Chapter 6
The Danish Pesticide Tax

Anders Branth Pedersen, Helle Ørsted Nielsen, and Mikael Skou Andersen

Abstract This chapter analyses the Danish pesticide tax (1996–2013) on agriculture which was introduced as an ad valorem tax in 1996, doubled in 1998, and redesigned in 2013 as a tax based on the toxicity of the pesticides. The Danish pesticide taxes probably represent the world's highest pesticide taxes on agriculture, which makes it interesting to analyse how effective they have been. The analysis demonstrates the challenges of choosing an optimal tax design in a complex political setting where, additionally, individuals in the target group have different rationales when making decisions on pesticide use. It also demonstrates that a small first, green tax step over time might develop into a better tax design.

Keywords Pesticide tax • Price elasticities • Behavioural responses • Effectiveness • Reimbursement

6.1 Introduction

Denmark's landscape is dominated by agriculture. In 1995, the year before the pesticide tax was first introduced, 66 % of the land use was agriculture and in 2014 it remains so (Statistics Denmark 2011, 2014). In 1999, OECD (1999: 3) concluded that there was a concern for nutrient and pesticide discharges from agriculture in Denmark. Meanwhile, Denmark was and is one of very few countries where the population has the privilege of consuming largely untreated tap water due to high water quality, making treatment unnecessary. In contrast to most other countries, the Danish water supply for drinking water purposes is sourced entirely from groundwater (GEUS 2010; Aarhus University 2011). This fact has contributed to the

A.B. Pedersen (✉) • M.S. Andersen
Department of Environmental Science, Aarhus University,
Frederiksborgvej 399, 4000 Roskilde, Denmark
e-mail: abp@envs.au.dk; msa@dmu.dk

H.Ø. Nielsen
Department of Environmental Science, Aarhus University,
Grenåvej 12, 8410 Rønde, Denmark
e-mail: hon@envs.au.dk

M. Lago et al. (eds.), *Use of Economic Instruments in Water Policy*,
Global Issues in Water Policy 14, DOI 10.1007/978-3-319-18287-2_6

development of a strong norm among Danes for having untreated tap water. According to an expert involved in the 1995 political processes regarding introduction of a pesticide tax this norm was shared by the politicians involved; pesticide pollution of drinking water was considered unacceptable, while there was less focus on the negative effects of pesticides on biodiversity (Interview, Ministry of Taxation 2011).

Prior to the 1996 pesticide tax, a general pesticide fee (3 % of the wholesale price of pesticides) had been in force, but the purpose of this tax was only to recover the administrative costs associated with the approval of pesticides, and it had no effect on pesticide use, nor was it expected to (Ministry of Taxation 2004; Andersen et al. 2001). Furthermore, some information and command-and-control policy instruments were in force prior to 1996 (Pedersen et al. 2011), but these didn't deliver the expected reduction in pesticide use.

The new tax was levied on sales and aimed to reduce use of approved pesticides to contribute to achievement of one of the objectives of the government's 1986 Pesticide Action Plan – a 50 % reduction of pesticide use (Pedersen et al. 2011). The tax revenue was fully reimbursed to the agricultural sector (ibid). An ex-ante impact assessment showed that the tax would reduce the use of pesticides by 8 %, assuming a price elasticity of demand of −0.5 and a price increase of 15 %. If the tax were to lead to development of more alternative (mechanical) pest protection methods, a total of 10 % reduction could be expected. If a more conservative price elasticity was used, a 5 % reduction could be expected, according to assessment, but it was underlined that uncertainties were high (Minister of Taxation 1995; L 44 1997/1998).

It soon became clear that the policy instruments included in the 1986 Pesticide Action Plan would not achieve the objective of a 50 % reduction in pesticide use, although the Ministry of Taxation assessed that the pesticide tax 'probably' had an – unspecified – effect on pesticide use. Consequently, the Danish Parliament decided to double pesticide taxes as an average across types as of November 1998; tax rates on fungicides, herbicides and growth regulators were more than doubled while the increase in tax rates on insecticides was lower, (see Table 6.1) (L 44 1997/1998; Ministry of Taxation 2004).

Ex-ante modelling predicted that the new tax rates would reduce pesticide use by 8–10 % from 1998 to 1999 (assuming a price elasticity of −0.75), compared to a situation without tax increases. The Ministry of Taxation estimated the elasticity of

Table 6.1 Danish pesticide tax 1996–2013 (% of retail price, exclusive VAT and other taxes)

	Period	
Pesticide type	1996–1998	1998–2013
Insecticides	37	54
Fungicides	15	33
Herbicides	15	33
Growth regulators	15	33

Source: Minister of Taxation (1998)

further tax changes to be within the range of −0.5 to −1.0, and that a projected 35 % decrease in the price of grain would reduce pesticide use by another 10 % (L 44 1997/1998). In total, a reduction of 18–20 % was expected from 1998 to 1999, which would result in pesticide use corresponding to a Treatment Frequency Index (TFI) just below 2.0 (L 44 1997/1998). The TFI represents the average number of pesticide applications on cultivated areas per calendar year in conventional farming (based on total cultivated area and total pesticide sales in Denmark), assuming use of a fixed standard dose, and is used as a standard measure of total pesticide use. A 1999 expert committee further assessed that the economically rational level of pesticide use for farmers overall, after the tax increase, would amount to a TFI of 1.7. In accordance with this, the government raised its level of ambition in the succeeding 2004–2009 Pesticide Action Plan, expecting the 1998 pesticide tax, in combination with some voluntary policy instruments, to reduce pesticide use to a TFI of 1.7 (Pedersen et al. 2011, 2012a). The reduced use of pesticides was expected, 'in the short or the long term', to reduce pesticide residues in crops, water courses, lakes, ground water, soil and rainwater and thereby to lower the risk of environmental damage and negative health effects (L 44 1997/1998). The tax rates of 1998 were in force until 2013, when the tax was redesigned as a tax based on the toxicity of the pesticide instead of the price of the pesticide (see below).

One of the arguments for differentiating the 1996/1998 tax among types of pesticides (see Table 6.1) was that the costs per treatment vary quite a lot for different types of pesticides. A differentiation of the tax would therefore approximate a tax-per-treatment principle. The tax was charged to manufacturers and importers who then incorporated it into the product price. All manufacturers/importers were obliged to register with the tax authorities. Taxed products had to be marked with a special label designed by the authorities. This special label indicated the tax category and the maximum price of the product, the argument being that this system precluded the possibility of registering the product at a low price (and a low tax) before selling it at a higher price without a higher tax. Customs and taxation authorities were obliged to control manufacturers and importers (Ministry of Taxation 1998). The tax also applied to other pesticide users such as private home owners and horticulturists (in the analysis below, the focus is on agriculture). The tax revenue – also the part of the revenue collected from pesticide use among private home owners – was fully reimbursed to the agricultural sector primarily through a lowering of the land tax and through different types of support (e.g. subsidies for organic agriculture and protection of the water environment) (Ministry of Taxation 2004; Interview Ministry of Taxation 2011).

6.2 Setting the Scene: Challenges, Opportunities and EPIs

The introduction of the 1996 pesticide tax took place against a background of failure to reach the aims of the Danish pesticide policy with the previous (regulatory and informational) policy measures and a general Danish move towards a green tax reform, shifting the tax burden from income taxes to environmental taxes (Ministry of Taxation 2001). Thus, an expert committee had paved the way for the tax with a 1992 report proposing a reform that would include, among others, more environmental taxes on water, energy and transportation in order to encourage work and discourage consumption (Ministry of Taxation 2001: 47).

As mentioned above, expectations were that the tax could reduce pesticide residues in crops, water courses, lakes, ground water, soil and rainwater and thereby lower the risk of environmental damage and negative health effects. However, the tax design was not optimal from an environmental viewpoint, as it was not based on the toxicity of the pesticides (OECD 1999: 3) (see discussion of this below).

All Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) have introduced pesticide levies on agriculture (Danish Competition Authority 2006: 253). Furthermore, a few other OECD countries, e.g. Italy, France and some North American states (e.g. British Columbia and Washington) have introduced pesticide levies on agriculture (OECD and EEA 2014). However, the average Danish tax level seems to have been substantially higher than tax rates in other countries (OECD and EEA 2014).

In connection with the Danish implementation of the EU Water Framework Directive (EC/60/2000) the pesticide tax was totally redesigned in 2013. The EU Water Framework Directive (WFD) prescribes a 'good chemical status' in surface waters and, in principle, a no-pollution-at-all standard for groundwater, although in practice the principle is defined as minimum anthropogenic impact in both surface waters and groundwater (European Commission 2011). In the Danish river basin management plans – produced to comply with the WFD – pollution from pesticides is listed as a source of pressure on groundwater and drinking water (Danish Nature Agency 2011). In order to achieve the objectives of the WFD, then, an effective tax design is imperative. The redesigned tax now reflects the environmental harm of the chemical compounds (measured by their environmental behaviour and their negative effects on human health and the environment (Danish Parliament 2012)) rather than the sales price of the product. Furthermore, average tax levels have been raised. The aim of the tax redesign was to increase farmers' economic incentive for using pesticides with low risk for human health and the environment. The effects of the reformed tax could not yet be assessed by the end of 2014, partly because statistics for 2013 were not yet available, partly because the tax was introduced in July of 2013 and therefore did not directly affect pesticide use for the 2013 season. Moreover, farmers appear to have hoarded chemicals in 2012, the year prior to the introduction of the tax, see Fig. 6.1 below. In fact, in 2012 pesticide purchases were significantly higher than pesticide use, a statistic which is also being collected as of 2012 (Danish Environmental Protection Agency 2013b). This implies that the effect of the tax may not be accurately assessed for the first couple of years following implementation.

6.3 The Pesticide Tax in Action

The introduction of the relatively high Danish pesticide tax in 1996 reflects in part a growing focus during the late 1980s and early 1990s on reducing pollution from agriculture, coupled with a strong norm related to untreated drinking water and a general move to replace high income taxes with green taxes. At the same time agricultural organizations were as per tradition invited to participate in negotiations about the design of the tax, and the choice of an ad valorem tax with reimbursement to the agricultural sector was in line with agricultural interests given that they were under pressure to accept a tax of some form. Even so economic models predicted that the tax would achieve the necessary reduction in pesticide use. However, farmers did not respond to the price signal to the degree expected.

6.3.1 The EPI Contribution

6.3.1.1 Environmental Outcomes

This section (and Sect. 6.3.2) focuses primarily on the response of the economic agents, i.e. farmers' use of pesticides – partly because a behavioural response, or lack thereof, by definition translates into changes, or lack thereof, in pressures and impacts on the water-related ecosystem and partly because studies on the environmental effects of the pesticide tax are lacking.

Measuring the exact effect of the pesticide tax on pesticide use is complicated by the fact that the Danish pesticide policy employs a mix of policy instruments – a common challenge for EPI's assessed in this book. The first Danish Pesticide Action Plan (1986) relied mainly on regulatory and information measures, but these were later supplemented with economic instruments such as the pesticide tax and voluntary agri-environmental schemes (Pedersen et al. 2011). As mentioned above, it was expected that the new tax rates in combination with a projected decrease in the price of grain would reduce pesticide use to a level of a TFI just below 2.0 in 1999 (see above). The development of the Danish TFI is illustrated in Fig. 6.1.

The figure for 1985 is an average of the years 1981–1985. For the years 1997–2012 the figures are a product of Danish EPA's so-called 'new method' for calculating TFI. The switch of calculation methods in the late 1990s meant that the TFI figure calculated was a bit higher (in the interval 0.07–0.27 for the years 1997–2012) compared to when the old method was used.

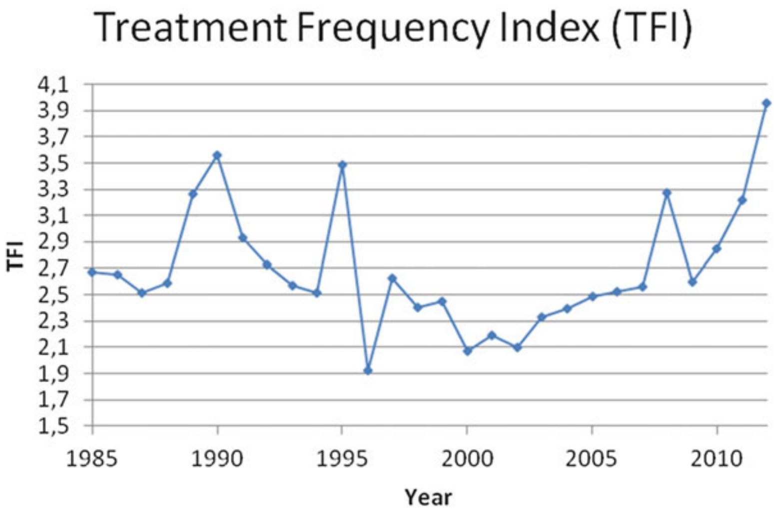

Fig. 6.1 Danish treatment frequency index (1985–2012) (Sources: Index made by Christina Bøje (Danish EPA) based on yearly EPA reports. The years 2007–2012 are corrected with the newest figures from Danish Environmental Protection Agency 2013; the 1981–1985 average is from Danish EPA (1998))

In the period before the introduction of the tax (1981–1995) the TFI hovered at around 2.5 (except for 1989, 1990 and 1995). In 1996, when the pesticide tax was first implemented, the TFI dropped to the lowest level (1.9) for the entire period 1981–2012. Much of the explanation for this decrease appears to be that farmers had hoarded pesticides in 1995 (TFI 3.5) in anticipation of the tax (Statistics Denmark 1997). In 1997–1999, pesticide use was back at a level around a TFI of 2.5 despite the doubling of tax rates in 1998. Consequently, the expectation of a TFI just below 2.0 was not met in 1999, despite the twin incentives of decreasing grain prices and increasing pesticide prices that year. By 2000 pesticide use did drop to a TFI level of 2.0, but since then the TFI gradually rebounded to a level around 2.5. In four of the last 5 years for which statistics are available (2008–2012) measured TFI has been well above 2.5. In 2012, a new ‘record’ was reached with a 3.96 TFI, possibly, again, due to a hoarding effect in anticipation of the redesigned pesticide tax to be implemented in 2013.

The assessment of the pesticide tax must also take into account changes in the external context that may have counteracted the pesticide tax. While the price on pesticides for most years has remained at the 1996 level, it did decrease during some years, e.g. 2005–2008. When the price decreases, so does the nominal value of the tax. The grain price has been fluctuating considerably (e.g. it was very high in 2007, but lower every year between 1997 and 2006 compared to 1995–1996) (Ørum et al. 2008:103; Pedersen et al. 2012a). Higher grain prices may have stimulated preventive spraying in some crops some years. The composition of crops also affects pesticide use and therefore the TFI – different crops need different treatment. However, the development in the composition of crops on Danish farms in the years 1996–2001 led to a *decrease* in the actual need for pesticides estimated to be 0.08 in the

TFI (Ørum 2003). For the period 2003–2007, the development in the composition of crops has not substantially changed the need for pesticides (Ørum et al. 2008: 105). The occurrence of new pests in Denmark, in particular more insects, stimulated by unusually mild Danish winters in some years might have influenced the use of pesticides, although while a popular argument among farmers this has not yet been systematically documented. Finally, an increase in the amount of winter crops combined with a poor crop rotation at approximately 50 % of the farms with winter crops has increased the need for herbicides (Ørum et al. 2008). Such changes would alter the economically optimal level of the TFI from the original estimate of 1.7 (Ørum et al. 2008), although the impacts, as outlined, exert pressure on the TFI in either directions, increasing or decreasing the TFI in any given year. Thus for 2007, Ørum et al. (2008) calculated the economically optimal TFI level to be 2.08 – and this figure may be too low, as the estimate was calculated before the exceptionally high price level for grain that year were known.

With the pesticide use currently well above 3 (the 3 year-average for 2010–2012 was 3.34, according to Danish Environmental Protection Agency 2013a), clearly the Danish mix of policy instruments has failed to deliver on the objective of reducing pesticide use to a level of 1.7 TFI. In a 2010 assessment, the Danish Economic Councils (2010: 158f) concluded that the 1998 tax has failed to give the farmers incentives to reach the 1.7 target – this despite the fact that Danish pesticide tax levels are the highest in the world according to the Danish Competition Authority (2006: 253). The explanation for the poor effect of the tax, according to the Danish Economic Councils, is an inelastic demand for pesticides – apparently, the expectations of the Ministry of Taxation regarding the elasticity (see above) were too optimistic. This conclusion is further supported by a study of pesticide decisions among Danish farmers, showing that for about half of the farmers price incentives were not a dominant factor in decisions on pesticide (Pedersen et al. 2011). The implication is that tax levels must be quite high for the tax to have the desired effect for a significant share of farmers.

No ex-post evaluations have assessed specifically whether the pesticide tax has delivered the expected reductions in the use of pesticides, namely a 5–10 % reduction (for the 1996 tax) and an additional 8–10 % reduction by 1999, following the rate increases in the 1998 tax (see above). The trajectory of the TFI alone indicates that the tax has only a small effect on the use of pesticides (this lack of effect will be discussed further in Sect. 6.3.2). Consequently, the environmental effects will likely be quite small, too. It is conceivable that the developments in grain prices (increases some years) as well as pesticide prices (decreases some years) have counteracted the taxes, obscuring an actual tax effect. But while this conclusion might hold for 2007 and 2008, which saw abnormal price developments, the pattern for the first half of the decade does not appear to support such a conclusion (Pedersen et al. 2012a: 10). Moreover, sharp ups and downs in grain prices in the last half of that decade do not match the continuous upward trajectory of pesticide use.

6.3.1.2 Economic Outcomes

A government analysis of pesticide policy instruments concluded that, *in general*, ad valorem taxes are cost effective policy instruments for reduction of pesticide use – although, this statement was not based on an empirical assessment of the cost effectiveness of the pesticide tax (Ministry of Environment et al. 2007: 17).

Needless to say, farmers being the target of the tax are therefore to some extent burdened by the tax. However, the revenue is fully reimbursed to the sector. Until 2003, the revenue was reimbursed minus the revenue from the old wholesale tax (see Sect. 6.2.2) primarily through a lowering of the land tax by 0.43 %. The remaining part of the revenue was channelled into the yearly Finance Act, where the Ministry of Food, after negotiations with the agricultural organisations, reimbursed the revenue to purposes within the agricultural sector. In 2003, the reimbursement system was changed, and it was decided to reimburse a fixed percentage (83 %) of the revenue to a lowering of the land tax. The remaining 17 % are distributed to different activities in the agricultural sector through the Ministry of Food and the Ministry of Environment. Between 2001 and 2008, total revenue has varied between DKK 359 and 423 mill (Dansk Landbrug 2007). While the sector as a whole is reimbursed, each individual farmer is still faced with an incentive to reduce his use of pesticides in order to reduce marginal costs, assuming he applies optimising principles to pesticide decisions.

6.3.1.3 Distributional Effects and Social Equity

The agricultural sector is the main sector affected by the Danish pesticide tax. Farmers who have reduced their use of pesticides due to the tax might hypothetically have experienced positive health effects. Use of pesticides in Denmark was assessed by a 1998 committee not to constitute a large threat to farmer health, and epidemiological analyses have detected no long-term health effects among farmers from occupational exposure to pesticide levels resembling current Danish use of pesticides (Bichel Committee 1998). However, 25 % of the Danish farmers hold the perception that their health risk of spraying pesticides is large or very large (Pedersen et al. 2011).

The pesticide tax has had some *distributional effects* within the agricultural sector. These effects were analysed before the implementation of the pesticide tax in 1996. Given market characteristics, pesticide prices are decided based on the product's use value for the farmers. While a pesticide tax does not increase the use value of the pesticide for the farmer, producers and suppliers will probably have to carry part of the tax burden (Minister of Taxation 1995).

In a 2006 analysis, the pesticide tax was deemed among the ten most costly regulations within the jurisdiction of the Ministry of Taxation, measured upon the burden induced on the businesses. This was due to a complex administrative system The average burden of this system is estimated to be DKK 21,000 per year per manufacturer/producer. The system is criticized for being too costly and inflexible.

Furthermore, it reduces competition, because the maximum price of the product has to appear on the label (Danish Competition Authority 2006: 254). When the tax was redesigned in 2013, the labelling system was no longer necessary and therefore cancelled.

Furthermore, ex-ante analyses showed geographic disparities in the tax due to the tax level, the reimbursement system as well as differences in crops. E.g. land prices differ in different regions of Denmark. Consequently, farmers living in areas with high land prices would get a higher amount of money through the reimbursement scheme than farmers living in areas with relatively low land prices.

The new 2013 pesticide taxes will affect different types of farmers differently, as the farmers use pesticides with different risk profiles. E.g. strawberry producers might experience decreasing pesticide prices, while potato producers might experience increasing prices (Danish Environmental Protection Agency, undated). In the mid-2000s an average farm of about 165 ha spent DKK 100,000–150,000 per year on pesticides (Danish Competition Authority 2006).

6.3.2 The EPI Setting Up

6.3.2.1 Institutional Set-up

The introduction of the pesticide tax in 1996 took place against a general move towards a green tax reform (Ministry of Taxation 2001). Even so, the introduction of the pesticide tax met with opposition. While the Social Democrat-led government proposed the tax with reference to the polluter pays principle (Ritzaus Bureau 30.11.1995), agriculture argued that it would weaken the competitive position of Danish agriculture, while the right-wing opposition parties argued that they were against allowing polluters to pay for their actions rather than to ban dangerous pesticides (Ritzaus Bureau 1.12.1994). In the end, the government also leaned on the EU which strongly espoused the polluter pays principle (Ritzaus Bureau 30.11.95).

An important aspect of the institutional setting is a strong network involving farmers organizations and the Ministry of Agriculture (Daugbjerg and Pedersen 2004), which affected the design of the pesticide tax both in 1995 and 1998. The government established a commission of high-level civil servants to produce a proposal for a pesticide tax, but with the mandate that the tax had to be put together so as not to diminish the international competitiveness of agriculture and so that revenues were reimbursed to agriculture (ibid: 234).

The pesticide tax did not change existing institutions directly related to pesticide policy, but it did change the land taxes as these were lowered in order to allow for a pesticide tax. Moreover, the pesticide tax led to the establishment of a new institution, a fund to administer the earmarked tax revenues, led by a board in which agricultural interests have the majority, while consumer and labour interest organizations are also included (Promilleafgiftsfonden 2011).

6.3.2.2 Transaction Costs and Design

When the tax was originally conceived in the 1990's, a tax based on toxicity was discussed in the government, particularly among the Ministry of Taxation, the Ministry of Environment and the Ministry of Agriculture (Interview, Ministry of Taxation 2011). The Ministry of Taxation preferred a tax based on the toxicity of pesticides, but according to the Environmental Protection Agency (EPA) it was impossible to establish such a tax because it was impossible to rank the different types of negative effects of pesticides (on groundwater, fish in watercourses, biodiversity in windbreaks etc. etc.) (Interview, Ministry of Taxation 2011). The Ministry of Agriculture preferred an ad-valorem-tax to a per-unit-tax because such a tax would confer a smaller share of the tax burden on farmers and a larger share on producers/importers, while the full revenue was reimbursed to the agricultural sector – thereby ensuring a net benefit for the sector. Furthermore, agriculture would also get a reimbursement of the tax revenue paid by private home owners (Interview, Ministry of Taxation 2011). This model was finally chosen. The tax design was not optimal from an environmental viewpoint. On the other hand, the average tax level has, to our knowledge (see also Danish Competition Authority 2006), for many years constituted the world's highest pesticide tax, representing a most likely case for a behavioural effect. Moreover, the formulation of the tax may serve to illustrate a rather classic path from economic text book into the real world of interests and politics as well as practical constraints on how to measure toxicity.

When the tax was introduced some transaction costs were assessed. Using sales as the tax base was expected to minimize inspection costs and administrative costs, due to the relatively few import and production companies compared with the number of retailers (Minister of Taxation 1995). It was estimated that non-recurrent expenses to the labelling system, information and computers would be DKK 2.1 mill. (1995). Monitoring costs were unknown. Operational costs were estimated at DKK 1 mill. for pressing and sending out of the price labels, but could be underestimated – in 2006, one of the two largest chemical companies estimated their labelling costs to be between DKK 1.5 and 2.0 mill. per year (Landbrugsavisen 2006).

This system was considered one of the ten most burdensome regulations for the companies within the jurisdiction of the Ministry of Taxation (see Sect. 6.3.3). The labelling system also imposed inflexibility on prices as labels were printed months in advance of sales. One company informed that it had to put labels on 300,000 products every season (Danish Competition Authority 2006). For instance, when world market prices decreased, the companies had to put new labels on the products (Interview, chemicals and feed company, August 2011).

Additionally, there were operational costs for the fund administering the earmarked funds.

6.3.2.3 Implementability

The Danish pesticide tax was a national tax and therefore not a flexible instrument in the sense that the tax could be adapted to local particularities. However, the tax was flexible in the sense that farmers could determine whether to pay the tax or to reduce their pesticide use. As for the policy process agricultural interests enjoyed a privileged position in the policy community while environmental and other groups at the time worked more at the periphery of the policy areas, when the tax was introduced (Daugbjerg and Pedersen 2004; Interview, Ministry of Taxation 2011; Interview, Danish Water and Wastewater Association 2011). Needless to say, agricultural organisations and farmers were against the introduction of the tax and were fighting it in the media, as well as other arenas. However, the policy design, particularly the reimbursement of the tax revenue through land taxes and the establishment of a new institution administering the revenue, reflected the wishes of agriculture and eased the implementation (Interview, Ministry of Taxation 2011).

An important barrier for the implementability of the pesticide tax seems to be that contrary to what is normally assumed in economic modelling not all farmers are profit maximizers. A 2011 Danish study based on a survey with 1.164 farmer respondents systematically analysed the most important economic and non-economic barriers in the decision patterns of Danish farmers regarding plant protection (Pedersen et al. 2011, 2012b; Christensen et al. 2011). One of the main findings of the study, which applied cluster analysis, was that approximately one third of the Danish farmers attach greater weight to obtaining physical yield than to prices on pesticides and crops, when they make decisions. These farmers primarily optimise physical yield (crops). On the other hand, around half of the farmers focus more on prices. They optimise economic yield. In other words, only about half of the farmers respond to price incentives in the manner assumed in ex-ante analyses of pesticide taxes. The diminished focus on prices is motivated by the professional satisfaction gained from producing the highest yield possible, while for farmers who are neither profit nor crop optimizers the explanation may be that relatively small price changes may not command adequate attention in a complex decision situation (Nielsen 2009). The analysis indicates that farmers who are more focused on optimising physical yield (and less on prices) are less responsive to increases in pesticide taxes and other types of economic instruments than the farmers in the price-oriented cluster. These differences do not appear to reflect underlying structural characteristics, as the farmers in the two groupings are alike with regard to structural variables such as farm size and distribution across plant, cattle and pig production (Pedersen et al. 2011, 2012; Christensen et al. 2011; Nielsen 2009).

Additionally, Ørum (2003) and Ørum et al. (2008) demonstrate that while a TFI of 1.7 is economically optimal for farmers, according to calculations, within a TFI interval between 1.7 and 2.0, farmers' economic outcome would not vary much. The implication – emphasised by the authors – is that behavioural changes would not happen automatically, but requires 'strong(er) incentives', for instance through a pesticide quota system or higher pesticide taxes (ibid). Furthermore, structural developments in Danish agriculture exhibit consistently increasing farm size. The share of farms larger than 75 ha increased from 8 % in 1989 to 25 % in 2009 (Statistics Denmark 2011: 243). A 2003 estimation indicated that larger farms (150–200 ha) tend to use 15 % more pesticides than smaller farms (50–80 ha) corrected for crop composition and location (Ørum 2003).

Current levels of illegal imports are impossible to estimate but every now and then illegal pesticide transports are uncovered by the authorities (Ministry of Environment 2011a). In December 2011, the Danish Ministry of Environment revealed the most severe example of illegal import of pesticides to date. An importer of pesticides was reported to the police for illegal import and resale of 45 tonnes of pesticides from Germany in the period 2006–2009. A second company and 44 farmers and horticulturists were reported to the police in the same case (Ministry of Environment 2011b).

All sector policies affecting the prices of crops and pesticides can reinforce/reduce the expected effects of the pesticide tax. A prime example is the EU Common Agricultural Policy (CAP), which previously revolved around product support rather than producer support, providing incentives for larger production and potentially reducing the effect of the pesticide tax. An example of the CAP affecting pesticide use is the dramatic decrease in fallow fields in recent years following the European Union 2008 abolishment of the requirement for arable farmers to leave 10 % of their land fallow to allow the farmers to maximise their production potential (European Commission, undated). Another example is the trend towards moving of measures from the CAP's single payment scheme to the rural development scheme.

6.4 Conclusion

The Danish pesticide tax was implemented in 1996 and the tax rate doubled in 1998. No ex-post evaluations have assessed specifically whether the 1996 pesticide tax has delivered the predicted 5–10 % reduction in pesticide use or whether the doubling of the tax rate in 1998 has delivered an additional 8–10 % reduction, as also predicted. The trajectory of the treatment frequency index (TFI) alone indicates that the tax has only a very small effect, at best. It is conceivable that the developments in grain prices (increases some years) as well as pesticide prices (decreases) have counteracted the taxes, obscuring an actual effect of the taxes. But while this may hold for 2007 and 2008 with abnormal price developments, the pattern for the first half of the decade does not appear to support such a conclusion. Nor has the development in the composition of crops substantially changed the need for pesticides. However, poor crop rotation at some farms and the appearance of new pests have increased the use of pesticides some (Ørum et al. 2008).

One reason for the small effects might be that about one third of Danish farmers can be considered to be less responsive to economic policy instruments than the main share of farmers, as the former focus more on optimizing yield than on prices on pesticides and crops (see Pedersen et al. 2011, 2012b). Professional pride in producing a large crop appears to drive the behaviour of these farmers rather than tweaking their profits. Therefore, a pesticide tax does not give these farmers as strong an incentive to change behaviour as it does the farmers who are more focused on optimizing economic yield. This is not to say that the crop yield optimizers would not respond to a stronger economic incentive, they are also businessmen, but it does corroborate and explain the rather low price elasticity on pesticide taxes and suggests that for these farmers taxes would have to be increased to well above economic optimization levels to have a significant impact on behaviour.

Overall, the Danish pesticide policy instrument mix can be considered a failure, as the policy mix has fallen considerably short of delivering on the policy objective of a TFI of 1.7, which was predicted based on ex-ante modelling. In fact, pesticide use has risen considerably over the years.

As for cost effectiveness of the pesticide tax no precise assessment has been undertaken. However, a government analysis of policy instruments to fulfil the aims of the Danish pesticide policy concludes that, in general, ad valorem taxes (such as the Danish pesticide tax) are cost-effective policy instruments for reduction of the use of pesticides (Ministry of Environment et al. 2007: 17). However, this rests on an assumption that the taxes are effective, which has not been demonstrated. Transaction costs of the pesticide tax were assessed ex ante to be quite small.

The tax has led to some distributional effects within the sector. For instance, farmers who grow crops with a higher pesticide need and farmers living in regions with lower land values will, on average, experience a poorer net result than other farmers.

Many farmers hold the opinion that the pesticide tax is unfair and represents just another burden reducing their income. Furthermore, importers and producers of pesticides found the price label system connected to the tax to be costly, a perception which was supported by a 2006 analysis concluding that the price label system was among the ten most costly regulations within the jurisdiction of the Ministry of Taxation. When the tax was redesigned in 2013, the labelling system was cancelled as the tax was no longer an ad valorem tax.

The agricultural sector is the main sector affected by the pesticide tax. However, the full revenue is reimbursed to the sector – primarily through lower land taxes – what eases the economic burden. This reimbursement model was the result of intense exchange/negotiations between agricultural organisations and three ministries, when the tax was designed.

The design may not have been optimal when the tax was designed in the 1990s given that the tax rate was based on price instead of on toxicity (OECD 1999). However, it's introduction in 1996 represents an important first step, and the design was improved in 1998, when the tax rates were doubled. Furthermore, the ad valorem tax (1996–2013) might have made it politically feasible to implement a redesigned pesticide tax in 2013 based on the toxicity of the pesticides (and with quite high tax rates from a comparative perspective). The new tax will most likely have an effect on pesticide use, but it remains a challenge that some Danish farmers do not react to price incentives in to the degree or in that manner economic modelling predicts.

References

Aarhus University. (2011). *Grundvandets kvalitet.* Available from http://naturogmiljoe.dmu.dk/vand/33/. Accessed 12 Sept 2011.

Andersen, M. S., Dengsøe, N., & Pedersen, A. B. (2001). *An evaluation of the impact of green taxes in the Nordic countries*. Copenhagen: Nordic Council of Ministers.

Bichel Committee, (1998). *Rapport fra hovedudvalget*. Copenhagen: Ministry of Environment.

Christensen, T., Pedersen, A. B., Nielsen, H., Mørkbak, M. R., Hasler, B., & Denver, S. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide free buffer zones – A choice experiment study. *Ecological Economics, 70*, 1558–1564.

Danish Competition Authority. (2006). *Konkurrenceredegørelse 2006*. Copenhagen.

Danish Economic Councils. (2010). *Økonomi og Miljø 2010*. Copenhagen.

Danish Environmental Protection Agency. (1998). *Bekæmpelsesmiddelstatistik 1997*. Copenhagen.

Danish Environmental Protection Agency. (2013a). *Bekæmpelsesmiddelstatistik 2012*. Copenhagen.

Danish Environmental Protection Agency. (2013b). *Bekæmpelsesmiddelstatistik 2012: Forbrug lavere end indkøb*. Available at http://mst.dk/service/nyheder/nyhedsarkiv/2013/nov/bekaempelsesmiddelstatistik-2012-forbrug-lavere-end-indkoeb/. Accessed 5 Nov 2013.

Danish Environmental Protection Agency. (undated). *Hvad betyder pesticidafgiften for landmandens omkostninger?* Copenhagen.

Danish Nature Agency. (2011). *River basin management plans*. Available at http://www.naturstyrelsen.dk/Vandet/Vandplaner/Se_vandplanerne. Accessed 15 Aug 2011.

Danish Parliament. (2012). *Forslag til Lov om ændring af lov om afgift af bekæmpelsesmidler*. Approved 12 Jun 2012.

Dansk Landbrug. (2007). *Dansk landbrug i tal 2007*. Copenhagen.

Daugbjerg, C., & Pedersen, A. B. (2004). New policy ideas and old policy networks: Implementing green taxes in Scandinavia. *Journal of Public Policy, 24*(2), 219–249.

European Commission. (2011). *Introduction to the new EU Water Framework Directive*. Available at http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm. Accessed 12 Sept 2011.

European Commission. (undated). *Health check of the Common Agricultural Policy*. Available at http://ec.europa.eu/agriculture/healthcheck/index_en.htm

GEUS. (2010). *Grundvand – Status og udvikling 1989–2009*. Copenhagen: GEUS.

Interview Chemicals and Feed Company. (2011). Employee (anonymous), interviewed August 2011 (unpublished).

Interview Danish Water and Wastewater Association. (2011). Employee (anonymous), interviewed November 2011 (unpublished).

Interview Ministry of Taxation. (2011). Interview with an expert in the 1995–1996 negotiations (anonymous), interviewed November 2011 (unpublished).

L 44 1997/98. L 44 (som fremsat): Forslag til lov om ændring af lov om afgift af bekæmpelsesmidler og lov om ændring af forskellige punktafgiftslove (Afgiftsforhøjelse m.v.).

Landbrugsavisen. (2006). *Klart ja til at undvære prismærker på pesticider*. 24 Mar 2006.

Minister of Taxation. (1995). *Forslag til lov om bekæmpelsesmidler.* Lovforslag nr. L 186. Fremsat den 7. marts 1995 af skatteministeren (Carsten Koch).

Minister of Taxation. (1998). *Forslag til Lov om ændring af lov om afgift af bekæmpelsesmidler og lov om ændring af forskellige punktafgiftslove (Afgiftsforhøjelse m.v.)* (LSF 44, approved 23 Jun 1998).

Ministry of Environment. (2011a). *Landmand politianmeldt for import af ulovlige sprøjtemidler*. Available at www.mst.dk. Accessed September 2011.

Ministry of Environment. (2011b). *Danmarkshistoriens største svindelsag med sprøjtemidler afdækket*. Available at www.mst.dk. Accessed 12 Dec 2011.

Ministry of Environment, Ministry of Finance and Ministry of Food. (2007). *Rapport fra et tværministerielt udvalg. Analyse af virkemidler til opfyldelse af Pesticidplan 2004–2009 mål om en behandlingshyppighed på 1.7*. Copenhagen.

Ministry of Taxation. (1998). *Bekendtgørelse af lov om afgift af bekæmpelsesmidler (LBK nr. 798 af 09.11.1998)*. Copenhagen: Ministry of Taxation.

Ministry of Taxation. (2001). *Indkomstopgørelser i ikke-erhvervsmæssig virksomhed – Hvorfor skatteministeret afviste udlevering af visse dokumenter i 10-mandsprojektsagerne – Omlægning af personskatterne 1987–2002*. Copenhagen: Ministry of Taxation.

Ministry of Taxation. (2004). *Rapport om Muligheden for at omlægge pesticidafgiften til en afgift på behandlingshyppighed*. Copenhagen: Ministry of Taxation.

Nielsen, H. (2009). *Bounded rationality in decision-making: How cognitive shortcuts and professional values may interfere with market-based regulation*. Manchester: Manchester University Press.

OECD. (1999). *Denmark – Conclusions and recommendations (OECD environmental performance reviews)*. Paris: OECD.

OECD & EEA. (2014). *Database on instruments used for environmental policy*. Available at http://www2.oecd.org/ecoinst/queries/. Accessed 3 Sept 2014.

Ørum, J. E. (2003). Opdatering af Bicheludvalgets driftsøkonomiske analyser (Working report no. 20). Copenhagen: Environmental Protection Agency.

Ørum, J. E., Boesen, M. V., Jørgensen, L. N., & Kudsk, P. (2008). *Opdateret analyse af de driftsøkonomiske muligheder for en reduceret pesticidanvendelse i dansk landbrug – en beskrivelse af udviklingen fra 2003–2008*. Copenhagen: University of Copenhagen.

Pedersen, A. B., Christensen, T., Nielsen, H., & Hasler, B. (2011). *Barrierer i landmændenes beslutningsmønstre vedrørende ændret pesticidanvendelse (Bekæmpelsesmiddelforskning fra Miljøstyrelsen nr. 134 2011)*. Copenhagen: Danish Environmental Protection Agency.

Pedersen, A. B., Nielsen, H. Ø., Andersen, M. S. (2012a). WP3 EX-POST case studies: The Danish Pesticide Tax (Deliverable D3.1: EPI-WATER – Evaluating Economic Policy Instruments for Sustainable Water Management in Europe, EUFP7-project).

Pedersen, A. B., Nielsen, H., Christensen, T., & Hasler, B. (2012b). Optimising the effect of policy instruments: A study of farmers' decision rationales and how they match the incentives in Danish pesticide policy. *Journal of Environmental Planning and Management, 55*(8), 1094–1110.

Promilleafgiftsfonden. (2011). Vedtægter for promilleafgiftsfonden. http://www.promilleafgiftsfonden.dk/~/media/promilleafgiftsfonden/Vedtaegter.ashx. Accessed 14 Oct 2011.

Ritzaus Bureau. 30.11.95. *EU siger ja til dansk pesticidafgift*.

Ritzaus Bureau. 1.12.94. *Farlige pesticider skal forbydes, ikke beskattes*.

Statistics Denmark. (1997). *Miljø*. Copenhagen: Statistics Denmark.

Statistics Denmark. (2011). *Statistical yearbook 2011*. Copenhagen: Statistics Denmark.

Statistics Denmark. (2014). *Statistical yearbook 2014*. Copenhagen: Statistics Denmark.