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Advisory services for nutrient utilisation

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Abstract

This paper analyses the effects of advisory services regarding the use of nutrients in Swedish agriculture on nutrient balances and farms' finances. The key to our research design is that consultation varies between counsellors (some counsellors give more consultation than others), which leads to random variation in "treatment". We find that counselling affects nutrient utilisation, which possibly reduces leakages and eutrophication in the Baltic Sea. A large and positive impact on farms value added implies that the net benefit from the advisory services is positive. The improvements is mainly due to better land management practises so that more efficient use of fertilizers increases crop production and thereby decreases the nitrogen balance.

JEL classification: L2, Q16, Q53, Q58

Key words: farm management, advisory service, counselling, nitrogen, phosphorous, eutrophication

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1. **Introduction**

A main input in agriculture production is fertilizers. In contrast to developing countries, where fertilizers are under-utilized and often government subsidized (Dunflo et al., 2008, 2011; Conley and Udry, 2010), fertilizers are commonly over-utilized in developed countries and they are sometime taxed. The main problem with over-use of fertilizers is that they are a principal cause of water pollution. Hence, more efficient use of fertilizers may reduce problems of eutrophication and increase farm profits.

In the present paper we analyse the effects of advisory services regarding the use of nutrients in Swedish agriculture on nutrient balances and farms' finances. Besides evaluating the environmental effect of this particular advisory service, the paper adds to the (farm) management literature and shows that counselling affects management practises and farm output.

As with all voluntary programmes, selection bias is a problem when attempting to analyse effects. Since data on nutrients is only available for farms participating in the programme, we cannot control for selection bias regarding the decision to enrol. However, to handle selection bias in the amount of counselling received, we exploit a feature in our unique source of farm level data on advisory services to randomize differences in consultant visits between farms. Panel data from the programme Greppa Näringen (including e.g. detailed information on counselling, farms' inflow- and outflow of nutrients and nutrient balances) is merged with register data on farms' financial records and CAP payments.

The key to our research design is that consultation varies between counsellors (some counsellors give more consultation than others), which leads to random variation in "treatment". Given observed farm characteristics the counsellors are assumed to be randomly assigned and the variation in consultation is therefore unrelated to farm management. We utilize this exogenous variation to see if counseling has an impact on nutrient balances and farm output and costs. That is, the average number of consultation visits the counsellor provides her other clients, is used as an instrument for a given farm's number of consultation visits. A similar identifying strategy is used in for example Dahl et al. (forthcoming), who use random assignment of judges in disability insurance cases, and Doyle (2008) who use random assignment of investigators in foster care placements.

Research has documented vast productivity differences even among firms producing similar or identical goods (Syversen, 2011). A similar variation is documented in the farming sector (Latruffe et al., 2005; Lawson et al., 2004; Oude Lansik et al., 2002; Heshmati and Kumbhakar, 1994; Tauer, 1993 and Bravo-Ureta and Rieger, 1991). Studies analysing the link between firms' management practises vis-à-vis their productivity and profitability find a strong positive correlation with better management practises (Bloom et al., 2012). The observed relationship may be spurious since more profitable firms are more likely to adopt innovative management practises, as well. Yet, Syversen (2011) who surveys the recent applied research concludes that the findings point to causality. However, besides in Bloom et al. (2013), who use a novel approach for analysing the management effect on productivity, causal identification strategies are scarce. Bloom et al. conduct a management field experiment where they provide free consultations on management practises to a random sample of Indian textile firms. After one year of consulting firms increased productivity by 17%, and within three years firms opened more production plants. The authors conclude that information constraints are the likely explanation to why firms had not already adopted the practises – firms did not believe the practises would improve profits.

In agriculture, management is regarded an important determinant of farm performance (Boehlje & Eidman, 1984; Wilson et al., 1998; Nuthal, 2001), and the individual management capacity is acknowledged as a fundamental factor (Rougoor et al., 1998). Swedish empirical evidence supports these claims, and farm management in Sweden may be improved (Hansson et al., 2010; Hansson, 2008; Hansson and Öhlmér, 2008). Relevant for this paper, but in the context of developing countries, studies show that farmers fail to fertilize despite profitable fertilizer investments. Dunflo et al. (2008; 2011) who provides free delivery of fertilizers to a random sample of farms finds that farmers do not fertilize optimally, and the result agrees with Conley and Udry (2010) who finds that pineapple farmers in Ghana under-fertilize.

Two reasons suggest that management may be particularly imperfect in the agricultural sector. First, the agricultural sector is dominated by family-owned farms, and management practises in family-owned firms is farther from the "best practises" (Bloom and Van Reenen, 2007). An explanation is that in family-owned firms mainly family members are given management positions (Bloom et al., 2013), which could result in a deficient matching between management skills and positions. Second, with decoupled farm subsidies land values are high, implying large entry costs into farming.

2. The advisory service, nutrient balances, and previous evaluations

2.1 The programme Greppa Näringen

In Sweden, advisory services targeting nutrient utilisation are provided by the programme "Greppa Näringen", organised by the Swedish Board of Agriculture (SJV), the Swedish Farmers' Association (LRF), the County Boards, and private consultants. The aim is to enhance the sustainability of farm operations by reducing nutrient and pesticide leaching, greenhouse gas emissions, and by increasing economic efficiency. Greppa Näringen started in the counties of Skåne, Halland, and Blekinge in the southernmost part of Sweden in 2001. During the period 2003-2010, other counties successively joined the programme and, in 2012, it covered all counties from Skåne to Dalarna and Gävleborg (i.e. approximately the southern half of Sweden). During the same period, the number of participating farms increased from about 1 100 in 2001 to about 8 700 in 2012, and the amounts spent annually on the programme increased from about SEK 14 million to about SEK 44 million (2012 prices). The services are free of charge for the participating farms as the programme is financed partly by support from the Swedish rural development programme (RDP) and partly by environmental taxes.

Participation in the programme entails that consultants visit the farms on a regular basis. At the first visit, an inventory of farm characteristics such as type of production, hectares of land according to soil quality, use of mineral fertilizer and manure, timing and method of fertilizer and manure application, etc. is made. Nutrient balances are constructed using a model (developed by the Swedish Board of Agriculture and the Swedish Farmers' Association) that estimates and subtracts the amount of nutrients leaving the farm tied up in products and manure sold to other farms, from the inflow of nutrients (mineral fertilizer and manure purchased, purchases of animals, seeds, air deposits, etc.). A positive nutrient balance (inflow exceeds outflow) implies a potential for nutrient leaching. Based on these findings, a strategy for how nutrients could be utilised more efficiently, given other characteristics of the farm, is drawn up. The conditions at the first visit serve as benchmark and new inventories and balances are recorded at successive visits during the enrolment period. Besides the visits recording nutrient balances, visits without inventory are given as well. Almost 65% of the registered consultation contacts are non-inventory (and some of these are by phone).

This study focuses on the inventory visits because it is the intensity of such visits that matters (we return to this issue in section 4.2).

2.2 Descriptive statistics on nutrient balances, and use and outflow of nitrogen

Figure 1 shows the development of nitrogen and phosphorous balances (inflow minus outflow of nitrogen and phosphorus) from 2001-2013 in farms participating in the Greppa Näringen programme. The change in nutrient balances is estimated using our data (described in closer detail in section 3.1) and year dummies to describe the trends (which might not be linear).[1] There is a negative trend in both balances, albeit the decrease in the former is almost four times as large as the decrease in the latter balance.

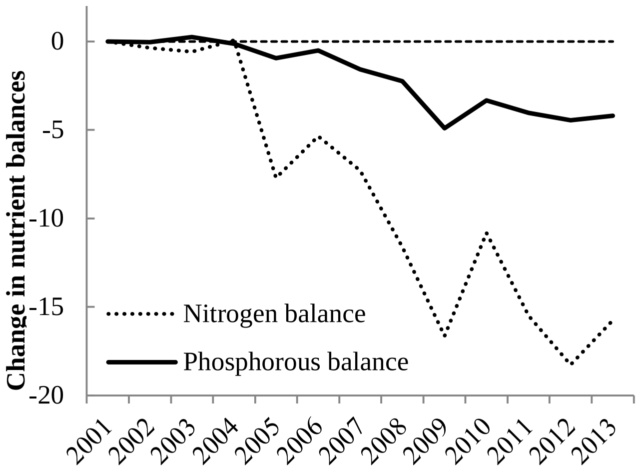

Figure 1. Illustrating the change in nutrient balances.

It is not surprising to find a small decrease in the phosphorous balance. Counselling did not begin to focus on reducing phosphorus losses until 2007, and then only a small pilot scheme on three agricultural catchments was launched. Hence, the analysis (including this descriptive background) will mainly focus on the nitrogen balance. Figure 2 shows the development of the use of nitrogen from, respectively,

[1] The descriptive model is estimated with farm fixed effects to account for differences between farms; otherwise selection in the inflow of new farms into the programme, might cause a trend in the nutrient balances.

mineral fertilizer and manure during the same period (using the same data and model as for the balances). While the use of nitrogen from mineral fertilizer is falling, use of nitrogen from manure is not.

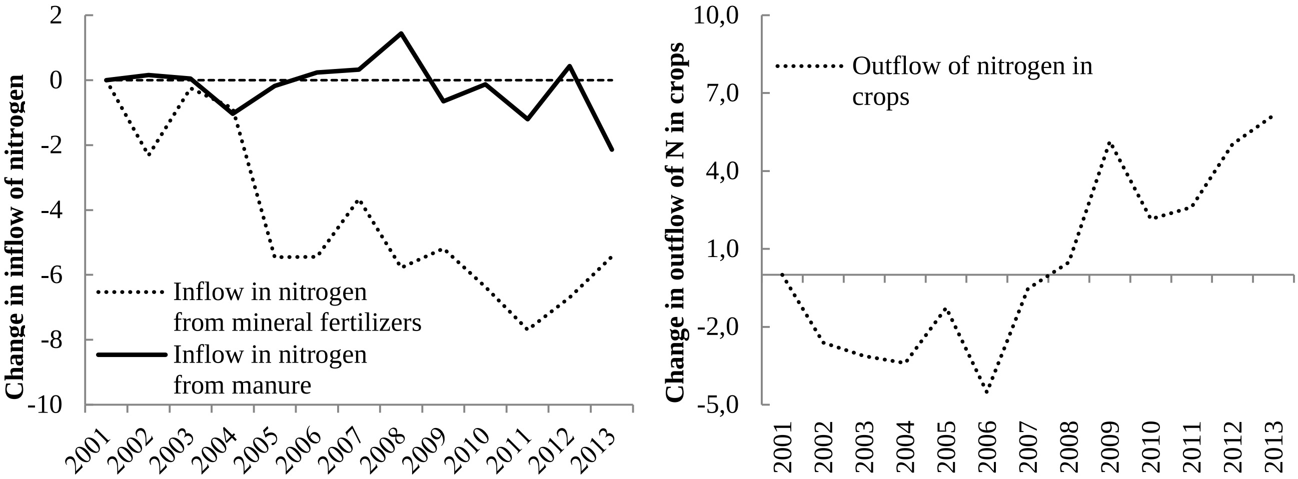

Figure 2 and 3. Illustrating changes in inflow of nitrogen from mineral fertilizers and manure, and outflow of nitrogen in crops

Figure 3, finally, shows the development of the amount of nitrogen leaving the farms tied up in crops during the same period (again, using the same data and model). Here, we find an increasing trend. Linking this with the findings in figures 1 and 2, suggests that the decrease in the nitrogen balances in Figure 1 may be a result of more efficient utilisation of nitrogen, as well as less use of nitrogen from mineral fertilizer.

The interesting question is, of course, if the trends are, indeed, the result of the farms' participation in the programme.

2.3 Previous evaluations

To our knowledge, there have been only two attempts to evaluate the effects of the programme; Swedish Board of Agriculture (SJV, 2008), and Greppa Näringen (Greppa Näringen, 2010). Both studies focused on the programme's effects of on nutrient balances.

Using data for the period 2001-2006 in farms before and after enrolment in the programme, SJV (2008) found statistically significant effects on nitrate balances in milk farms only (reducing surpluses), while the effects on phosphorous balances where statistically significant for both milk and pig farms (reducing surpluses). Finally, the effects on potassium balances were statistically significant, reducing deficits in crop and pig farms and increasing surpluses in milk farms. It was suggested that the lack of statistically significant effects on nitrate balances in crop and pig farms, and on phosphorous balances in crop farms, partly, could be a result of the limited number of observations (563 crop farms, 701 milk farms, and 109 pig farms).

Using data for the period 2001-2008 from 745 crop farms, 878 milk farms, 147 pig farms, and 87 cattle farms, Greppa Näringen (2010) estimated the effect of advisory services on nitrate and phosphorous balances only. Results indicated that nitrate balances were significantly reduced in crop, milk, and pig farms, while the effect on phosphorous balances was statistically significant for pig farms only (reducing surpluses). No effects were found on any of the nutrient balances for cattle farms.

Both studies estimated the effects by pooling data from the participating farms and comparing the inflow of nutrients from different sources with the outflow in products leaving the farm before and after enrolment in the program, letting the farms serve as their own controls. As the observations where collected during an eight year period, during which several factors that could affect the use of nutrients and other inputs that affect production may have changed, it is important to control for the effects of these other factors to elicit the effects of the advisory services. The two studies above are not very clear on what other factors that have been controlled for, or how this has been accomplished. Hence, the results may be uncertain and should be interpreted cautiously (for example, the negative trend in nutrient balances and use of nitrogen from mineral fertilizer in Figures 1 and 3 above may be the result of changes in such other factors).

3. Material and method

3.1 Data

The present study utilises panel data from the programme Greppa Näringen for the period 2001-2013. So far, 8,207 farms have received counselling and are included in the data. The data include information on *when* each farm joined the programme; its *location* (municipality); *type of farm* (crop or animal production, what kind of animal production, and if it is ecological crop or animal production); hectares of *arable land*; share of different *soil types*; number of *animals according to type*; number and type of *consultations* received; the *inflow of nutrients* from purchases of mineral fertiliser and manure, feed, animals according to specie, etc., at first consultation and when successive balances are made; *the outflow of nutrients* in products of different types leaving the farm at first consultation and when successive balances are made.

The data from Greppa Näringen is merged with information on each *farm's financial records* (obtained from Statistics Sweden, SCB). From the Swedish Board of Agriculture (SJV), we have obtained and added information on *supports granted from the Swedish CAP* (if, when, which type of, and how much support each farm have received). These data also cover the period 2001-2013.

Contrary to previous evaluations, we do not analyse milk-, cattle-, pig-, and crop farms separately but pool data for all farms. The reason is partly that disaggregating according to type of production would leave us with very few observations in some cases and partly that all farms have a considerable area of agricultural lands whatever the type of production (cf. Table 1). Accordingly, besides a few farms with no animals, they could all be characterised as "crop farms" with different types of animal production.

Table 1. Average number of hectares and animal units according to farm category.

Farm category	Number of farms	Average number of hectares	Average number of animal units
Milk farms	1,502	112.5	101.9
Cattle farms	331	92.7	49.3
Pig farms	300	173.1	139.6
Other animal farms	122	149.1	256.9
Mixed animal farms	384	108.1	63.0
Crop farms	1,604	145.4	2.6

To analyse the effects of the advisory programme, nutrient balances and financial results at first consultation for each farm are used as benchmarks and compared with the outcomes at later consultations. So far, 3,948 farms have only received the first consultation and, because we lack a "post-treatment" outcome in nutrient balances for these farms, they are excluded in the nutrient analysis. As participation is voluntary, there are concerns regarding self-selection bias. That is, more environmental friendly or entrepreneurial farm managers may be more likely to enrol and also to seek more counselling. Thus, the number of consultations received by a given farm may be correlated with changes in nutritional balances and management practices even when there are no causal effects (farms run by more environmental friendly or entrepreneurial managers may have experienced similar changes in nutritional balances and management practices without the advisory programme). To infer causality, random participation or intensity of counselling is needed.

3.2 Identifying random variation in counselling intensity

As noted, we cannot control for selection bias regarding the decision to enrol. However, we do control for selection bias regarding consultation intensity for those farmers that have decided to participate. To do this, we exploit a source of randomization revealed when examining differences in the number of consultations per farm in our material. It turns out that, for some reason, some consultants provide more visits than other consultants. Understanding the cause of the variation is not necessary as long as the assignment of consultants to farms is random. The variation in visits is largely due to unobserved consultant characteristic, although a significant part is determined by observed farm characteristics; which we can control for. This is as expected, as consultant expertise, of course, is matched with farm type, and farm type is plausibly related to counselling intensity. However, the assignment process is not assumed to be caused by matching on unobservable farm characteristics; instead unobserved consultant characteristics, for example differences in skills, must drive the underlying variation.

Yet, there may still be concerns of selection bias if highly-skilled consultants have incentives to match with more entrepreneurial or environmental friendly farmers. But no such incentives exist; consultant provision is based on the number of visits procured by the regional government and not on the outcome of the counselling. In fact, the public procurement is based on price and the procurement agency does not even have access to the farmer’s response to the consultation (i.e. the Greppa Näringen database). The administrators of Greppa (for which we have presented the findings of this study) also rejects any type of unobserved matching. Unmatched variation in consultant characteristics gives heterogeneity in the consultant effect, but no bias (we return to this issue in the discussion).

As the number of consultant visits received by a farm is positively related to the assigned consultant's mean number of visits, we can use this link to estimate a causal effect of the number of visits on nutrient utilization and farm's output and costs. This is done in an instrumental variable (IV) design, where the consultant's mean number of visits is our instrument for the number of visits actually received by the farm.

We pursue the analysis as follows. First, we calculate the mean number of visits for the assigned counsellor ($\overline{V_{Ci}}$) leaving out the treated farm's own number of visits. Because the counselling intensity for a given farm, ($\overline{V_{Ci}}$), is not affected by its own number of visits, there is farm variation is the measure (and therefore the index *i*).

Before specifying the model for investigating the counsellor effect, we analyse $\overline{V_{Ci}}$, descriptively. In this analysis, $\overline{V_{Ci}}$ is regressed on two sets of dummies to capture factors affecting all farms at the first (λ_{0i}) and last (λ_{1i}) visit (i.e. we add 12 first-visit dummies for the years 2001 to 2012, and 13 last-visit dummies for the years 2002 to 2014), a number of farm characteristics (X_{1i}, i.e. county, farm type, shares of different soil types, dummies for ecological crop and live-stock production, hectares of arable land, and number of animal units, at the year of the last visit), and changes in these characteristics between the first and the last visit ($X_{1i} - X_{0i}$):

$$\overline{V_{Ci}} = \lambda_{0i} + \lambda_{1i} + \rho X_i + \vartheta(X_{1i} - X_{0i}) + \upsilon_i \quad (1)$$

The control variables explain 55.6% of the variation in mean number of visits given by counsellors, i.e. roughly half of the variation is due to observed farm characteristics and half is due to unobserved variation. If we had estimated the reduced form[2] instead of the IV specification, the residual from this regression would have been our consultation measure. Here, the residuals from regression (1) are used to further analyse the process for assignment of consultants. Figure 4 shows the distribution of $\overline{V_{Ci}}$ and the distribution of the residuals (varying around the mean number of visits) from regression (1). While the distribution of $\overline{V_{Ci}}$ without controls is skewed, the distribution of the residuals (υ_i) is almost normal, suggesting that a random assignment process of consultants is more likely. At least, the farm characteristics that cause the distribution of $\overline{V_{Ci}}$ to be skewed are accounted for. Later in the paper, we conduct an analysis with advisory firm fixed effects, providing additional evidence of a random assignment process between farmers and counsellors.

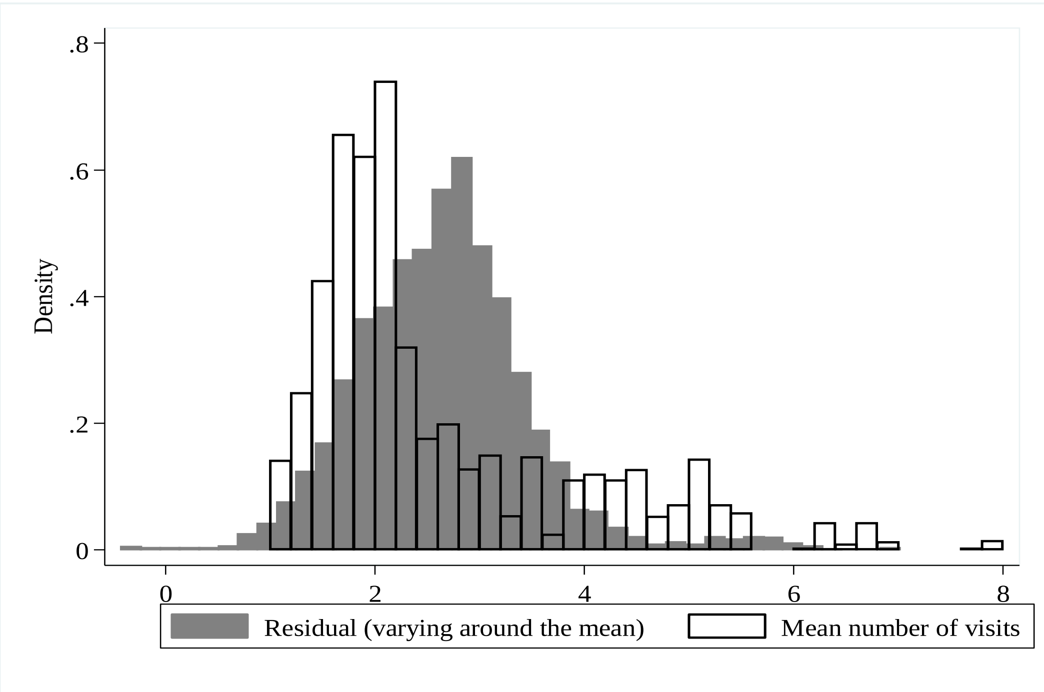

Figure 4: Distribution of mean number of visits ($\overline{V_{Ci}}$) and the residuals (υ varying around the mean number of visits) from regr. (1)

[2] The reduced form is where the instrument (here consultant's mean number of visits) is directly regressed on the dependent variable (farm outcome), and not used to predict the independent variable (farms number of visits).

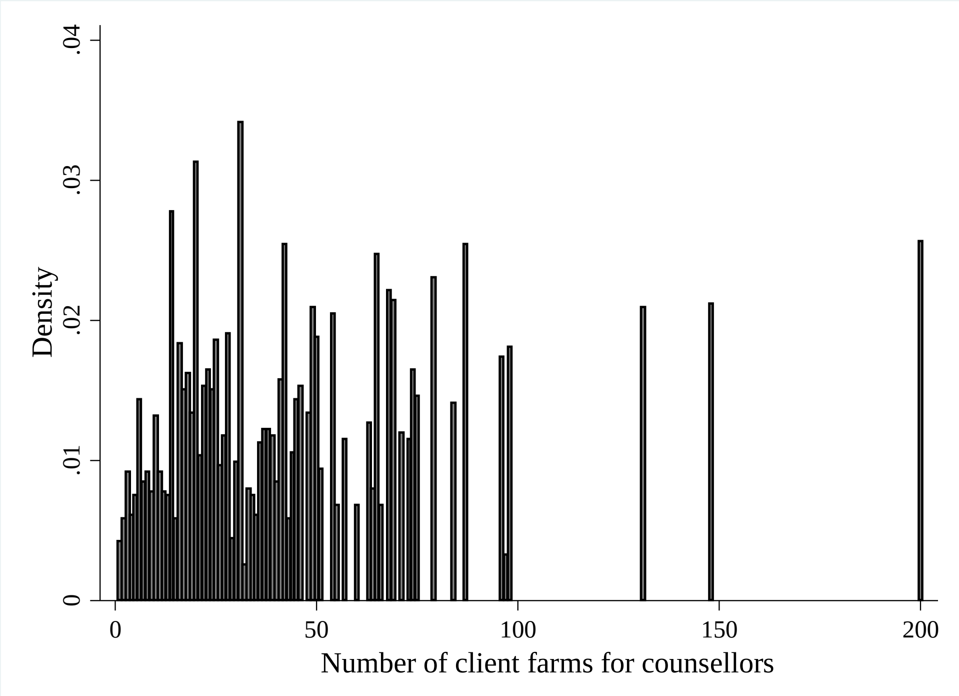

Figure 5: Number of clients per counsellor

Moreover, Figure 5 illustrates that each counselor has on average 50 client farms. Some counsellors have a very large number of clients but the results in this paper are not caused by these “extreme” counsellors. On the other hand, for inactive counsellors with few client farms, the mean number of visits may be a poor measure of their underlying counselling intensity. We therefore exclude farms receiving counselling from counsellors with less than 15 client farms.

3.3 Econometric specification for estimating the counselling effect

Next, we regress the number of visits received by a farm (V_i) on the same set of control variables as in regression (1) *and* the average number of consultations provided by the assigned consultant ($\overline{V_{Ci}}$):

$$V_i = \delta_{0i} + \delta_{1i} + \pi\overline{V_{ci}} + \omega X_{1i} + \tau(X_{1i} - X_{0i}) + \mu_i \quad (2)$$

Finally, to elicit the effects of the programme, we specify a model where the dependent variable is the observed changes in nutrient balances/economic result from the first to the last visit ($y_{1i} - y_{0i}$). We then regress this variable on the same set of control variables as in regressions (1) and (2) *and* the estimated number of visits ($\widehat{V_i}$) from regression (2):

$$y_{1i} - y_{0i} = \alpha_{0i} + \alpha_{1i} + \beta \hat{V}_i(\overline{V_{ci}}) + \theta X_{1i} + \gamma (X_{1i} - X_{0i}) + \varepsilon_i \qquad (3)$$

In our model, the first stage-equation (regr. 2) computes the predicted number of consultation visits ($\widehat{V_i}$), and the second stage-equation (regr. 3) estimates the IV-consultation effect using the estimated mean number of consultations of the assigned counsellor ($\overline{V}_{Ci}$) from regr. (1) as instrument to predict the number of consultation visits received ($\hat{V}_i$) by a farm with given observed characteristics. The idea is to minimize the risk that the number of visits depends on farm/farmer characteristics and, hence, result in biased estimates of the counselling effect. The instrument, mean number of consultation visits by counsellors ($\overline{V_{Ci}}$) is better in explaining the total number of visits than the sequence of visits and therefore our "final-effect model" is preferred to using the entire panel.[3] However, the total number of visits is "right censored" (that is, we do not know when the farms actually leave the programme, implying that we do not know how many visits they will receive in total), and with information on the final number of visits the model would probably have performed even better**.** Thus, rather than using the instrument for estimating the effect of the sequence of visits (how many visits are needed to reach an effect), we focus on the effect of the total number of visits. The model is chosen so that the first stage regression (regr. 2) is modelled properly.

[3] Otherwise, a counsellor's mean number of visits is used for explaining both the first revisit, the sequence of visits and the last visit.

Although this decreases the number of observations significantly (since we exclude farms that have received only one visit and observations from visits between the first and the last one), it has no major impact on the estimated effect of counselling, but a much stronger first stage regression is established.

In accordance with a farm fixed effect model, the model nets out time-invariant farm characteristics. Time fixed effects at the first (α_{0i}) and last (α_{1i}) visit, capture differences between farms in *pre- and post-conditions* affecting the dependent variable (hence, we do not need to control for changes in weather conditions, and prices of inputs and outputs or other factors that affect all farms in a given year), as well as the time trend in the dependent variable. Moreover, differences in the *duration* between the first and last visit is captured as well, i.e. the effect of being in the programme but not receiving any further counselling is cancelled out with the dual set of time indicators. Using an alternative specification with only one set of time dummies and the duration between the first and last visit included, we find that the duration has no impact on the outcome (results available on request). However, we prefer the chosen specification because it controls for time dependent effects more efficiently (i.e. a full set of time dummies is better than only a linear duration measure).[4]

4. Results

We proceed in two steps and begin our presentation of the result by showing the paper's main results; the effect of counselling on farm nutrient balances, and farms output and costs. We next explain (i) which type of management practises the advisory services are affecting, and (ii) what aspect of the counselling that make them affective.

[4] Note, including both sets of dummies and the duration measure implies perfect collinearity.

4.1 Estimating the counselling effect with OLS and IV

Farm nutrients

Table 2 reports the OLS- and IV-results for nutrient balances. The OLS-estimates are the results obtained when not controlling for selection bias (i.e. apart from not instrumenting the number of consultations, the OLS-regression includes the same control variables as the IV-regressions in columns (3) and (8)). Both the OLS- and the IV-estimates measure the outcomes in units per hectare. Column (1) shows the OLS-estimate of the counselling effect on nitrogen balances and column (6) the OLS-estimate of the counselling effect on phosphorous balance.[5] The number of visits is negatively associated with nitrogen balance. For phosphorous balance, the estimate is small and insignificant; which is an expected finding because reducing losses of phosphorus has not been the aim of the counselling.

Columns (2) to (5) and (7) to (10) show the IV-results (the first stage regression results for models (3) and (8) are reported in Table A2). In columns (2) and (3), for nitrogen balance, and columns (6) and (7), for phosphorous balance, we present the counselling effect, with and without control variables. Firstly, on nitrogen balance the IV-estimate of the counselling effect is larger than that found in the OLS-estimate; a result we return to in the discussion. Secondly, for nitrogen balance, the IV counselling effect decreases somewhat when additional control variables are added and it is almost entirely due to a decrease in the number of animals, i.e. with fewer animals less manure is produced. However, the counselling effects are, in general, unaffected by additional controls which provide additional evidence of a random assignment of counsellors. The argument is as follows: since observed farm characteristics are unconnected to the

[5] The sample is larger for the OLS-models because we do not restrict the OLS-sample to only farms receiving counselling from active counsellors, i.e. those with at least 15 client farms. Including these farms in the OLS-sample does not change the OLS-estimate but reduces the standard errors.

counsellor effect, it is unlikely that the counsellor effect is caused by unobserved farm characteristics.[6] Finally, for phosphorous balance the IV-counselling effect is always insignificant.

Table 2. Estimating the counselling effect on nutrient balances.

	Nitrogen balance					Phosphorus balance				
	OLS	IV				OLS	IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No. consultations	-1.309**	-4.316***	-3.602**	-3.103*	-4.263	-0.103	-0.155	-.171	-.086	-.356
	(.626)	(1.464)	(1.420)	(1.798)	(3.434)	(.141)	(0.151)	(.150)	(.421)	(.636)
Livestock	-.0115		-.0088	0,0098	-.0167	-.0027		-.0009	.003	-.0033
	(.0170)		(.0187)	(.0303)	(.0200)	(.0036)		(.0037)	(.005)	(.0043)
Arable land (ha)	.0170**		.0109	.0380**	.0252***	-.0024		-.0011	-.000	.0043*
	(.0077)		(.0081)	(.0180)	(.0092)	(.0026)		(.0020)	(.004)	(.0023)
Ecological livestock	7.265*		6.710	4,964	5.227	3.008***		3.104***	4.257***	1.291
	(3.744)		(4.161)	(6.049)	(5.169)	(.977)		(1.079)	(1.367)	(1.073)
Ecological crop	-6.508*		-5.772	-0,117	-4.611	-1.373		-1.126	-1.654	.801
	(3.362)		(3.701)	(6.808)	(4.524)	(.907)		(.992)	(1.192)	(.999)
Changes:										
Livestock	.137***		.140***	.159**	.197***	.0114**		.0105*	.010	.0236***
	(.0284)		(.0312)	(.0697)	(.0293)	(.0054)		(.0058)	(.011)	(.0073)
Arable land (ha)	-.0572***		-.0508***	-.145***	-.108***	.0072		.0060	-.005	-.0123**
	(.0164)		(.0165)	(.0354)	(.0257)	(.0045)		(.0042)	(.008)	(.0059)
Ecological livestock	-2.08***		-22.23***	-29.75***	-24.63***	-1.615*		-1.561	-3.098**	-.596
	(4.119)		(4.408)	(6.233)	(5.635)	(.913)		(1.010)	(1.374)	(1.321)
Ecological crop	-6.802**		-6.489*	-1.94**	2.562	1.526**		1.380*	1.148	1.778*
	(3.330)		(3.695)	(5.320)	(4.881)	(.696)		(0.766)	(1.018.)	(.941)
CAP payments	no	no	no	yes	no	no	no	no	yes	no
Firm fixed effects	no	no	no	no	yes	no	no	no	no	yes
Weak IV test		883.8	885.9	509.9	164.1		883.8	885.9	505.9	164.1
Observations	4,243	3,656	3,656	2,093	2,263	4,243	3,656	3,656	2,087	2,263
R-squared	.081	.029	.079	0,107	.111	.058	.051	.062	.056	.097

Notes: The dependent variables are defined as changes between the first and last counselling visit. The independent variable Number of consultations is instrumented with the counsellors mean number visits to other clients in the IV-models. All models include fixed effects for first- and last visit, farm and soil type and region. Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1.

[6] The models without controls, columns (2) and 7), actually do include some controls: fixed effects for first- and last visit, farm and soil type and region. These controls affect the first stage, but hardly the second. That is, without these controls included the first stage becomes weaker; implying increased standard errors, but a counselling estimate of the same size.

The point-estimate, -3.60, implies that a consultation visit reduces the nitrogen balance by 3.6 Kg per hectare, that is, with 4.0% (calculated at the mean nitrogen balance per hectare). In terms of the total inflow of nitrogen, the reduction in the nitrogen balance represents a reduction of 2.1% per hectare.

As a next step (columns 4 and 9) we include CAP subsidies as controls well. Particularly, the agri-environmental subsidies in the second Pillar, where some subsidies have similar objectives as the counselling programme, may improve nutrient utilization. Failing to control for them may therefore imply that we mistake a subsidy effect for a counselling effect. To add information on subsidies, the data from Greppa Näringen was matched with data from Statistics Sweden's Business Register (SBR). For roughly 25% of the farms the identification number in the Greppa Näringen data do not match with the firm identification number in SBR. Thus, in columns (4) and (9) we find that the smaller sample results in larger standard errors, but apart from this the results are intact when including the CAP subsidies[7] as controls (the decrease in the counselling effect on nitrogen balance is from the change in sample and not from including the subsidies).

So far we have used the variation in counselling intensity between counsellors. Nevertheless, a matching between farmers and counsellors on farmers' unobserved characteristics may still bias the counselling effect. We argue that such matching is most likely to appear at the farmer-advisory firm level, i.e. that farmers may choose counselling based on the reputation of firms, and not on counsellor's reputation. Because we have information on advisory firms as well, we can include advisory firm fixed effects, and thereby identify the counselling effect using variation in counselling

[7] Because all farms receive direct payments (Pillar I) we include the logarithm of direct payments. Logarithmic Pillar II subsides are not an option because a particular type of subsidy is received by only a sample of the farms (i.e. zeros are common). Instead we include indicator variables for: i) subsidies aimed at reducing nutrient leakages, ii) ecological production subsidies, iii) other environmental subsidies, iv) firm subsidies, and v) other Pillar II subsidies. Other specifications have been tested as well; but no specification has an impact on the counselling effects.

intensity between counsellors *within* a certain advisory firm, i.e. potential matching between farmers and advisory firms is thus removed. In column (5) for nitrogen balance, we find that the coefficient for the counselling effect is robust to this change in specification. However, whereas the coefficients of the counselling effects are almost the same with firm fixed effects included, they become insignificant. When loosing almost 40% of the farms due to missing advisory firm information, and adding 55 firm indicators, large standard errors and, therefore, non-significant effects are not a surprise. Still, this exercise shows that the estimated counselling effect is not biased because of a matching between farmers and counsellor firms.

For all IV-models the F-statistics of the weak IV-test is large. Weak instruments give biased estimates and underestimated standard errors (Murray, 2006; Stock and Yogo, 2005). A rule of thumb is that the test-statistic should be above 10 (Stock and Yogo, 2005), and here the F-statistics are between 164 and 886, depending on sample size and specification, i.e. a weak instrument is not a problem in this study.

Farms' financial records

As already acknowledged, adding firm level data reduce the farm sample. However, another feature of the modelling of the farms' financial records increases the sample. Because the first counselling visit may have an impact on farms' financial results, observed at the end of the year, the pre-treatment outcome is the year before first visit, and because the year of the first visit can be considered the first post-treatment year, firms receiving only one visit are added to the sample. This change in specification does not affect the results generally, but excluding farms receiving one visit only makes the sample too small when including subsidies and firm fixed effect.

The counselling is assumed to affect the farms' financial records positively in two ways; either fertilizers are used more effectively so that production increases, or less fertilizers are used so that costs decreases. The costs may also increase if a more efficient use implies higher costs of labour or fuel. Moreover, a reduction in fertilizer utilization may either decrease production or keep production constant if the reduction comes with a more efficient use of fertilizers. To separate between these scenarios we cannot analyse farm production (which capture production changes due to changes in the input of fertilizers) or profits (which are distorted by capital depreciation, and changes in rents and taxes etc.). Instead we analyse: *total value added* (production value minus input (but not capital and labour) costs) and *input costs* (agricultural raw materials as for example: seeds, animals and fertilizers). Changes in total value added would indicate that the programme has affected the efficiency in the production (i.e. fertilizer efficiency) and changes in costs that it has affected input use (i.e. if less fertilizers are used).

In Table 3 we find the results for these two outcomes. Columns (1) and (6) show that the OLS-estimate of the counselling effect is insignificant for both outcomes. The IV-results show that the number of consultations increases value added (columns (2) to (4)) but has no impact on costs (columns (7) to (9)). The added control variables in column (3) and the added CAP subsidies in column (4) do not matter for the effect of counselling on total value added. When including the firm fixed effect, the point estimate of the counselling effect is roughly the same, but larger standard errors makes it non-significant.

Table 3. Estimating the counselling effect on total valued added and costs.

	Ln. Firms value added					Ln. Firm costs				
	OLS	IV				OLS	IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No. consultations	.0147	.113**	.118**	.118**	.145	-.0010	-.0005	.0005	.00103	.0109
	(.0218)	(.0520)	(.0516)	(.0514)	(.125)	(.0017)	(.0028)	(.0027)	(.0027)	(.0066)
Livestock	-.0006*		-.0006*	-.0006*	-.0009*	-.0000		-.0000	-.0000	-.0000
	(.0003)		(.0003)	(.0003)	(.0005)	(.0000)		(.0000)	(.0000)	(.0000)
Arable land (ha)	.000287		.0003	.0002	.0002	.0000		.0000	-.0000	.00001
	(.0002)		(.0002)	(.0002)	(.0003)	(.0000)		(.0000)	(.0000)	(.0000)
Ecological livestock	-.158*		-.147*	-.135	-.185*	.0031		.0033	.0041	.0094*
	(.0813)		(.0813)	(.0828)	(.108)	(.0041)		(.0041)	(.0042)	(.0054)
Ecological crop	.0322		.0134	.0811	.0743	.0023		.002	.0081*	-.0011
	(.0690)		(.0691)	(.0861)	(.0876)	(.0037)		(.0036)	(.0045)	(.0049)
Changes:										
Livestock	.0024***		.0023***	.0023***	.0016	.0001		.0001	.0001	.0001
	(.0008)		(.0008)	(.0008)	(.0010)	(.0001)		(.0000)	(.0001)	(.0001)
Arable land (ha)	.0024***		.0025***	.0025***	.0031***	.0002***		.0002***	.0002***	.0001***
	(.0007)		(.0007)	(.0007)	(.0008)	(.0000)		(.0000)	(.0000)	(.0001
Ecological livestock	.236		.245	.241	.176	-.0006		-.0004	-.0012	-.0067
	(.155)		(.156)	(.156)	(.216)	(.0090)		(.0089)	(.0086)	(.0096)
Ecological crop	.0562		-.0632	-.0652	-.0014	-.0072		-.0072	-.0067	-.0051
	(.123)		(.122)	(.122)	(.172)	(.0078)		(.0077)	(.0075)	(.0068)
CAP payments	No	no	no	yes	no	no	no	no	yes	no
Firm fixed effects	No	no	no	no	yes	no	no	no	no	yes
Weak IV test		498.7	499.7	504.3	93.8		535.7	534.6	539.6	92.9
Observations	2,759	2,759	2,759	2,759	1,724	2,919	2,919	2,919	2,919	1,825
R-squared	.101	.073	.092	.095	.148	.083	.064	.083	.099	.096

Notes: The dependent variables are defined as changes between the year preceding the first visit, and the last counselling visit. The independent variable, Number of consultations, is instrumented with the counsellors mean number visits to other clients. All models include fixed effects for: first- and last visit, farm and soil type and region Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1.

4.2 Understanding the counselling effect

So far the analysis has aimed at inquiring if the advisory services have a causal effect on different outcomes. We have found that counselling indeed has an impact on farm management. The next step aims at understanding the counselling effect: w*hich* management practises are the advisory services affecting, and *what* aspect of the counselling makes it affective.

Farm management and counselling

The results so far indicate that farmers adopt new land management practises (which increases efficiency in production), but although we don't see any reduction in the costs we cannot yet rule out that there also may be a reduction in fertilizer use. Thus, in column (1) and (2) of Table 4, we estimate the counselling effect on the input of mineral fertilizers and manure (both measured as nitrogen per hectare land). The result agrees with the result for costs, i.e. no impact.

Table 4. Estimating the counselling effect on other outcomes

	Inflow of nitrogen in mineral fertilizers	Inflow of nitrogen in manure	Outflow of nitrogen in crops	No land cultivation
	(1)	(2)	(3)	(4)
No. of consultations	.364	-60.46	2.481***	4.603***
	(.998)	(55.93)	(.729)	(1.055)
Observations	3,656	3,656	3,656	3,560
R-squared	.144	.141	.093	.065

Notes: The dependent variables are defined as changes between the first visit and the last counselling visit. The independent variable, Number of consultations, is instrumented with the counsellors mean number visits to other clients. All models include fixed effects for: first- and last visit, farm and soil type and region Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1.

Our results indicate that counselling does not affect the costs or the use of nutrients, but does affect farms' total value added. It is, therefore, likely that the advisory services improve fertilizer efficiency. In column (3) of Table 4 it is shown that counselling increases the outflow of nitrogen in crops. This suggests that counselling improves land management practises so that increases in fertilizer efficiency result in higher crop production. However, in order to conclude that farmers respond to the counselling by altering their land management practices, it is important to also document changes in land management practices due to the counselling. In column (4) of Table 4 it is found that counselling reduces land cultivation**,** (hectares of land cultivated).[8] This provides a final and valuable piece of evidence as Greppa Näringen consultants advice to cultivate less (or cultivate in the spring time), because cultivation is assumed to increase nutrient leakages particularly after harvest when the lands are bare of vegetation.

Do the non-inventory visits matter?

As already mentioned, besides visits when new nutrient balances are calculated (which we have analysed so far), there are also visits without inventory of nutrients. These "non-inventory" visits are in most cases more common than the inventory visits. To examine the impact of these contacts we include them in the analysis as additional controls. Columns (1) and (2) in Table 5 show that the impact of the inventory visits are roughly the same as in the main results (columns (3) and (8) in Table 2). The non-inventory visits, on the other hand, have no impact on nutrient balances or farms finances.[9]

Table 5. Including the non-inventory visits to the specification.

	Nitrogen balance	Phosphorus balance	Firm value added	Firm costs
	(1)	(2)	(3)	(4)
No. of inventory visits	-4.610**	-.621	.160**	.002
	(2.154)	(.468)	(.067)	(.003)
No. of non-inventroy visits	.978	.097	.049	-.002*
	(.843)	(.170)	(.019)	(.001)
Observations	3,656	3,656	2,759	2,919
R-squared	.077	.061	.091	.084

Notes: The nutrient outcomes are defined as changes between the first visit and the last counselling visit. The financial outcomes are defined as changes between the year preceding the first visit, and the last counselling visit. The independent variable, Number of consultations, is instrumented with the counsellors mean number visits to other clients. All models include fixed effects for: first- and last visit, farm and soil type and region. Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1.

[8] We would like to analyse a broader set of land management practices, but the only practice that is well documented in the data is land cultivation.

[9] We have also added the non-inventory visits as the dependent variable in the IV-regression (using the inventory visits as controls), and found that the non-inventory have no impact on nutrients and farm finances.

Costs and benefits of the programme

Finally, we address the question of whether the programme Greppa Näringen may be regarded an example of good use of public resources. Our IV-results in Tables 2 and 3 indicate that counselling reduces nutrient balances, increases the stock of phosphorous in agricultural lands, and increases value added. The total costs of the programme are SEK 440 million up until 2013, or about SEK 23,390 per inventory visit. Is the value of the counselling effect large enough to cover these costs?

The reduction in nitrogen balance implies a reduction in *potential* leaching (Parris, 1998; OECD 2003). Still, changes in nitrogen balances are often used as proxies to estimate actual changes in leaching (Parris, 1998). According to Salo and Turtola (2006) variation in nitrogen balances explains about 71% of the variation in actual leaching on experimental clay soil plots (70% percent of the variation in leaching on sandy plots). They also found that variation in nitrogen balances explains less of the variation in leaching when more environmental friendly agricultural methods are applied since a larger part of the surplus nitrogen are retained by fixation crops and buffer zones. Now, the former result suggest that we should scale down the change in nitrogen balances by 30% percent to get an estimate of the effect on leaching while the latter result suggests that this might be to go too far. Nevertheless, to minimise the risk of overestimating the reduction, we consider the effect on nitrogen leaching from the agricultural lands to be 70% of the reduction in the nitrogen balance.

The next question is how much of the nitrogen leaching from the agricultural lands that will reach the Baltic Sea and contribute to the eutrophication problem. This depends on how much that will be retained along the way which, in turn, depends on precipitation, run-off conditions, and soil-types which, off course, differ between regions. However, according to Brandt and Ejhed (2002) about 60% of the nitrogen leaching from agricultural lands in those parts of Sweden covered by Greppa Näringen will reach the Baltic Sea.

Eutrophication is a negative externality; hence, it has no market price and the value of reduced nitrogen leaching must be estimated from contingent valuation studies. The Swedish Environmental protection Agency (SwEPA, 2009) has calculated the societal value in Sweden of a 1 kg reduction in nitrogen reaching the Baltic Sea (including the Danish straits, and the Kattegat) using results from eight Swedish studies of peoples' willingness to pay (WTP) for reduced leaching. As there are substantial differences between studies in the methods applied to elicit WTP and in the region of the Baltic concerned, we do not use the unweighted average societal value (SEK 31 per kg nitrogen in 2006 prices) computed by SwEPA, but the end points in the interval given by the studies (SEK 4 – 70 per kg in 2006 prices).[10] In 2012 prices, the societal value of a 1 kg reduction in nitrogen reaching the Baltic Sea is between SEK 4.7 and 81.8.

Our analysis reveals that the random variation in the number of consultant visits reduces the nitrogen balance by 3.6 kg per hectare (see column (3) in Table 2). However, according to the first-stage regression coefficient for *Mean number of visits by consultant,* only 58.9% (see the first stage regression in Table A2) of the consultant visits can be considered random, and it is this part of the consultant visits that has a causal impact of 3.6. In other words, for the remaining part 41.1% (100-58.9) of the visits the effect is uncertain, and when calculating the benefit of the programme we choose a conservative approach and consider only the effect of the random visits, but keeps in mind that the nonrandom visits may have some positive impact as well.

[10] Using the results in a more recent study (Ahtiainen et al., 2012) who elicits WTP using contingent valuation, the societal value of a 1 kg reduction in nitrogen to the Baltic can be estimated to SEK 17. However, this study also has unresolved methodological issues concerning hypothetical bias.

Thus, when we scale down the impact of the random marginal inventory visit with 0.589, the average visit reduces the nitrogen balance by 2.12 (0.589×3.6) kg per hectare, it reduces the amount leaching from agricultural lands by 1.5 kg per hectare, and the amount reaching the Baltic Sea by about 0.9 kg per hectare, resulting in benefits of between SEK (486 and 8,090) per farm (cf. Table 6).

Table 6. The value of reduced nitrogen leaching (SEK, 2012 prices).

	Effect on N-balance kg/hectare	Effect on N-leaching kg/hectare	Effect on N reaching the Baltic kg/hectare	Average area per farm hectares	WTP per kg reduction in N-leaching	Value of reduced N-leaching per farm
Average effect	-2.12	-1.48	-0.89	115	4.7 – 81.8	486 – 8,090

To receive the average effect on firms value added, the IV result in Table 3 (column(3)) is also scaled down by 0.589 and the average impact becomes 6.9% (11.8×0.589). According to our data, the average value added per hectare in 2012 is about SEK 4 500 per farm, implying that the average gain from an inventory visit is SEK 311 per hectare (Table 7), and about SEK 36,000 per farm.

Table 7. Effect on farm value added (SEK 2012 prices).

	Effect on value added per hectare	Average area per farm hectares	Value added per farm
Average effect	311	115	36,000

Our average impact of a visit suggest that it results in a *net benefit* of between SEK 13 096 (486 + 36,000 – 23,390) and 20,700 (8,090 + 36,000 – 23,390) per farm.

5. Discussion

The effects on nitrogen balances and phosphorous stock obtained from the IV-regressions are larger than those obtained from the OLS-regressions, and the effects on value added are significant only for the IV-regressions. The OLS-estimates are the results obtained when not controlling for selection bias and interpreted as the change in outcome when receiving another visit from the *assigned* counsellor. On the other hand, the IV-estimate measures the local average partial effect of a marginal change in the number of visits had the farmer been assigned a *different* counsellor. Thus, the IV-estimate incorporates both a change in the number of visits and a change in counsellor.

That the IV-estimate is larger than the OLS-estimate indicates that the latter is not excessively overestimated due to a positive correlation between the number of visits and unobserved farm characteristics. Assuming that the OLS-estimate is unbiased and estimates the *average treatment effect*, the difference between the OLS- and IV-estimate then depends on counsellor characteristics. This may indicate that counsellors who, generally, provide more consultation visits, offer counselling of higher quality as well. That is, some counsellors may be more committed, but if the unobservable counsellor characteristic is related to experience or enthusiasm is uncertain. Nevertheless, being assigned a “committed” counsellor appears important, and the discrepancy between the OLS- and the IV-estimates shows that the specific counsellor is more important that the number of visits, per se.

Another explanation is that it is self-selection effects that cause the OLS-estimate to be biased downward, implying that unengaged farmers (who do not change their management practices) or farms where it is difficult to change the nutrient usage, receive many consultations.

The results also indicate that it is not the total number of visits that is important, but rather the informative (or controlling) feature of the *inventory* visits. This strengthens our previous interpretation, i.e. that the quality of the counsellor matters. Thus, we bring further clarity to the nature of the farmer-counsellor interaction, i.e.

besides advising the farmers on better management practises, the counsellors use (intentionally or unintentionally) the inventory visits as a control device. Without these follow-ups, it is far from certain that the counselling would have affected farm management. That is, without knowing that someone evaluates your response it is easy to disregard the advice (or pass it on to the future). Our main conclusion is that it is this specific element of the counselling that makes it affective, contrary to entirely voluntary responses to, for example, courses or information campaigns.

Finally, the bulk of the benefit is generated by the effect on farm value added (which by itself more than covers the average cost per visit). Accordingly, one might consider not making the programme completely free of charge to the participating farms. An alternative is to pay only for the benefit generated by reduced nitrogen leaching, but then a more precise estimate of that benefit would be needed.

6. Conclusion

The findings in this study establish that farm management is frequently imperfect and there is room for improvements. Counselling increases farm value added with at least 11%, which resembles the finding in Bloom et al. (2013) where Indian textile firms increased their productivity by 17%. The improvement is mainly due to better land management practises so that more efficient use of fertilizers increases crop production. The counselling also decreases the nitrogen balance, which likely decreases nutrient leaching to the Baltic Sea and reduces eutrophication. When only considering the decreases in the nitrogen balance the counselling does not pay off, but when also considering the increased valued added the societal net benefit from the advisory services is positive. The key to our identification approach is that some counsellors systematically provide more counselling than others. Even if the assignment of counsellors cannot be proven random, the available evidence indicates that there is no unobserved matching between farmers and counsellors that biases the counsellor effect. For the sample of farms receiving consultation the result are internally valid, but without data for the entire sample of farms external validity cannot be achieved.

References

Ahtiainen H., Hasselström L., Artell, J., Angeli, D., and Czajkowski, M. 2012. Benefits of meeting the baltic sea nutrient reduction targets – combining ecological modelling and contingent valuation in the nine littoral states. MTT discussion papers 1, 2012. MTT Agrifood Research, Helsinki.

Boehlje, M.D. and Eidman, V.R. 1984. *Farm management*. John Wiley & Sons:, Canada.

Bloom, N., Mahajan, B., McKenzie, D. and Roberts, J. 2013. Does Management Matter? Evidence from India, *Quarterly Journal of Economics*. 128(1), 1–51.

Bloom, N., Sadun, R. and Van Reenen, J. 2012. The Organization of Firms across Countries, *Quarterly Journal of Economics*. 127(4), 1663–1705.

Bloom, N. and Reenen, J. 2007. Measuring and Explaining Management Practices across Firms and Countries, *Quarterly Journal of Economics*. 122(4), 1341–1408.

Brandt, M. and Ejhed, H. 2002. Transport – retention – Källfördelning. Belastning på havet. Rapport 5237, 2002 (in Swedish). Swedish Environmental Protection Agency.

Bravo-Ureta B.E. and Rieger, L. 1991. Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. *American Journal of Agricultural Economics*. 73, 421–428.

Conley, T.G. and Udry, C.R. 2010. Learning about a New Technology: Pineapple in Ghana. *American Economic Review*. 100(1), 35–69.

Dahl, G., Kostol, A.R. and Mogstad, M. forthcoming, Family Welfare Cultures. *Quarterly Journal of Economics*.

Doyle, J. 2008. Child Protection and Adult Crime: Using Investigator Assignment to Estimate Causal Effects of Foster Care. *Journal of Political Economy*, 116(4), 746–770.

Duflo, E., Kremer, M. and Robinson, J. 2008. How high are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. *American Economic Review Papers (Papers and Proceedings Issue)*. 98(2), 482–488.

Duflo, E., Kremer, M. amd Robinson, J. 2011. Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya, *American Economic Review*. 101(6), 2350–2390.

Greppa Näringen 2010. Resultat av upprepade växtnäringsbalanser, beräknad utlakningsminskning av kväve samt miljömålsavstämningar gjorda vid rådgivningsbesök i Greppa Näringen under perioden 2001-2008 (in Swedish). Greppa Näringen.

Hansson, H. 2008. How can farmer managerial capacity contribute to improved farm performance? A study of dairy farms in Sweden. *Food Economics –Acta Agricult Scand. Sect. C.* 5, 44–61.

Hansson, H. and Öhlmér, B. 2008. The effect of operational managerial practices on economic, technical and allocative efficiency at Swedish dairy farms. *Livestock Science*. 118, 34–43.

Hansson, H., Oskarsson, M. and Öhlmér, B. 2010. Successful implementation of new strategies in the farm business – Facilitators and inhibitions found at Swedish sugar beet farms, *Journal of International Farm Management*. 5(2).

Heshmati, A. and Kumbhakar, S.C. 1994. Farm heterogeneity and technical efficiency: some results from Swedish dairy farms. *Journal of Productivity Analysis*. 5, 45–61.

Latruffe, L., Balcombe, K., Davidova, S. and Zawalinska, K. 2005. Technical and scale efficiency of crop and livestock farms in Poland: does specialization matter? *Agricultural Economics*, 32: 281–296.

Lawson, L.G., Agger, J.F., Lund, M. and Coelli, T. 2004. Lameness, metabolic and digestive disorders, and technical efficiency in Danish herds: a stochastic frontier production function approach. *Livestock Production Science*. 91, 157–172.

Murray, M. 2006. Avoiding Invalid Instruments and Coping with Weak Instruments, *Journal of Economic Perspectives*, 20. 111–132.

Nuthal, P.L. 2001. Managerial ability - a review of its basis and potential improvements using psychological concepts, *Agricultural Economics*. 24, 247–262.

OECD/EUROSTAT. 2003. Gross nitrogen balances. Handbook. December 2003.

Oude Lansink, A., Pietola, K. and Bäckman, S. 2002. Efficiency and productivity of conventional and organic farms in Finland 1994-1997. *European Review of Agricultural Economics*. 29, 51–65.

Parris, K. 1998. Agricultural nutrient balances as agri-environmental indicators: an OECD perspective. *Environmental Pollution*, 102, 219–225.

Rougoor, C.W., Trip, G., Huirne, R. and Renkema, J.A. 1998. How to define and study farmers' management capacity: theory and use in agricultural economics. *Agricultural Economics*. 18, 261–272.

Salo, T. and Turtola, E. 2006. Nitrogen balance as a indicator of nitrogen leaching in Finland. *Agriculture Ecosystems and Environment*, 113, 98-107.

SJV. 2008. Växtnäringsbalanser och kväveutlakning på gårdar i Greppa Näringen åren 2000-2006 (in Swedish). Rapport 2008:25. Swedish Board of Agriculture.

SwEPA. 2009. Monetära schablonvärden för miljöförändringar. Rapport 6322, 2009 (in Swedish). Swedish Environmental Protection Agency.

Syversen, C. 2011. What Determines Productivity?, *Journal of Economic Literature*. 49(2), 326–365.

Stigler, G. 1976. The Xistence of X-efficiency, *American Economic Review*. 66(1), 213–216.

Stock, J. and Yogo, M. 2005. Testing for Weak Instruments in Linear IV Regression, in D.W.K. Andrews and J.H. Stock, eds., *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*. Cambridge, Cambridge University Press, 80–108.

Tauer, L.W. 1993. Short-run and long-run efficiencies of New York dairy farms. *Agricultural and Resource Economics Review*. 22, 1–9.

Wilson, P., Hadley, D. and Asby, C. 2001. The influence of management characteristics on the technical efficiency of wheat farmers in eastern England, *Agricultural Economics*. 24, 329–338.

Appendix

Table A1. Descriptive Statistics

	Mean	*Standard deviation*		*Mean*	*Standard deviation*
Number of consultations	3.231	1.735	Kalmar	0.067	0.251
Mean number of visits by consultants	2.656	1.284	Gotland	0.015	0.122
Nitrogen balance	83.565	57.075	Blekinge	0.023	0.15
Phosphorous balance	0.276	8.82	Skåne	0.501	0.5
Soil phosphorous stock	3.365	0.859	Halland	0.08	0.272
Inflow of N in mineral fertilizers	82.454	47.196	Västra Götaland	0.222	0.416
Inflow of N in manure	-0.39	30.613	Örebro	0.001	0.029
Outflow of N in crops	49.422	47.075	Västermanland	0.007	0.084
Firms value added	13.163	1.023	*First visit*		
Firms costs	13.793	0.950	2000	0.009	0.095
Livestock	60.21	103.899	2001	0.186	0.389
Hectares of arable land	124.291	126.756	2002	0.19	0.392
Change i livestock	4.711	60.728	2003	0.207	0.405
Change in hectares of arable land	15.557	64.419	2004	0.094	0.292
Ec. livestock prod.	0.12	0.324	2005	0.085	0.278
Ec. crop prod.	0.16	0.366	2006	0.057	0.232
Change in Ec. livestock prod.	0.033	0.212	2007	0.048	0.215
Change in Ec. crop prod.	0.009	0.253	2008	0.035	0.185
Hectares of land with soil type:			2009	0.028	0.165
Sandy	21.311	32.379	2010	0.036	0.186
High clay level	28.37	34.179	2011	0.021	0.143
Middle-high clay level	13.911	25.677	2012	0.004	0.064
Some clay	23.942	31.692	Last visit:		
Loam clay	8.301	19.187	2001	0.001	0.029
Farm type (ref=milk)			2002	0.008	0.089
Only crops	0.384	0.486	2003	0.022	0.145
Milk	0.349	0.477	2004	0.034	0.181
Beef	0.079	0.270	2005	0.069	0.254
Pig	0.065	0.247	2006	0.063	0.242
Other animal	0.029	0.169	2007	0.058	0.234
Mixed animal	0.093	0.290	2008	0.132	0.338
Region:			2009	0.08	0.271
Stockholm	0.01	0.1	2010	0.12	0.324
Uppsala	0.024	0.152	2011	0.167	0.373
Södermanland	0.01	0.101	2012	0.172	0.378
Östergötland	0.034	0.181	2013	0.075	0.263
Jönköping	0.001	0.029	2014	0.001	0.033
Kronoberg	0.002	0.047			

Note: The difference in *Number of consultations* and *Mean number of visits by consultants* is because the latter contains those receiving only one visit, but when constructing *Number of consultations* these are removed.

Table A2. First-stage model of the relationship between consultation visits and counsellors mean number of visits

	Number of consulatations				
		cont.		cont.	
Mean number of visits by consultant	0.589***	*Region (ref=Stockholm)*		2008	-3.375***
	(0.027)	Uppsala	0.0577		(0.285)
Livestock	0.0001		(0.0844)	2009	-3.514***
	(0.0003)	Södermanland	0.0044		(0.282)
Hectares of arable land	-6.35e-05		(0.124)	2010	-3.552***
	(0.0002)	Östergötland	-0.0139		(0.284)
Change i livestock	0.0008**		(0.0805)	2011	-3.671***
	(0.0004)	Jönköping	-0.139		(0.290)
Change in hectares of arable land	-0.00001		(0.116)	2012	-3.517***
	(0.0003)	Kronoberg	-1.229***		(0.291)
Ec. livestock prod.	-0.142		(0.456)	*Last visit (ref=2001)*	
	(0.0996)	Kalmar	-0.250***	2002	1.841***
Ec. crop prod.	0.256***		(0.0881)		(0.352)
	(0.0883)	Gotland	-0.245**	2003	2.716***
Change in Ec. livestock prod.	-0.0873		(0.0977)		(0.312)
	(0.0941)	Blekinge	-0.478***	2004	3.289***
Change in Ec. crop prod.	0.148**		(0.120)		(0.302)
	(0.0721)	Skåne	-0.0235	2005	4.014***
Hectares of land with soil type:			(0.0912)		(0.294)
Sandy	0.00280***	Halland	-0.567***	2006	4.413***
	(0.00106)		(0.0904)		(0.299)
High clay level	0.00356***	Västra Götaland	-0.349***	2007	4.499***
	(0.0011)		(0.0743)		(0.297)
Middle-high clay level	0.00399***	Örebro	0.139	2008	4.824***
	(0.0012)	*First visit (ref=2000)*			(0.296)
Some clay	0.0037***	2001	-0.965***	2009	4.986***
	(0.0011)		(0.272)		(0.298)
Loam clay	0.0043***	2002	-1.787***	2010	5.297***
	(0.0014)		(0.273)		(0.300)
Farm type (ref=milk)		2003	-2.458***	2011	5.543***
Beef	0.376***		(0.274)		(0.301)
	(0.0524)	2004	-2.574***	2012	5.707***
Pig	0.0146		(0.275)		(0.299)
	(0.0649)	2005	-2.984***	2013	5.675***
Other animal	0.0207		(0.276)		(0.301)
	(0.0678)	2006	-3.040***	2014	5.903***
Mixed animal	0.0848		(0.278)		(0.379)
	(0.103)	2007	-3.147***		
Crop	0.162**		(0.280)		
	(0.0690)				
Observations					3,656
R-squared					0.677

Notes: The dependent variable is Number of consultations. Robust standard errors in parentheses. *** p<.01, ** p<.05, * p<.1.