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Estimating the Impact of Decoupled Payments on Farm Production in Northern Ireland: An Instrumental Variable Fixed Effect Approach

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Abstract: The production stimulating impact of agricultural subsidies has been a well-debated topic in agricultural policy analysis for some decades. In light of the EU reform of the Common Agricultural Policy (CAP) in year 2005 in which agricultural subsidies were decoupled from current production decisions and the modification to this payment in 2015, this study investigates the impact of decoupled payments under these two reforms on livestock production in Northern Ireland. The study uses a farm-level panel dataset covering 2008–2016 period and employs an instrumental variable fixed effect model to control for relevant sources of endogeneity bias. According to the empirical results, the production impacts of decoupled payments were positive and significant but with differential impacts across livestock production sectors, suggesting that decoupled payments still maintain a significant effect on agricultural production and provide an indication of the supply response to changes in decoupled payments.

Keywords: farm production; instrumental variable; subsidy; fixed effect

1. Introduction

The governments of most developed countries provide income support for farmers in the form of agricultural subsidies. During 2015–2017, about USD 317 billion per year, on average, was transferred to farmers, which constitutes approximately 15% of gross farm receipts in the 36 OECD countries [1]. The European Union (EU) devotes about 58 billion Euro of her annual budget on the Common Agricultural Policy (CAP) with the overarching objective of stabilising farmers' revenue in the face of volatile market prices and unpredictable weather conditions, as well as enhancing the production of positive externalities and public goods, such as the retention of landscape features. The majority of the agricultural supports are transferred in the form of decoupled payments, commonly known as the Pillar I direct payments. In the EU, decoupled payments were implemented in 2005 as part of the 2003 CAP reform which further experienced a significant change in 2015 in terms of payment levels and implementation design (see [2] for full details).

There is a considerable level of uncertainty concerning the future of the agricultural subsidy scheme, especially direct payments to farmers as the UK leaves the EU. Currently, farmers receive support payments of approximately €327 million per annum under Pillar I of the CAP. These payments are not linked to current production (i.e., are decoupled) and are fully funded by the EU budget. The UK government has provided assurances to continue this form of support in cash terms until the end of the existing parliament (2022). However, the UK's exit from the EU means that agriculture's share of the Treasury budget may be reduced in the future to focus spending on higher priority areas, resulting in reductions in Pillar I direct payments. Besides, Pillar I payments may be diminished by transfers of monies from Pillar I to Pillar II (rural development schemes that assist farm businesses) under future agricultural policy reforms. While the system for paying Pillar I direct payments was fundamentally changed in 2005, little empirical evidence exists on the impact of these decoupled payments on agricultural production. It is important to quantify the impact of these payments in order to provide a better understanding of the implications of changes in Pillar I direct payments in the post-Brexit era. The quantitative analysis undertaken as part of this study provides an indication of the supply response to changes in Pillar I payments.

Historically, direct payments under Pillar I of the CAP, popularly known as coupled subsidies, exerted a strong influence on production as they were directly linked to activity levels (for example, livestock numbers, crop area). However, in 2005 the Single Farm Payment (SFP) was introduced, in which financial support to farmers was decoupled from farmers' current production. This was superseded by the area-based Basic Payment Scheme in 2015 (Both the 2005 and the 2015 payment schemes are decoupled from production although with varying payments conditions (See [2] for details)). Although these payments are not directly linked with farm production decisions in terms of administrative structure, it is widely accepted that decoupled payments still exert influence on the level of production. There are several pathways through which the production impact of decoupled payments can occur. Particularly, risk preference of farmers can be altered by decoupled payments due to wealth and insurance effects [3], easing farmers' credit constraints by increasing total cash flow [4,5] and alter the allocation of factors of production such as labour, land and other inputs [6–8]. Additionally, there is supporting evidence that decoupled payments provide motivation for low productive farms that may have otherwise exited the market to remain, resulting in an increase in aggregate production [9,10]. Likewise, farmers tend to act in anticipation that the future subsidy scheme may be based on current production and thereby use the decoupled payment to boast their production levels [11,12]. Another reason for supposing Pillar I direct payments are not fully decoupled from production are related to cross-compliance requirements that must be met to ensure farmers' claim payments. Under the cross-compliance obligations, farmers are required to keep farmland in good agricultural and environmental conditions and standards, implying that at least some levels of production will still take place.

A number of empirical studies have tested the theoretical findings of the production impact of decoupled payments. Most of this literature has investigated the production effects in the US, with a particular focus on crop production [5,12–14]. Several studies established that although decoupled payments have a statistically significant distorting impact on acreage, the magnitude is small (Adams, Westhoff, Willott and Young [12], Weber and Key [14], Goodwin and Mishra [5], Key and Roberts [15], and Serra et al. [16]). On the other hand, O'Donoghue and Whitaker [13] empirically established that decoupled payments change individual acreage decisions significantly, ranging from about 9% to 16% changes. Within the EU context, only a few studies have investigated the farm production impact of decoupled payments. For example, using a partial equilibrium model, Howley et al. [17] examined whether decoupled payments influence farmers' behaviour in Ireland. The study found that decoupled payments still exert a significant effect on agricultural production decisions, with farming households using payments to partly support farm production that is not profitable. Rizov et al. [18] and Kazukauskas et al. [19] found that decoupled payments positively impact productivity. Some additional studies have considered the impact of agricultural support on market participants along the supply chain. For instance, an extensive number of studies have been carried out empirically to examine the effect of direct payments on farmland rental prices (Allen Klaiber et al. [20,21], Michalek and Ciaian [22], Ciaian and Kancs [23], Van Herck et al. [24,25], and Patton et al. [26]). These studies indicate that between 10% and 80% of decoupled payments are leaked out of the farming sector by inflating the farmland rental or sales prices.

The key contribution of this present study to the policy debate and existing literature is in offering new empirical evidence of the production impact of decoupled payments. To the best of our knowledge, most of the existing studies on econometric analysis of the impact of decoupled payments on production are focused on crop production with little attention on livestock production. The large concentration of existing studies on crop production with little or none on livestock production is rather surprising considering that amount of payments received by farms differ production choice [19,27], suggesting that farmers' behaviour in response to agricultural subsidies can differ across farming enterprises [5,17,21,28]. Using farm-level panel data from Northern Ireland's dairy, beef and sheep production farm enterprises, this paper aims to fill this vacuum in the literature by exploring the impact of decoupled payments on production. Furthermore, in the EU context, unlike previous studies that used simulation methods/ex-ante analysis, our approach is an ex-post analysis and is based on a robust econometric model at the farm level using the instrumental variable fixed effect (IVFE) approach that takes into account the time series and cross-sectional properties of the data used in the analysis of this nature, as argued by Baltagi [29]. The IVFE approach is efficient in addressing different sources of endogeneity and provides unbiased estimates reliable for policy recommendations. From a policy perspective, the findings from this study will provide new insights into the suitability of categorisation of the EU 2003 and 2013 CAP policy reform as "green box", non-production distorting subsidies, as prescribed by the World Trade Organization (WTO) with respect to livestock production. Moreover, this study is also timely in the light of potential reforms to the CAP post-2020 and possible changes in the structure of direct payments when the UK eventually leaves the EU.

The remaining parts of the paper are structured as follows. Section 2 presents the overview of decoupled payment programs in Northern Ireland (NI) and reviews the literature on the impacts of decoupled payments on production. In the third section, we outline the estimation method and the data used. Section 4 details the empirical results, followed by the final section of the paper which offers the concluding remarks.

2. Context and Review of Literature

2.1. Decoupled Payment Programs in NI

Following the 1992 MacSharry reforms, the EU CAP incorporated direct payments to farmers as a fundamental component of the reform. This necessitated farmers to receive compensation for income loss due to price cut intervention. This direct price support system was later replaced by direct income support in the Agenda 2000 CAP reform of 1999. Payments to farmers, however, remain coupled to production, that is, the current production level was a pre-condition to receiving direct support.

The need to manage the limited budget allocated to agriculture after the expansion of the EU brought about the shift from a subsidy scheme that was production-centred to a more market-focused scheme. This was also done to realign the EU CAP with the World Trade Organization's (WTO) "green boxing" process which further prompted the pressure to reform direct payment process. Specifically, in 2003 the "Fischler Reform" of the CAP was introduced in which the direct payments to farmers were decoupled from production (called the SFP) as well as the introduction of the scheme in which funds were moved to the rural development component of CAP (this is called modulation) [30]. Additionally, there was a condition of cross-compliance attached to SFP in which farmers must make sure their farms are kept in good agricultural and environmental conditions as well as adhering to animal welfare and food safety regulations. Under the 2003 CAP policy reform, EU member states were presented with a set of implementation choices, depending on the prevailing agricultural production and market situation in these countries. Member states are presented with three models of the SFP scheme to choose, namely the historical model, regional model and the hybrid model. Under the framework of the historical model, the payments are determined on basis of subsidy payments disbursed to farmers during the period 2000–2002 while under regional (flat rate) model, the payment entitlements within a given region have an equal per hectare values, and therefore, all farms within the same region receive the same value of entitlements per hectare. The hybrid model is a blend of regional and historical models. It exists in two forms, namely the static and the dynamic forms. Unlike the latter that transits to becoming a flat rate model step wisely, payment entitlements in the former are calculated using a part-historic/part-flat rate payments with no further transition towards a regional model. In January 2005, NI opted for the static hybrid model of the SFP which was based on a historical and a flat rate component, with no further transition towards a flat area payment model, unlike the dynamic hybrid model adopted in England, Germany and Finland where there was a continuous transition towards a flat rate payment. The motivation for adopting the static hybrid model of the SFP in NI was to manage the redistribution of payments across farms. The historical component, which forms about 80%, was calculated based on payments received by farms during 2000–2002 (reference period) for all agricultural production, except for dairy farms, in which 2005 was used as the reference period [2]. This was calculated by taking the average number of eligible hectares/animal declared in 2000, 2001 and 2002, multiplied by a set percentage of subsides received in 2002. The area component of the SPS payments was obtained by multiplying the number of entitlements by the fixed area rate. In 2013, SPS further underwent reform giving birth to the Basic Payment Scheme.

Subsequently, in 2015, there was another CAP reform which sought to further encourage decoupling of farm payments from production decisions with the inclusion of the 'greening' requirements. The new payment scheme is disbursed in form of the basic payments (BPS) and other payments, namely payments for young farmers and green direct payments. The conditions that farmers are required to qualify them for payments are similar to that of the pre-2015 payment scheme although with a slight difference. Farmers are being allocated payment entitlements but with the condition of active farming which requires that farmers need at least the same quality of eligible land to activate payment entitlements every year. The greening payment component of the 2015 reform forms about 30% of all subsidies and are disbursed to farmers on the condition that farmers fulfil the "good agricultural and environmental condition" through environmentally sustainable practices. Receiving BPS payments is a precondition for all these payments. To receive payment, a farm business must hold entitlements that can only be activated against an equivalent hectare of land in order to claim payments under the BPS. The framework for the payment scheme in NI is designed such that the payment entitlements with the value that exceeds the regional average will be subjected to a linear reduction to the difference in the regional average and the initial 2015 unit value of entitlement to generate funds for a rise in the value of the entitlements that are less than the regional average. This harmonisation process will continue until a flat rate is reached by 2021. In 2018, the total value of agricultural supports estimated to have accrued was £286 million, out of which direct payments accounted for 95% [31].

2.2. Previous Studies

The direction and the extent of the effect of direct payments on production have received considerable research attention [3,32–35], although with divergent conclusions which is attributed to the complex mechanism of the relationship [36,37]. This complexity can be associated with differential mechanisms where direct payment could affect production [36,38,39].

Direct payments exert a "wealth effect" on the agricultural production process by encouraging farmers to engage in "riskier" production activities; facilitates the covering of some proportion of production cost especially for unprofitable farms while also making farmers make use of more non-labour income, work less and still maintain production and consumption [3,34,40]. Additionally, decoupled payments afford farmers income risk protection particularly during the surge in commodity price volatility. Furthermore, farm investments can be stimulated with decoupled payments in the presence of financial market imperfections. Farmers that receive decoupled payments may be perceived to be more creditworthy, given that the decoupled payments can be capitalised into land values for landowners and help facilitate lenders' capacity to repay repayments while minimising the risk of loan defaults by lenders [4,14].

On the other hand, several studies have established that value may be placed on farming as a vocation [41,42]. For example, Vanclay [43] argues that farmers engage in farming with the expectation of generating reasonable income for themselves, as well as other lifestyles related to farming may serve as compensation during times when income streams from farming may be less than what could have been obtainable in other economic activities. Key and Roberts [15] and Key [44] explains that farmers take pride in the independence attribute associated with farming as well as owning a business enterprise which may not be potentially available in other employments [45]. Based on these aforementioned non-pecuniary benefits related to agriculture, it suggests that farmers may be using decoupled payments in maintaining an associated farming lifestyle whether such engagements are productive or not.

Furthermore, decoupled payments tend to increase farmers' access to regular incomes as well as access to capital inputs and other productive inputs that can facilitate farm production. More so, there are arguments that farmers may increase their level of production with the belief that future payment schemes may be assessed based on previous levels of production [11,27].

The production impact of decoupled payments is complex and remains ambiguous [46]. Various economic simulation approaches such as AGLINK, FAPRI, CAPRI, AGMEMOD, SAPSIM, etc., have been employed to examine the potential impact of changes in policy such as decoupling of direct payments. The findings obtained from these models seemed to be divergent significantly. This may be because the assumptions related to the supply-inducing impact of direct payments differ by the different modelling approach employed. Besides, this may be attributed to the fact that different farms' response behaviour differs, which depends on the level of support received, farm structural features and farm production type. In addition, there are differences in how farmers treat the direct payment. Consequently, an attempt to measure, in a robust manner, the supply response of decoupled payments, should consider it in a specific context and also empirically [32].

There are a few empirical studies that have examined this subject. Using Italian farms as a case study, Bonfiglio et al. [47] examined the effects of decoupled payments on technical efficiency. The study found that direct payments still exert a significant impact on farms' ability in converting inputs to outputs. In Ireland, Martinez Cillero et al. [48,49] found that both coupled and decoupled payments had a positive significant effect on the efficiency of beef farms. Other studies that reported a positive impact of subsidies' impact include Nikola et al. [50] in Macedonia, Lehtonen and Niemi [51] in Finland, and Galluzzo [52] in Ireland. Using an EU wide dataset, Ciaian, Kancs and Sergio [27] reported a positive relationship between decoupled payments and farm income. Conversely, some studies also reported that decoupled payments exert negative impact on production. For example, Devadoss et al. [53] examined in the influence of direct payments on the US corn market and found that the removal of direct payments would increase productivity. Using NI as a case study, our current study aims at contributing to the existing debate by providing, for the first time in NI, an estimate of the production stimulating impact of decoupled payments on the beef, sheep and cattle sector.

3. Empirical Model and Data

3.1. Empirical Model

The main aim of this paper is to examine the impact of decoupled payments on farm production. Based on the premise that decoupled payments affect farm production both directly (by influencing the farm behaviour as well as payments received) and indirectly (by affecting output and input prices) [4,14,54], we specify the following model:

$$Prod_{it} = \beta_0 + \beta_1 DP_{it} + \beta_2 MR_{it-1} + \beta_3 C_{it-1} + \beta_4 X_{it} + \delta_i + \psi_t + \varepsilon_{it} \quad (1)$$

where the $Prod_{it}$ represents the production outcomes of interest (milk output, number of suckler cows and number of ewes) for farm i in year t; β_j represents the parameter coefficients to be estimated; DP_{it} is the amount of decoupled payments received by farm i in year t; MR_{it-1} and C_{it-1} represent the one-year lagged form of market revenue and costs for farm i in year t respectively. Similar to [13], we measured market revenue and cost variables using lagged values to avoid endogeneity biases from entering our results. This is valid because at the beginning of the current year, the values of the previous year's market revenue and costs are all known and can be considered as exogenous. X_{it} denotes a set of other farm-specific variables; δ_i and ψ_t are the farm and year fixed effects, respectively, and ε_{it} is the idiosyncratic error term. The farm fixed effect controls for any farm characteristics that cannot be observed, such as landscapes with different agro-climatic conditions, do not change over time and that may influence farm production outcomes. The inclusion of the year fixed effect, ψ_t, in Equation (1), is to control for shocks common to all the farms, for example, changes in market signals to all farms and price volatility [55,56].

Several factors confound the identification of the causal impact of decoupled payments on farm-level production [13,14,19]. These include unobserved farm-, system-, and time-specific factors that influence production level as well as decoupled payments that farmers get, thereby subjecting the model to the potential endogeneity issue. Estimating Equation (1) using the ordinary least squares estimation will yield biased and inconsistent estimates [57]. One common approach used in addressing the endogeneity issue is the use of instrumental variables estimation approach. Studies such as Roberts, Kirwan and Hopkins [57] and Kirwan, Uchida and White [7] employed instrumental variables to address endogeneity issues in examining the impact of subsidies on crop production in the US. Similarly, Goodwin and Mishra [39] employed lagged realised market returns variables as instruments, with the argument that lagged realisations, under a generalised method of moments (GMM) framework, are not correlated with the residual. This is because the realised values are a set of information already known at the time in which a production decision is made. For proper identification of the causal impact of decoupled payments on production, we employed an appropriate instrumental variable for the receipt of decoupled payments.

Instruments for DP_{it} are obtained using the following reduced form equation:

$$DP_{it} = \pi_0 + \pi_1 z_1 + \pi_2 z_2 + \pi X + v_{it} \tag{2}$$

where π_k is the estimated parameter coefficients; X is the vector of all the explanatory variables; z_k are our instruments. Following Miao et al. [58], we use one-year and two-year lagged of DP_{it} for the milk output model; one-year lagged of DP_{it} for the suckler cow model and one-year lagged of DP_{it} for the sheep output model. The selection of these instruments are on the basis that they are exogenous and are strongly correlated with the endogenous regressor, in this case DP_{it}, and uncorrelated with the error term, ε_{it}, in Equation (1). In addition, the selection reflects the fact that the decoupled payments are already determined and therefore may be uncorrelated with the current production outcomes. We show in the empirical results section that our instruments are strong predictors of the receipt of decoupled payments. We also perform diagnostic tests that shed light on the extent to which possible correlation with the error term might affect our results. We estimate three production equations based on Equation (1). The first relates to decoupled payments for milk output for dairy farms, while the second outcome variable relates to number of suckler cows for beef farms. The third equation relates to number of ewes for sheep farms. A farm is classified as a dairy farm if at least a two-thirds proportion of farm standard output comes from grazing livestock and dairy cows. Similar classification procedures apply for beef and sheep farms. In order to ameliorate the influence of outliers and to be able to interpret coefficients as elasticities, we employ the natural logarithms to transform the production outcomes variables, $Prod_{it}$, and the decoupled payments variable, DP_{it}.

3.2. Data

The dataset used in this study was obtained from the NI Farm Business Survey (FBS). The NI FBS is conducted as part of the EU Farm Accountancy Data Network (FADN). Annually, the Department of Agriculture, Environment and Rural Affairs (DAERA) conducts a nationally representative survey of farm businesses in NI. For the purpose of this study, we focus on the panel of farms for the periods from 2008 to 2016. In sum, there are 2938 observations relating to 342 different farms, with approximately 53% of farms being present for all eight years understudied. To ensure consistency in the data set, we perform some data cleaning. We exclude farms indicating zero net area farmed with inexplicably high subsidies. After the data cleaning process, we have a panel of 1805 observations.

Our analyses focus on the impact of decoupled payments on Northern Irish livestock production decisions, which include dairy, beef and sheep production. For dairy farm type, the dependent variable is milk output, defined as quantity of milk produced per farm, while for beef and sheep farm types, the dependent variables are number of beef cows and ewe respectively. In order to control for output and input prices, we employed market revenue per hectare and variable cost per hectare respectively. In addition to decoupled payments, farmers also receive other forms of payments such as the agri-environmental payments, disadvantaged area payments and general subsidies which are included in the model. Due to the excess number of zeroes, these amounts were aggregated in the variable called other government subsidies defined on a per hectare basis.

We also include other farm-level variables that potentially influence farm production. Given that the share of family labour may lead to an increase in farm production mainly due to differences in productivity between hired and family labour, we include a variable relating share of family labour in total labour [20,59]. To proxy for wealth, we included a variable representing value of asset in the model. As wealth increases, production may increase because more funds are available.

Farmers who are engaged in off-farm employment may have less time and resources to commit to agriculture, and so may produce less, ceteris paribus [60]. For this reason, we include a binary indicator to proxy for farms with off-farm activity. Finally, to account for farm-owned factor inputs, we include a rental ratio variable constructed by dividing the area rented by the total area farmed. Age may have two opposing impacts on farm production. On the one hand, farmers that are older may not wish to farm as actively as a younger farmer and thereby may produce lesser outputs [28]. On the other hand, experience may have a positive impact on production. To account for these effects, we included the age of the head of household in a quadratic form (age and age^2) in the model as a proxy for farmer experience. Farm size defined as the net area farmed is included to control for possible economies of scale. We also control for differences in education status of farm households by including the level of education attained. Lastly, we include dummy variables for each of the Less Favoured Areas (LFAs) to account for regional variability that is not captured by the other regressors, specifically differences in soil and land quality. All the variables in monetary value units were adjusted for inflation based on appropriate annual prices' indices in the UK Office for National Statistics (ONS) publications. In Table 1, we report the descriptive statistics of all the variables used in the model.

Table 1. Data description and summary statistics (2008–2016).

Variable	Description	Mean	Std. Dev.	Min.	Max.
	Dependent Variables				
Milk Output	Output of milk ('000 litres)	676.29	665.49	44.96	5015.94
Beef Cows	Number of beef cows	43.854	23.497	20.00	182.00
Ewes	Number of ewes	252.53	206.32	20.00	990.00
	Main Independent Variable				
Decoupled Payments	Decoupled payments ('000 £) per farm	22.95	17.85	0.43	169.04
	Control Variables				
Market Revenue	Market revenue per hectare (£/ha)	1305.27	717.44	131.00	2995.57
Dairy Revenue	Dairy revenue per hectare (£/ha)	2048.32	1169.10	637.98	2995.57
Beef Revenue	Beef revenue per hectare (£/ha)	252.65	166.97	13.57	939.47
Sheep Revenue	Sheep revenue per hectare (£/ha)	141.52	124.20	20.12	744.92
Costs	Cost of variable inputs per hectare (£/ha)	1184.65	836.24	55.60	4907.57
Other Government Payment	Other government payments per hectare (£/ha)	49.78	45.62	0.00	418.96
Age	Age of farmer (years)	57.73	12.67	21.00	88.00
Farm Size	Net area farmed (ha)	93.95	94.20	5.50	850.40
Education: GSCE	=1 if farmer has GSCE certificate	0.48	0.50	0.00	1.00
A-Level	=1 if farmer has A-level certificate	0.17	0.37	0.00	1.00

Table 1. *Cont.*

Variable	Description	Mean	Std. Dev.	Min.	Max.
Higher Education	=1 if farmer has higher education	0.04	0.18	0.00	1.00
Off-Farm Employment	=1 if farmer has off-farm employment	0.35	0.47	0.00	1.00
Asset Value	Value of asset ('000 £)	1347.10	850.87	46.66	8835.20
Family Labour Ratio	Share of family labour in total labour	0.92	0.12	0.01	1.00
Rent Ratio	Share of area rented in net area farmed	0.24	0.24	0	1

4. Empirical Results

4.1. First Stage Results

The estimates of the first stage of the IVFE are reported in Table 2, confirming the statistical relevance of our instruments on decoupled payments. The results show that, in all the equations, the one-year and two-year lagged decoupled payments per farm are statistically significant in explaining the variation of decoupled payments. The tests for the joint significance of all the instruments employed in the study is based on the Cragg-Donald Wald F test. The tests statistically ascertain the validity and relevance of the instruments. Our results show that the joint significance test statistics across all the equations are significantly greater than the [61] rule-of-thumb condition that the F-value should not be less than 10. Therefore, we are safe to conclude that the instruments are valid.

Table 2. IV First stage of estimation results: log Decoupled Payments.

Variable	Milk Output Equation		Number of Beef Cows Equation		Number of Ewes Equation	
Instruments	**Coeff. (SE)**	***p*-Value**	**Coeff. (SE)**	***p*-Value**	**Coeff. (SE)**	***p*-Value**
One-Year Lagged ln Decoupled Payments	0.595 *** (0.078)	0.000	0.638 *** (0.145)	0.000	0.646 *** (0.096)	0.000
Two-Year Lagged ln Decoupled Payments	0.148 * (0.089)	0.098				
CD Wald F Statistics	103.140		224.660		215.904	
Sargan *p*-value	0.645		0.000		0.000	

Note: All the explanatory variables in Equation (2) are included. The asterisks *** and * indicate statistical significance at 1% and 10% respectively. Sargan overidentification $p > 0.1$ implies that we fail to reject the null hypothesis that the instruments are valid, not applicable with number of beef cows and number of ewes equation as the equations are exactly identified.

4.2. The Impact of Decoupled Payments on Milk Output

In Table 3, we present the estimates of the impact of decoupled payments on milk output. We ran the regression using different specifications by allowing revenue to enter the model in different forms. Model (1) includes market revenue for all outputs, while model (2) includes revenue from dairy output only (dairy cows plus milk output). Model (3) includes the three-year weighted average of market revenue and weighted average of overhead costs, whereas model (4) reports the estimation that includes the three-year weighted average of dairy revenue and weighted average of overhead costs.

According to the empirical results reported in Table 3, all estimated decoupled payments and revenue coefficients have positive signs and are statistically significant suggesting that both the decoupled payments and revenue have significant stimulating impacts on milk output. With respect to model (1), the results show that receipt of decoupled payments is associated with an increase of about 0.24% in milk output while market revenue is associated with a higher increase of about 0.41%. Similarly, in model (2), the results suggest that the positive impact of dairy revenue on milk output is about 1.7 times that of decoupled payments. When the market revenue and overhead costs are weighted as reported in model (3), decoupled payments and market revenue still retain their signs and significance. The elasticity of decoupled payments is 0.234, while that of weighted market revenue is 1.289, suggesting that the responsiveness of milk output to market return is about 5.5 times that of decoupled payments. The relationship is also reported in model (4) as the results show that the elasticity of decoupled payments is 0.267 and that of weighted dairy revenue is 1.118, suggesting that the impact of dairy revenue on milk output is about 4 times that of decoupled payments. Overall, the results indicate that the impact of decoupled payments was significant but with lower elasticities compared to market revenue, suggesting that milk production decisions are more guided by economic principles rather than the receipt of decoupled payments by dairy farmers. Findings that found modest impact of decoupled payments include [14,16]. Not surprisingly, the coefficient for the cost variable was found to be significant and negative in models (3) and (4) suggesting that milk output reduces with farm overhead costs. However, the results suggest that farmers are more responsive to changes in output returns than input costs.

The estimates of the other covariates are also reported in Table 3. We observe uniformities in the signs of the coefficients of the control variables across models (1), (2), (3) and (4), albeit with different significant levels. The coefficient of the variable representing other government subsidies' payments (including mainly agri-environment and Less Favoured Areas payments) is not significant across the four models. This may reflect the fact that they form an insignificant proportion of farm business income and therefore do not have a significant influence on milk output. As expected, the asset value coefficient has a positive and significant impact on milk output, indicating that farms with a higher asset value are not credit constrained and have the ability to raise finance for the expansion of milk output. The coefficients of age were found to be negative, while its quadratic form was found to be positive (albeit, this was only significant in model (3)). This indicates that the younger farmer tends to increase their milk output. The variable farm size was found to be positive and significant across all the models, suggesting that milk output increases with farm size. This may reflect the presence of economies of scale, especially among larger dairy farms. The share of rented land was found to be positive and significant across all the models. It is likely that farmers who rent land do so due to a need to accommodate more livestock. This positive impact offsets possible negative effects such as lower incentives associated with cultivating rented land compared to owned land and costs of renting. Finally, the family labour ratio was found to reduce milk output across all the models, albeit only significant in models (3) and (4). This implies that dairy farmers that are more market-oriented use more paid labour so as to increase and or maintain milk output.

Table 3. The impact of decoupled payment on milk output, 2008-2016.

Variable	Market Revenue and Cost	Dairy Revenue and Cost	Three-Year Market Revenue (Weighted Average)	Three-Year Dairy Revenue (Weighted Average)
	(1)	(2)	(3)	(4)
ln Decoupled Payments	0.239 **	0.324 ***	0.234 **	0.267 ***
	(0.106)	(0.100)	(0.102)	(0.099)
ln Market Revenue	0.411 ***			
	(0.059)			
ln Dairy Revenue		0.564 ***		
		(0.054)		
ln Dairy Revenue (3 years avg.)				1.118 ***
				(0.079)
ln Market Revenue (3 years avg.)			1.289 ***	
			(0.094)	
Ln Costs	0.081	−0.008		
	(0.060)	(0.055)		
ln Costs (3 years avg.)			−0.411 ***	−0.381 ***
			(0.084)	(0.068)

Table 3. *Cont.*

Variable	Market Revenue and Cost	Dairy Revenue and Cost	Three-Year Market Revenue (Weighted Average)	Three-Year Dairy Revenue (Weighted Average)
	(1)	**(2)**	**(3)**	**(4)**
Other Government Payment	0.000	0.000	0.012	0.012
	(0.000)	(0.000)	(0.009)	(0.008)
ln Asset Value	0.154 **	0.113 *	0.220 **	0.102
	(0.062)	(0.059)	(0.093)	(0.085)
ln Age	−0.128	−1.903	−1.978	−3.742 ***
	(2.011)	(1.889)	(1.450)	(1.331)
ln Age Squared	0.033	0.268	0.264	0.488 ***
	(0.264)	(0.248)	(0.186)	(0.171)
ln Farm Size	0.213 **	0.183 **	0.333 ***	0.310 ***
	(0.098)	(0.093)	(0.099)	(0.090)
Off-Farm Employment	0.015	−0.001	0.025	0.028
	(0.034)	(0.033)	(0.031)	(0.032)
GSCE	0.021	0.020	0.001	0.001
	(0.042)	(0.040)	(0.031)	(0.029)
A-Level	0.026	0.064	0.032	0.031
	(0.052)	(0.049)	(0.043)	(0.042)
Rent Ratio	0.604 ***	0.640 ***	0.537 ***	0.424 ***
	(0.164)	(0.155)	(0.153)	(0.144)
Family Labour Ratio	−0.122	−0.149	−0.204 *	−0.223 *
	(0.114)	(0.108)	(0.123)	(0.121)
Observations	525	525	462	462
R-Squared	0.451	0.508	0.72	0.77
Number of Farms	75	75	66	66

Robust Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ indicate statistical significance at 1%, 5% and 10% respectively.

4.3. The Impact of Decoupled Payments on Beef Production (Number of Beef Cows)

Similar to Table 3, we report four model specifications with different revenue and costs variables in Table 4. Model (1) includes market revenue for all outputs while model (2) includes revenue from beef output only. Model (3) includes the three-year weighted average of market revenue and weighted average of overhead costs, whereas model (4) reports the estimation that includes the three-year weighted average of beef revenue and weighted average of overhead costs.

The coefficients of decoupled payments across all the models, as reported in Table 4, are positive and significant which imply that an increase in decoupled payments of 1% is associated with an increase in the number of beef cows, ranging from 0.13% to 0.15%. Similarly, the results across all the models also show that the coefficients of market and beef revenue are positive and significantly impact number of beef cows produced except in model (3) where it was found insignificant. The impact of revenue ranges from 0.13% to 0.19%. Specifically, the results reported in model (1) shows that the impact of decoupled payments on number of beef cows is about 1.1 times higher than the impact of market revenue. In contrast, the results of model (2) show that the positive impact of beef revenue on the number of beef cows is 1.3 times higher than the impact of decoupled payments. When the market revenue and overhead costs are weighted as reported in model (3), only decoupled payments was found to be significant, while weighted market revenue was not significant. In model (4), the results show that the elasticity of decoupled payments is 0.13 and that of weighted beef revenue is 0.19, suggesting that the impact of beef revenue on number of beef cows is about 1.5 times that of decoupled payments. The finding that the elasticities of beef revenue are significantly higher than the elasticities of decoupled payments, suggests that the production decisions by beef farmers are more guided by market conditions than policy incentives. Additionally, this may possibly be adduced to non-monetary motivation for beef farming, for example, as a habit. The cost and other government subsidies' payments variables were found to be insignificant.

Table 4. The impact of Decoupled Payment on number of beef cows, 2008–2016.

Variable	Market Revenue and Cost	Beef Revenue and Cost	Three-Year Market Revenue (Weighted Average)	Three-Year Beef Revenue (Weighted Average)
	(1)	(2)	(3)	(4)
ln Decoupled Payments	0.145 **	0.134 *	0.140 *	0.127 *
	(0.074)	(0.072)	(0.074)	(0.073)
ln Market Revenue	0.128 **			
	(0.057)			
ln Beef Revenue		0.172 ***		
		(0.056)		
ln Beef Revenue (3 years avg.)				0.191 **
				(0.086)
ln Market Revenue (3 years avg.)			0.097	
			(0.087)	
ln Costs	0.014	0.020		
	(0.057)	(0.057)		
ln Costs (3 years avg.)			−0.018	−0.048
			(0.091)	(0.092)
ln Other Government Payment	−0.024	−0.025	−0.021	−0.019
	(0.019)	(0.019)	(0.019)	(0.019)
ln Asset Value	0.171 *	0.165 *	0.181 *	0.176 *
	(0.094)	(0.093)	(0.101)	(0.099)
ln Age	−1.951	−2.520	−2.384	−2.644
	(4.525)	(4.464)	(4.715)	(4.601)
ln Age Squared	0.193	0.260	0.249	0.278
	(0.592)	(0.584)	(0.615)	(0.600)
ln Farm Size	0.356 **	0.416 ***	0.290 **	0.349 **
	(0.140)	(0.141)	(0.139)	(0.139)
Off-Farm Employment	−0.008	−0.009	−0.012	−0.014
	(0.031)	(0.031)	(0.032)	(0.033)
GSCE	0.152 *	0.158 *	0.159 *	0.165 **
	(0.081)	(0.082)	(0.083)	(0.084)
A-Level	0.272 **	0.278 **	0.289 ***	0.287 **
	(0.111)	(0.111)	(0.112)	(0.113)
Higher Education	0.616 ***	0.645 ***	0.636 ***	0.659 ***
	(0.149)	(0.151)	(0.151)	(0.152)
Rent Ratio	0.016	−0.006	0.023	−0.016
	(0.212)	(0.210)	(0.217)	(0.217)
Family Labour Ratio	−0.708 ***	−0.715 ***	−0.792 ***	−0.790 ***
	(0.226)	(0.224)	(0.233)	(0.230)
Observations	471	471	471	471
R-Squared	0.122	0.135	0.108	0.118
Number of Farms	62	62	62	62

Robust standard errors in parentheses*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ indicate statistical significance at 1%, 5% and 10% respectively.

Turning to the other control variables, we observe uniformities in the signs of the coefficients across all the models, but at different significant levels. As expected, asset value was positively significant, with its elasticities ranging from 0.165 to 0.181. This suggests that wealthier farmers are not credit constrained and thereby they can expand beef production. The variable farm size was found to be positive and significant across all the models, suggesting that an increase in farm size will increase the number of beef cows. The results also show that increase in human capital through education are associated with increased beef cow production. This reflects that better resource management is a result of the education status of farmers. The results also revealed that rent ratio is positive and significant, suggesting that farmers with higher shares of rented land have a stronger motivation for expansion. The family labour ratio was found to reduce beef cows produced. This may imply that beef farmers use more of hired labour as an incentive to increase the level of production.

4.4. The Impact of Decoupled Payment on Sheep Production (Number of Ewes)

Similar to Tables 3 and 4, we report four model specifications with different revenue and costs variables in Table 5. Model (1) includes market revenue for all outputs, while model (2) includes revenue from sheep output only. Model (3) includes the three-year weighted average of market revenue and weighted average of overhead costs whereas model (4) reports the estimation that includes the three-year weighted average of sheep revenue and weighted average of overhead costs.

The empirical results across all the models suggest a statistical relationship between decoupled payments and number of ewes produced. The coefficients imply that a 1% increase in decoupled payments is associated with an increase ranging from about 0.23% to 0.24% in the number of ewes. The coefficient of market revenue, and its weighted term in model (1) and model (3) respectively, are found to be insignificant. However, the results of model (2) and model (4) show that sheep revenue and its weighted term are positive and significantly influence number of ewes. Comparing the impact of decoupled payments and revenue on number of ewes, our results suggest that decoupled payments has more production stimulating impacts than revenue in the sheep sector. For example, in model (2), the impact of decoupled payments is approximately two times that of sheep revenue, while in model (1) the impact of market revenue is negative and insignificant. One possible explanation for this is that sheep farmers in NI are less economically viable and may have been using decoupled payments to continue or increase sheep production.

The results for the other explanatory variables are consistent in signs, although with different significance levels, lending credence to our estimates. As expected, having off-farm employment reduces the number of ewes produced. One explanation for this relationship is that farmers that have an off-farm job commit less time to sheep farming. Similarly, participation in off-farm employment may reduce a farm's sole dependency on sheep production, leading to fewer resources being devoted to sheep farming. The results also show that an increase in human capital through education are associated with increased ewe production. The estimated coefficient associated with family labour ratio was negative and significant, suggesting that the number of ewes reduces with share of family labour employed in sheep farming.

Table 5. The impact of Decoupled Payment on number of ews, 2008-2016.

Variable	Market Revenue and Cost	Sheep Revenue and Cost	Three-Year Market Revenue Average	Three-Year Sheep Revenue Average
	(1)	(2)	(3)	(4)
ln Decoupled Payments	0.242 ***	0.238 ***	0.232 **	0.262 ***
	(0.090)	(0.087)	(0.094)	(0.091)
ln Market Revenue	−0.010			
	(0.051)			
ln Sheep Revenue		0.132 ***		
		(0.044)		
ln Sheep Revenue (3 years avg.)				0.189 ***
				(0.064)
ln Market Revenue (3 years avg.)			−0.044	
			(0.098)	
ln Costs	0.042	−0.022		
	(0.070)	(0.067)		
ln Costs (3 years avg.)			0.099	−0.020
			(0.106)	(0.094)
ln Other Government Payment	−0.017	−0.019	−0.016	−0.015
	(0.024)	(0.023)	(0.024)	(0.023)
ln Asset Value	0.101	0.066	0.170	0.052
	(0.083)	(0.081)	(0.115)	(0.082)
ln Age	0.037	−0.127	−0.134	1.100
	(5.163)	(5.095)	(5.295)	(4.933)
ln Age Squared	0.141	0.169	0.164	0.015
	(0.677)	(0.668)	(0.695)	(0.647)
ln Farm Size	0.054	0.106	0.019	0.087
	(0.167)	(0.164)	(0.175)	(0.161)
Off-Farm Employment	−0.058 *	−0.045	−0.063 **	−0.040
	(0.031)	(0.033)	(0.031)	(0.034)
GSCE	0.021	0.009	0.021	0.022
	(0.068)	(0.064)	(0.068)	(0.066)
A-Level	0.168 **	0.161 **	0.163 **	0.185 **
	(0.080)	(0.078)	(0.080)	(0.079)
Rent Ratio	−0.039	−0.057	0.041	−0.046
	(0.346)	(0.342)	(0.376)	(0.346)
Family Labour Ratio	−0.635 **	−0.565 **	−0.622 **	−0.574 **
	(0.250)	(0.245)	(0.251)	(0.247)
Observations	460	459	460	460
R-Squared	0.181	0.209	0.187	0.209
Number of Farms	58	58	58	58

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ indicate statistical significance at 1%, 5% and 10% respectively.

5. Conclusions

In this paper, we study the impact of Pillar I payments (decoupled payments) on farm production, with a particular emphasis on livestock production in NI. Although these payments are not directly linked with farm production decisions in terms of administrative structure, several pathways through which the production impact of decoupled payments can occur are well established in the literature.

To estimate empirically the impact of decoupled payments on farm production in NI, we employed the IVFE approach and used the FBS farm-level panel data for the period 2008–2016. The results emanating from this study suggest that even though decoupled payments are delinked from production, they continue to exert an influence on production outcome. According to our elasticity estimates, the production effect of decoupled payments on milk output ranges from 0.23% to 0.32%, but is less compared to the impact of revenue, which range from 0.41% to 1.28%. For beef farmers, the production stimulating impact of decoupled payments ranges from 0.12% to 0.14%, albeit higher than the impact of market revenue. For the sheep farms, our estimates revealed that elasticities of decoupled payment range from 0.23% to 0.26%, while insignificant elasticities of market revenue were observed. Hence, our results provide evidence that agricultural subsidies in NI, although decoupled from current production, farmers still treat these payments as coupled, particularly beef and sheep farmers.

The results have important implications for the implementation of future reforms of agricultural subsidies in the EU and UK. Pillar I decoupled payments are likely to be squeezed in the future, particularly in the UK post-Brexit with either more money being transferred to Pillar II payments (i.e., Less Favoured Areas and more explicit agri-environmental payments) or a reduction in the overall agricultural budget. The finding that decoupled payments have a significant impact on production, suggests that such reductions will lead to a decline in agricultural production. However, it is important to bear in mind that the estimated elasticities in this analysis capture marginal changes in the level of direct payments and hence, care needs to be taken in making inferences in substantial changes in these payments such as the full elimination of direct payments.

In this present study, we have been only able to cover the production impact of decoupled payments in NI, which is one of the implemented policy options of CAP as implemented in the UK. Although the production impact of other elements of CAP such as the agri-environment scheme and rural development scheme among others, is outside the scope of our study, it is important for the design of future agricultural and environmental policies in the UK and the EU. Future studies can be devoted to assessing the impact of these policies on agricultural production.

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