 83(5): 1204–1214.

Dutch Government. (2014). *De toekenning van de betalingsrechten.* http://www.hetlnvloket.nl/onderwerpen/gemeenschappelijk-landbouwbeleid/dossiers/dossier/nieuw-gemeenschappelijk-landbouwbeleid/de-toekenning-van-de-betalingsrechten. Accessed May 2014Esselink, W. (2013). DR: 2014 peiljaar voor overgangsregeling GLB, *De Boerderij*. August 15, 2013. http://www.boerderij.nl/Home/Nieuws/2013/8/DR-2014-peiljaar-voor-overgangsregeling-GLB-1335862W/. Accessed October 2014.

European Commission (2014). Regulation No. 1307/2013 of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and amending Annex X to that regulation. C(2014) 1476 final. http://ec.europa.eu/transparency/regdoc/rep/3/2014/EN/3-2014-1476-EN-F1-1.Pdf. Accessed August 2014.

Finger, R., and Lehmann, N. (2012). The influence of direct payments on farmers' hail insurance decisions. *Agricultural Economics* 43: 343-354.

Freund, R.J., (1956). The Introduction of Risk into a Programming Model, *Econometrica* 24(3): 253-263.

Gohin, A. (2006). Assessing the CAP reform: Sensitivity of modelling decoupled policies. *Journal of Agricultural Economics* 57: 415–440.

Hauser, R.J., Sherrick, B.J. and Schnitkey, G.D. (2004). Relationships among government payments, crop insurance payments and crop revenue. *European Review of Agricultural Economics* 31: 353-368.

Heckelei, T., Wolfgang, B. and Zhang, Y. (2012). Positive Mathematical Programming Approaches – Recent Developments in Literature and Applied Modelling. *Bio-based and Applied Economics Journal* 1: 1-16.

Helming, J.F.M. (2005) A model of Dutch agriculture based on Positive Mathematical Programming with regional and environmental applications. Dissertation, Mansholt Graduate School of Social Sciences, Wageningen University, Wageningen, NL.

Helming, J., Oudendag, D. and Zimmerman, A. (2010). Common Agricultural Policy Regionalized Impact – The Rural Development Dimension. Seventh Framework Program. Project No.: 226195. Deliverable 3.3.4. http://www.ilr.uni-bonn.de/agpo/rsrch/capri-rd/docs/D3.3.4.pdf. Accessed August 2014.

Helming, J. and Peerlings, J. (2014). Economic and environmental effects of a flat rate for Dutch agriculture. *NJAS* 68: 53-60.

Hennessy, D.A. (1998). The Production Effects of Agricultural Income Support Policies under Uncertainty. *American Journal of Agricultural Economics* 80: 46-57.

Hennesy, D.A. and Thorne, F.S. (2005). How decoupled are decoupled payments? The evidence from Ireland. *EuroChoices* 4(3): 30-35.

Hermans, T., Naeff, H. and Terluin, I. (2006). Ruimtelijke neerslag van GLB-betalingen in Nederland. Wageningen, Alterra. (In Dutch).

Howitt, R.E. (1995). Positive Mathematical Programming. *American Journal of Agricultural Economics* 77: 329-342.

Howitt, R.E.. (2005). *Agricultural and Environmental Policy Models: Calibration, Estimation and Optimization*. Davis, CA: University of California. http://aoatools.aua.gr/pilotec/files/bibliography/Agricultural_and_Environmental_Policy Models(Master_Book)-3976680193/Agricultural and Environmental Policy Models(Master_Book).pdf. [accessed February 10, 2015].

Jeder, H., Sgfhaier, M. and Louhichi, K. (2011). Impact of water pricing policy on the sustainability of the irrigated farming systems: A case study in the south-east of Tunisia. *New Medit*, 10(1): 50–57

Jongeneel, R.A. (2000). The EU's grains, oilseeds, livestock and feed related markets complex: welfare measurement, modelling, and policy analysis. PhD thesis. Wageningen University, Wageningen. pp. 160.

Key, N. and Roberts, R. (2009). Nonpecuniary benefits to farming: Implications for supply response to decoupled payments. *American Journal of Agricultural Economics* 91(1): 1-18.

Koundouri, P., Laukkanen, M., Myyrä, S. and Nauges, C. (2009). The effects of EU agricultural policy changes on farmers' risk attitudes. *European Review of Agricultural Economics* 36(1): 53-57.

LEI, (2014a). Agricultural and Horticultural Statistics at http://www.lei.wur.nl/NL/statistieken/Land-+en+tuinbouwcijfers/. Accessed December 2014.

LEI, (2014b). Farm Accountancy Data Network (FADN). http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/lei/Statistics/Binternet-1.htm. Accessed December 2014.

McCarl, B.A. and Bessler, D.A. (1989). Estimating an Upper Bound on the Pratt Risk Aversion Coefficient when the Utility Function is Unknown, *Australian Journal of Agricultural Economics* 33(1): 56-63

Moschini, G. and Hennessy, D.A. (2001). Chapter 2 Uncertainty, risk aversion, and risk management for agricultural producers. In: Handbook of Agricultural Economics: Volume 1. Elsevier Science B.V, 87-152.

Mosnier, C., Ridier, A., Képhaliacos, C. and Carpy-Goulard, F. (2009). Economic and environmental impact of the CAP mid-term review on arable crop farming in South-western France. *Ecological Economics* 68: 1408-1416.

Pennings, J., Garcia, P., and Oskam, A. (2010). Private market and price stabilisation methods. In A. Oskam, G. Meester and H. Silvis (eds), *EU policy for agriculture, food and rural areas.* Wageningen: Wageningen Acedemic Publishers, 183-189.

Petsakos, A. and Rozakis, S. (2011). Integrating Risk and Uncertainty in PMP Models. Paper presented at the EAAE Congress, August 30 to September 2, Zurich, Switzerland.

Petsakos, A. and Rozakis, S. (2015). Calibration of Agricultural Risk Programming Models, *European Journal of Operational Research* 242: 536-545.

Röhm, O. and Dabbert, S. (2003). Integrating Agri-Environmental Programs into Regional Production Models: An Extension of Positive Mathematical Programming. *American Journal of Agricultural Economics* 85: 254-265.

Rosenthal, R.E. (2008). GAMS – A User's Guide. Washington, DC: GAMS Development Corporation.

RVO (2015). Gemeenschappelijk landbouwbeleid nieuw GLB. https://mijn.rvo.nl/gemeenschappelijk-landbouwbeleid-nieuw-glb. Accessed 04-03-2015.

Salhofer, K. (2000). Elasticities of Substitution and Factor Supply Elasticities in European Agriculture: A Review of Past Studies. Diskussionspapier Nr. 83-W-2000. Wien, DE: Institut für Wirtschaft, Politik und Recht, Universität für Bodenkultur.

Sckokai, P. and Moro, D. (2006). Modeling the Reforms of the Common Agricultural Policy for Arable Crops under Uncertainty. *American Journal of Agricultural Economics* 88: 43-56.

Sckokai, P. and Moro, D. (2009). Modelling the impact of the CAP Single Farm payment on farm investment and output. *European Review of Agricultural Economics* 36(3): 395-423.

Solazzo, R., Donati, M., Arfini, F., and Petriccione, G. (2014). A PMP model for the impact assessment of the Common Agricultural Policy reform 2014-2020 on the Italian tomato sector. *New Medit* 13(2): 9-19.