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Title: **Common Agriculture Police in the EU, Direct Payments, Solvency and Income.**

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Purpose: This study examines the impact of direct payments, which include all subsidies, of the EU's Common Agriculture Policy (CAP) on agriculture income as measured by the net value added. We also control for solvency. Despite the magnitude of CAP on the EU budget, few studies investigate the impact of direct payments on income in the aftermath of the financial crisis. This is surprising given the importance of agriculture for the economic recovery of the EU that remains anaemic more than a decade post the crisis.

Design/methodology/approach: We employ agriculture data for all twenty-eight EU Member States. The data comes from the public Farm Accountancy Data Network (FADN) of the EU. In terms of methodology we employ panel regression and panel Vector Autoregression analysis (panel VAR) to take into account possible endogeneity issues.

Findings: The reported panel regressions, impulse response functions (IRFs) and variance decompositions (VDCs) show that agriculture income has been subdued due to negative shocks in direct payments and solvency. Our results do not support the hypothesis that higher direct payments would increase agriculture income. In addition, whilst solvency subdues agriculture income, investment asserts a positive impact on agriculture income.

Research limitations/implications: Further research on the impact of direct payments of CAP on EU agriculture is warranted at a disaggregate level so as to examine whether there is variability in the underlying interlinkages at regional level.

Practical implications: As a policy implication, and in light of the ongoing reform of the EU's CAP, we would propose to raise net value added in agriculture using targeted income support to small and medium-sized farms. The European Economic Recovery Plan (EERP) would be also supportive. In addition, further enhancing financial integration across the EU would provide funds for investment in agriculture.

Originality/value: This paper shows that direct payments of CAP are not panacea for the EU agriculture.

Keywords: EU Common Agriculture Policy, Direct Payments, Net Value Added, panel VAR.

Article Type: Research paper

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1. Introduction

Following the financial meltdown in 2008, a plethora of studies, mostly focusing on the financial industry or the macroeconomy, offered insights over what caused the crisis and over the economic policy interventions that followed (see for reviews Gordon, 2015; Lo 2012). Agriculture has been rather overseen in the aforementioned investigations, though its importance is unequivocal. Clearly, the EU agriculture has not been immune from the credit crunch that the financial crisis caused. However, few studies (Petrick and Kloss, 2013; Petrick and Kloss, 2012 and Pietola, et al. 2011 are notable exceptions) inquire how agriculture was affected by the financial crisis.

In particular, there is limited research on the EU agriculture income, as measured by the net value added, in the aftermath of the crisis (Antoshin et al. 2017). This paper focuses on the EU agriculture income. In some detail, it examines the impact of direct payments of the Common Agriculture Policy (CAP thereafter) for all twenty eight Member States of the EU on agriculture income. It is widely perceived (Petrick and Kloss, 2013; Petrick and Kloss, 2012 and Pietola, et al. 2011) that direct payments would support the EU agriculture income, especially over the financial crisis period. However, we show that there is variability over time and across direct payments.

The present focus on the EU is not without significance, as it appears that the EU recovery from the financial crisis, more than ten years after the financial crisis, is still anaemic (Antoshin et al. 2017) at best as evidence shows that there was a double-dip recession in many of the EU Member States in 2012 and 2013. To this date, the EU recovery remains very sluggish and this has raised concerns across policy makers and academics alike. Antoshin et al. (2017) propose that credit constraints have remained many years after the crisis and contribute to the slow EU recovery. In an earlier study for agriculture, Petrick and Kloss (2013) argue that the financial crisis led to low agriculture productivity in the EU and propose to invest in the sector. In parallel, the EU is in the process of reforming the CAP (see European Commission, 2018a; European Commission, 2018b). So, this study comes in a timely manner.

Moreover, following Petrick and Kloss (2013) and Benjamin and Phimister (2002) we study the underlying dynamic interactions between direct payments and agriculture net value added in the aftermath of the credit crunch. In addition, we also focus on solvency as measured by the liabilities to assets ratio, which indicates the percentage of an agricultural holding's assets that is financed through debt. This measure of solvency provides information regarding a farm's capability to serve its debt obligations that is to repay its liabilities if all of the assets were sold. Of course some caution is warranted as a high liabilities-to-assets ratio does not imply that the underlying farm faces severe risk. It could be the case that a high ratio would suggest that the farm is able to raise external funding. Alas, there could be the case that beyond a threshold of indebtedness risks would materialise. We, also, include in our analysis investment on agriculture.

Thus, the purpose of this paper is fourfold: (i) to examine in detail the underlying dynamic interconnections between agriculture income and direct payments as well as solvency and invstment in the EU using micro-econometric data, (ii) to develop a flexible identification that employs panel regression analysis and a panel VAR model in which the main variables are treated as endogenous and thereby addressing criticism related to endogeneity bias, (iii) to apply this methodology to all twenty eight EU Member States, that is to a comprehensive data set, and lastly (iv) to derive some policy implications.

The reported findings suggest that agriculture net value added has been subject to negative shocks in direct payments as well as solvency that have severely undermined the economic activity of the sector. There is also reported some variability, but overall it appears that direct payments are not panacea for agriculture income. Thus, future reform efforts should take into account direct payments and total indebtedness of the EU agriculture as both seriously impend net value added. Some variability across countries exists, but causality clearly runs form direct payments to agriculture net value added. Therefore, this study shows that traditional EU agriculture policies, such as subsidies, would not suffice to enhance agriculture income. However, boosting agriculture investment would enhance agriculture income. As a way forwards, the EU's CAP should be adequately reviewed in light, also, of the financial crisis so as to address some chronic deficiencies of the sector (see European Commission, 2010, 2012 and 2018a, 2018b).

The remainder of the paper is organised as follows; section 2 presents our identification models, section 3 shows the data set and the main variables of our analysis, whereas section 4 discusses the main empirical findings. Lastly, section 5 offers some conclusions and possible economic policy responses.

2. A flexible panel regression analysis and panel VAR model of the EU agriculture income.

The starting point of our analysis is to identify the main variables of our model for agriculture income as measured by the net value added. We follow the seminal analysis proposed by Benjamin and Phimister (2002) so as to model the detrimental impact of financial constraints on agriculture net value added (see for a survey Petrick, 2005). To this end, we employ a flexible agriculture net value added function where emphasis is given to direct payments and also solvency, measuring the underlying risk.

Moreover, we propose to employ, as a first stage identification, the following panel regression fixed effects model that captures heterogeneity across EU Member States and time:

$$NVA_{it} = \mu_0 + \mu_{1t} + a_1 DP_{it} + a_2 Solvency_{it} + a_3 \sum_{j=1}^{J} Z_{it} + e_{it} \quad (1)$$

where NVA_{it} is agriculture income, measured as net value added, DP_{it} is direct payments to EU agriculture. $Solvency_{it}$ is solvency and Z_{it} includes some control variables, such as investment. μ_0 and μ_{1t} captures fixed and time affects. We also include country dummies to capture heterogeneity across countries.

The above is a simple panel analysis model that would provide first insights into the underlying relationship between agriculture income and direct payments. A possible criticism to this model refers to possible endogeneity issues.

Therefore, as a second stage identification analysis, we opt for a panel Sims's Vector Autoregressive (VAR) methodology that fits the purpose of this paper, given concerns about possible endogeneity in estimating an agriculture net value added function (Petrick and Kloss 2013). The panel VAR employs a system of equations that adequately deals with the endogeneity of all variables. In some detail, the Sims's methodology is based on the framework that all variables would enter as endogenous where the underlying dynamic relationships can be subsequently identified. Effectively, the VAR would allow us to explore the underlying causal relationships between our main variables: agriculture net value added, direct payments and solvency. It is possible to have one-way causality, i.e. running from direct payment to net value added or vis-a-versa, but also a bi-directional causality.

Moreover, herein we would employ a micro-econometric data set that contains a rich source of information, and as such we opt for a panel VAR analysis. The panel dimension of our sample would also imply that the panel VAR should adequately address the heterogeneity across countries. In this paper we address this issue using the methodology proposed by Arellano and Bover (1995).

In detail, our panel-data vector autoregression (panel VAR) treats all variables in the system as endogenous, while allows for unobserved individual heterogeneity. We, thus, specify a first order panel VAR model as follows:

$$w_{it} = \mu_{io} + \Phi w_{it-1} + e_{it},\ i = 1,\ldots, N, t=1,\ldots,T. \quad (2)$$

where w_{it} is a vector of three random variables (NVA_{it}, DP_{it} $Solvency_{it}$), Φ is an $3x3$ matrix of coefficients, μ_i is a vector of μ individual country effects and $e_{i,t}$ is a multivariate white-noise vector of residuals. In line with the simple time series VAR model, all variables are endogenous and depend on their past values. However, herein there is also cross sectional dimension and country specific terms μ_{io}.

The system of equations (2) allows to proceed with dynamic simulations so as to estimate impulse response functions (IRF) and variance decompositions (VDC).[1] In

[1] The system of equations (2) follows a prior identification using the Choleski decomposition. The ordering of variables in such identification is of some significance and t, therefore, we select it so as to ensure that results are valid also under reverse ordering. A recursive orthogonal structure in the shocks $e_{i,t}$ is applied. In what follows as the direct payments to agriculture holdings, given that is outside their control, it is treated as more exogenous compared to agriculture income and solvency. However, the reverse causation is also tested. A point though that it might worth noting is that the ordering of variables

detail, we model agriculture net value added (*NVA_{it}* thereafter) and direct payments (*DP_{it}* thereafter) in two-equations panel VAR with the following structure (for simplicity of exposition we drop solvency, but in the empirical estimations we also employ a three-equations panel VAR):

$$NVA_{it} = \mu_{1i0} + \mu_{10t} + a_{11}\sum_{j=1}^{J} NVA_{it-j} + a_{12}\sum_{j=1}^{J} DP_{it-j} + e_{1it},$$

$$DP_{it} = \mu_{2i0} + \mu_{20t} + a_{21}\sum_{j=1}^{J} DP_{it-j} + a_{22}\sum_{j=1}^{J} NVA_{it-j} + e_{2it} \quad (3)$$

Here, NVA_{it} and DP_{it} capture the agriculture net value added and direct payments respectively, and μ_{i0} and μ_{0t} are the country and time effects respectively.[2]

Following Sim's argument of the importance of the errors terms in the system of equations (3), we employ a moving average (MA) representation where all variables in the panel VAR, NVA_{it} and DP_{it} capture the agriculture net value added and direct payments respectively, are considered endogenous variables that depend on the lagged residuals from the reduced form in (3).

Hence, the MA representation refers to a system of equations for NVA_{it} and DP_{it} that depend on present and past residuals e_1 and e_2 as follows:

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might not alter results if the estimated covariances between the errors across equations are low, as it is the case herein.

[2] Sims in his VAR analysis argues that the individual parameter estimates of the system of equations (2) are not of any statistical and economic importance. Sims, instead, shows that what is of importance lies is the error terms of the system of equations (2) and (3). Those error terms are employed to estimate impulse response functions (IRF) and variance decompositions VDC. To this end, we estimate the system of equations (2) and thereafter estimate the underlying moving average (MA) representation in the system of equations (3). It is worth noting that the underlying data generating process of all variables should be stationary. Panel unit roots tests show that our variables are stationary. This is not surprising given that the time series dimension of our analysis is not long.

$$NVA_{it} = a_{10} + b_{11} \sum_{j=1}^{\infty} e_{1it-j} + b_{12} \sum_{j=1}^{J} e_{2it-j}$$

$$DP_{it} = a_{20} + b_{21} \sum_{j=1}^{\infty} e_{2it-j} + b_{22} \sum_{j=1}^{J} e_{2it-j}$$

(4)

The orthogonalized MA representation[3] is:

$$NVA_{it} = a_{10} + \beta_{11} \sum_{j=1}^{\infty} \varepsilon_{1it-j} + \beta_{12} \sum_{j=1}^{J} \varepsilon_{2it-j}$$

$$DP_{it} = a_{20} + \beta_{21} \sum_{j=1}^{\infty} \varepsilon_{2it-j} + \beta_{22} \sum_{j=1}^{J} \varepsilon_{2it-j}$$

and

$$\begin{pmatrix} \beta_{11j} & \beta_{12j} \\ \beta_{21j} & \beta_{22j} \end{pmatrix} = \begin{pmatrix} b_{11j} & b_{12j} \\ b_{21j} & b_{22j} \end{pmatrix} P \begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{pmatrix} = P^{-1} \varepsilon_{2it} \begin{pmatrix} e_{1it} \\ e_{2it} \end{pmatrix}, \quad (5)$$

where P is the Cholesky decomposition of the covariance matrix of the residuals.

The orthogonal residuals in (5) are shocks: ε_{1it} is a shock in agriculture net value added and ε_{2it} is a shock in direct payments. To this end, the coefficients in the equations (4), β_{11} and β_{21}, are the impact multipliers of the underlying shocks and provide the

[3] The residuals in (4) could be correlated because of possible endogeneity of some of the variable. Therefore, the coefficients of the MA representation could not be subject to interpretation. Thus, we orthogonalise the residuals by multiplying the MA representation with the Cholesky decomposition of the covariance matrix of the residuals.

current response of the endogenous variables to shocks that would take place *j* periods ago.

Such MA representation as in the system of equations (4) where residuals are orthogonal, we call it impulse response function (IRF). Thus, the IRF would provide the response of each endogenous variable in the system of equations (4) to shocks for *j* periods ahead. In our case the first IRF would provide estimates for the impact of a shock in direct payment on agriculture net value added for a chosen set of periods ahead, as well as the impact of a sock in agriculture net value added itself. We are primarily interested in the impact multiplier ε_{2it-j}, which reflects the response of net value added to a shock in direct payment for different time horizons *j*. But since there are no theoretically motivated priors, it could be also the case that direct payment responds to shocks in agriculture net value added. The advantage of this reduced form panel-VAR specification is that we can assess the dynamic interdependencies between agriculture net value added and direct payments with the minimum of restrictions imposed.

3. Data on agriculture income and direct payments in the EU

We employ the micro-econometric data set of the Farm Accountancy Data Network (FADN) of the EU. The FADN collects accountancy data on annual frequency at farm level from a sample of the Member States of the EU. Given the panel dimension of our data set we propose to employ the panel regression analysis and panel-VAR. This analysis considers the microeconomic data set of FADN at farm level and provides an identification of the underlying dynamics without suffering from aggregation bias.

Our data contains all twenty-eight EU Member States, namely Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Germany, Greece, Spain, Estonia, France, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Austria, Poland, Portugal, Romania, Finland, Sweden, Slovakia, Slovenia and the United Kingdom over the period 2004 to 2017. In some detail, the data set is assembled for the following variables: net value added, direct payments, solvency s, total liabilities (including short term, medium-term and long-term liabilities).[4]

The main variable of our analysis refers to farm net value added (FNVA) which equals to gross farm income minus costs of depreciation. This variable measures all factor of farm production that include labour, land and capital. Note that FNVA includes both external and family production factors. Therefore, we can proceed with the empirical estimation of agriculture income whether the underlying production factors are family or non-family. Note also that FNVA is estimated per annual work unit so as to control for differences in the scale of farms, whilst also efficiently measuring productivity of the agricultural workforce.

Direct payments include total subsidies on operations linked to production, with the exception of investment. The role direct payments play in sustaining farm income becomes even more apparent at periods of crisis, like the period we examine. This is so because production factors might be negatively affected by any economic slowdown, but direct payments direct payments could counter balance such effects.

[4] It is worth noting that the FADN survey on an annual base assembles a data set of accountancy data from around 60.000 agricultural holdings from the Member States of the EU. The FADN collects the data from national surveys of the Member States and then harmonises the data set across countries. To this end, the accounting bookkeeping principles do not differ across countries. Note that the FADN does not cover all agriculture firms in the EU but based in sampling plans as set as each region of EU it selects agriculture firms that their size allows that to rank as commercial firms. This is essential for having a harmonised micro-econometric data set across the Member States of the EU.

Solvency reflects leverage, that is the external debt that finances assets, and would indicate whether the farm invests that in turn would increase return. However, returns also come with risks and as such could pose a threat to the solvency of the farm.

Table 1 provides descriptive statistics of the variables used in this study for the overall sample over the period 2004-2017 that includes 391 balanced panel observations for all twenty-eight Member States of the EU.

Table 1: Descriptive Statistics.

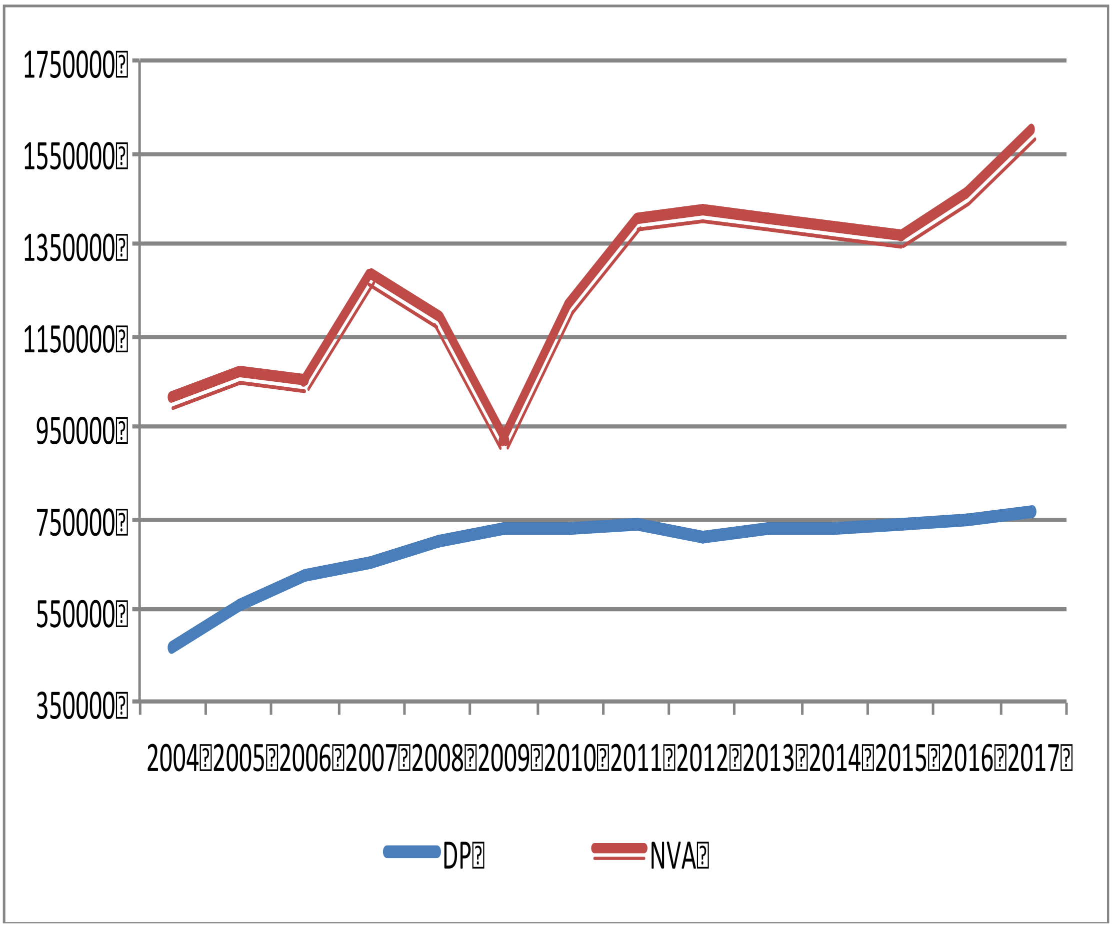
Variable	Obs	Mean	Std. Dev.	Min	Max
NVA	391	45026.63	41485.11	4167	272975
DP	391	24625.78	28582.29	1213	169185
DPcrops	391	1296.294	3133.688	0	24702
DPlive	391	1900.624	3196.036	0	22333
DPrural	391	6376.302	9452.028	0	65562
Solvency	391	0.17191	0.142895	0.0001084	0.594264

Note: NVA is agriculture net value added is in mil. EUR and it is gross net value added minus depreciation. DP is direct payments to EU agriculture and include all subsidies. DPcrops are subsidies to crops, while DPlive and DPrural refer to subsidies given to livestock production and rural development respectively. Solvency is the ratio of liabilities to assets ratio. All variables are in EUR, but solvency.
Source: Farm Accountancy Data Network (FADN), EU Commission.

Note that NVA measures income in agriculture, it is in EUR and it is gross net value added minus depreciation. DP is direct payments to EU agriculture and include all subsidies, excluding investment. We shall also focus on the empirical estimation on th decomposition of direct payment to its underlying components: DPcrops are subsidies to crops, while DPlive and DPrural refer to subsidies given to livestock production and rural development respectively. From Table 1 appears that subsidies for rural development are higher in magnitude than the other two components of subsidies. The mean of 0.17 and the low standard deviation from Table 1 of solvency seems to show that agriculture external funding indebtedness is abided, and it should not pose significant risk.

Moreover, Diagram 1 shows both NVA and DP over time. It reveals that there is some variation over time for NVA as the crisis led to a considerable dip from 2007 to 2011.

Diagram 1: Agriculture Net Value Added and Direct Payments.



Note: Agriculture net value added (NVA) is in EUR and it is gross net value added minus depreciation. DP captures all subsidies to agriculture, excluding on investments. The sample includes twenty-eight Member States of the EU.
Source: Farm Accountancy Data Network (FADN), EU Commission.

Evidently, net value added fall dramatically in 2008, whereas there is a slow recovery thereafter. It appears that agriculture net value added recovers somewhat from 2011 to 2013. Alas, this recovery is rather anaemic as in 2014 and 2015 net value added dips again. The Diagram 1 confirms the double dip in terms of the agriculture net value added as it has been the case of double-dip in the economic activity of the EU. Alas, it is alarming that EU agriculture net value added appears to be on declining path also in 2015, though there is some positive progress thereafter. Regarding the direct payments to agriculture excluding in investment from 2004 to 2009 there was a steady positive trajectory but it has been flat thereafter. It appears that early in the financial crisis direct payments were increased so as to counter balances negative effects on agriculture income due to credit constraints, though this development reached its pick in 2009 and thereafter there was a rather anaemic increase.

The reported double-dip in agriculture net value added is not as pronounced as the aggregate EU output, however it raises concerns over whether the EU economy could be on the path of recovery ten years after the financial crisis (Antoshin, et al 2017). In fact, Antoshin et al. (2017) report evidence that shows the recovery Europe from the financial crisis has been weaker than in previous recessions due to the double-dip in many EU Member States. Antoshin et al. (2017) argue that the EU firms still face credit constraints that could help explain the sluggish EU recovery.

In an earlier research, Jansson, et al. (2013) offer some discussion regarding the constraints faced by the EU agriculture as a result of the credit crunch across countries. The authors argue that agriculture credit institutions have been severely affected by the financial crisis and thereby their act as transmission mechanism to the sector. As a result, agriculture net value added did dive in 2009. Antoshin, et al (2017) highlight that economic activity has not been fully recovered in the EU, largely due to weak supportive policies.

4. Panel estimations

4.1. Panel Fixed Effects for agriculture net value added.

Prior to moving into the panel VAR estimations we shall examine in a panel fixed effects model the impact of direct payments and solvency on net value added. This modelling could be subject to some endogeneity but it would assist our analysis using a simple econometric regression. Issues with endogeneity would be dealt thereafter.

We estimate the following fixed effects model:

$$NVA_{it} = \mu_0 + \mu_{1t} + a_1 DP_{it} + a_2 Solvency_{it} + a_3 \sum_{j=1}^{J} Z_{it} + e_{it} \quad (6)$$

where NVA_{it} is agriculture net value added, DP_{it} is direct payments to EU agriculture. $Solvency_{it}$ is solvency and Z_{it} includes some control variables, i.e. investment. μ_0, μ_{1t} captures fixed and time affects. We also include country dummies to capture heterogeneity across countries.

Table 2 reports the panel fixed effects estimation while controlling for country heterogeneity and also for time effects. Clearly the impact of direct payments on agriculture income is positive but rather small in magnitude but for model 3. However overall it seems that direct payments would increase agriculture income. Solvency on the other hand has a detrimental impact on NVA as the sign is negative across all models. As a results, solvency plays a role like a risk factor rather than a leverage factor for agriculture income. Clearly, investment has a positive impact on agriculture income, implying that the return to agriculture is not low. This is not surprising given the chronic underinvestment in the sector (see Mamatzakis 2003; Petrick and Kloss, 2013; Petrick and Kloss, 2012). Mamatzakis (2003) argues that investment in infrastructure would boost agriculture productivity and income. This result also provides support for efforts to reform CAP towards simplification and investing in innovation and environmental farms (see European Commission, 2018a; European Commission, 2018b).

Table 2: Panel fixed affects for NVA

	(1)	(2)	(3)
VARIABLES	Fixed Effects	Fixed Effects	Fixed Effects
DP	0.0593	0.0760	0.114
	(0.182)	(0.183)	(0.205)
solvency		-0.0993	-0.111
		(0.162)	(0.135)
INV			0.272**
			(0.128)
Constant	11.31***	11.81***	11.25***
	(3.012)	(3.055)	(3.130)
Observations	391	391	385
R-squared	0.000	0.002	0.011
Number of countries	28	28	2
FE	YES	YES	YES
Time, Country Dummies	YES	YES	YES

NVA is agriculture net value added. DP is direct payments to EU agriculture. Solvency is solvency and INV is investment. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 3 proceeds with a decomposition of the impact of direct payments on agriculture income. Direct payments on crops has the higher positive impact on agriculture income compared to direct payments in livestock and rural development. Solvency has a negative impact on NVA whereas agriculture investment asserts a positive impact in line with Table 2.

Table 3: Panel fixed affects for NVA and direct payments decomposition.

	(1)	(2)	(3)
VARIABLES	Fixed Effects	Fixed Effects	Fixed Effects
DPcrop	0.0823*	0.0816*	0.104**
	(0.0426)	(0.0430)	(0.0429)
DPlive	0.0397	0.0404	0.0375
	(0.0462)	(0.0480)	(0.0471)
DPrural	0.0758	0.0568	0.00216
	(0.107)	(0.103)	(0.0998)
solvency		-0.151	-0.188
		(0.161)	(0.113)
INV			0.377***
			(0.135)
Constant	11.70***	11.92***	15.14***
	(1.025)	(1.057)	(1.113)

Observations	311	311	308
R-squared	0.023	0.027	0.048
Number of countries	28	28	28
Time, Country Dummies	YES	YES	YES
FE	YES	YES	YES

NVA is agriculture net value added. DPcrops are subsidies to crops, while DPlive and DPrural refer to subsidies given to livestock production and rural development respectively. Solvency is solvency and INV is investment. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.1.1 Dynamic Panel for agriculture net value added.

As issues with endogeneity might affect the accuracy of the above findings. To this end, we proceed herein with Arellano and Bover dynamic panel analysis where instruments are used to deal with possible endogeneity.

We estimate the following dynamic panel date model:

$$NVA_{it} = \mu_0 + \mu_{1t} + a_1 NVA_{it-1} + a_2 DP_{it} + a_3 Solvency + a_4 \sum_{j=1}^{J} Z_{it} + e_{it} \quad (7)$$

where NVA is agriculture net value added and NVA_{it-1} is with one lag. DP is direct payments to EU agriculture. Solvency is solvency and Z includes some control variables. μ_0, μ_{1t} captures fixed and time affects. We also include country dummies to capture heterogeneity across countries.

Table 4 reports the dynamic panel analysis. Once more we get similar results as the panel fixed effects estimations. The impact of direct payments on agriculture income is positive but rather small in magnitude but for model 3 and overall it seems that direct payments would increase agriculture income. Solvency on the other hand has a detrimental impact on NVA as the sign is negative across all models. As a results, solvency plays a role like a risk factor rather than a leverage factor for agriculture income. Investment, once more, has a positive impact on agriculture income, insinuating that it is key to the recovery of the sector.

Table 4: Dynamic panel analysis for NVA

	(1)	(2)	(3)
VARIABLES	lnNVA	lnNVA	lnNVA
NVA_{t-1}	0.0350	0.0327	0.00996
	(0.0317)	(0.0336)	(0.0373)
DP	0.161	0.108	0.308
	(0.199)	(0.261)	(0.264)
Solvency		0.0699	-0.106
		(0.181)	(0.182)
INV			0.471***
			(0.140)
Constant	13.37***	12.32***	10.03**
	(3.329)	(4.709)	(4.272)

Observations	362	362	357
Number of countries	28	28	28

NVA_{t-1} is lagged NVA, DP direct payments, Solvency is solvency and INV is investment. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 5 reports the dynamic panel analysis but we decompose direct payments to its components. Results remain largely similar to the one above. Moreover, the impact of direct payments in crop and rural development appear to have the larger impact on agriculture income compared to direct payments in livestock. Solvency has a negative impact on NVA. As above, investment has a positive impact on agriculture income.

Table 5: Dynamic panel analysis for NVA and direct payments decomposition.

	(1)	(2)	(3)
VARIABLES	lnNVA	lnNVA	lnNVA
NVA_{t-1}	0.0595	0.0564	0.0422
	(0.0423)	(0.0439)	(0.0478)
DPcrop	0.103*	0.0981*	0.0997*
	(0.0557)	(0.0560)	(0.0576)
DPlive	0.0362	0.0365	0.0671
	(0.0748)	(0.0771)	(0.0826)
DPrural	0.0629	0.0513	0.185
	(0.111)	(0.125)	(0.163)
solvency		-0.0464	-0.261
		(0.139)	(0.164)

INV			0.552***
			(0.201)
Constant	11.84***	11.58***	15.21***
	(1.516)	(1.898)	(2.166)
Observations	286	286	283
Number of countries	28	28	28

NVA_{t-1} is lagged NVA, DP direct payments, Solvency is solvency and INV is investment. DPcrops are subsidies to crops, while DPlive and DPrural refer to subsidies given to livestock production and rural development respectively. Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

4.2. Panel VAR estimations.

Following Petrick and Kloss (2013) who demonstrate the detrimental impact of financial crisis on EU farmers and in particular they highlight the farmers' exposure to lending rates hikes, we opt for two alternative specifications regarding zero contemporaneous impact multipliers of agriculture net value added and direct payments, respectively in the panel VAR: First, shocks in agriculture net value added would not instantaneously impact on the direct payments. Second, shocks in direct payment would have no instantaneous impact on the agriculture net value added. The justification of employing the above specifications lies on disentangling the interdependencies between financial variables such as direct payment and agriculture net value added as reported in the seminal paper of Hubbard (1998). Hubbard (1998) emphasises the importance of capital market imperfections for reaching the optimal level of net value added, whereas Petrick and Kloss (2013) argue that such imperfections may have exacerbated their impact on agriculture net value added in the EU in the aftermath of the financial crisis.

We, herein, propose the panel VAR model to examine the underlying interdependencies between direct payment and agriculture net value added. To do so, we opt not to impose a restrictive structural framework in the panel VAR that would impose constraints in the underlying responses of either agriculture net value added or direct payment by farmers to shocks.[5] As identification we opt for Cholesky decomposition which implies that for example when agriculture net value added is the first variable in the panel VAR, the direct payment shocks would have no instantaneous impact on agriculture net value added. We employ also the reverse ordering of the panel VAR and estimate a panel-VAR model where the order of the variables sets direct payment as first and then calculate the IRF functions. By doing so, we relax any imposing instantaneous zero restrictions on shocks from agriculture net value added to direct payments.[6]

In some detail, following the specification of agriculture net value added as in Benjamin and Phimister (2002) and also in line with the discussion of Petrick and Kloss (2013) of the possible detrimental impact of financial crisis on the EU agriculture, our panel VAR specification would reveal whether shocks to the direct payment by agriculture would have an effect on agriculture net value added, whereas agriculture net value added would be also allowed to have an effect on direct payment with a lag.[7] As a result, net value added may be the most endogenous variable in the panel VAR (see

[5] Imposing restrictions in the panel VAR has been criticised as such restrictions are sensitive to a-priori identifications (see Love and Zicchino, 2006). In the context of our analysis, we opt not restrict our modelling by selecting a-priori identifications.

[6] Both orderings in the panel VAR provide the full map of the interdependencies between agriculture income and direct payments. In the first ordering, shocks in income are identified as those shocks which do not immediately change the direct payment profile of the agriculture holding. In the second case, shocks in direct payment are only those shocks without immediate impacts on agriculture income.

[7] Petrick and Kloss (2013) discuss in some detail why the direct payment by agriculture in the EU is primarily based on the developments that are commonly taken as exogenous to the individual farmer.

Benjamin and Phimister 2002), thus capturing all available information, i.e. all the contemporaneous shocks to the direct payments.[8]

Given that in the present paper we employ a micro-econometric sample with cross-country variation, we capture heterogeneity across countries by introducing fixed effects, denoted by μ_{i0} in the system of equations (2) (see Love and Zicchino, 2006).[9] This forward-mean transformation of our variables in the system of equations (2) is in line with the orthogonality condition of identification between transformed variables and lagged regressors. Thus, we employ lagged regressors as instruments and estimate the panel VAR by GMM.

As a first step towards estimating the panel VAR, we select the optimal lag order j in the system of equations in (3). We employ the Arellano-Bover GMM estimator for the lags of j=1,…,3. Therefore, we proceed with the estimation of the panel VAR for different lags.[10] Then, we apply the Sargan test that reports that the lag order one is appropriate, while the Arellano-Bond AR tests also reports lag order of one.

Herein, we do not report parameter estimates from the panel-VAR as are not of importance. Note also that all variables in the panel VAR estimations would be in logs to facilitate the interpretation across various Impulse Response Functions (IRFs) and Variance Decompositions (VDCs).

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[8] Note that in order to test whether a specific ordering drives our results we also apply the reverse ordering. The investment is considered as the most exogenous variable.

[9] Note, that a complication of including fixed effects is that the latter are correlated with the regressors in the panel VAR due to lags of endogenous variables on the right-hand side of the system of equations (2). If we employ the mean-differencing procedure commonly used to eliminate fixed effects this would create biased coefficients. To avoid this problem, Love and Zicchino (2006) suggest to opt instead for forward mean-differencing, also referred to as the Helmert's procedure. This procedure would remove the forward mean, i.e. the mean of all the future observations available for each country-year observation.

[10] A common method for estimating the optimal lag length for a VAR is the Akaike information criterion. In addition, the usual diagnostic checks need to be made, to ensure the VAR is well specified. If there is evidence of autocorrelation, more lags need to be added until the autocorrelation has been removed.

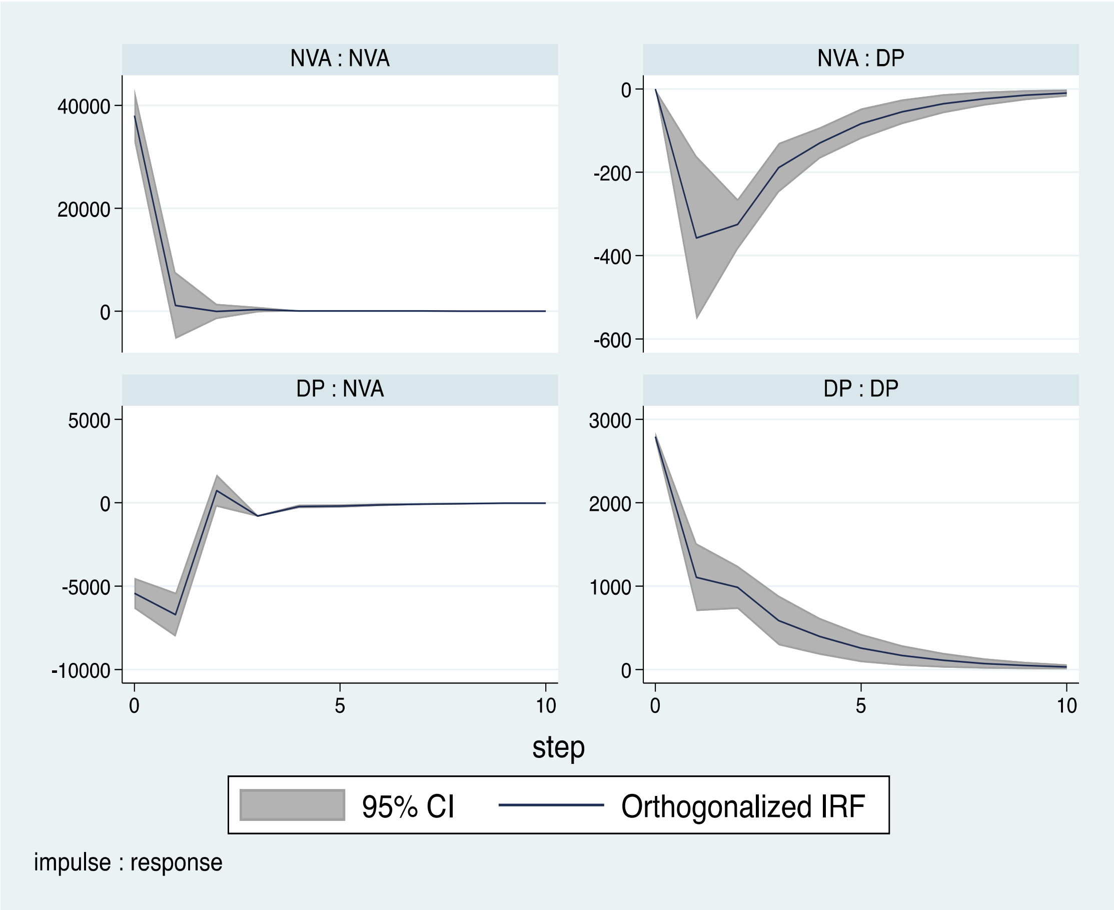
In what follows, we present IRFs and VDCs. Thus, we follows the Sims' argument that we shall report to the underlying MA representation of the VAR model and the resulted IRFs and VDCs. Thus, we report next the IRFs and VDCs. Parameter estimates for the corresponding panel-VAR are available upon request.

4.2.1 IRFs and VDCs for agriculture net value added and direct payments.

The IRF's derived from the unrestricted panel-VAR are presented in Diagram 2 below. Diagram 2 presents the results for the case of a 2x2 panel-VAR, that is for the vector of variables agriculture net value added and direct payments. Diagram 2 also reports confidence intervals, using 50 Monte Carlo replications.

From the first raw of the diagram it becomes clear that the effect of one standard deviation shock in direct payments on agriculture net value added is negative and of some magnitude. The highest negative response of agriculture net value added to a shock in direct payments takes place after one period, that is in the very short run. However, this response is reversed thereafter, after the second period. It is also of interest that the response of the net value added to direct payment is also negative. Effectively this outcome could imply that that there might exist a causal relationship from the direct payments to agriculture net value added, but also the other way around.

Diagram 2: IRFs of agriculture net value added and direct payments.



Note: NVA is agriculture net value added, whilst DP is the direct payments. Shading area up and down the principal line represent 95% confidence interval as generated by 50 Monte Carlo replications. Widening bounds of confidence interval implies that the corresponding response is not significant. All variables are in logs. Horizontal axis indicates periods ahead. For simplicity we present 0 to 10 periods, steps, ahead.

We also present variance decompositions (VDCs), which show for example the per cent of the variation in agriculture net value added that is explained by the shock in the direct payments, accumulated over time. The variance decompositions show the magnitude of the total effect. We report the total effect accumulated over the 5 and 10, but longer time horizons produced equivalent results. Table 5 presents the VDC estimations. Specifically, 95% (95%) of agriculture net value added's forecast error variance after ten (twenty) years is explained by itself with direct payments explaining the remaining. Similarly, a small part, around 3%, of the variation of direct payments is explained by the agriculture net value added.

Table 4: VDCs for agriculture net value added and direct payments.

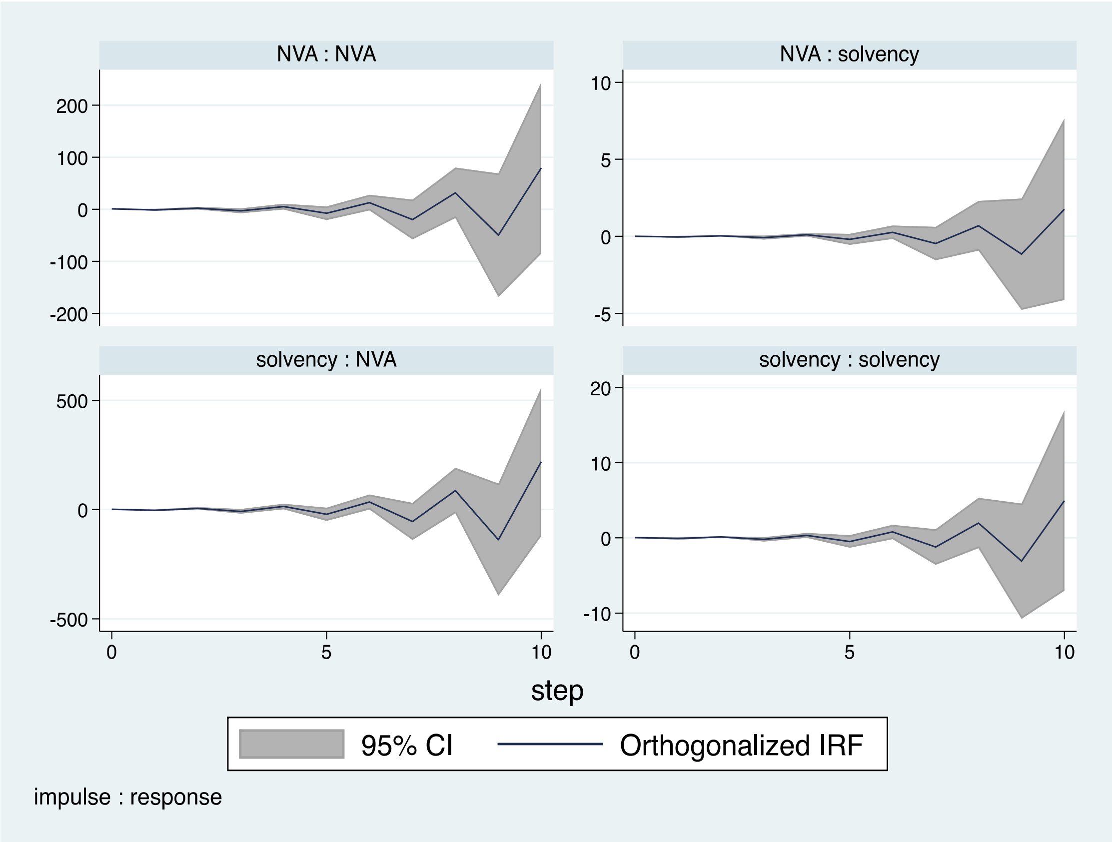
	s	NVA	DP
NVA	5	0.9503195	0.0496805
DP	5	0.0265071	0.9734929
NVA	10	0.9502476	0.0497524
DP	10	0.0273061	0.972694

Note: NVA is agriculture net value added, whilst DP is the direct payments. All variables are in logs. We present 0 to 10 periods, steps, ahead.

4.2.2 IRFs and VDCs for agriculture net value added and solvency.

Herein we examine the underlying interactions between agriculture net value added and solvency. Diagram 3 presents the IRFs. The solvency asserts a close to zero impact on agriculture net value added during the first five periods, and thereafter shows some variation. After the first five periods the response of agriculture net value added to solvency in the EU remains small but somewhat shows some variability and is negative in periods 6 and seven in line with panel regression estimations.

Diagram 3: IRFs of agriculture net value added and solvency.



Note: NVA is agriculture net value added, whilst solvency captures solvency. Shading area up and down the principal line represent 95% confidence interval (CI) as generated by 50 Monte Carlo replications. Thus, widening bounds of confidence interval would imply that the corresponding response is not significant. All variables are in logs. Horizontal axis indicates periods ahead. For simplicity we present 0 to 10 periods, steps, ahead.

The reverse causation from net value added to solvency is not so strong and it mainly refers to periods 6 and 7.

We also present VDCs estimations. These results come in agreement with the ones reported by the IRFs, and provide further evidence favouring the importance of solvency in explaining the variation of agriculture net value added. However, the magnitudes of VDCs are bigger compared to the ones reported in Table 4. Specifically, 11% of agriculture net value added forecast error variance after ten years is explained by solvency disturbances. In addition, 11% of solvency is explained by agriculture net value added after five (ten) years.

Table 5: VDCs for agriculture net value added and solvency

	s	NVA	solvency
NVA	5	0.8871711	0.1128289
solvency	5	0.1031706	0 .8968294
NVA	10	0.8844783	0.1155216
solvency	10	0.1185398	0.8814602

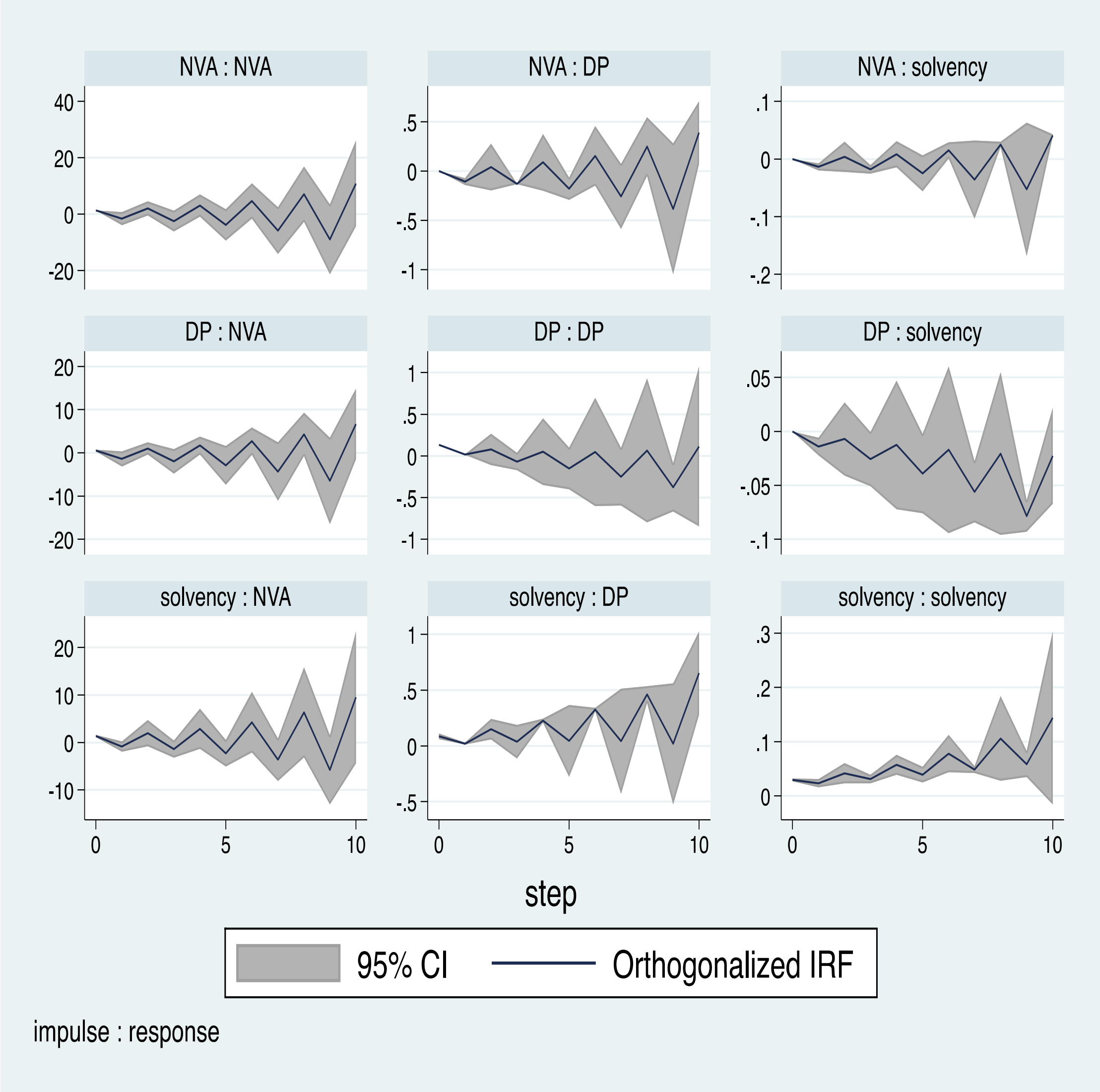
Note: NVA is agriculture net value added, whilst solvency captures solvency. All variables are in logs. We present 0 to 10 periods, steps, ahead.

4.2.3 IRFs and VDCs agriculture net value added, direct payments and solvency.

As the credit crunch is associated with higher levels of debt (Petrick and Kloss, 2013; Petrick and Kloss, 2012 and Pietola, et al. 2011), next we report IRF's derived from an unrestricted 3x3 panel-VAR, where we include in the panel VAR: net value added, direct payments and solvency.

Similarly to previous evidence, the effect of one standard deviation shock of direct payments on agriculture net value added is negative and significant for the first two periods before converging to zero thereafter (see Diagram 4). Shocks in solvency in agriculture have also a negative impact in agriculture net value added, though the magnitude is less than the one of direct payments and there is some variability after the first three periods period. On the other hand, the response of direct payments to net value added's innovation is close to zero for the whole period, whereas the response to solvency is significant and negative. This IRF suggests that high indebtedness would reduce direct payments to agriculture. It is of interest that solvency, on the other hand, responds positively to a shock in direct payments, insinuating that some of the direct payments would contribute to higher level of agriculture debt.

Diagram 4: IRFs for agriculture net value added, direct payments and solvency.



Note: NVA is agriculture net value added, whilst DP is direct payments and solvency captures solvency. All variables are in logs. Shading area up and down the principal line represent 95% confidence interval as generated by 50 Monte Carlo replications. Thus, widening bounds of confidence interval would imply that the corresponding response is not significant. All variables are in logs. Horizontal axis indicates periods ahead. For simplicity we present 0 to 10 periods, steps, ahead.

Table 6 below presents the VDC estimations. The reported results show that 32% of agriculture net value added's forecast error variance after five years is explained by shocks in direct payments and 20% by shocks in solvency. Interestingly, after ten periods the response of agriculture net value added's forecast error variance is explained by shocks in direct payments by 27% and around 22% by shocks in solvency.

These results imply the importance of direct payments and solvency for agriculture income. Interestingly shocks in net value added and solvency explain 34% of forecast error variance in direct payments, suggesting reverse causality. Regarding the forecast error variance of solvency, it is mainly explained, 82%, by its own shocks.

Table 6: VDCs for agriculture net value added, direct payments and solvency.

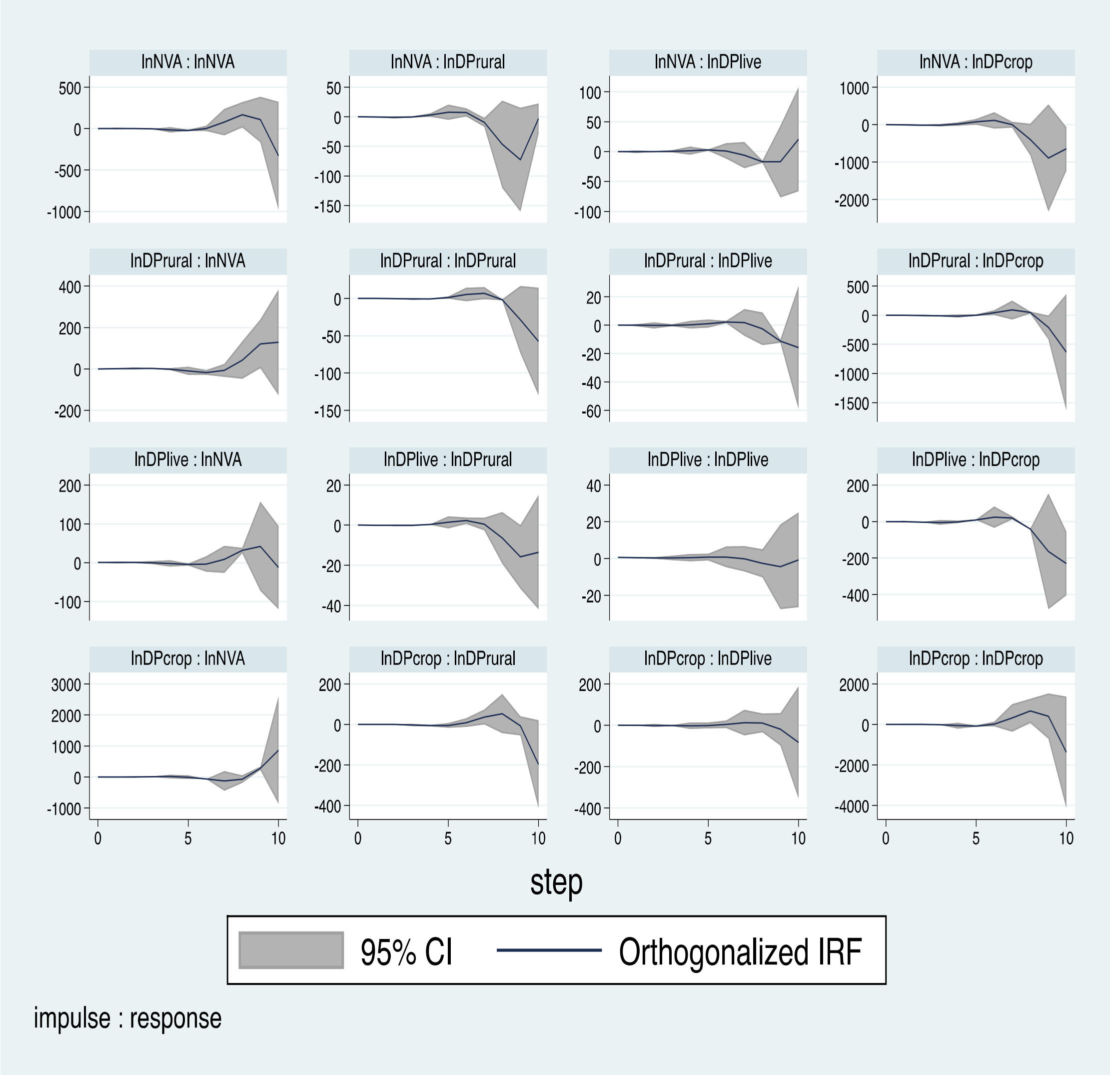
	s	NVA	DP	solvency
NVA	5	0.4718122	0.3280953	0.2000924
DP	5	0.318923	0.3472299	0.3472299
solvency	5	0.1181551	0.065084	0.8167609
NVA	10	0.4932683	0.2770742	0.2296575
DP	10	0.2562454	0.3889755	0.3547791
solvency	10	0.2483879	0.1207739	0.6308383

Note: NVA is agriculture net value added, whilst DP is direct payments and solvency captures solvency. All variables are in logs. We present 0 to 10 periods, steps, ahead.

4.2.4 IRFs and VDCs for VDCs for NVA, DPrural , DPlive & DPcrop

Diagram 5 shows the IRFs for the components of direct payments: rural development (DPrural), livestock (DPlive), and crop (DPcrop). Direct payments in crops has the higher negative impact on agriculture income compared to direct payments in livestock and rural development, though overall significance is an issue. There is also limited evidence of reverse causality.

Diagram 5: IRFs for agriculture net value added, DPrural , and DPcorp.



Note: NVA is agriculture net value added, whilst DPrural is direct payments in rural areas and DPlive is direct payments in livestock and DPcorp is direct payments in corp. Shading area up and down the principal line represent 95% confidence interval as generated by 50 Monte Carlo replications. Thus, widening bounds of confidence interval would imply that the corresponding response is not significant. All variables are in logs. Horizontal axis indicates periods ahead. For simplicity we present 0 to 10 periods, steps, ahead.

Table 7 presents the VDCs estimations. Similarly with the IRFs the provided evidence favouring the importance of direct payments in crop in explaining the variation of net value added compared to the other components of direct payments. Direct payments in crop explain some 38% of agriculture net value added's forecast error variance after ten periods, dropping to 27% after ten years. Interestingly net value added explains significant magnitude of forecast error variance for DPrural 32%, DPliv 46%, and DPcorp 41%.

Table 7: VDCs for agriculture net value added, *DPrural, DPlive* and *DPcorp*.

	s	NVA	DPrural	DPlive	DPcorp
NVA	5	0.5991727	0.0079103	0.0133791	0.3795379
DPrural	5	0.7901851	0.0028948	0.0173962	0.1895239
DPlive	5	0.605641	0.116942	0.0084884	0.2689286
DPcorp	5	0.8134518	0.0066518	0.0535623	0.126334
NVA	10	0.6097578	0.0166254	0.0987549	0.2748621
DPrural	10	0.3298022	0.5799072	0.0678039	0.0224867
DPlive	10	0.4686942	0.0195049	0.4157419	0.0960591
DPcorp	10	0.4121917	0.0164491	0.0315523	0.539806

Note: VA is agriculture net value added, whilst DPrural is direct payments in rural areas and DPlive is direct payments in livestock and DPcorp is direct payments in corp. All variables are in logs. We present 0 to 10 periods, steps, ahead.

5. Conclusions

In this paper we assess the interaction between agriculture net value added and direct payments of the CAP and solvency for all EU Member States so as to analyse the underlying dynamic relationships. To do so, we opt for a panel regression analysis but also for a panel vector autoregression (panel-VAR) approach as an efficient way to isolate the response of agriculture net value added to shocks in direct payments and solvency. Specifically, we focus on the orthogonalised impulse-response functions, which show the response of agriculture net value added to an orthogonal shock in i.e. direct payments.

To the best of our knowledge, our results shed new light on the underlying dynamic relationship between agriculture net value added and direct payments of CAP in light of the credit crunch. Our results show that shocks in direct payments are associated with lower agriculture net value added, whereas shocks in solvency would also reduce net value added. The reverse causal relationship is not excluded, but the evidence is weaker.

As a policy suggestion, our results suggest that direct payments might not be panacea for the EU agriculture income. Thus, different interventions are warranted. In recent years the EU Commission has launched an ambitious agenda to reform the CAP (see European Commission, 2018a; European Commission, 2018b). In particular regarding direct payments, the EU Commission proposes that although income support shall continue, the future CAP would give priority to support small and medium-sized farms while it would encourage young farmers. Other initiatives such as the European Economic Recovery Plan (EERP) of the EU could also enhance agriculture income. The EERP provides investment funds to agriculture so as to mitigate the consequences of the credit constraints due to the crisis. Our findings show that such initiatives would enhance agriculture income as agriculture investment would positive affect agriculture income. Easing credit constraints through the on-going quantitative easing of the ECB could be also valuable as the unconventional monetary policy is aiming to support the growth prospect of the Euro area. Providing low interest credit to agriculture could assist agriculture solvency and it might be the key to recovery as it would provide necessary boost to enhance net value added and hence economic activity. Enhancing the process of financial integration, also by providing alternative sources of funding, in the EU would further assist the credit expansion to agriculture (Petrick and Kloss, 2013;

and Antoshin, et al, 2017). However, more than ten years after the crisis the degree of financial market integration within the EU is rather far from optimal.

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