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Optimising the effect of policy instruments: A study of farmers' decision rationales and how they match the incentives in Danish pesticide policy

Pedersen, A.B., Nielsen, H.Ø., Christensen, T., Hasler, B., 2012

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Abstract: Economic modelling generally assumes that businesses are profit maximisers. But behavioural economics holds that businesses pursue multiple objectives and may even sacrifice some profit. This has implications for the effectiveness of incentive-based environmental policies. Using Danish farmers' as a case, this paper examines whether non-economic rationales may trump economic ones in farmer decisions, and, unlike previous research, we quantify how widespread non-economic values are compared to more economic values. Data derive from a survey (1.164 responses) of Danish conventional farmers' decision rationales regarding their use of pesticides. Using cluster analysis, we show that some farmers are more economically motivated while other farmers are more focused on optimizing yield and pay less attention to expenditures and crop prices. Furthermore, we find that the two groups differ in their response to policy instruments; farmers who focus on yield indicate less responsiveness to economic policy instruments. The results imply that it is important to implement a broad array of policy instruments to match different farmer rationales.

Keywords: Pesticides; policy instruments; farmers; motivation

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Introduction

Incentive-based policy instruments¹ have increasingly gained favour with environmental policy makers (OECD 2001, Speck et al. 2006). For such instruments to deliver as efficiently as promised by textbooks policy initiatives must build on adequate models of behaviour (Ostrom 1998, Feola and Binder 2010, van den Bergh 2000, Nielsen 2011). While there are indeed many successful examples of application of economic instruments (Andersen & Ekins 2009), there is also evidence that these policy instruments do not produce the kinds of responses predicted in ex-ante policy analyses based on neo-classical economic models (Speck et al. 2006). In Denmark, for instance, taxes on pesticides have not been as effective as expected, and voluntary agri-environmental subsidy schemes intended to reduce pesticide use have been largely ignored by farmers. Moreover, farmers have not responded much to information-based tools.

Studies have shown that there are great differences in the extent to which farmers base their actions on economic rationales (see Gasson 1973, Falconer and Hodge 2000, Mettepenningen et al. 2007, Nielsen 2009). This is in line with the general literatures within bounded rationality, behavioural economics and cultural theory, which question the assumptions of economic theory that decision makers are necessarily self-interested utility- or profit-maximisers (for classics on each of these strands see Simon, 1947; Cyert and March, 1962; Wildawsky, 1987, 1994, respectively). Studies of farmers have identified distinct management or decision styles, grouping farmers by the values and objectives that guide their decisions as well as by decision strategies (for instance, Gasson 1973, Brodt et al. 2006). However, typically these studies apply a qualitative methodology or categorise farmers as ideal

types (in the Weberian sense). Few, if any, studies have attempted to assess the numerical coverage of each type.

In this paper we therefore aim to extend the literature on management styles by quantifying the distribution of farmers across styles. Our analysis concerns the decisions regarding use of pesticides of Danish farmers. We focus specifically on the decision rationales rather than full management styles, and we are particularly interested in how many farmers are more likely to be motivated by non-economic incentives compared to the number of farmers who are primarily driven by economic incentives.

Subsequently, we examine the farmers' attitudes towards different policy instruments in order to establish a link between decision rationales and farmer perceptions of policy instruments. If decision rationales matter for policy response, as predicted by behavioural theory (see for instance van den Bergh et al. 2000), environmental policies may be designed for greater effectiveness by targeting different incentive structures in a more precise manner. Policy considerations may concern both the choice of instruments as well as design of the chosen instruments. The paper therefore aims to move from a tradition of analysing policy options based on a unimodal to a multi-modal description of the regulated community, i.e. farmers, to pave the way for a more segmented and targeted approach to policy design.

Other studies have suggested that policies be targeted more directly to decision rationales (regarding farmers, see Brodt et al. 2006, Coppin et al. 2002, Feola and Binder 2010; regarding residential use of pesticides, see Robbins and Sharp, 2003; Hirsch and Baxter, 2011). These studies do not suggest that preferences are exogenously determined or static; rather, they confirm the argument forcefully advanced by Wildawsky (1987) that preferences are formed in social and institutional

contexts. Even so, for any given choice of policy it is necessary to acknowledge and to understand the different decision rationales at play.

The analysis is based on a comprehensive survey sent to 1.740 Danish farmers (1.164 responses) examining the decision rationales of farmers in relation to pesticides. We use cluster analysis to establish whether distinct decision rationales exist, and to assess how many farmers are in each category.

Based on the literature on management styles, we apply the following hypotheses: 1) One group of farmers optimises profits, while another group optimises production values such as high yield (paying less attention to profit) 2) Farmer attitudes towards policy instruments regulating pesticide consumption depend on their dominant decision rationale; production oriented farmers will indicate a smaller behavioural response to economic incentives than profit-oriented farmers.

Danish farmers are generally considered to be rather profit-driven (see, for instance, Bichel Committee 1998, 1999). Hence, if we find that other values than profit drive decisions for a large share of Danish farmers, this would be a strong case that it applies also to farmers across the rest of the EU.

The paper is structured as follows: First, a short summary of Danish pesticide policies is presented followed by a discussion of the literature on management styles of farmers. Next, we describe the methodology of the survey, followed by a presentation of the results of our analyses. The final section discusses our findings and concludes the paper.

Background: Danish pesticide policies

Agriculture dominates the Danish landscape. In 2008, the farmed area amounted to 66% (Statistics Denmark 2011). Since the 1950s, agricultural production has

intensified rapidly with an increasing use of pesticides and fertilisers. Detrimental effects such as contamination of groundwater, which is the source of largely untreated drinking water, started to cause concern (Ministry of Taxation 2004).

In 1986, the Danish government introduced its first Pesticide Action Plan. The plan staked out two parallel tracks for the Danish pesticide policy 1) A system for review of plant protection chemicals and a requirement that import, sale and usage of any plant protection chemicals are subject to approval by the Minister of Environment and 2) Measures to reduce the use of pesticides by 50% before 1997 (Freier & Boller 2009:442, Ministry of Environment and Ministry of Food, Agriculture and Fisheries 2003:24, Ministry of Finance 2001:58). The analysis below focuses solely on measures to reduce the use of pesticides approved under this system.

Danish policy objectives regarding pesticide consumption are measured in relation to a 'treatment frequency index' (TFI). The TFI represents the number of pesticide applications on cultivated areas per calendar year in conventional farming assuming that a fixed standard dose is used². The measure was introduced with the first action plan in 1986, when the TFI was at about 2.7 (Freier & Boller 2009:442, Environmental Protection Agency 2009, Christensen & Huusom 2003:15).

The first Pesticide Action Plan relied mainly on regulatory and informational measures (Bichel Committee 1999:20), but the policy instruments did not deliver the expected 50% reduction. In 1998, when TFI was at 2.3, an expert committee under the Ministry of Environment and Energy therefore suggested a greater emphasis on incentive-based policies, arguing that a strong pesticide tax would effectively encourage economically optimising farmers to reduce pesticide consumption (Bichel Committee 1999:34). The committee assessed that a treatment frequency index of 1.7 would approximate an economically optimal level of pesticide consumption for the

farming community at large and could therefore realistically be achieved by economically optimising farmers (Bichel Committee 1998:142). The second action plan adopted in 1998 thus set a policy objective of a TFI of 1.7, increased previous tax rates to more significant levels of 54% of retail prices on insecticides and 33% on herbicides and fungicides (Ministry of Environment & Ministry of Food, Agriculture, and Fisheries 2000). Furthermore, agri-environmental schemes were introduced (from 1999) to encourage farmers to carry out environmentally beneficial activities on their land, such as establishing pesticide-free zones around lakes and watercourses. The purpose was to ensure more direct protection of water courses than a general reduction of pesticides would allow for. The subsequent Pesticide Action Plan for 2004-2009 set as a goal to have 25,000 ha committed to subsidy schemes for pesticide-free zones (Ministry of Environment and Ministry of Food, Agriculture and Fisheries 2003).

The pesticide policies have failed to accomplish their objectives. While pesticide consumption dropped to a TFI level just around 2.0 for the years 2000-2004, it bounced back to stay at around 2.3-2.4 for the remainder of the decade³ (Environmental Protection Agency 1998-2010). An evaluation suggested several reasons for the increase, including low prices on pesticides despite the tax and new pest problems due to climate change, but it offered no conclusive evidence (Environmental Protection Agency 2008). Moreover, by 2006 only 9,000 ha had been signed up under agreements for pesticide-free zones (Christensen et al. 2011).

Theory regarding farmers' values and goals

Much modelling of farmer decision-making behaviour is based on neo-classical economic theory assuming that all farmers are profit maximisers who respond to

marginal price changes (Willock et al. 1999). This assumption has also carried over into the adoption of incentive-based pesticide policies in Denmark and even shaped the content of information based-policies (Pedersen et al. 2011). However, a small but increasing number of studies suggest that the assumption of profit-maximisation is inadequate. As mentioned in the introduction, these studies have identified different management styles, each of which represent different approaches to decision making and farm management.

Gasson (1973) provided ground-breaking empirical research on farmers' values and goals (DEFRA 2005:15). Gasson identified four different farmer types, differentiated by the values that drive their decisions (DEFRA 2005:18). According to DEFRA, the main contribution of this research is an "established recognition that farmers' goals and values are complex, and that dividing [farmers] into behavioural types on the assumption of simple profit maximising behaviour is increasingly difficult to sustain" (DEFRA 2005:19).

In a study of California almond and wine grape growers, Brodt et al. (2006) identified three management styles based on their rankings of economic and social values as well as specific farming objectives. They labelled the types Environmental Stewards, Production Maximisers, who are business oriented, and Networking Entrepreneurs, who focus more on off-farm activities such as positions as farm advisors (Brodt et al. 2006: 98).

These and similar typologies overlap, but the specific types also vary by the framework of the study, as well as by the types of farms included. What cuts across typologies, however, is the recognition that farmer decisions are shaped by a multitude of values and goals, including profit, but also the intrinsic value of being a

skilled farmer, professional and community recognition and environmental stewardship.

Studies showing that farmers are economic optimisers also suggest that they may include considerations not always included in ex ante modelling. Falconer (2000) showed that farmers may use a rather broad definition of transaction costs when they calculate the merits of signing up for agri-environmental subsidies, including also an expectation of administrative hassle. For Danish farmers, Jørgensen et al. (2007) found that economic considerations affected farmers' pesticide management in very different ways depending whether they grow high-value crops, whether they have small or large farms, and whether their main focus is on plant production. Finally, different degrees of risk aversion may also affect how farmers approach economic optimisation. Pest control strategies involve uncertainty as to the timing and dosage; applying too much too soon represents a waste of resources; applying too little, too late may lead to the loss of a crop. In a Danish context both Jørgensen et al. (2007) and Nielsen (2009) found that farmers were risk-averse and tended towards erring on the side of caution.

As for non-economic values, studies have found that farmers are motivated by a strong sense of professionalism, either because it offers a sense of intrinsic satisfaction or because they seek the social recognition that follows from being a good craftsman (Burton et al. 2008, Kaljonen 2004, Lassen et al. 2007, Nielsen 2009). Comparing farmers in Hessen (Germany) and Aberdeenshire (Scotland), Burton et al. (2008) found that agricultural activities embed more or less cultural capital, i.e. the opportunity to develop or demonstrate skilled role performance, and that farmers were less likely to sign up for agri-environmental schemes unless these also compensate such non-economic losses. Likewise, Nielsen (2009) in an in-depth study of Danish

farmers' decision-making found that some farmers use fertilizers and pesticides above economically optimal levels in order to get a bigger crop as well as nice-looking fields (ibid, see also Vanslebrouck et al. 2002). Similar social and cultural norms to associate lawn aesthetics with community standing have been shown to drive residential use of pesticides in the US (Robbins and Sharp 2003, Hirsch and Baxter 2011).

The literature thus offers sufficient indications that farmers may be guided not only by pure economic rationales. However, the weighting of the importance of economic goals contra other goals such as professional satisfaction is not covered in these studies. The present quantitative study aims therefore to examine whether it is possible to identify different segments within the population of Danish farmers based on the weight farmers give to economic values vs. the weight they give to non-economic values when using pesticides.

Method and data

We constructed a survey in order to analyse 1) how farmers weigh different objectives in their decisions regarding use of pesticides, including prices, yield, and environment and 2) farmer attitudes towards different pesticide policy instruments. The survey questions were chosen based on a literature survey with particular use of Jørgensen et al. (2007) and Nielsen (2009), two interviews with agricultural advisors, and two group interviews with nine and six farmers, respectively, representing a range of farm sizes and types.

In order to focus on the farmers most relevant for pesticide use, organic farmers and farmers smaller than 30 hectares were excluded from the survey because 1) Danish organic farmers do not use synthetic pesticides; 2) farms smaller than 30

hectares cultivate only about 10% of the Danish farm land, but in numbers they constitute almost half of Danish farms.

The survey was web-based and conducted in March-April 2009 by the consultancy the Nielsen Company. It was sent to 1,740 Danish farmers in the Nielsen Company's nationwide farmer panel. About 90% of Danish farmers were online by 2006 (Dansk Landbrug, 2006) and therefore eligible for the Nielsen Company's panel. Of the 1,740 farmers in the sample, 1,164 farmers returned a completed questionnaire, 430 never started the survey, while 146 farmers started the survey, but never finished it. The typical reason given for not completing the survey was that it was too long (respondents used 23 minutes on average). Furthermore, some farmers feared that the results of the survey would be (mis)used politically. However, the response rate of 67% is rather high for the social sciences in general and also for surveys among farmers – not least considering the sensitive subject (pesticide reductions). Babbie (1989: 242) suggests that a 60% response rate is good and a 70% rate very good.

Regarding representativeness, younger farmers and larger farms (above 100 ha) are overrepresented in the sample, e.g. the average age of the sample is 5 years younger than the average Danish farmer. Consequently, the results may not be completely generalisable to the Danish farmer population of today. On the other hand, data are more robust with regards to the farmers (the younger farmers) and the farms (the larger farms) of tomorrow.

In order to measure decision rationale, farmers were presented with a suite of rationales for using pesticides and asked to rate the importance of each for their decisions. Policy effectiveness was also based on farmers' assessments of how much they would respond to different policy instruments by cutting pesticide use. Data on

individual-level actual behaviour was not available; and the self-reported responses cannot be controlled for strategic answering, perhaps to affect policy. The specific formulations used to elicit motivations and attitudes towards policy instruments will be described in conjunction with the presentation of the findings below. As for measurement scale, answers were typically given on a numerical scale from 1 to 5 in which the beginning point (1) was defined as 'none' or 'not at all' and the end point (5) as 'to a very high degree', for instance. Other questions used a 5-point Likert-scale going from e.g. 'strongly disagree' to 'strongly agree' with a neutral mid-point.

The survey data have been analysed, firstly, with descriptive statistical methods, calculating frequencies and means. Secondly, two-step cluster analysis was used to explore whether farmers could be segmented into groups based on their type of motivation. Thirdly, associations between clusters and policy instruments were analysed using simple cross tabulations and non-parametric correlation measures (Pearson's chi-square).

Cluster analysis aims to identify homogenous groups within a sample (see for instance Härdle and Simar, 2007). Group membership can be used as an explanatory variable in further statistical analysis. A two-step clustering is used because it allows for a combination of categorical and continuous variables and is appropriate for very large datasets (Garson 2010). In this case the number of clusters was preset to three. Garson lists three validity criteria: 1) Size: all clusters should have enough respondents to be meaningful; as the three clusters are distributed with 45%, 32% and 18% of the respondents this criterion appears to be fulfilled. 2) Meaningfulness: the meaning of each cluster should be readily intuited from the constituent variables used to create the clusters. Variance importance plots can be used to measure meaningfulness. As will be shown, this criterion holds for at least the two larger

clusters. 3) Criterion validity: cross tabulation of clusters with other variables known from the literature as reflecting the cluster concept should be used as validity test. In lieu of this, we use the cross tabulation with policy preferences as a test of validity.

Moreover, as a measure of robustness the data have also been analysed using principal component analysis (PCA). PCA (factor analysis) may reveal underlying structures and relationships within a set of variables; it clusters variables rather than respondents (Agresti and Finlay 1997, Garson 2010). Even so, overlap in the type of components that are identified in the factor analysis and the clusters validates the interpretation of each component as representative of a particular type of rationale.

Cluster analysis is very much an exploratory statistical tool and it is sensitive to the restrictions and choices made including the sequencing of data. Therefore randomization is recommended. However, as the problem is considered less significant with larger datasets (Garson 2010) randomization is not carried out in the present analysis.

Analysis: decision rationales and policy instruments

Farmers' motivation: Does money rule all?

This paper makes two claims: 1) farmers can be categorized according to the motivations that drive their decisions and 2) each farmer will respond differently to pesticide policy instruments depending on his dominant motivation for use of pesticides; specifically, we hypothesize that farmers who are categorised as economically oriented will be indicate a stronger response to economic policy instruments than will farmers who are categorised as production oriented.

Farmer motivation in relation to pesticide use was captured by asking the respondents to indicate the importance of each of a suite of rationales for using plant protection chemicals (see section on methodology for more detail). The items,

presented in Table 1, were intended to cover different types of motivation. Items referring to prices reflect economic optimising in the traditional textbook fashion. Items such as *highest possible yield*, a preference for *clean fields* and *professional ambition to use as little pesticide* as possible were intended to capture motivation geared toward professionalism or craftsmanship rather than profit optimisation; it may also hold a social component since high yields and clean fields demonstrate skilled performance by the norms of the farming community (Burton et al. 2008, Nielsen 2009). One could argue that attention to yield may also be economically motivated. Whether this is the case is tested by examining, if attention to yield co-varies with attention to prices, or not. If not, we argue that the former should be interpreted as reflecting a non-economic rationale.

TABLE 1 APPROXIMATELY HERE

Table 1 provides an overview of the distribution of responses across rationales and shows that most of the rationales listed are perceived to be important by the farmers as indicated by mean scores above the midpoint of 3. Overall, the most important rationale affecting pesticide decisions is ‘ensuring the greatest possible crop yield’. More than 80% of the farmers give this a score of four or five. ‘Forestalling serious problems at a later stage’ ranks second in importance for farmers on average. We interpret both of these items as related to a production orientation. The price items score somewhat lower. Hence, 64% and 62% of the farmers indicate scores of 4 or 5 for the price of herbicides and the price of crops, respectively, and fewer give high scores for the prices of other types of chemicals. Notably, environmental protection and the ambition to use few chemicals score higher than the price variables.

The great concern with yield is underlined in an examination of farmers' risk perceptions. Table 2 shows the respondents' ratings of different types of risks

associated with using plant protection chemicals. Loss of crop is rated as the most severe risk in relation to (reduced) pesticide use with more than two-thirds of the farmers (68%) rating this risk as a four or five.

TABLE 2 APPROXIMATELY HERE

Average scores below 3 on risks to environment and nature, including the risk to the farmer's own health, appear low in light of considerable public attention to groundwater pollution from pesticides in the last ten years, as well as more recent stories about the risk to the reproductive health of agri- and horticulture workers working with plant chemicals. But it is in line with findings from international studies showing that use of pesticides is negatively correlated with risk perception (Hirsch and Baxter 2011 for residential use; Coppin et al. 2002 for farmers). Moreover, from focus group interviews and interviews with agricultural advisers we learned that there is a near-consensus in the conventional farming community that currently used chemicals, approved by the Danish EPA, are fairly harmless. Altogether, these results indicate that farmers are more concerned about loss of yield than about environmental and health risks when they consider the use of pesticides.

The mean scores offer little information as to how each farmer ranks the different rationales in relation to each other. The question is whether the mean scores mask groups of farmers differentiated by the types of rationales they prioritize in their decisions to use pesticides. Indeed, the cluster analysis did identify such groups among the farmers. Confirming the first hypothesis, one cluster of farmers emerged as more economically motivated while another cluster appeared to be driven more by the desire to have the greatest yield possible. Table 3 describes the clusters, defined by how their ratings of rationales co-vary.

TABLE 3 APPROXIMATELY HERE

The largest cluster, cluster 1, is defined primarily by farmers placing greater weight on prices compared with the other farmers in the study. Thus farmers in this cluster, which we will refer to as the price-oriented cluster, resemble the agent in economic models whose decisions are determined by price relations. However, farmers in this cluster also score above average on all other items. Whether this reflects a decision style in which all factors are considered important or a general inclination towards high scores in response behaviour cannot be determined. Farmers in cluster 2 exhibit the opposite tendency: they score below average on all items, although they differ the most from the average on items related to production. Again, this may reflect a general inclination towards low scores rather than actual decision behaviour. As these results for cluster 2 are harder to interpret than the other clusters, due in part to a lack of clearly defined expectations, we will not include this cluster in the remainder of the discussion. Finally, farmers in cluster 3 are very attentive to yield, above average attentive to clean fields, and, conversely, pay relatively little attention to pesticide prices. We will refer to these farmers as the production-oriented cluster. The analysis indicates that a focus on yield is not driven by an economic logic, as farmers in the production-oriented cluster also assign lesser weight to crop prices. Hence, they do not appear to be gambling on high crop prices to offset expensive chemicals. Rather, we interpret this type as professionally oriented in the sense that they are driven by a motivation to do a good job (cf. Gasson 1973), possibly an orientation to demonstrate skilled performance (Burton et al. 2008), both of which have been found in interview studies of Danish farmers (Nielsen 2009).

The importance assigned to clean fields of the farmers in cluster 3 match findings that residential usage of pesticides is driven by a socially constructed lawn

aesthetic (Robbins and Sharp 2003). But the drive for the highest possible yield is a stronger determinant of this cluster than the clean fields, which leads us to emphasise the aspect of craftsmanship over the aesthetic component, but in both cases it is clear that social and cultural norms are important drivers of the use of pesticides.

The robustness of the cluster analysis was tested using PCA. The PCA supports the findings of the cluster analysis, producing components that closely resemble the profiles of the economically oriented cluster and the production oriented cluster, respectively. Thus, one component is characterised by a high correlation among the different variables concerning the prices of pesticides and to some extent the price of the crops. Another component is defined by a high correlation among the variables ‘clean fields’, ‘crop yield’ and ‘forestalling future problems’. The PCA revealed two further components: one in which the variables ‘environmental protection’ and ‘a professional ambition to use few pesticides’ correlate and one which indicates a correlation between planning of work and the costs of spreading pesticides in the fields.

Our findings bear resemblance to other typologies, including Gasson (1973) and Brodt et al. (2006), but they do not completely overlap with these. Our analysis indicates that attention to prices and attention to production represent two different dimensions, which are mixed as a general business orientation in other studies, e.g. in the production maximiser identified in Brodt et al. (2006). In comparing these typologies, it should be kept in mind that the analysis presented here has a more narrow focus on reasons for pesticide usage, while the other typologies attempt to give a more complete picture of farmer types.

Respondents are alike across clusters with regards to structural variables such as farm size and distribution across plant, pig and cattle production, indicating that the

cluster profiles do not reflect underlying structural factors, but individual management styles. Yet, another question is whether the clusters found here represent context-specific types or more general decision types. Cultural theory would lead to an interpretation that each decision rationale represents a specific culture, which provides guidelines for action also in contexts that go beyond pesticide use (Wildawsky 1987). Others scholars suggest that any given typology only holds for specific contexts and that the orientations of individuals vary with the institutional or social context (Hirsch and Baxter 2011, Tansey and O’Riordan 2011). Given the narrow focus of our study, we cannot conclude whether the distinction found in relation to pesticide use holds for other contexts. However, our results match general findings in behavioural economics and the sociology of professions that professional objectives may override economic incentives, suggesting that the findings are more general than the context of pesticide use (Simon 1997, Andersen 2005). But these literatures also suggest that the institutional context may affect the manner in which different decision rationales come into play.

Farmers’ attitudes towards the effectiveness of policy instruments

The expectations regarding the relationship between cluster profiles and responses to different policy instruments are tested in two steps: 1) A descriptive analysis of farmers’ attitudes and perceptions of the effectiveness of a range of policy instruments; 2) correlation analyses examining whether motivation clusters vary systematically in their reactions to three types of economic instruments (taxes, tradable quotas and subsidy schemes). As mentioned, our data are self-reported perceptions of policy effectiveness rather than data on actual behaviour. .

Not surprisingly farmers seem to prefer policy instruments that offer carrots rather than sticks. As shown in Table 4, new technologies rank highest among means

that would encourage farmers to reduce usage of plant protection chemicals, followed by subsidies for pesticide free cultivation practices either in specified areas or altogether. The questionnaire did not imply that adoption of new technologies would be *required*, but from a policy instrument perspective the response is relevant to the extent that policies could involve either such a requirement or subsidies for development or use of new technologies. Among the more forceful means that farmers think would curb their pesticide use is a ban on spraying in selected areas. While it is obvious that a ban reduces pesticide usage in the specified areas, farmers do not seem to expect that this effect would be offset by more intensive spraying in other areas. Furthermore, a significant increase in the pesticide tax also receives a mean score just above the midpoint score of 3, whereas farmers do not consider information-based policy means to be effective.

TABLE 4 APPROXIMATELY HERE

These mean scores cover variations in response patterns. But again we were interested to see whether the clusters vary systematically in their responses. The analysis focused on economic policy measures. Firstly, responses to an increase in the pesticide tax (from Table 4) were examined in a cluster context. As expected, farmers in the price-oriented cluster indicated a stronger inclination to respond to a significant tax increase by reducing their use of plant protection chemicals than farmers in the production-oriented cluster. Thus, 16% of respondents in the economically oriented marked a 5, compared to 9% of respondents in the production oriented cluster, and the former had a lower frequency on the scores in the 1 - 3 range. The differences are statistically significant. Likewise, the economically oriented farmers were more likely to respond that they would definitely reduce usage of pesticides if taxes were increased to 100 % of the sales price (not shown).

TABLE 5 APPROXIMATELY HERE.

The overall expectation that the economically oriented farmers would be more responsive to economic measures than production oriented farmers also holds when the policy takes the form of a tradable pesticide quota. The respondents were informed that they would receive a pesticide quota amounting to 25% less pesticide than their current level of usage and that they would be able to sell or buy quotas. The quota instrument thus ensures an overall cap of the total level of pesticides applied but allows the individual farmer to exceed his quota if someone else is willing to sell quota. Table 6 shows the distribution across four response options for the clusters.

TABLE 6 APPROXIMATELY HERE

The most significant finding is that 28% of the farmers in the production cluster, who prioritize high yields, would buy extra quota rather than reduce usage as compared with 21% of the economically-oriented farmers. Again, the difference is statistically significant.

Even so, the main trend across all the clusters is that the largest share of farmers would use the quota they were allocated, and that very few would reduce consumption to sell part of their quota. Given the discrepancy in numbers between those interested in selling and those wanting to buy, either the price on pesticide quotas would be high or very little trading would occur.

Finally, attitudes towards subsidy schemes (no-spray margins, no spray in sensitive areas and no pesticides altogether) have been analysed with respect to the three clusters. Confirming hypothesis 2 yet again, the economically oriented farmers were more likely to respond to increased subsidies, regardless of the scheme, than

were production oriented farmers Table 7 shows the findings for pesticide-free cultivation; 35% of farmers in cluster 1 would be encouraged to reduce pesticide use ‘to a very high degree’ if subsidies for pesticide-free cultivation were increased. Among the farmers in cluster 3, who prioritize high yields, only 16 % indicated that they would respond to a very high degree. The other items relating to subsidies showed similar patterns, although slightly smaller differences.

TABLE 7 APPROXIMATELY HERE

Conclusion: the implication for policy design

A survey of conventional Danish farmers (1.164 responses) showed that farmers in general pay more attention to maintaining a good crop than to the costs of pesticides, and that they are also more concerned with keeping up yield than with environmental and health risks when they consider the use of pesticides. This is also in line with other findings that use of pesticides increases acceptance and reduces risk perceptions (Coppin et al. 2002, Hirsch and Baxter 2011).

But importantly, our analysis also showed that farmers may be grouped into distinct segments based on the degree to which they weigh economic rationales versus more professionally oriented rationales, confirming our first hypothesis. One cluster of farmers contains the more economically motivated farmers who place greater weight on prices on pesticides when making decisions regarding pesticide use. They constitute about half of the farmers. Another cluster consists of farmers who are very focused on optimising yield but pay relatively little attention to both expenses and crop prices when making decisions on pesticides. This includes about one-third of the farmers. A third, smaller cluster score below average on all variables.

Not surprisingly, farmers in general seem to prefer policy instruments that offer carrots rather than sticks. However, there are systematic variations in response

patterns across the clusters. Respondents in the economically oriented cluster are more likely to indicate strong responses to the three economic instruments - a tax increase, a tradable pesticide quota and an increase in subsidy schemes for reduced pesticide consumption – than are the farmers in the production-oriented cluster.

The results imply that it is important for policy-makers to implement a broad array of policy instruments to match the reality that farmers are driven by different types of motivation. Additionally, it would be worthwhile designing specific instruments in a more targeted manner towards different types of farmers. The analysis shows that policies based on economic incentive mechanisms may be effective with at least half of the farmers, who indicate that their decisions on pesticides are significantly driven by prices. But, importantly, it also suggests that nearly one third of the farmers would be less responsive to economic instruments than predicted by economic modelling. Needless to say, farmers not motivated to change behaviour by the pesticide tax could not be exempted from the tax. But while the pesticide tax does not change their behaviour, the revenue obtained from these farmers can be used to offset the externalities incurred by pesticide use.

Economic instruments may be effective even with this group of farmers, but the incentives would have to be compelling, either in the form of a substantially higher tax rate or much higher subsidies. This, however, raises the issue of economic efficiency. It is doubtful whether it would be economically efficient to apply to all farmers tax rates high enough to compel the one third of farmers who are less tuned into economic incentives to react; such rates would be higher than necessary to prompt reductions among the more economically motivated. Likewise, it is questionable whether an economic assessment of benefits would justify the level of subsidies necessary to entice the farmers who place a high value on yield. A tradable

emission quota would work, as it does place an overall cap on the amount of pesticides allocated to the farmer.

But generally the limited behavioural changes due to economic incentives, makes it important to address these farmers by using other types of instruments. In the short run command-and-control instruments, i.e. rules regarding the use of pesticides might be among the few truly effective policy instruments. Farmers in this group would probably also respond to offering strategies to maintain yield, be it alternative forms of pest control or other compensatory methods. A possibility might be to investigate whether agricultural advisory more effectively could address questions regarding these farmers' pesticide reductions (see also Brodt et al. 2006, Coppin et al. 2002).

In the long run, it seems necessary to attempt to affect the professional norms among farmers as to what constitutes good agricultural standards; hence, yield and clean fields as signs of craftsmanship would have to be replaced by other values that would offer a sense of accomplishment. Both Wildawsky (1987) and Feola and Binder (2010) point to the importance of changing the institutional context in order to change preferences. This would require further study of the complex relationship between the institutional context and formation of preferences or decision rationales, especially how policies may affect social norms that shape decisions.

These considerations are relevant also for the design of EU agricultural policy which relies heavily on economic incentives through the agri-environmental schemes. We suggest that a significant number of farmers all over Europe might indeed also be optimizing yield rather than profits. If that is the case, one implication would be that agri-environmental subsidies may not be effective for a sizable share of farmers throughout the European countries.

Finally, our study indicates the relevance of paying greater attention to the characteristics of target groups when designing policy instruments and to differentiate the choice and design of environmental policy to improve the effect of the overall policy.

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Table 1: How important are the following objectives for your usage of plant protection chemicals. Please mark a number between 1 and 5 where 1 equals not important at all and 5 equals very important. %. N varies*

Rationale	1	2	3	4	5	Do not know	Mean score *
Ensure greatest crop yield	1	2	15	40	41	0	4,2
Forestall future problems	1	5	20	44	29	0	3,9
Professional ambition to use few chemicals	2	7	26	37	28	0	3,8
Environmental protection	3	6	29	40	21	1	3,7
Price of crop	3	7	27	38	24	1	3,7
Clean fields	1	12	33	38	16	1	3,6
Price, herbicides	3	9	33	35	20	1	3,6
Price, fungicides	3	9	31	35	20	2	3,6
Price, insecticides	6	12	34	28	16	4	3,4
Costs of bringing out	11	24	30	25	10	1	3,0
Work time, planning	15	20	32	25	8	1	2,9
Price, growth inhibitors	24	14	20	14	11	16	2,7

* The mean score for each item was calculated excluding “do not know” answers. N is around 1150 on most items, except for the item ‘price of insecticides’ which drew 1117 responses and the item ‘price of growth inhibitors’ which drew 975 responses.

Table 2: How do you assess the risk of the use of plant protection chemicals with regards to the following issues? Please rate on a scale from 1 to 5 where 1 indicates 'no risk' and 5 indicates 'very great risk'. %. N varies*

Risk of...	1	2	3	4	5	Don't know	Mean score
Risk of reduced yield from reducing the use of PPCs	3	6	22	37	31	1	3,9
Risk to farmer's health from application	15	33	27	16	9	1	2,7
Risk of pollution of water courses and lakes	13	36	26	14	9	1	2,7
Risk of damage to wildlife and wild plants	11	37	31	13	6	1	2,7
Risk of damage to crop	17	39	24	14	5	1	2,5
Risk of pollution of groundwater/drinking water	19	37	21	12	10	2	2,5
Risk of pesticide residues in food	26	36	20	8	8	1	2,4

Note: N* is around 1,150 respondents for all items.

Table 3: Clusters: variables that contribute to defining cluster profiles

Cluster no.	Characteristics	Focus	n (%)
1	<p>Respondents score above average on all items</p> <p>Items that contribute mostly to cluster definition are:</p> <ol style="list-style-type: none"> 1. Prices on chemicals (student's t-scores above 20) 2. Crop price, crop yield and forestalling future problems (student's t-scores at 15) 	Prices	519 (45 %)
2	<p>Respondents indicate values below average on all items.</p> <p>Items that contribute mostly to cluster definition are:</p> <ol style="list-style-type: none"> 1. crop yield (negatively, i.e. student's t score of -20) 2. clean fields and forestalling future problems (student's t-score of -15) 	Limited focus on production	215 (18 %)
3	<p>Differentiated focus. Items contributing mostly to cluster definition are:</p> <p>Positively:</p> <ol style="list-style-type: none"> 1. Crop yield (student's t score of 7) <p>Negatively:</p> <ol style="list-style-type: none"> 2. All price variables on chemicals (t-score -20) 3. Price of crop (t-score -10) 4. Environmental protection (t-score -8) 	Yield /production)	372 (32 %)
	Excluded cases		58 (5 %)
	Total		1164 (100 %)

Note 1: The variables 'price on growth inhibitors' and 'work time and work planning' were excluded from the cluster analysis to reduce complexity as they did not contribute to cluster formation and caused too many respondents to be excluded from the analysis..

Note 2: All variables included exceed the critical values at a 95-percent confidence level

Table 4: To what degree do you expect the following instruments to encourage you to reduce your usage of plant protection chemicals, please indicate on a scale from 1 to 5, where 1 indicates 'not at all' and 5 indicates 'to a very high degree'. %. N*

Policy instrument	1	2	3	4	5	Don't know	Total	Mean score*
New technologies	3	3	22	38	29	5	100	3,9
Increased subsidies: No spray sensitive environmental areas	6	9	20	31	28	6	100	3,7
Increased subsidies: No spray buffer zones	9	9	21	29	28	5	101	3,6
Increased subsidies: Pesticide free cultivation	10	12	20	28	24	5	99	3,5
Ban on spraying in selected areas	12	15	28	22	15	9	101	3,2
Significant increase in pesticide tax	13	14	30	26	13	5	101	3,1
Use of injection technology	13	15	29	24	10	10	101	3,0
Prescription required	17	17	33	18	6	9	100	2,8
Restrictions on rotation	19	18	34	15	5	9	100	2,7
Mandatory advisory services, requirements regarding treatment records	24	22	30	15	5	5	101	2,5
Regular updating of pest management courses	23	22	30	15	5	5	100	2,5
Requirement for green accounting	27	20	31	13	2	7	100	2,4
Requirement to publish treatment records	45	22	20	7	3	4	101	2,0

* Mean scores calculated without don't know answers. N varies between about 1005 and 1110.

Table 5: To what degree do you expect the following instruments to encourage you to reduce your usage of plant protection chemicals, please indicate on a scale from 1 to 5, where 1 indicates 'not at all' and 5 indicates 'to a very high degree'. %, %,

Significant increase in pesticide tax	1	2	3	4	5	Don't know	Total % (n)
Cluster no. 1 Price focus	15	13	26	25	16	5	100 (519)
Cluster no. 2 Lesser focus on production	7	14	34	34	9	3	101 (215)
Cluster no. 3 Focus on yield/production	13	16	33	24	9	5	100 (372)

Note: Pearson Chi-square 32,074, *** (sig. <0.01). 0 cells (,0%) have expected count less than 5. The minimum expected count is 10.50.

Table 6: Reactions to a tradable pesticide quota 25% below current levels. %.

Reaction to tradable pesticide quota	Cluster no. 1 Price focus	Cluster no. 2 Lesser focus on production	Cluster no. 3 Focus on yield/ production
Use allocated quota	40	46	37
Reduce usage to sell excess quota	4	4	2
Reduce usage to save up for later	20	27	21
Buy extra quota depending on the price	21	10	28
Don't know	16	13	13
Total %	100	100	100
Total, N	519	215	372

Note: Pearson's chi-square 31,362, *** (sig<0.01). 0 cells have expected count less than 5. The minimum expected count is 6.42.

Table 7. To what degree do you expect the following instruments to encourage you to reduce your usage of plant protection chemicals, please indicate on a scale from 1 to 5, where 1 indicates 'not at all' and 5 indicates 'to a very high degree'. %.

Increased subsidy for pesticide-free cultivation	1	2	3	4	5	Don't know	Total % (n)
Cluster no. 1 Price focus	11	9	18	24	35	4	101 (519)
Cluster no. 2 Lesser focus on production	6	17	27	32	16	3	101 (215)
Cluster no. 3 Focus on yield, production	12	15	20	32	16	5	100 (372)

Note: Pearson Chi-square 67,618 *** (sig < 0.01). 0 cells (,0%) have expected count less than 5. The minimum expected count is 8.16.

¹ Leaning on Vedung's (1998: 21) definition policy instruments refer to "the set of techniques by which governmental authorities wield their power" in order to effect change; it includes the broad categories of rules, economic incentives and information.

² Some areas such as organically cultivated fields and fallow fields are not included in the TFI calculation

³ To allow for comparison, all TFIs are reported using EPA's old estimation method; it has been revised