ENGLISH SUMMARY

The present report from the Chairmen of the Danish Economic Council of Environmental Economics consists of three chapters:

- Regulation of the agricultural emissions of nitrogen to coastal waters
- Green taxes and effective environmental regulation
- Genuine Savings

Reducing the agricultural emissions of nitrogen into coastal water bodies would have a positive effect on the marine environment. Reductions are also necessary in order to achieve the target of the Water Framework Directive of "good ecological status" in all coastal water bodies in Denmark. *The first chapter* describes a model for regulating agricultural emissions of nitrogen without imposing unnecessarily high costs on society in doing so.

The second chapter describes the principles of how green (environmental) taxes should be designed. Calculations show that great efficiency gains might be achieved by changing the design of the existing green taxes.

The Genuine Savings rate is a widely used indicator of sustainable development. It measures the total change in a nation's capital stock, which consists of all assets from which people derive well-being. A non-negative Genuine Savings rate is required for sustainable economic development. In *the third chapter*, the Genuine Savings rate for Denmark is calculated for the period 1980-2015.

Chapter I: Regulation of the Agricultural Emissions of Nitrogen to Coastal Waters

In agricultural production crops are supplied with nitrogen-rich fertilizer in order to increase output and, thereby, also

profits. However, this supply of nitrogen can lead to negative environmental impacts because some of the supplied nitrogen is not used by the crops. Instead, it leaches from the fields and some of it is eventually emitted to the coastal waters bodies. Emissions of nitrogen to coastal waters can affect the ecological status of these water bodies as it can lead to unclear water, oxygen depletion and deteriorated living conditions for flora and fauna in the marine environment.

Through the Water Framework Directive, Denmark is committed to achieving "good ecological status" in all lakes, rivers and coastal waters. To achieve this goal in the coastal waters it is necessary to reduce the agricultural emissions of nitrogen. Denmark has operationalised the goal through emission reduction targets for the years 2021 and 2027 in each of 90 different water catchment areas in the country.

In December 2015 a political agreement eased the existing nitrogen regulation and, at the same time, outlined a new type of nitrogen regulation. This future regulation, so-called "leaching rights", will be fully implemented in 2021 but the exact design of this regulation has yet to be decided upon.

In chapter I, the economic costs of achieving the 2021 reduction targets using three different types of regulations are analysed. The analyses are performed in collaboration with researchers from the University of Copenhagen and Aarhus University.

Since the exact design of the leaching rights is not yet known, the following two possible designs are analysed. *Allowance-based leaching rights* regulate the amount of applied fertilizer so that all farmers in a catchment area must reduce the supplied amount of fertilizer by a share of the profit-maximising amount. *Tradable leaching rights* instead impose limits on the amount of leached nitrogen per hectare in each water catchment area. The rights are assumed to be tradable with other farmers in the water catchment area.

In addition to the two leaching rights designs, the economic impacts of regulation based on *targeted crop taxes* are also analysed. This type of regulation is based on the set of principles for cost-effective regulation of nitrogen emissions that were laid out in a previous report from the chairmanship of the Economic Councils in 2015.

The analyses show that regulation using targeted crop taxes results in lower economic costs than either of the two types of leaching rights, see table A. Another advantage of targeted crop taxes is that, from the farmers' point of view, it is a simpler type of regulation. It is therefore recommended that targeted crop taxes be used to regulate agricultural nitrogen emissions in Denmark.

Table A Costs of nitrogen regulation

	Billion DKK
Allowance-based leaching rights	1.03
Tradable leaching rights	0.64
Targeted crop taxes	0.58

Note: Yearly economic costs of different types of regulation are based on the agricultural nitrogen emission targets for 2021.
Source: Own calculations.

The crop tax paid by the individual farmer depends on the size of the cultivated area and the farmer's choice of crops. The underlying principle of targeted crop taxes is that they vary with the environmental impact of growing a specific crop. In addition, there is a tax per livestock unit, which corresponds to the additional nitrogen emissions caused by using livestock manure instead of artificial nitrogen fertilizers.

The targeted crop taxes also differ between farmers due to geographical differences in soil types and how much of the leached nitrogen never reaches coastal waters (so-called retention). Crop taxes will be higher for farmers located in water catchment areas where emission reduction targets are higher. On the other hand, no tax will be imposed in areas without a reduction target. The targeted crop tax generates

revenue, and it is a political choice whether the revenue should be returned to the farmers or be used for something else.

Using the targeted crop taxes instead of one of the other analysed types of regulation will lead to an economic benefit because they target geographical differences in environmental impacts of nitrogen emissions more precisely. Further, targeted crop taxes provide farmers with long-run incentives to place the agricultural production with the highest leaching of nitrogen in locations where nitrogen leaching has the least environmental impact. Leaching rights are less geographically targeted towards the environmental impacts of nitrogen leaching, as they do not take account of differences in retention rates within water catchment areas. The analyses also show that the specific design of leaching rights can substantially impact the costs of regulation. If tradable leaching rights are used, the yearly economic costs are around DKK 400 million lower than if allowance-based leaching rights are used.

If regulation must be based on leaching rights, it is recommended that tradable leaching rights be implemented. However, the economic costs of tradable leaching rights may be underestimated. Trade in these leaching rights would be permitted within each of the 90 water catchment areas and the analysis presupposes that the trading markets function perfectly. However, in some cases the trading markets would be very small. If this leads to less than perfectly functioning markets, it would increase the economic costs of regulation based on tradable leaching rights. Targeted crop cultivation taxes do not depend on trading markets, and would, therefore, reduce costs with higher certainty.

Allowance-based leaching rights achieve the reduction target in a more costly manner than tradable leaching rights because allowance based leaching rights do not give farmers appropriate incentives to choose crops and livestock production that reduces nitrogen emissions.

An additional complication of using allowance-based leaching rights is that many farmers would have incentives to

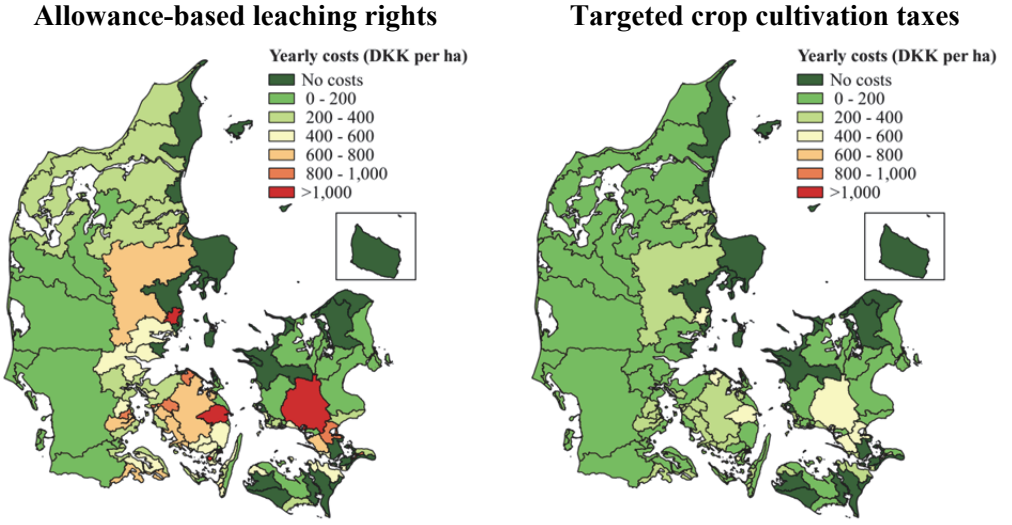
trade nitrogen illegally with each other. Whether such illegal trade would take place is not analysed. However, the analysis shows that if illegal trading took place, the allowance-based leaching rights would be less effective and the costs of reaching the reduction targets would be raised significantly. Tradable leaching rights and targeted crop cultivation taxes do not suffer from this adverse incentive structure. The risk of illegal trade could, therefore, cause the difference in economic costs between allowance-based leaching rights and tradable leaching rights to be significantly larger than DKK 400 million.

The analysed types of regulation also differ in how the economic costs are distributed between farmers. The analysis shows that targeted crop taxes would be the least costly for most farmers if the tax revenues were returned to the farmers, see figure A.

Whether the tax revenue generated by targeted crop taxes is returned to the farmers is a political choice. If the revenue were returned, it is important that the transfer mechanism be decoupled from the production decisions of the farmer to ensure that the transfer does not distort production decisions. A lack of decoupling could increase the economic costs of reaching the reduction targets.

Implementation of targeted crop taxes would not increase the administrative burden for the farmer, compared to the existing regulation. Furthermore, other locally differentiated nitrogen reduction targets, for instance targets to protect the quality of the groundwater, could be included in the targeted crop taxes without increasing the administrative burden for the farmer. This is a further advantage of this regulation compared to either type of leaching rights.

Figure A Geographical distribution of private costs



Note: The average private economic costs per hectare for farmers in each of the 90 water catchment areas under two types of regulation. The tax revenue from the targeted crop taxes are returned to the farmers using a decoupled transfer mechanism.

Source: Own calculations.

The economic benefit of using targeted crop cultivation taxes compared to leaching rights depends on the scope of emission reduction that must be achieved. The emission targets for the period 2021-27 are substantially more ambitious than those of the period 2015-21, on which the cost estimates of the current chapter are based. Therefore, the economic benefits of using targeted crop taxes would be even higher when the targets for the period 2021-27 are considered.

Chapter II: Green taxes and effective environmental regulation

There are negative environmental effects associated with many production processes and parts of our consumption. Green (environmental) taxes are common in Denmark as a way of reducing these environmental effects. Furthermore,

relative to GDP, the revenue from these taxes is high in Denmark compared to our neighbouring countries and the average in the OECD countries.

Green taxes are generally a cost-effective instrument for regulating environmental effects if the level of the tax is set to reflect the cost of the environmental impact, and the tax applies to all emitters. However, this is not the case for all green taxes in Denmark.

Some green taxes have only doubtful or indirect effects on the environment, while others are set higher than the environmental costs dictate. The latter is the case with the Danish tax on electricity and the taxation of water in the parts of Denmark where groundwater resources are ample.

There are also a number of examples of green taxes from which companies are fully or partly exempted. If the tax is environmentally justified, the tax exemption increases the environmental costs or increases the economic cost of achieving a given environmental objective.

The chapter on green taxes and effective environmental regulation presents a series of calculations that illustrate the socio-economic benefits of reducing green taxes that are set too high and removing company exemptions from paying these. The calculations are done in relation to the green taxes on electricity and water. The calculations are performed with the CGE model REFORM developed by DREAM.

The green tax on ordinary electricity consumption is much higher than what is imposed on other types of energy, both in relation to the emission of CO_2 and relative to the energy content. The tax on electricity for ordinary consumption is also considerably higher than for manufacturing (process energy), see figures B and C.

Figure B *Energy and CO_2 tax per GJ*

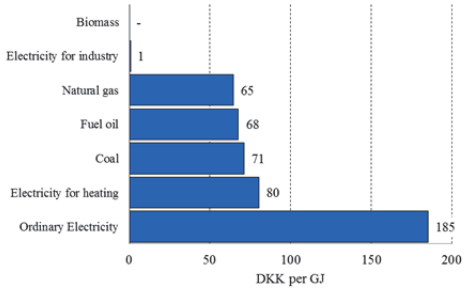
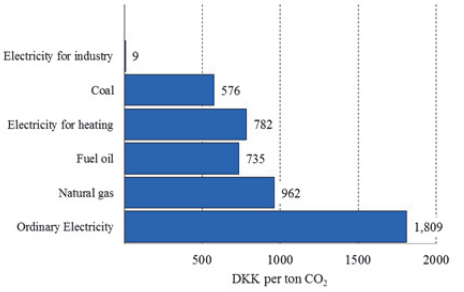


Figure C *Energy and CO_2 tax per ton CO_2*



Note: The costs of using CO_2 allowances in electricity production are not included, but these are modest compared to the green taxes.

Source: Energinet (2016), Sekretariatet for afgifts- og tilskudsanalysen på energiområdet (2016) and own calculations.

Restructuring the tax on electricity would affect the demand and production of electricity, and give rise to emissions of CO_2. However, a change in the Danish production of electricity would not affect the total European emissions of CO_2 as these are limited by the CO_2 allowances in the European Emissions Trading System (ETS). The tax on electricity has – as long as the number of allowances is given – no real impact on emissions of CO_2 in the ETS sectors. The high tax on electricity might even contribute to increasing the total emissions of CO_2 as it could counteract the transition away from fossil fuels in non-ETS sectors.

The tax on electricity provides revenue for the government; however this revenue could be collected with fewer distortions through a tax on income. Model calculations show that an annual economic benefit of DKK 1.8 billion could be obtained if the tax on electricity for ordinary consumption were lowered to the level of the general energy tax on oil and gas. This reduction is equivalent to a decrease in the electricity tax from DKK 0.89 to 0.27 per kWh, and corresponds to a reduction in the cost of electricity consumption of about 40-45 percent.

The high taxes on electricity and other types of energy should be seen in light of a general desire to reduce overall

energy consumption. It is sensible to reduce the negative environmental effects of energy consumption, which can be done through taxes on e.g. fossil fuels that cause emissions of CO_2. However, it is difficult to argue that energy in itself is harmful to the environment or the climate – hence energy saving objectives are not justified, as the environmental impacts of energy consumption are regulated through other means. Nevertheless, there are EU targets for energy savings that in the short term are regarded as a given condition.

Lower consumption of electricity can be achieved most cost-effectively by having the same tax on electricity for all consumers. This is, however, not the case today as electricity used for industrial processes is practically exempted from green taxes, c.f. Figure B and C. Model calculations show, that an economic gain of DKK 1.3 billion per year could be achieved by restructuring the tax on electricity such that everyone pays the same tax rate, while the total power consumption is unchanged.

There is also lower taxation on e.g. oil, coal and gas used in manufacturing industries. An additional benefit would be obtained from removing these exemptions, making the energy tax similar across use and energy consumption. This would reduce the total cost of achieving a given target of energy saving. A uniform energy tax should also include biomass.

There can also be economic gains from changing the green tax on water. Today there is a uniform charge across households in Denmark, while most companies are exempted from the tax. However, over-extraction of groundwater, which leads to environmental problems, is primarily an issue in parts of Zealand (in the metropolitan area). There should, therefore, be an equally geographically differentiated tax paid by all consumers. This would imply that the tax would be zero in the parts of Denmark where the groundwater resource is abundant.

Model calculations suggest that a restructuring of the tax on water could lead to socio-economic gains of DKK 0.1-0.2 billion per year. The gains would be substantially lower

than those from the restructured tax on electricity, which basically reflects much lower revenues collected from the tax on water.

Command and control regulation in the form of technology requirements is widely used in Danish environmental regulation, often instead of green taxes. Command and control is typically characterized by the fact that companies are allowed to emit more when their production increases, as long as the given technology requirements, etc. are met. In this way regulation is limiting emissions, but a tax equal to the environmental cost is not paid.

Command and control can be seen as a subsidy to the polluting companies, which means that they are favoured in comparison with companies that do not pollute or companies that pay a tax on their emissions. This leads to too much pollution and sectorial compositions where polluting sectors account for a larger share of the economy than if their emissions were regulated through taxes.

An example is the emission of ammonia from Danish agriculture. Despite extensive command and control, the emissions of ammonia cause health related costs of about DKK 2.7 billion per year.

Command and control regulation implies that employment and production in the agriculture and food industry is higher compared to a situation of tax regulation. The higher activity in agriculture and food is, however, offset by a similar lower activity in other parts of the economy. Model calculations show that the higher agricultural production leads to increased emissions of ammonia, which result in additional health costs of DKK 0.2 billion per year. The calculations illustrate that command and control can lead to an inappropriate sectorial composition, where polluting sectors constitute a bigger part of the economy, at the expense of non-polluting sectors.

Overall the calculations illustrate that there would be significant economic gains from imposing or changing green taxes to reflect the environmental costs of production and consumption.

Chapter III: Genuine Savings

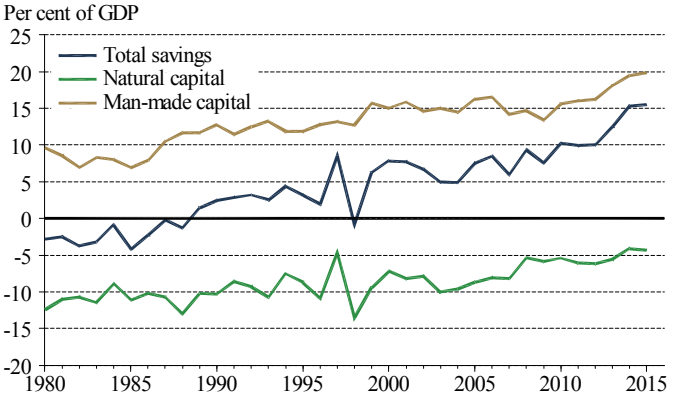
Genuine Savings, also known as adjusted net savings, is an indicator of sustainability that measures how a nation's total capital stock changes year-on-year. The total capital stock comprises all assets from which people obtain well-being, directly or indirectly. These include produced capital (machines, infrastructure, buildings etc.), human capital, natural capital (renewable and non-renewable resources, ecosystem services) and social capital. Non-negative Genuine Savings rates imply undiminished (or increased) consumption possibilities for future generations, which is in line with the intergenerational fairness required for sustainable economic development.

Although the Genuine Savings rate is generally considered to be amongst the most operational measures of sustainability, it is far from straightforward to calculate. The main obstacles include quantifying the changes in capital stocks (e.g. biodiversity and social capital) and valuing these changes correctly (e.g. climate change). Despite these difficulties, the calculation presented in this report encompasses more types of capital than typical contributions to the Genuine Savings literature. However, it has not been possible to include all potentially important assets for current and future welfare in the analysis. Hence, the Genuine Savings rate presented in the chapter is a partial calculation, which cannot answer the question of whether the economic development in Denmark has been sustainable or not. Rather, the calculated Genuine Savings rate reveals whether changes in the considered capital stocks have contributed towards a more or less sustainable development.

The chapter presents a calculation of the Genuine Savings rate for Denmark for the period 1980-2015 based on ten different capital stocks. The analysis shows that the Genuine Savings rate was negative until 1988, but has since improved steadily, see figure D. In other words, the cumulative changes in the considered capital stocks as measured by the Genuine Savings rate imply a movement towards a more sustainable development. The upward trend in the

Genuine Savings rate was driven by positive developments in both natural and man-made capital.

Figure D Genuine Savings rate for Denmark



Note.: "Natural capital" includes the impact of greenhouse gas emissions, air pollution, groundwater pollution, non-renewable resources (including oil and gas), fish stocks and forests. "Man-made capital" includes physical-, financial-, knowledge- and human capital.

On average, the Genuine Savings rate during the last 35 years constituted 4½ per cent of GDP, as detailed in table B. The single greatest contribution came from human capital, measured as investments in education. The savings rate in natural capital was negative throughout the whole period, reflecting negative contributions from health deteriorations due to air pollution and expected damage from climate change. Neither human capital nor natural capital is included in the traditional savings measure in the national accounts, which highlights the importance of Genuine Savings as an alternative indicator. Also worth noting is that forests, fisheries and groundwater only made marginal contributions to the Genuine Savings rate.

Table B Genuine Savings rates for Denmark, 1980-2015.

	1980-89	1990-99	2000-09	2010-15	1980-2015
	---------- Per cent of GDP ----------				
Climate change	-4.6	-3.0	-2.4	-2.5	**-3.2**
Air pollution	-6.1	-4.0	-2.8	-2.3	**-4.0**
Groundwater[a]		0.0	-0.1	0.0	**-0.0**
Non-renewables[b]	-0.3	-2.0	-2.9	-1.1	**-1.6**
Fisheries[a]		-0.4	0.2	0.6	**0.1**
Forests	0.1	0.0	0.0	0.0	**0.0**
Physical capital	1.7	2.0	3.7	1.5	**2.3**
Financial capital	-2.2	2.2	3.3	7.5	**2.2**
Knowledge capital	0.0	0.6	0.6	0.5	**0.4**
Human capital	9.4	8.0	7.5	8.1	**8.3**
Total	-2.0	3.4	7.1	12.3	**4.5**

a) Savings rates could not be calculated for the years 1980-1990 due to lack of data. The savings in these years are assumed to be 0.
b) This category consists of extractive resources, primarily oil and gas from the North Sea.
Note: Due to rounding, the figures don't always sum to the total.

The positive trend in the Genuine Savings rate can primarily be attributed to two important policy developments during the period. First, net savings in financial capital increased by 11 per cent of GDP from 1980 to 2015. This growth should be seen in conjunction with the growing importance of compulsory pension schemes and with several Danish fiscal policy reforms during the period concerning interest deductions. Second, air pollution has been greatly reduced, mainly as a result of regulations at the European level. Consequently, the costs of air pollution in terms of health deterioration have more than halved during the period.

As illustrated by the case of air pollution, the Danish Genuine Savings rate is affected by international developments. This is also the case for climate change, which, like air pollution, is transboundary in nature. Hence, the welfare of current and future Danish generations is affected by activities elsewhere. The calculation of the Genuine Savings rate

is, therefore, based on the total emissions that affect Danish welfare, regardless of where these emissions originated.

There are considerable uncertainties associated with the presented Genuine Savings rate. First, it was not possible to include some potentially important capital stocks in the analysis due to a lack of information about their development. This is true for biodiversity and social capital. Also, health capital was not included as the valuation of the increase in life expectancy is very uncertain. Second, there is considerable uncertainty about the right valuation for some of the included capital stocks, in particular, the expected future costs of climate change. Third, for some natural capital stocks there may exist tipping points that cannot be crossed without causing substantial and irreversible damage to human welfare. In the proximity of such tipping points, a small change in the capital stock could cause an exponential increase in the price of the asset. This is potentially relevant in relation to biodiversity and climate change. These uncertainties highlight the need for further knowledge about the development of capital stocks as well as methodological improvements.

The Chairmanship of the Danish Economic Councils last calculated the Genuine Savings rate for Denmark in 2012. In the current report, the considered time period is expanded by a total of 15 years, and a number of methodological and computational aspects have been updated on the basis of new knowledge. As a result, the Genuine Savings rate in the current calculation is, on average, about 2 per cent of GDP lower than the 2012 calculation (for the same time period). This is mainly due to a downward revision of the contribution from human capital as well as an upward revision of the negative contribution from air pollution.

The upward revision of the cost of air pollution is mainly due to the use of a higher *value of statistical life* (VSL), in line with the latest Danish research. The VSL is extensively used in cost-benefit analyses in Denmark and abroad in the valuation of reduced life expectancy, e.g. due to air pollution. Its importance for decision-making is, therefore, considerable. Hence, the use of an updated VSL figure is paramount in reaching economically efficient outcomes.

Another significant figure in the calculation of the Genuine Savings rate is the *social cost of carbon* (SCC). In this report, a SCC of DKK 386 is used, based on a review of recent literature.[1] In the international Genuine Savings literature, including the World Bank's annual publications, older and much lower SCC figures are used. The use of such outdated SCC figures likely underestimates the negative contribution from greenhouse gas emissions by a considerable amount. As a consequence, the Genuine Savings rate will be biased upwards, hence, assessing the economic development to be more sustainable than it really is.

The emission of greenhouse gasses is intrinsically linked to the use of fossil fuels. Denmark has considerable oil and gas reserves in the North Sea. In addition to the negative impact on the global climate, the isolated contribution from the extraction of these resources to the Genuine Savings rate is negative, as it reduces the consumption possibilities of future generations. However, this does not imply that the resources shouldn't be exploited, as the investment of the proceeds from their sale elsewhere in the economy may compensate for the reduction in the capital stock. Still, it is of great importance that the incentives for extraction are appropriate.

The North Sea reserves belong to the Danish state, and thus the Danish population, whereas the oil companies' task is to discover and extract the resources. A natural principle for taxation would, therefore, be that the government receives the full value of the resources, minus a reasonable return to the extraction companies. This is equivalent to the government obtaining the actual resource rent from the reserves.

Recently, there has been renewed debate about the taxation of the extraction companies. There seems to be considerable scope for the state to obtain a higher share of the resource rent, as well as room for improvement of the current tax regime in the direction of more neutral taxation. Changes in the taxation should therefore only be considered if they take these issues into account.

1) In March 2017, USD 1 ≈ DKK 7.