Intra-national importation of pig and poultry manure: acceptability under EU Nitrates Directive constraints

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ABSTRACT

Matching the agronomic limits of manure spread lands from housed animal units is an international concern where receiving lands can become over supplied and lead to water quality problems where eutrophication is a risk. Across the EU, this means establishing policy to export manures to off-farm spread lands under tight regulation. Transitional arrangements across, for example, the Republic of Ireland between 2006–2010 allowed pig and poultry manures to be spread subject only to the nitrogen amendment limits of the EU Nitrates Directive and not the phosphorus limits. From 2013 this arrangement is to be phased out, and pig and poultry producers have consequently expressed concerns about the availability of recipient spread lands for these manures. Using a national farm survey and a multinomial model this paper investigates the willingness of the farming population to import these manures. Results indicate that between 9 and 15 per cent of farmers nationally would be willing to pay to import these manures; a further 17–28 per cent would import if offered on a free of charge basis. Demand is strongest among arable farmers, younger farmer cohorts and those of larger farm size with greater expenditure on chemical fertilisers per hectare and who are not restricted by a Nitrates Directive derogation. The nature of this demand could assist in achieving environmental goals under the EU Nitrates and Water Framework Directives.

KEYWORDS: Pig and poultry manure; willingness to import; multinomial logit model

1. Introduction

The 1991 Nitrates Directive (ND) is one of the earliest pieces of EU legislation aimed at controlling and improving water quality. The ND aims to minimise surplus phosphorus (P) and nitrogen (N) losses from agriculture to the aquatic environment by constraining use to agronomic optima and limiting to periods where mobilisation during runoff events is minimised. The Directive was implemented in the Republic of Ireland through Statutory Instrument (S.I.) 378 of 2006, and updated in Statutory Instrument 101 of 2009 (Government of Ireland, 2006; 2009). Commonly referred to as the Good Agricultural Practice (GAP) regulations, these gave statutory effect to Ireland's national ND National Action Programme. The GAP regulations mandate a minimum slurry storage requirement for the housing of livestock over the winter period and closed periods for spreading organic manures during autumn and winter months. Limits on livestock intensity are also implemented to indirectly constrain organic N use to 170 kg organic N ha^{-1} per annum and up to 250 kg N ha^{-1} per annum where a derogation has been granted[3] (see Fealy et al., 2010 for a more detailed review of ND regulation requirements). The application limit of chemical fertilizers is recommended by crop type at rates defined by crop demand (Coulter and Lalor, 2008). A restriction on spreading according to a P limit is primarily related to a soil P index system which is based on the measured concentration of available P in soil as determined by the Morgan's P test (Morgan, 1941; Schulte et al., 2010).

Export-import of housed animal manures is common throughout the EU and other countries especially for intensive systems such a pig and poultry. In areas of intense pig and poultry production over fertilisation of land locally can result in negative environmental consequences for water quality (Langeveld et al., 2007). Application of these manure to suitable spread lands with correspondent nutrient demand is a challenge across many developed countries (Teira-Esmatges and Flotats, 2003; Adhikari et al., 2005; Paudel and McIntosh, 2005; Biberacher et al., 2009 Paudel et al., 2009;) especially in the EU with the advent of the Nitrates and Water framework Directives (Van der Straeten et al. 2010; Schroder and Verloop 2010; Warneck et al., 2010; Jacobson, 2011).

Across the Republic of Ireland a four year transitional arrangement between 2006–10 applied to pig and poultry manures as well as spent compost from the

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[3] A total of 4,190 farmers secured Derogation in 2010. This equates to 3 per cent of the population. Statistics from the Teagasc National Farm Survey 2009 (EU Farm Accountancy Data Network based) indicate a mean organic N and P across all farm systems of 95 kg Ha^{-1} and 14 kg Ha^{-1} respectively (Teagasc, 2010).

mushroom (SMC) industry (Schulte, et al., 2010). This transitional arrangement allowed these manures to be spread subject only to the N part of the regulation and not the P limits of the Directive. The Nitrates Action Programme was reviewed in 2010, and a second Action Programme has come into effect through S.I. 610 of 2010 (Government of Ireland, 2010). In the second programme, the transitional arrangements for pig and poultry manure and spent mushroom compost (SMC) were extended until 31 December 2012. However, from 1 January 2013 onwards, spreading of pig and poultry manure and SMC will be subject to maximum available P application rates. Starting from 2013, P in these organic manures may only be applied at excess rates of 5 kg ha^{-1}; from 1 January 2015 this surplus will be reduced to 3 kg ha^{-1}, and from the 1 January 2017 the transitional arrangements will end, with no further P excess allowed for pig and poultry manure or SMC. The short-term extension of the transitional period effectively recognised the difficulties that implementing the regulations would have on the pig and poultry sectors.

The phasing out of the transitional arrangements will impose significant restrictions on the use of grassland as recipient land for pig and poultry slurry. It is estimated that this could lead to a 50 per cent increase in the land area required for application of this manure (Schulte et al., 2010). From 2013 onwards, where recipient grassland fields are assumed to be in the optimum target Soil P Index 3 (5.1–8.0 mg l^{-1} available P for grass soils) [4], the annual 'maximum fertilisation rate' of P is restricted to between 15 and 29 kg ha^{-1}, depending on Nitrates Derogation and prevailing stocking rate. However, once P inputs from livestock and purchased concentrates[5] are counted and deducted from the maximum annual total P input, the amount of P that may be brought onto these grassland based holdings in the form of either chemical fertiliser or externally produced slurry / manure is likely to be minimal. This is in contrast to arable or root crop area where depending on the crop sown, and assuming P index 3 (6.1–10.0 mg l^{-1} available P for arable soils), maximum fertiliser rates range from 20 to 100 kg ha^{-1} (Government of Ireland, 2010).

Farms generating excessive supplies of N and P can either reduce production, export surpluses as processed or unprocessed manure. Burton and Turner (2003) note that the redistribution of surpluses is a particular issue in a number of EU countries (or regions therein) where local manure surpluses are particularly large due to intensive production (e.g. - Netherlands, Denmark, Belgium). Netherlands pioneered the development of a sophisticated system for distribution, control and accounting of manure from the livestock intense southern region to the more arable north. Van der Straeten et al (2010) notes the issue can be viewed as an allocative problem. Affected farmers have limited spread lands and assuming no decrease in production, are faced with two allocation options; transporting manure to other farmers' land or processing manure. The most common processing options include separation, anaerobic digestion and nitrification/de-nitrification. Teagasc Pig Development Unit (2009) notes denitrification /nitrification is only relevant when there is no economical solution to excess organic N and anaerobic digestion has nothing to offer in dealing with excess N and P. Separation of the slurry into a liquid nitrogen rich fraction and solid based phosphorus rich fraction, which is exported from the farm, has been discussed in the literature (Schroder and Verloop 2010; Jacobson, 2011). The P rich solid fraction is less bulky and can be exported at lower costs to arable farms as a substitute for chemical P fertilizer. Livestock farms could substitute the N rich liquid fraction for chemical N fertilizer. Because of the high density of pigs and cattle in some EU regions, manure processing has become more prevalent. In many cases after separation the P-rich solid fraction is composted before being exported long distances to cropland, however, land application is more difficult requiring specialist equipment (Butron and Turner, 2003; Teagasc Pig Development Unit, 2009). While processing offers an alternative to transporting slurry, it is capital and energy intensive (Lopez-Ridaura et al., 2008) and Jacobson (2011) concludes that traditional handling of animal manure has the lowest costs and separation is difficult to justify unless the farm is situated in a very livestock intensive area where it is difficult to get rid of the slurry.

In the Republic of Ireland a general response to the sector's concerns was that the pig and poultry sectors could shift the focus of land spreading to arable areas. The argument for an arable land based solution to the issue of pig/poultry manure holds that with 10 per cent of the national land area in crop production, there should be land available[6] to take the national output from pig and poultry producers. In response the pig and poultry sectors argued that the concentration of the industry in the border region of Ireland (bordering Northern Ireland) and the lack of arable land in this region could lead to the demise of these industries.

There were 1.62 million pigs in the Republic of Ireland in 2007 (CSO, 2008). The border region[7] accounted for 30 percent of the total pig population while the south west and south east accounted for 22 and 19 per cent respectively. The total poultry population was 11.9 million birds (CSO, 2008) and was dominated by the border region which accounted for 64 per cent of the total population. 375,000 hectares is devoted to cereal or root crops in the Republic of Ireland in 2009 (CSO, 2011a), approximately 10 per cent of this production takes place in the border region. The main cereal or root crop producing regions are the south east (32 per cent), mid-east (23 per cent) and the south west (17 per cent) as outlined in Table 1.

It clear from Table 1 that the border region with 30 and 64 per cent of the pig and poultry populations and 10 per cent of arable and root crop area has the greatest potential disparity between supply of these manures and

[4] Greater quantities are allowed where the field soil P index is sub-optimal level (index 1 and 2), no P is allow where soil P status is enriched at index 4. Refer S.I. No 610 of 2010 for detail of allowances.

[5] Under Nitrates regulations in the Republic of Ireland (S.I. 610 of 2010) the P content of imported feedstuffs is set at 0.5 kg P in respect of each 100 kg except where the actual P content is known and provided by the supplier. There is hence an incentive to import lower P content feedstuffs.

[6] There is no geographical restriction on recipient spread lands.

[7] The regional composition is based on the NUTS (Nomenclature of Territorial Units) classification used by Eurostat. The NUTS3 regions correspond to the eight Regional Authorities established under the Local Government Act, 1991 (Regional Authorities) (Establishment) Order, 1993, which came into operation on 1 January 1994.

Table 1: Regional distribution or pig, poultry and arable production across the Republic of Ireland

Region	Pig Population	Poultry population	Cereals & root crops area
Border	30%	64%	10%
South-West	22%	8%	17%
South-East	19%	9%	32%
Midland	14%	1%	9%
Mid-West	6%	12%	4%
Mid East	5%	4%	23%
West	3%	2%	3%

availably of recipient arable land locally. Historically, grassland farms have been the main receptors of these manures in this region. However, with the ending of the transitional arrangements in 2013, where these manures become subject to P as well as N limits, recipient grassland farms maybe become more difficult to source.

A national survey of manure application and storage practices on Irish farms (Hennessy et al, 2011) reported that 4 per cent of all farmers' imported slurry and/or farmyard manure in 2009. Of those importing, three-quarters reported importing pig slurry. The tillage farm system are the most likely to be importing, almost 20 percent of tillage farmers report that they imported organic fertilisers in 2009. Of these farms, 72 percent had imported pig slurry, 20 percent had imported cattle slurry while the remaining 8 percent had imported poultry manure.

It is estimated that pig manure generates approximately 13,500 tonnes of N and 2,600 tonnes of P annually across the Republic of Ireland (Teagasc Pig Production Development Unit, 2009). This is equivalent to 4.4 and 9.9 per cent of chemical N and P used on farms in the Republic of Ireland (DAFF, 2009). A total of 172,735 tonnes of poultry litter is produced annually (Leahy et al, 2006) it is estimated that this is equivalent to 2,708 tonnes of N and 1,120 tonnes of P based on poultry production profile data (CSO, 2009) and associated average nutrient values (Coulter and Lalor, 2008). This corresponds to 0.8 and 4.2 per cent of chemical N and P used on farms in the Republic of Ireland. The fertilizer replacement value of P for these manures is set at 100 per cent for P and 50 per cent for N under the regulations (Coulter and Lalor, 2008) although N availability maybe increased based on optimal application, timing and method.

Fealy et al., (2012) recently investigated the cost of transporting pig slurry to arable lands. They found that the average distance from a commercial pig unit to arable land was 21 kilometres. However, the counties with an average distance of less than 5 kilometres account for less than 7 per cent of total sow numbers. At the other extreme, the border and western counties had average distances of over 20 kilometres and this area accounts for over one third of all sows. Cavan a county in the border region with nearly 20 per cent of the total sow population has an average distance of 56 kilometres. McCutcheon and Lynch (2008) suggested that, depending on the dry matter content, at distances of 25 to 100 kilometres[8] the marginal cost of the manure may exceed the nutrient benefit derived from importation. This will be influenced by prevailing chemical fertiliser and fuel prices.

[8] This range is based on dry matter content of between 3 to 6 per cent.

The decision to import pig and/or poultry manure is ultimately dependant on the nutrient value of the manure; the cost of transport and application; and farmer preferences. The nutrient value of pig and poultry manure is dependant on the price of chemical fertilisers as there is direct substitution potential. Chemical fertiliser prices have been subject to significant price volatility over the last decade as indicated by an 80 per cent increase between 2005 and 2008 (CSOa, 2011). Sales of 308,960 tonnes of nitrogen and 26,350 tonnes of P chemical fertilisers were recorded in 2008 (DAFF, 2009). Application rates of chemical N on grassland ranged from 106 kg N Ha^{-1} in the south-east to 48 kg N Ha^{-1} in the west and 75–76 N kg N Ha^{-1} in the midlands and border regions. Cereal farms in the mid-east and border regions reported the highest level of chemical N applications at 159 and 151 kg N Ha^{-1} respectively, compared to 84 kg N Ha^{-1} in the south and 128 kg N Ha^{-1} in the south-east. Average P applications on grassland were relatively uniform averaging 5 kg P Ha^{-1} ranging from 6 kg P Ha^{-1} in the south-east to 4 kg P Ha^{-1} in the west and mid-east. Chemical P application averaged 20 kg P Ha^{-1} across cereal farms ranging from 17 kg P Ha^{-1} in the mid-east to 24 kg P Ha^{-1} in the south-west (Lalor et al., 2008).

Farmers' nutrient management preferences will affect their willingness to import pig and poultry manures. Some farmers have express concern about handling pig and poultry slurry and the potential variability of nutrient content across these manures. In a tillage context, pig/poultry manure must be applied within a narrow time period, using specialist equipment, typically immediately before ploughing, hence the manure needs to be available on or close to the tillage farm at the appropriate time or storage facilities need to be available on tillage farms (Schulte et al., 2010). Livestock farmers have also expressed concerns around potential pathogens associated with these manures and many have traditional viewed these organic manures as a waste product to be disposed of more than a nutrient source (Burton and Turner, 2003). On the positive side recent research has shown that pig slurry has the potential to offset crop stressors such as drought (Plunkett, 2011).

Assuming farmer preferences are not biased against pig or poultry manure sources, economic rationality would suggest that they should consider importation of these manures if the cost of importation (nutrient value, transport and applications costs) is less than or equal to the equivalent cost of chemical fertilisers application. In this context this paper seeks to examine if there is a potential market for these organic manures and to investigate the farm and demographic variables which influence farmers' willingness to import these nutrient sources.

2. Methodology

The main data source employed in this analysis is a National Farm Survey (NFS) conducted in 2007. This NFS is collected annually as part of the Farm Accountancy Data Network requirements of the European Union (Farm Accountancy Data Network (FADN), 2005). The purpose of FADN and the NFS is to collect and analyse information relating to farm activities, financial returns to agriculture and demographic characteristics. A farm accounts book is recorded on a random representative sample of farms throughout the Republic of Ireland. The sample is weighted to be representative of farming nationally across Ireland. In the 2007 NFS survey 1,151 farmers were surveyed representing 111,913 farmers nationally.

In addition to the main survey, additional special supplementary surveys on specific topics are conducted annually. Questions investigating farmers' willingness to import pig and poultry manures onto their land were included and conducted in conjunction with the regular NFS data collection schedule in autumn 2007. Interviews were undertaken on site by a team of trained NFS recorders. Not all the respondents from the main survey participated in the supplementary survey in 2007. Hence it was necessary to re-weight the sample to produce a matched balanced dataset. The final dataset used in this analysis consisted of 986 farmers which represents 97,752 farmers when weighted and is still nationally representative at approximately 1% based on random sampling.

A multinomial logit model was used to investigate the willingness of farmers to import (WTI) pig and/or poultry manures. The landowner decision process had three exclusive outcomes, indexed by $j \in \mathrm{J} = \{0, 1, 2\}$: not willing to import pig and/or poultry manures onto farm (j=0), willing to import pig and/or poultry on a free of charge basis where slurry, transport and spreading was free, (j=1) willing to import pig and/or poultry manures on a payment basis, where a farmer would pay towards slurry, transport and spreading (j=2). Assuming that the utility that landowner, n, derives from the chosen alternative, j (denoted U_{nj}) can be written as (Long, 1997):

$$U_{nj} = X_n\beta_j^{'} + \varepsilon_{nj} \tag{1}$$

Where the deterministic part $X_n\beta'_j$ relates to characteristics of the landowner and ε_{nj} is an error term. The framework is based on random utility theory (McFadden, 1973 and Pudney, 1989). The probability that landowner $_n$ will select outcome j from outcome set J is then:

$$\Pr_{nj} = P(j \mid \mathrm{J}) = \Pr\left(X_n\beta_j^{'} + \varepsilon_{nj} > X_n\beta_k^{'} + \varepsilon_{nk}\right) \quad \forall k \in \mathrm{J},\ j \neq k \tag{2}$$

By using the logistic distribution the probability, Pr, that landowner n will choose alternative j can be written as (McFadden, 1973):

$$\Pr(y_n = j) = \frac{\exp\left(\mathrm{x}_n\beta_j^{'}\right)}{1 + \Sigma_k^K \exp\left(\mathrm{x}_n\beta_k^{'}\right)} \tag{3}$$

The probabilities shown in equation (3) are those for the multinomial logit model (Long and Freese, 2006). Interpretation of multinomial logit results requires that one potential outcome is selected as the "default", hence all coefficients for a characteristic group should be interpreted as relative to a default category. In this application farmers not willing to import these manure were set as the primary base category and the model investigates factors which influence willingness to import these manure on a payment and free of charge basis.

3. Results

Descriptive analyses of results show that 58 per cent of the sample were not willing to import pig slurry and 74 per cent were not willing to import poultry manure. A total of 15 and 9 per cent indicated a WTI pig and poultry manure on a payment basis respectively, while 28 percent indicated a willingness to import pig slurry only if offered on a free of charge basis while the relevant statistic for poultry was 17 per cent as outlined in Table 2.

A number of independent variables *a priori* could be expected to affect the probability that a farmer is willingness to import these manures. These include age, expenditure on chemical fertilisers, farm size, per cent of the farm under arable crops and whether the farm is subject to Nitrates Directive derogation. These variables are included in the multinomial logit model and descriptive statistics and a definition for these variables are given in Table 3.

The multinomial logit model requires that one potential outcome be selected as the default or base category and outcomes for all other categories are interpreted relative to this base. The base category for columns 1 and 2 in Tables 4 and 5 are those landowners who were not willing to import these manures. Hence all

Table 2: Willingness of farmers to import pig and poultry manures

	Pig Manure		Poultry Manure	
	No.	%	No.	%
WTI on a payment basis	144	(15%)	92	(9%)
WTI on a free of charge basis	275	(28%)	167	(17%)
Not WTI	567	(58%)	727	(74%)
Total	986	(100%)	986	(100%)

Table 3: Descriptive statistics for variables in multinomial logit model

	Mean	S.D	Min	Max
Age (yrs)	56	12	22	86
Fertiliser expenditure (€ ha^{-1})[1]	76	56	0	381
Farm size (ha)	33	29	3	346
Per cent of farm under cereal/root crops	4	13	0	100
Nitrates derogation (% of farmers)	7	26	0	1

[1]Average fertiliser € ha^{-1} among tillage farmers in the sample was €132 ha^{-1}

coefficients should be interpreted as relative to this base category. Column 3 has a base of WTI for free and compares this with farmers who are WTI on a payment basis.

Willingness to import pig manure

Age was found to be negatively associated with WTI pig manure both on a payment and free of charge basis. Younger farmers tend to be more aware of the nutrient value and potential of these manures and hence more likely to import. Pig slurry is a direct substitute for chemical fertilisers and results indicate that farmers who are applying greater quantities of chemical fertiliser as measured here by fertiliser expenditure per hectare are significantly more likely to be willing to import pig slurry on a payment basis. Farm size is positively related to WTI (free and payment), this suggests larger more commercial farms are more willing to consider this alternative.

Derogation farmers are prohibited from importing organic manure and results reflect this, farmers not restricted under derogation were more likely to be WTI pig manure both on a free of charge and payment basis. Finally, farms with larger proportions of land devoted to arable or root crops were strongly associated with WTI on a payment basis, these farms are growing crops with higher nutrient demand and can potentially utilise these manures most efficiently by incorporation into soils at the cultivation stage.

A Wald test was performed to test whether the parameters of the model are all equal to zero. The Wald χ^2 statistic shows that, taken jointly, the coefficients for this model specification are significant at the 1% level.

Willingness to import poultry manure

Results for WTI poultry manure follow a similar pattern to that for pig manure, however the relationships were not seen to be as strong statistically. Age was again found to be negatively associated with WTI poultry manure as were restrictions under a Nitrates Directive derogation. Farm size was again positively related to WTI, particularly for those WTI on a free of charge basis. Results indicate that farmers with higher levels of expenditure on chemical fertiliser per hectare are more likely to be WTI, but the relationship was not statistically significant. As before farms with a greater

Table 4: Results of multinomial logit model examining landowner WTI pig manure

Variable	WTI – payment (Base=not willing to import) (1)	WTI – Free (Base=non willing to import) (2)	WTI – payment (Base= WTI - Free) (3)
Age	−0.017 (0.01)*	−0.19 (0.09)**	0.001 (0.011)
Fertiliser expenditure € Ha^{-1}	0.003 (0.002)*	0.002 (0.002)	0.0011 (0.0018)
Farm size (hectares)	0.01 (0.005)**	0.01 (0.004)***	−0.001 (0.004)
Nitrates derogation	−0.9 (0.42)**	−0.85 (0.35)**	−0.019 (0.459)
% of farm under arable crops	1.53 (0.63)**	0.41 (0.66)	1.05 (0.65)*
Constant	−1.38 (0.54)**	−0.56 (0.50)	−0.88 (0.594)
Log pseudo-likelihood	−842.61		
Wald chi2	37.89		

(N=975) Standard errors are given in parenthesis beside co-efficients. Individual co-efficients are statistically significant at the *10% level; **5% level; ***1% level.

Table 5: Results of multinomial logit model examining landowner WTI poultry manure

Variable	WTI – payment (Base =not willing to import) (1)	WTI - Free (Base=non willing to import) (2)	WTI – payment (Base = WTI - Free) (3)
Age	−0.003 (0.01)	−0.12 (0.011)	0.008 (0.15)
Fertiliser expenditure € Ha^{-1}	0.002 (0.002)	0.0005 (0.002)	0.001 (0.003)
Farm size (hectares)	0.008 (0.006)	0.012 (0.004)***	−0.004 (0.005)
Nitrates derogation	−0.59 (0.6)	−0.72 (0.38)**	0.13 (0.67)
% of farm under arable crops	1.9 (0.67)***	0.34 (0.64)	1.56 (0.72)**
Constant	−2.47 (0.636)***	−1.43 (0.58)**	−1.00 (0.762)
Log pseudo-likelihood	−660.74		
Wald chi2	30.95		

(N=975) Standard errors are given in parenthesis beside co-efficients. Individual co-efficients are statistically significant at the *10% level; **5% level; ***1% level.

percent of land under arable crops are significantly associated with WTI on a payment basis compared to the other two groups.

The Wald χ^2 statistic again shows that, taken jointly, the coefficients for this model specification are significant at the 1% level.

4. Discussion and Conclusions

Assuming no decrease in production, farms with excessive N and P need to export surpluses, this is either potentially a cost to the system or a benefit if a willing buyer can be located. The long term price outlook for chemical fertiliser is unclear but future energy prices and growing demand from emerging economies would tend to suggest strong future demand with upward price pressure (Heffer and Prud'homme, 2010). This may make the economics of importing pig and poultry manure attractive.

Results from this study indicate that demand for importation of pig and poultry manures is generally highest among younger farmers of larger farm size with greater expenditure on chemical fertilisers per hectare who are not restricted by nitrates derogation and who are arable orientated. The desirability of pig and poultry manure as an imported farm nutrient source will depend on a number of factors including the price of chemical fertilisers, transport and application costs and farmers nutrient preferences. A large number of farmers in this sample indicated that they would not be willing to import these manures even if offered them on a free of charge basis. Issues around nutrient variability of these manures, tight windows for application and specialist equipment necessary for application have been cited as potential constraints (Vermeire et al. 2009; Schulte et al., 2010). More research is needed to examine the rationale behind this preference. Farmers in this study were not asked how much they would be willing to pay to import pig and poultry manures; additional research is also required to establish these price schedules as it may be that farmers value these manures at less or more than chemical nutrient sources.

Pig and poultry farmers across the Republic of Ireland have expressed concerns that the phasing out of the transitional arrangements for land spreading of manures from these sectors will pose significant difficulties with associated production cost implications. However, results from this analysis indicate there is a potential market for these manures across the Republic of Ireland which could be revenue generating as there is a cohort or mainly arable farmers who are willing to import these manures on a payment basis. Historically these manures were supplied to recipient farmers free of charge, but with the increase in chemical fertiliser prices a market has developed for these manures. Depending on local supply and demand conditions these manures can be revenue generating or at least have cost sharing around transportation and spreading (Carroll, 2012).The market for these manures at present is in its infancy and tends to be between local farmers of relative close proximity based on word of mouth and some third party farm advisory facilitation. If chemical fertiliser prices continue in an upward trend and with the ending of the transitional arrangements a more nationally based market may well emerge where these manures are traded much as other agricultural commodities are at present. However, the export and trade of these manures maybe constrained by regional disparities between supply and demand. Beyond 30 kilometres the transport and spreading costs exceed the nutrient value (Fealy et al., 2012). Exporters of these manures in the southern and eastern regions are generally located close to potential arable spread lands and below this threshold. However, in the pig and poultry intensive border region average distance are over double the 30 kilometre which would involve cost subsidisation by exporters. Unless grassland recipient spread lands are available locally, then these exporters are faced with reducing production, subsidising manure redistribution or investing in processing technology as happens in Netherland, Belgium, Denmark, Italy and Spain (Burton and Turner, 2003). Recent analysis in the Republic of Ireland suggests that spreading pig manure on land is still the most economic way of utilising it and that transporting the manure over long distances still compares more favourably than the processing technology alternatives currently available (Teagasc Pig Development Department, 2011).

There is potentially a role for regulators and agricultural agencies in assisting this market to develop. It's clear from this research that demand is strongest among arable farms and this will most likely be reflected in the price they are willing to pay for these nutrient sources. Additionally, depending on the prevailing soil type and hydrology of recipient lands this could prove an environmentally positive outcome as these systems are best able to utilise these manures both from an agronomic and eco-efficiency perspective and could reduce the risk of nutrient loss to the wider water environment and assist in achieving environmental goals under the EU Nitrates and Water Framework Directives.

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