

# A CGE Analysis of the Danish 1993 Tax Reform <sup>\*</sup>

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## Abstract

The structural effects of the Danish tax reform of 1993 are evaluated using DREAM, a dynamic CGE model of the Danish economy featuring overlapping generations of agents who have perfect foresight. The tax reform implied a reduction in the tax burden and the progressivity of the labor income taxation, an introduction of "green" taxes as revenue raising instrument and a restructuring of the capital income taxation.

We find that the overall macroeconomic effects of the total reform are limited, but that the accumulation of wealth in the private sector is stimulated, which generates a long run increase in aggregate consumption. Analyzing the three parts of the reform separately reveals that the small net effect of the reform is due to counteracting forces of each of the parts. The reform is a strict Pareto improvement - given the initial calibration of the model - in the sense that all generations are better off after the reform.

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## **Table of Contents:**

1. Introduction . . . . .	5
2. Reduction in the taxation of labor income . . . . .	11
3. Green taxes . . . . .	19
4. Capital income taxation . . . . .	24
5. The effect of the total reform . . . . .	31
Appendix 1: Sensitivity analysis . . . . .	33
Appendix 2: The Danish Tax system and its implementation in DREAM . . . . .	38
6. References . . . . .	50

## 1. Introduction

Recent tax reforms in most European countries have aimed at reducing the tax burden and the progressivity of the labor income taxation. The Danish tax reform of June 1993 is in line with this development. Furthermore, the Danish tax reform may be seen as an attempt to introduce "green" elements in the tax structure, as the reform introduced taxation of polluting consumption goods as a revenue raising instrument. The reform was initiated in 1994 and is phased in over a period of 5 years, such that the reform is fully implemented in 1998. In addition to the elements mentioned above, the reform contains a restructuring of taxing income from capital goods which implies a reduction in the capital income taxation and measures towards broadening the tax base of both corporate and personal taxation including taxation of capital gains on shares.

In this paper we aim at describing the effects of the reform on the incentives of consumers and producers. We quantify the effects by applying the benchmark version of DREAM - a model that is currently being developed at Statistics Denmark. DREAM (Danish Rational Economic Agents Model) is a dynamic computable general equilibrium (CGE) model of a small, open economy with overlapping generations, endogenous capital accumulation, a public and a private production sector and rational agents with perfect foresight. The presentation of the model is kept to a minimum and serves only as a remedy for analyzing how changes in the tax structure are fed into the economy through changes in the individual behavior. For a description including a complete derivation of the behavioral equations from first principles see Knudsen *et al.* (1998)<sup>1</sup>.

DREAM is being designed with the specific aim of evaluating welfare state and labor market reforms, such as the 1993 tax reform. However, as the version used for this analysis is a benchmark version of the model, we abstract from any imperfections in the markets in the economy. In particular this implies that the labor market is assumed to be perfectly competitive and that the level of unemployment in the initial equilibrium is assumed to be voluntary. In the present version, the only "distortions" from first best are caused by the tax and transfer system and the Armington approach to model foreign trade.

In the initial equilibrium the behavior of the consumers are subject to the following major distortions: First, the labor supply is distorted by the labor income tax system and by the presence of unemployment benefits that in this perfectly competitive model is modelled as a subsidy to leisure. *Ceteris paribus* these dis-

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<sup>1</sup>This paper, as well as additional information about the DREAM model, can be found on the Internet at <http://www.dst.dk>.

tortions both tend to reduce the labor supply. Second, the savings decision is distorted by the presence of capital income taxation and age-dependent transfers such as pensions. The life cycle motive and a positive utility from leaving a bequest drive savings. Again both distortions tend to imply, *ceteris paribus*, that the level of savings becomes too low. Third, the behavior of firms is distorted by the presence of capital income taxation, accelerated depreciation for tax purposes and a difference in the taxation of equity of debt. These distortions imply that the private cost of capital in the stationary state is lower than the social cost of capital, which is equal to the world market rate of interest, such that the domestic stock of capital (*ceteris paribus*) is higher than the social optimum.

These distortions may be taken to imply that in the initial equilibrium, the stock of assets held by the private sector is too low and that the composition of the assets is biased towards a too high proportion of domestic capital stock.

The final major distortion is caused by the modelling of the foreign trade that follows the Armington approach (Armington, 1969). This implies that the domestic economy produces a tradable good, which is differentiated from the tradable goods produced abroad. The terms of trade is therefore endogenous. On the other hand domestic firms are price takers, and thus the potential "monopoly" gain from the finite elasticity of foreign demand is not exploited by the domestic firms. Economic policy actions that increase the domestic price level serve as "beggar thy neighbor policies" through the resulting increase in the terms of trade, even if the Danish economy is considered "small" with respect to capital markets.

### **1.1. The tax reform act**

The evaluation of the tax reform is performed with the outset in a stationary state equilibrium where the model is calibrated to data for the Danish economy in 1995 given these initial distortions. The result of the evaluation therefore depends on whether the overall effect of the "distortions" is increased or decreased by the reform and how this in turn affects welfare. When evaluating the reform we divide the reform into 3 sub reforms: a) The reform of labor income taxation, b) The green taxes, c) The capital income taxation. Finally, we simulate the total reform package. Even if the 3 sub reforms do not add up to the total reform, due to the non-linear nature of the general equilibrium model, there is considerable insights to be gained from a decomposition of the reform as the 3 parts affect different parts of the economy.

For all three parts of the reform it is necessary to transform the complex Danish

tax system into the relative simple tax system of DREAM. A documentation of the procedures applied in this process is given in appendix 2 that also contains an overview of the Danish tax system.

The total reform package contains several aspects from which we abstract in the present paper. Our definition of the tax reform implies that the following taxes and transfers in the model are affected:

1. A change in the personal income taxation scale which implies that the effective average tax rate for a fully employed person is reduced from 45.1 per cent in 1993 to 41.5 per cent in 1998. For a fully unemployed person receiving the maximum unemployment benefit level, the effective average tax rate is reduced from 35.7 per cent in 1993 to 28.1 per cent in 1998.
2. A reduction in the pre-tax unemployment benefit level of 4.3 per cent (in fixed prices) in the period from 1993 to 1998. The resulting effect on the real unemployment benefit after tax is an increase of 7.0 per cent in the period from 1993 to 1998.
3. Other taxable public transfers such as public pension is assumed to be regulated such that the after tax value of the transfers are not affected by the reform.
4. A reduction in the effective marginal capital income tax rate from 51.5 per cent in 1993 to 46.7 per cent in 1998.
5. A reduction in the effective tax rate on dividends from 36.1 per cent in 1993 to 31.6 per cent in 1998.
6. An increase in the effective accrued equivalent marginal tax rate on real capital gains from 15.1 per cent in 1993 to 25.1 per cent in 1998.
7. An increase in excise taxes ("green taxes") by 3.0 percentage points from 1993 to 1998.

In the evaluation of the tax reform it is assumed that the government runs a balanced budget in each period. To be able to isolate the incentive effects of the reform from the incentive effects from the financing of government deficit/surplus we assume that the government uses a lump sum transfer to each adult in the economy as financing instrument. The tax reform is not fully financed in the short run. The deficit is 8.6 billion Dkr. after 5 years. Due to the dynamic effects of the model the deficit is gradually reduced to 2.1 billion Dkr. after 50 years.

In the new stationary state there is a surplus of 4.7 billion Dkr. all measured in 1995 prices.<sup>2</sup>

## 1.2. Summary of results

The main macroeconomic results are summarized in Table 1 below.

Billion Dkr.	Initial stationary state	5 years	10 years	25 years	50 years	New stationary state
<b>Private consumption</b>	416	419 (0.7)	417 (0.2)	418 (0.5)	422 (1.4)	433 (4.1)
<b>Real GDP</b>	830	834 (0.6)	832 (0.3)	820 (-1.2)	813 (-2.0)	812 (-2.2)
<b>Employment, index</b>	100.0	100.1 (0.1)	100.1 (0.1)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
<b>Capital stock</b>	2664	2640 (-0.9)	2612 (-1.9)	2563 (-3.8)	2533 (-4.9)	2527 (-5.2)
<b>Value of firms</b>	1489	1695 (13.9)	1714 (15.1)	1741 (16.9)	1763 (18.4)	1791 (20.3)
<b>Foreign assets</b>	-259	-241	-211	-145	-82	45

*Note: The numbers in parantheses are the percentage change compared to the initial stationary state*

Table 1. Effects of the reform package

The main message from the table is that the effects on the overall performance of the economy are very minor, especially if one focuses on the first 25 years. There are three main effects: First, there is a tendency toward higher savings in the economy. This tends to increase the stock of private non-human wealth in the economy over time. Gradually and very slowly the increased wealth tends to increase consumption. However in the first part of the period the main effect of the increased savings is an increase in the stock of foreign assets held by the private sector. This effect is sufficient to change the foreign asset position of the

<sup>2</sup>Observe that a financing rule where the government uses debt to finance the short run deficits would imply a different evolution in the government budget, since interest payments on the increased debt would tend to increase government expenditures. Therefore it is not evident that the increased revenue in the long would be sufficient for the reform to be fully financed in the long run in this case.

economy from a substantial debt to a positive net foreign position in the very long run<sup>3</sup>. Second, the reduction in the capital income taxation and the increase in the capital gains tax both tends to increase the cost of capital in the stationary state of the model. This gives the firms an incentive to reduce their stock of capital. Third, the reduction in the labor income taxation - *ceteris paribus* - tends to decrease the labor cost in the model. Total demand for labor remains however virtually unaffected since the reduction in the wage is counteracted by the reduction in the marginal productivity of labor, which is a consequence of the reduced capital stock in the economy.

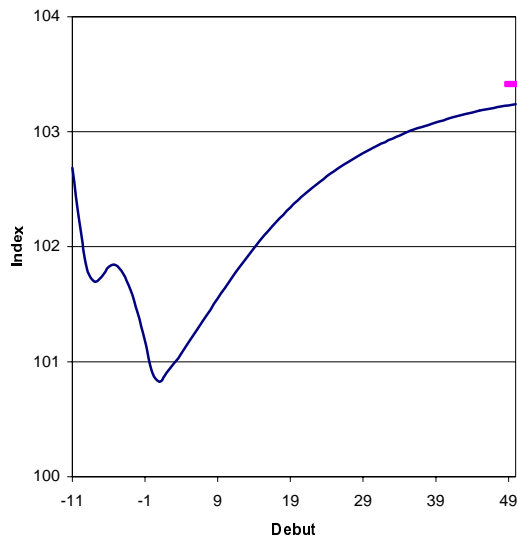


Figure 1. Generational welfare for the reform package

Concerning the welfare consequences of the reform, Figure 1 shows the relative increase in the utility for current and future generations. On the vertical axis the index value of utility is measured. The level 100 is the situation where the generation in question has the same utility as in the stationary equilibrium that prevails prior to the reform. A level above 100 implies an increase in utility as a consequence of the reform. The horizontal axis (labelled *début*) measures the generations according to birth year. The generation labelled -11 has lived

<sup>3</sup>The government is assumed to run a balanced budget in each period. The entire change in the net foreign position is therefore due to changes in the behavior of the private sector.

for 11 5-year periods as adults prior to the reform. These persons are 73 years old and experience one 5-year period after the reform has been introduced. The generation labelled 0 is the generation that enters the economy as adults at the age of 18 at the time when the reform is implemented. Therefore generation 1 is the generation that enters the economy one 5-year period after the reform has been implemented.

The figure reveals that the tax reform implies a Pareto-improvement, in the sense that all generations are better off than before the reform. For those generations that enter the economy around the time of the reform, the welfare improvements are the smallest.<sup>4</sup>

The very small net effect of the tax reform covers up the fact that each of the components of the reform has a significant effect on the economy, but these gross effects tend to counteract one another. The remaining part of the paper discusses the incentive effects of the 3 parts of the total reform in some detail. The distinctive features of DREAM are described along with the presentation of the incentive effects. The rest of the paper has the following structure: Section 2 discusses the effect of the reduction in the labor income taxation. Section 3 contains a similar discussion of the introduction of green taxes on consumption, and section 4 discusses the changes in the capital income taxation. This amounts to a discussion of the effect of a reduction in the taxation of interest income and in the dividend taxation complemented with an increase in the taxation of capital gains. Finally, the outcome of the total tax reform is described in section 5.

All parts of the tax reform are introduced as unforeseen changes implemented at the beginning of period 1. For period 0 the variables assume their value in the steady state baseline, except for the forward looking variables (such as the value of firms) which are allowed to jump on impact. It should be stressed that the public sector budget is assumed to be balanced in each period *via* lump sum transfers to households, so that for example tax rate cuts are counteracted by increased lump sum taxes (decreased lump sum transfers) of households. In this way the incentive effects of the tax reduction may be separated from the incentive effect of the financing rule.

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<sup>4</sup>Lange, Pedersen and Sørensen (1998) also perform a dynamic CGE analysis of the tax reform act of 1993. This is done using the EPRU-model, which differs from the present model in several aspects. However, the qualitative structural effects reported in their paper, do not differ distinctively from the present experiments. They too find the reform to be a Pareto improvement.



## 2. Reduction in the taxation of labor income

This section evaluates the effects of the reduction in the labor income tax rates only. The experiment consists of a gradual reduction in the tax rates applied to wages by 3.6 percentage points, and to unemployment benefits by 7.6 percentage points, whereas pensions after tax are not affected by the reform. The nominal unemployment benefits before tax fall by 4.3 per cent as a direct consequence of regulations connected with the tax reform. The total effect on the (absolute) marginal reward from employment is increased by 4 per cent from 1993 to 1998. Finally, a relatively small increase of employers payroll tax rate at 0.6 percentage points is also a part of the experiment.

There are two main channels through which the reduction in the labor income tax rate affects the economy: A supply effect and a demand effect. The supply effect appears because the reduction in the marginal tax rate generates a permanent outward shift in the labor supply curve. On impact this increases employment by 0.1 percent. This increases the marginal product of capital, which leads to increased investments and gradually increased capital stock. In the final stationary state the capital stock has increased by 0.9 per cent (see Table 2). After 25 years, more than 50 per cent of the total increase in output has taken place.

The demand effect is the following: The experiment favors the younger generations (who are in the labor force) at the expense of the elder generations, therefore the life cycle behavior of the agents is affected. There are two effects that counteracts one another: (i) Young agents increase their propensity to save so that they are able to smooth consumption over the life cycle, and (ii) The supply side effect implies that the activity in the economy is increased which adds to the value of firms and gradually also to the level of human capital<sup>5</sup> in the economy. The two latter effects tend to increase consumption whereas the former tends to reduce consumption. The result of the simulation reveals that in the first 25 years the net effect on consumption is negative, whereas the expansive effects dominates in all following periods. Therefore expansion of consumption is fairly slow compared to the expansion of production.

We start the analysis by concentrating on the supply side effects.

### 2.1. Supply side effects

#### *Initial labor supply*

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<sup>5</sup>In this paper *human capital* is defined as the discounted stream of future non-interest income.

The total labor supply is the sum of the labor supply of the households. Each adult below 61 years supplies labor, whereas older household members are retired from the labor market and receive pension. The labor supply of the household members is chosen such that the life-time utility of the household is maximized. The present version of the model embodies the simplifying assumption that the instantaneous<sup>6</sup> utility function is additively separable in utility of leisure. This assumption implies that the amount of work is chosen such that, at each moment of time the level of non-interest income net of disutility from work is maximized, since this expands the feasible value of the instantaneous utility index. Therefore the labor supply decision is not subject to intertemporal speculation, but rather chosen as a sequence of atemporal optimization problems. Perhaps more importantly, this means that the labor supply is independent of the wealth of the household.

To be able to calibrate the model (with a perfect competitive labor market) to the actual level of unemployment in the Danish economy, we assume that persons who belong to the workforce and supply less labor than an institutionally fixed maximum supply,  $\bar{\ell}$ , are entitled to (supplementary) unemployment benefits. Thus the labor market equilibrium implies that agents voluntarily reduce their individual labor supply,  $\ell_{i,t}$ , such that underemployment and work sharing prevails. The calibrated level of unemployment in the model is thus by assumption entirely voluntary.

The non-interest income associated with activity in the labor market is the sum of the salary net of taxes, and the unemployment benefit net of taxes. This amounts to

$$(1 - T_t^w) W_t \ell_{i,t} + (1 - T_t^b) b_t (\bar{\ell} - \ell_{i,t}) \quad (2.1)$$

where  $W_t$  is the wage rate<sup>7</sup> at time  $t$ ,  $b_t$  is the level of unemployment benefits measured per hour,  $T_t^w$  and  $T_t^b$  are the effective average tax rates of income from employment and unemployment benefits respectively.

Given the specified utility function, the labor supply decision that is identical for

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<sup>6</sup>The instantaneous utility function is the utility function for each period in the life time. Utility is derived from consumption, and disutility is incurred from time spent working. An agent's life-time utility function depends on these utilities as well as utility from leaving a bequest.

<sup>7</sup>Observe that the wage is assumed to be identical across generations and gender, implying that labor productivity is the same for all generations and both genders.

all generations and both genders, and is given by

$$\ell_t = \left( \frac{(1 - T_t^w) W_t - (1 - T_t^b) b_t}{\gamma_1 P_t} \right)^\gamma \quad (2.2)$$

where  $\gamma$  is the labor supply elasticity, and  $\gamma_1$  is a level parameter for the disutility of labor supply. In modelling the tax system, we assume that the income from employment and unemployment benefit is taxed by separate tax systems.

Observe that this very simple labor supply function has the property that if there is a fixed replacement level after tax (i.e. after tax unemployment benefits are increased by the same (absolute) amount as the real after tax wages), then complete real wage flexibility with respect to the labor tax rate prevails. On the other hand if unemployment benefits are indexed to e.g. the wage level (as in the present case), then real wage resistance is the outcome and a decrease in the tax rate of employed persons will increase employment. These effects are the typical outcome of models with imperfect competition in the labor market, irrespectively of whether models of bargaining, search or efficiency wages are employed. (See e.g. Pissarides (1998) for a survey of these models). Therefore one should not expect the qualitative effects to differ from these kinds of models.

On the other hand it is well established that in labor markets with imperfect competition a decrease in the progressivity of the tax system tends to increase the equilibrium wage whereas the opposite is true in labor markets with perfect competition. Hansen *et al.* (1995) show that if the bargaining model is extended to the case where both the wage and the length of the working day is negotiated then decreased progressivity may have both a decreasing and an increasing effect on the wage rate. The sign of the effect depends upon the elasticity of the labor supply and the bargaining power of the union. The present formulation of the tax system where no progressivity effect is present sidesteps this problem. This lack of progressivity effects is consistent with a recent analysis based on panel data for the Danish economy in Pedersen *et al.* (1998), where only very small progressivity effects (of both signs) are reported.

Given this simple labor supply function (2.2), the tax reform affects labor supply through the changes in the average tax rates (note that the average and marginal tax rates are equal). These are calculated using the structure of the Danish labor income taxation and the distribution of taxable incomes. The results are presented in table 2 below.<sup>8</sup>

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<sup>8</sup>A detailed description of the Danish tax-system and the calculations that leads to these average tax rates are given in appendix 2.

	1993	1994	1995	1996	1997	1998	(94-98)
Average taxation rate of an employed worker	45.1	43.3	42.7	42.3	42.1	41.0	42.4
Average taxation rate of an unemployed worker	35.7	31.4	30.6	30.0	29.2	28.1	29.2
Marginal reward from employment as per cent of the wage rate	11.2	11.5	11.7	11.7	11.7	11.7	11.7

Table 2. Average tax rates, 1993-1998

Inserting actual numbers into the labor supply function (2.2) shows the quantitative effect of the shift in the labor supply function. Normalizing the wage rate to 1, the numerator for 1993 (prior to the tax reform) amounts to

$$(1 - .451) - .680 \cdot (1 - .357) = .549 - .437 = .112$$

The reform changes the numerator for 1998 to

$$(1 - .415) - .680 \cdot (1 - .043) \cdot (1 - .281) = .585 - .468 = .117$$

As the denominator is not directly affected by the labor income tax changes, the direct initial effect is therefore an increase in the marginal reward of working of  $\frac{0.117}{0.112} - 1 = 4$  per cent. This initially expands the labor supply by around 0.4 per cent as the labor supply elasticity,  $\gamma$ , is equal to 0.1. In sum, increasing the marginal reward of work, in a standard competitive labor market with an upward sloping labor supply schedule, initially shifts the labor supply curve outwards (to the right), since in optimum the marginal disutility of work must be equal to the marginal benefit from work.

#### *Initial labor demand*

The increase in the payroll tax rate from zero to 0.6 per cent shifts the firms' labor demand schedule inwards. The net outcome of the outward shift of the labor supply curve and the inward shift of the labor demand curve, is that the real wage rate drops, while the impact on employment is theoretically undetermined. However, the payroll tax hike is so small that the impact on employment can safely be expected to be positive, dominated by the outward shift of the labor supply curve.

### *Capital accumulation*

The firms in the private sector have convex cost of installation of capital, so that investments are a function of Tobin's  $q$ . This implies that the capital stock only gradually adjusts as a function of the increased marginal productivity of capital. Due to the solution in 5 year steps no overshooting of investments appears. However, as mentioned this does not prevent the supply side of the economy to react relatively fast to the change in the tax structure.

## **2.2. The demand side effects**

### *Budgetary effects of the labor income tax reduction*

The reduction in the tax rate implies that the tax revenue to the public sector is reduced. Even though the wage sum is increased and the level of unemployment is reduced the automatic stabilizers are not sufficiently strong to prevent a substantial loss in revenue of 15 billion Dkr. As mentioned we assume that this revenue loss is financed through lump sum taxes. The lump sum tax/transfer is identical for all adults - workers as well as pensioners. The net initial effect on current disposable income of the generations alive is that generations that belong to the labor force experience a positive effect, whereas the current disposable income of each pensioner declines. The present value of future disposable income flows therefore initially declines for pensioner generations. It increases initially for generations who are young enough for their remaining periods in the labor force to generate additional disposable wage income sufficient to outweigh their discounted future loss as pensioners. This picture of gains and losses initially stimulates the savings of the younger generations to smooth consumption over the life cycle.

### *Consumption of households*

The combined assumption of perfect capital markets and perfect foresight implies that the consumption of a household in DREAM is a function of the sum of the stock of financial assets,  $a_{b-1,t-1}$  and the level of human capital,  $H_{b-1,t-1}$ . As we assume that the intertemporal elasticity of substitution is less than one, the consumption function may be written as a standard CES function in current prices and an index of future prices,  $\eta_{b,t}$ , where  $b$  is the age of the household at time  $t$ . Future prices are age specific as the household faces a finite time horizon and therefore the vector of relevant future prices depend upon the remaining life

time of the household.<sup>9</sup>

$$C_{b,t} = \xi_b^S \left( \frac{1+\theta}{(1+r_t(1-t_t^r))N_{b-1,t-1}^{EF}} \right)^{-S} \left( \frac{P_t}{\eta_{b-1,t-1}} \right)^{-S} \frac{a_{b-1,t-1} + H_{b-1,t-1}}{\eta_{b-1,t-1}} + Z_{b,t}, \quad 18 \leq b \leq 78$$

where  $\eta_{b-1,t-1}$  is the index of future consumption prices for generation  $b$  and  $a_{b-1,t-1}$  is the level of non-human wealth, while  $H_{b-1,t-1}$  is the level of human capital.  $Z_{b,t}$  is the disutility of work.

To determine the evolution of the consumption over time we analyze the impact of the reform on the two components of total wealth and on the development of consumer prices.

#### *Human capital*

Recall, that human capital is defined as the discounted stream of future non-interest income. For the retired part of the population this amounts to the stream of future pensions after tax and other transfers from the government including the lump sum tax that is used to finance the public deficit. As pensions after tax are unaffected by the reform the public deficit implies that the level of human capital for pensioners is reduced on impact. Therefore this tends to reduce consumption for these age groups.

For younger generations the expected lower level of pensions also tend to reduce the human capital. On the other hand the increased wage after tax that follows from the reduction in the labor income taxation and the increased employment, tend to increase the stock of human capital. If the age group in question has a sufficiently long remaining time as active on the labor market the positive effect will dominate the reduced expected pensions. The aggregate level of human capital is reduced on impact but gradually the increase in the wage sum becomes pronounced as new generations enter the economy in a phase with a higher production and therefore higher wage sum.

#### *Non-human capital*

The non-human capital consists of the net financial wealth of the private sector. The domestic private sector owns by assumption the domestic stock of shares<sup>10</sup>. In addition to this the domestic private sector holds a stock of bonds (either government bonds or foreign bonds).

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<sup>9</sup>The age of the household is by definition equal to the age of the female in the household. Households exist until the female reaches the age of 78 years. People who survive this limit are assumed to consume the value of their age dependent transfers.

<sup>10</sup>The value of shares is determined from an arbitrage condition that states that the after tax yield from holding bonds must be identical to the after tax yield from holding domestic shares in equilibrium.

The increased production described in the previous subsection implies that the dividends of the domestic firms are increased from after 5 years. Forward looking markets foresee this and the value of firms increases on impact.

#### *Consumer prices*

Consumer prices initially fall by 0.3 per cent and gradually increase from this point on. After 50 years the prices have returned to the original level and continue to increase. The steady state price level is 1 per cent higher than the original level. This development tends to increase the initial level of consumption *ceteris paribus* as the consumers engage in intertemporal price speculations. The price development follows from the fact that the increase in production is faster than the increase in consumption. Therefore excess domestic supply has to be sold in the foreign markets in the initial phase. This causes lower prices on domestic productions that drives the reduction in the consumer prices. Gradually this is reversed such that excess domestic demand prevails relative to the initial equilibrium.

#### *Consumption*

Initially the negative effect on human capital for most generations alive when the reform is introduced dominates a positive stimulus to consumption from increased non-human wealth and temporarily low consumer prices. The resulting initial drop in aggregate private consumption is 0.8 per cent. The process of increasing consumption is very slow. Private consumption is back to the original level after approximately 25 years and after 50 years the increase is about 1 per cent. This slow adjustment is explained by the fact that with perfect foresight the gradual increase in the aggregate level of human capital which generates the increase in consumption is a consequence of the turn over of generations. Aggregate human capital only increases because the human capital of new generations is higher than that of their predecessors. This increase appears because activity in the economy in their life span is higher. Therefore the long horizon of each cohort determines the slow turnover.

### **2.3. The total effect of the labor income tax reduction**

Table 3 below shows the main macroeconomic effects of the reduction in the labor income taxation.

	Initial stationary state	5 years	10 years	25 years	50 years	New stationary state
<b>Private consumption</b>	416	413	414	417	421	432
		(-0.8)	(-0.5)	(0.2)	(1.2)	(3.8)
<b>Real GDP</b>	830	830	831	833	834	835
		(0.0)	(0.2)	(0.4)	(0.5)	(0.7)
<b>Employment, index</b>	100.0	100.1	100.4	100.4	100.4	100.5
		(0.1)	(0.4)	(0.4)	(0.4)	(0.5)
<b>Capital stock</b>	2664	2667	2669	2675	2681	2690
		(0.1)	(0.2)	(0.4)	(0.6)	(0.9)
<b>Value of firms</b>	1489	1490	1492	1495	1501	1519
		(0.1)	(0.2)	(0.4)	(0.8)	(2.0)
<b>Foreign assets</b>	-259	-250	-241	-214	-176	-70

*Note: The numbers in parantheses are the percentage change compared to the initial stationary state*

Table 3. Effects of the labor income tax reduction

It is hardly surprising that by reducing the distorting tax on labor income and replacing it with a non-distorting tax, one generates higher labor market participation and thereby higher activity in the economy. Perhaps more surprisingly is the fact that a very large part of the population alive at the introduction of the reform is actually better off without the reduction of the distorting tax.

Figure 2 below shows that the generations that have not yet entered the labor market, all gain from the introduction of the reform. Among the existing generations, only the younger generations gain from the reform. This is caused by opposite effects: after-tax wages increase, whereas the value of lump sum transfers (that all individuals receive) falls. The reason that the middle-aged are worse off than the old, is that they are subject to the new tax system for a longer period.

The most striking development presented in table 3 is the effect on the foreign asset position that moves from a debt of 259 billion Dkr. to a debt of 70 billion Dkr. from the initial to the final steady state. This effect is the accumulated result of the increased savings rate of each generation. Observe however that also this development is pretty slow as less than 50 per cent of the reduction has taken place after 50 years.



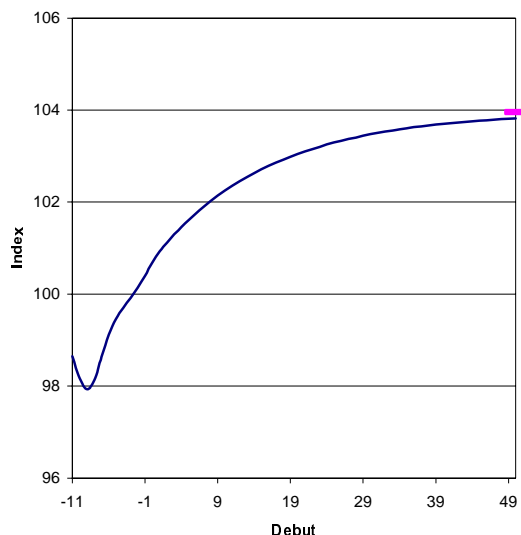


Figure 2. Generational welfare for the labor income tax reduction

Observe also that this improvement in long run macroeconomic measures comes at a cost: First, to generate the increased labor supply the difference between the net wage rate and the net unemployment benefit rate must raise, thereby generating higher intra-generational inequality on impact. Second, to increase the savings rate, the income after tax of the retired generations has to fall (at least relatively). This generates higher inter-generational income inequality on impact. Therefore one may conclude that the long run efficiency gains appear at the cost of higher inequality on impact.

### 3. Green taxes

The introduction of green taxes on the (household) consumption of energy and use of water is modelled as an increase in the general excise on the aggregate consumption good. This is obviously not a satisfactory way of introducing green taxes (especially from an environmental point of view) as it ignores the substitution effects within the consumption bundle - away from polluting goods. From a green perspective this is perhaps the most important effect and probably the main reason for the introduction. However, the high level of aggregation of the product market in the version of DREAM that is used in the present analysis

leaves no alternative. This is especially worth noticing since the resulting long run effect of the pure increase in the green duties is an increase in consumption and production and therefore probably also on (flow) pollution.

Green taxes are therefore consumption taxes. The revenue from green taxes is raised gradually from 2.7 billion Dkr. in 1994 to 12 billion Dkr. in 1998. The excise tax rates in the model are calibrated such that these revenues are generated.

Like the labor income taxation, the green taxes have both a supply and a demand effect. The supply effect appears because the increased indirect taxes reduces the net gain from being employed and therefore shifts the labor supply curve inwards generating a contraction of the supply in the economy that work through the same mechanisms the supply expansion described in the previous section. In addition the green taxes generate a demand effect, similar to the demand effect described in the previous section. It may seem paradoxical that introduction of a consumption tax gives raise to a shift in the demand over the life cycle, as it is a proportional tax on lifetime resources. However, as noted by Frederiksen (1997), the effect cannot be isolated from the impact of the recycling of revenue over generations. In the present simulation the increase in net revenue is distributed by lump sump transfers that are identical for all adult individuals. On the other hand the calibration of the model implies that consumption for a given adult is increasing through the life cycle, due to the fact that the interest rate after tax exceeds the rate of pure time preference. This consumption path implies that the net income loss from the green taxes is increasing with the age of the individual in question. Thus older generations become worse of on impact and younger generations foresee that this will also be the case for them and therefore increase their savings.

#### *The supply effect*

Following the procedure employed in the previous section, we may calculate the direct initial effect on the marginal reward from being employed to 2 percent. This implies an contraction of the labor supply with 0.2 percent. On impact this reduces the marginal product of capital leading to a lower level of investment and therefore also to a lower capital stock.

#### *The demand effect*

Initially the introduction of green taxes implies an increase in the consumer price index which ceteris paribus tends to reduce the real value of both the stock of human capital and the stock of non-human capital. For the retired persons and the older age-groups on the labor market this effect is not neutralized by an increase in the stock of human capital. For pensioners this is due to that the

increase in the lump sum transfer is not sufficiently large as argued above. For those generations who are active on the labor market the initial phase also implies a reduction in the real value of the stock of human capital as the disposable income is almost constant the first 25 years whereas employment is reduced.<sup>11</sup> These effects imply that total consumption drops by 0.5 per cent in the initial phase and only gradually recovers such that after 50 year the original level has been exceeded by 0.2 percent. From this point on consumption continues to grow and in the steady state consumption is approximately 2 per cent higher than in the original equilibrium.

The slow gradual increase in consumption follows from the increased incentive to save. This gradually increases the stock of non-human assets held by the private sector, which again stimulates consumption. The relative increase in consumption gradually generates a excess demand for the domestically produced good relative to the initial phase. Through the Armington specification of the foreign trade this generates an increased price of the domestic product. The increased producer price increases the value of the marginal input factors, which increases factor demand. The effect is however slow and very small. After 50 years the capital stock recover to the initial level after a minor redressing in the initial phase. In the new stationary state the capital stock has increased by 0.1 percent. The employment remains virtually unaffected by the increased labor demand, which is due to the indexation of the unemployment benefits that keeps the replacement ratio constant and in this way keeps employment down. The macroeconomic effects of the green taxes are shown in table 4 below.

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<sup>11</sup>The gradual in-phasing of the reform implies that green taxes are known to increase rapidly from the first period to the next. This implies that consumers engage in intertemporal speculation and in fact increase consumption in the first period.

	Initial stationary state	5 years	10 years	25 years	50 years	New stationary state
<b>Private consumption</b>	416	418 (0.3)	414 (-0.5)	416 (-0.2)	417 (0.2)	422 (1.4)
<b>Real GDP</b>	830	830 (0.0)	828 (-0.1)	829 (-0.1)	829 (-0.1)	830 (0.0)
<b>Employment, index</b>	100.0	100.0 (0.0)	99.8 (-0.2)	99.9 (-0.1)	99.9 (-0.1)	99.9 (-0.1)
<b>Capital stock</b>	2664	2662 (-0.1)	2662 (-0.1)	2663 (0.0)	2665 (0.0)	2668 (0.1)
<b>Value of firms</b>	1489	1485 (-0.3)	1487 (-0.1)	1489 (0.0)	1492 (0.2)	1500 (0.7)
<b>Foreign assets</b>	-259	-261	-257	-246	-229	-181

*Note: The numbers in parantheses are the percentage change compared to the initial stationary state*

Table 4. Effects of the green taxes

Figure 3 below shows the inter-generational welfare effects. It shows the impact of the net income loss, that as previously mentioned is increasing with the age of the individual. On impact older generations become worse of, whereas younger generations foresee the change and increase their savings.

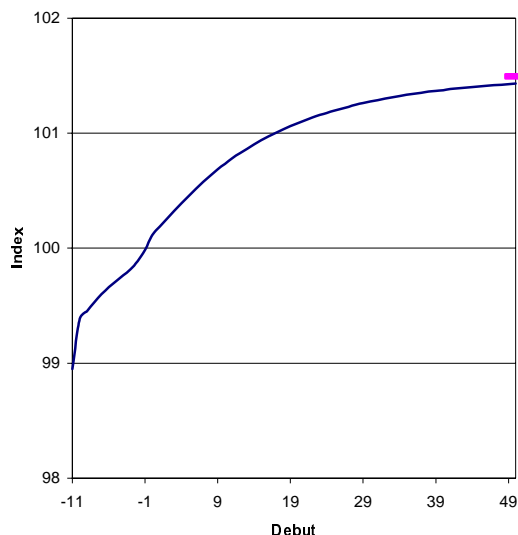


Figure 3. Generational welfare for the green taxes

*The total effect of the green taxes*

As mentioned in the introduction to this section the evaluation of the green part of the reform cannot take into account shift towards a more environmentally friendly composition of the private consumption bundle, as the production sector of DREAM is highly aggregated at a given point in time. Therefore no attempts has been made to model welfare effects of the reform's influence on the environment. The welfare measure is highly traditional and includes only utility from private consumption of consumer goods and utility from leisure. Utility from consuming the publicly produced good is also ignored.

For these reasons the effect described in this section comes down to an evaluation of a general consumption tax. As in the case of the labor income taxation this part of the reform implies that the stock of wealth of the private sector is increased in the long run. This increase generates higher consumption in the long run. Observe however that this asset accumulation effect depends on the generational distribution of the revenue from the taxes. Given the assumption of age-independent transfer per individual one may also in this case argue that the positive long run result has a short run cost, as the elder part of the population alive at the introduction of the reform are better off before the introduction of the consumption tax. The negative effect on employment may also increase

intra-generational inequality.

#### 4. Capital income taxation

The tax reform affects 3 different capital income taxes in DREAM: The tax rate on interest income is reduced, the tax rate on dividends is reduced and the capital gains tax is increased. The calculated changes in these 3 different tax rates are shown in table 5 below:<sup>12</sup>

	1993	1994	1995	1996	1997	1998	(94-98)
Tax on interest income	51.5	49.3	48.7	48.2	48.0	46.7	48.2
Tax on dividends	36.2	35.7	35.0	32.7	32.6	31.6	33.5
Tax on capital gains	15.1	25.8	25.7	25.5	25.5	25.1	25.5

Figure 4.1: Table 5. Capital income taxes, 1993-1998

One should note that the capital gains tax of DREAM follow the mainstream formulation and assumes taxation of capital gains on accrual, whereas the capital gains tax in Denmark taxes the gain on realization. The calculation of effective tax rate on accrual follows the procedure of King and Fullerton (1984).

Before evaluating the supply and demand effects of these taxes it will be useful to describe the modelling of firm behavior in DREAM in some detail.

##### 4.1. Behavior of firms

All firms are assumed to be organized as joint stock companies. The value of firms is determined from an arbitrage condition (equation (4.1) explained below), which states that the gains from investing in shares must be the same after tax as investing in bonds.

The assumption of perfect capital mobility and absence of uncertainty implies that domestic and foreign bonds are perfect substitutes. Therefore a tax-adjusted version of the uncovered interest parity (UIP) holds in the model. Absence of exchange rate movements implies that, in equilibrium, the domestic interest rate

<sup>12</sup>For a detailed description of the calculations of these tax rates see appendix 2.

after tax equals the foreign interest rate after tax. With a residence-based taxation of personal capital income this implies that the domestic (pre-tax) interest rate is equal to the foreign (pre-tax) interest rate.

Since Danish personal capital income taxation is a residence based tax, we assume as a starting point that the marginal Danish investor is a domestic citizen, who is subject to Danish domestic tax laws.<sup>13</sup> This assumption is not innocent for two reasons. First, foreign investors may be the marginal source of funds, if domestic tax laws give higher incentives to investment in bonds than do foreign tax laws (assuming all countries use a residence based tax). In this case foreign tax rates are the relevant ones. Second, a large part of Danish savings take place in pension funds, which are not subject to the same tax laws as citizens. The tax laws give pension funds an incentive to invest in shares.

The consequence of the domestic-private-investor-assumption is that the effect of changes in personal capital income taxation on the market value of shares will be exaggerated by the model.

The assumption that the investor is subject to Danish tax laws for private agents and the fact that there is no risk in the model, implies that the marginal investor will be indifferent between investing in bonds and in shares if

$$r(1 - t_t^r) V_{t-1} = (1 - t_t^d) D_t + (1 - t_t^g) (V_t - V_{t-1}) \quad (4.1)$$

where  $r$  is the interest rate equal to the world interest rate, which in a world with perfect mobility of financial capital is exogenously given for the small open economy. For simplicity we assume that the interest rate is constant through time.  $V_s$  is the (end of period) value of the firm<sup>14</sup>.  $D_s$  is dividends. The tax rates are:  $t_s^r$ , tax rate on interest income,  $t_s^d$ , tax rate on dividend income, and,  $t_s^g$ , tax rate on capital gains.

The left hand side is the opportunity cost of holding shares, whereas the right hand side is the sum of dividends and capital gains after tax, which is equal to the total income from holding the value  $V_{s-1}$  in shares.

Observe that due to the possibility of different tax rates the investor is not indifferent between a unit increase in the (pre-tax) dividends and a unit increase in the (pre-tax) market value of shares. A unit decrease in the dividends may

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<sup>13</sup>By personal capital income taxation we mean: taxation of personal interest income, dividend taxation and taxation of capital gains. Observe that corporate income taxation is source based.

<sup>14</sup>Note that the end-of-period dating rule is used. This means that stock variables active in period  $t+1$  are nominated  $t$ . For instance the relationship between investment and capital stock in the model (with exponential decay) is written as  $K_t = (1 - \delta) K_{t-1} + I_t$ .

be compensated by  $\frac{1-t_s^d}{1-t_s^g}$  units increase in the market value of shares. Similarly, a 1 percentage point increase in the (pre-tax) interest rate requires an increase in the market value of shares of  $\frac{1-t_s^r}{1-t_s^g}$  per cent for the arbitrage condition (4.1) to hold. These tax adjustment factors will appear frequently in the expressions concerning the behavior of the firm.

Solving the arbitrage condition (4.1) for  $V_s$  yields the result that the market value of firms is given as the tax adjusted stream of dividends:

$$V_s = \sum_{t=s+1}^{\infty} \frac{1-t_t^d}{1-t_t^g} D_t \prod_{v=s+1}^t \frac{1}{1+r_v \left( \frac{1-t_v^r}{1-t_v^g} \right)} \quad (4.2)$$

Dividends are defined as

$$\begin{aligned} D_t = & (1-t_t^c) \left( p_t Y_t - p_t^M M_t - (1+t_t^a) W_t L_t - r_t B_{t-1}^c \right) \\ & - p_t^I I_t + t_t^c \hat{\delta}_t \hat{K}_{t-1} + (B_t^c - B_{t-1}^c) \end{aligned} \quad (4.3)$$

where  $p_t$  is the (producer)price of the domestically produced good,  $Y_t$  is the (net) production,  $p_t^M$  is the price index of materials,  $M_t$  is the input of materials,  $t_t^a$  is the payroll tax rate,  $W_t$  is the wage,  $L_t$  is employment,  $B_{t-1}^c$  is the stock of corporate debt at the beginning of period  $t$ ,  $p_t^I$  is the price index of investments,  $I_t$  is investment,  $\hat{K}_{t-1}$  is the book value of the capital stock given the tax system,  $\hat{\delta}_t$  is the rate of depreciation allowed by the tax system and  $t_t^c$  is the corporate tax rate.

Concerning the financing decision of the firm we adopt the so-called "new view on dividend taxation", and assume that the firm in question debt finances a fixed part of its current capital stock, and abstain from issuing new shares. Therefore investments are financed through retained earnings plus debt, and the residual cash flow is always distributed to the owners.

This financing rule implies that (personal) tax rates will affect the investment decision of the firm. Due to the convex cost of installation of capital, the firm has a demand for investments and in general not a demand for capital. In the stationary state we may however, write an implicit demand for the stock of capital using the cost of capital. Given the tax system of the model the required marginal product of capital is given by the following expression (time subscripts are eliminated to indicate that the expression is only valid in the stationary state of the model):

$$F'_K - \frac{p^I}{p} \delta = \frac{p^I}{p} \left[ r \left( g + \frac{(1-t^r)}{(1-t^g)(1-t^e)} (1-g) \right) + \frac{\frac{(1-t^r)}{(1-t^g)(1-t^e)} r t^c (\delta - \hat{\delta})}{\left( \frac{(1-t^r)}{(1-t^g)} r + \hat{\delta} \right)} \right] +$$



$$\frac{\partial \Phi}{\partial K}(\delta, 1) + \left( \frac{1 - t^r}{1 - t^g} r + \delta \right) \frac{p^I(p, 1)}{p} \frac{\partial \Phi}{\partial I}(\delta, 1) \quad (4.4)$$

where  $p^I$  is a CES price index of domestic and foreign investment goods,  $g$  is the debt ratio of the firm and  $\Phi$  is the cost of installation of capital. The left hand side of equation (4.4) is the required net marginal product of capital in the stationary state. The right hand side is the cost of capital. Observe that the cost of capital may be decomposed into three components: financial costs, costs of depreciation, and costs of installation; these terms correspond to the three terms in expression (4.4) (two terms in the first line, and the last term in the second line). If the capital income taxation is neutral, i.e. if  $(1 - t^r) = (1 - t^g)(1 - t^c)$ , then the degree of debt financing does not affect the financial cost which remains equal to the rate of interest,  $r$ . Similarly if the depreciation allowed by the tax system is identical to the true rate of depreciation, then the cost of depreciation vanishes.

Given the current calibration of the initial steady state, there is a minor advantageous tax treatment of financing through retained earnings, which implies that the financial costs are lower than the rate of interest. The cost of depreciation is negative, since the allowed rate of depreciation of the tax system exceeds the true rate of depreciation. Therefore the effect of the capital income taxation in the initial stationary state is - ceteris paribus - a distortion towards a too high level of the domestic capital stock.

Given this description of the behavior of firms we are now in a position to evaluate the changes in the capital income taxation. We do this by focusing on each of the tax rates separately.

## 4.2. The reduction in the dividend taxation

If the change in the dividend taxation is considered a once and for all change, then the dividend tax rate is a neutral tax rate, in the sense that the level of the tax rate does not affect the optimal decision rule of investments and employment. From the fact that the value of the firm is the discounted stream of tax adjusted dividends it follows that if the reduction in the dividend tax rate is a once and for all change, then the value of the firms increase by the discounted value of the sum of saved dividend taxes in all future. Thus the present shareholders reap the entire gain from the reduction in the tax rate.

The fact that the change in the dividend taxations is not a once and for all change but a gradual reduction over 2 periods in the model, implies that the behavior

of firms in fact is affected as well. The effect is the following; at the introduction of the tax reform the phase-in of changes in the tax rates are announced with certainty. In period one the firm therefore knows that the dividend taxation is lower in period 2 and the following periods. To increase the after tax stream of dividends the firm will want to postpone dividends until the low tax rate has been introduced. However given the fact that the financing rule is fixed in the model the only way to postpone dividends is to undertake physical investments.<sup>15</sup> Therefore investment peaks in period 1 and is reduced again in period 2.

Apart from this investment peak the reduction in dividend taxation only affects the economy through the shift of resources from future generations to current shareholders, since the lack of revenue is financed through lump sum taxes on future generations.

#### 4.3. Reduction in the taxation of interest income

The reduction in the taxation of interest income contains both a supply and a demand effect. The supply effect follows from the fact that the interest rate after tax is increased from the reduction. This implies that the user cost of capital in the stationary state is increased, see the right hand side of (4.4). The firm therefore reacts by reducing the level of investments. This gradually reduces the capital stock, which again reduces the marginal product of labor and therefore labor demand.

The demand effect are driven by the following changes: First, the current population experience an initial capital loss on shares. This capital loss accrues both due to the reduced activity in the economy and due to the increased discounting of future dividends that follows from the increased interest rate after tax. Second, the increased interest rate after tax increases the excess of interest payments over the pure rate of time preference implying that each individual prefer a steeper consumption path over the life cycle, than was the case prior to the reduction in the tax rate. This reduces the initial consumption and increases the savings ratio.

On impact the contraction in demand exceeds the contraction in supply, which generates an excess supply of the domestic production that has to be sold in the world market, generating a price reduction on the domestic product. However,

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<sup>15</sup>This highly unreliable feature of the model appears because the financing decision is not a result of optimal behavior but a fixed (arbitrary) rule, which is applied to avoid corner solutions to the financing problem. It highlights the danger of introducing ad hoc assumptions in CGE models. It should be noted that this is the only arbitrary rule that is applied in DREAM.

accumulation of non-human capital, which to a large extent takes the form of reduced foreign debt gradually increases domestic demand so that consumption is 0.3 per cent higher than in the initial equilibrium after 25 years. The speed of growth remains relatively high and in the new stationary state consumption is 8.6 per cent higher than in the initial steady state. This is financed through a significant increase in the stock of assets of the private sector. Domestic activity remains fairly constant through time.

#### **4.4. The increase in the capital gains tax**

An increase in the capital gains tax shares some characteristics with both a reduction in the tax rate on interest income and a reduction in the dividend taxation. The capital gains tax works through both a supply and a demand effect.

The supply effect of an increase in this tax is similar to the supply effect of a reduction in the taxation of interest income. Both tax changes tend to increase the cost of capital in the stationary state, see the right hand side of (4.4). This generates a reduction in investment and gradually also in the stock of capital, which leads to the contraction of supply as explained earlier.

The reason why the capital gains tax appears in the user cost of capital is that the financing decision implies that investments are partly financed through retained earnings i.e. through a reduction in current dividends.

The demand effect is initiated in much the same way as the supply effect. The increased capital gains tax gives the firm an incentive to avoid capital gains by increasing dividend to the owners. From the definition of dividends, see (4.3), it follows that the only way that the firm can increase dividends is to reduce investments. The increase in current dividends increases the initial value of the firm since the present value of the sum of future dividends increases due to the increase in current dividends. Thus the current generation of shareholders experience a capital gain at the expense of future generations who will inherit an economy with a lower productive capacity.

Therefore consumption initially increases but gradually as the aggregate human capital is reduced due to the lower activity in the economy this is gradually reduced. After approximately 25 years consumption is back to the original level. The slow reduction in demand implies a rather rapid accumulation of foreign debt. In the final steady state the foreign debt has doubled compared to the initial equilibrium and has reached a level of approximately 500 billion Dkr.

#### 4.5. The total effects of the changes in the capital income taxation

Combining the three elements discussed above raises the interesting question of whether this favors current or future generations (or both). The reduction in the interest income taxation generally favors future generations at the expense of those currently alive. On the other hand both the increase in the capital gains tax and the reduction in the dividend taxation tend to favor current generations at the expense of future generations. Table 6 below shows the macroeconomic consequences of the change in the capital income taxation whereas figure 4 shows the generational distribution of utility relative to the initial stationary state.

	Initial stationary state	5 years	10 years	25 years	50 years	New stationary state
<b>Private consumption</b>	416	421	421	418	416	411
		(1.1)	(1.2)	(0.5)	(0.0)	(-1.4)
<b>Real GDP</b>	830	834	831	818	810	805
		(0.5)	(0.2)	(-1.4)	(-2.4)	(-2.9)
<b>Employment, index</b>	100.0	100.0	99.9	99.8	99.7	99.6
		(0.0)	(-0.1)	(-0.2)	(-0.3)	(-0.4)
<b>Capital stock</b>	2664	2640	2610	2554	2517	2497
		(-0.9)	(-2.1)	(-4.1)	(-5.5)	(-6.3)
<b>Value of firms</b>	1489	1699	1713	1733	1744	1740
		(14.1)	(15.1)	(16.4)	(17.2)	(16.8)
<b>Foreign assets</b>	-259	-247	-231	-205	-199	-242

*Note: The numbers in parantheses are the percentage change compared to the initial stationary state*

Table 6. Effects of the changes in the capital income taxation

The macroeconomic variables in table 6 reveal that even if the life time consumption path becomes more steep for each individual, and the increased propensity to save caused by this effect, is not sufficient for the aggregate consumption to remain at the initial level. This is due to the decreased activity in the economy in the long run.

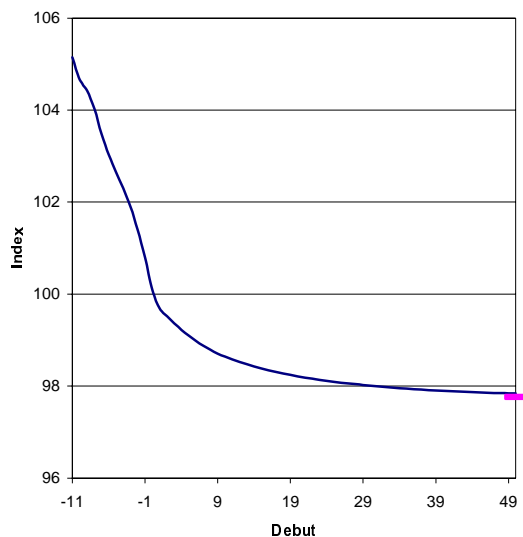


Figure 4. Generational welfare for the changes in the capital income taxation

The utility diagram shows that the combined effect of the reduced dividend taxation and the increased capital gains tax dominates the effect from the reduced taxation of interest income, so that the total capital income tax part of the reform redistribute utility from future generations to current generations and especially to the older part of the generations currently alive. This is so since most of the positive transfer to current generations takes the form of capital gains and the older generations are the wealthiest generations.

## 5. The effect of the total reform

The Danish tax reform of 1993 involves all major part of the tax system except the corporate tax rate and the VAT. The reform features a shift of the tax burden away from labor income taxation towards green taxes on consumption. At the same time it involves a change in the structure of both the labor income taxation and the capital income taxation.

This paper has shown that the net-effect of these change on the macroeconomic performance is modest if one considers a time horizon of 50 years. The only relatively large effect is the accumulated increase in the total stock of assets

held by the private sector in the economy, and the simultaneous reduction in the domestic stock of capital. However these two effects are important as the initial equilibrium was subject to distortions that created a too low level of asset accumulation and a too high domestic capital stock. Therefore the tax reform is a move in the right direction from an efficiency point of view. Furthermore, the analysis revealed that the reform generates a (strict) Pareto improvement, in the sense that all current and future generations are better off (in terms of welfare) than before the reform. To this one may add that to the extent that the reform succeed in shifting consumption away from polluting goods there may be an additional positive utility effect from cleaner environment.

The conclusion of the analysis is that the reform is well balanced when inter-generational distribution is considered. As the analysis revealed each of the elements of the reform do not strike this balance. The labor income tax part of the reform tends (when considered in isolation) to favor future generations at the expense of generations currently alive. The same is true for the green part of the tax reform isolation. On the other hand, the capital income tax part of the reform tends to favor current generations at the expense of future generations. Given the relative sizes of the different parts the total reform becomes balanced.<sup>16</sup> Note, however that the effect from capital income taxation may be exaggerated in the simulation since we assume that the total amount of private wealth is taxed according to the personal capital income taxation system whereas a large part of the wealth in fact is taxed according to special taxation of private pension funds. Therefore the positive effect on generations currently alive may be less positive.

In the appendix presented below a sensitivity analysis is performed. This analysis may be taken to reveal that the economic effects of the reform and therefore the conclusion presented above seems fairly robust to changes in key parameters in the model.

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<sup>16</sup>The question remains whether the same is true when the intra-generational distribution is concerned. The present analysis which considers a representative household in each generation is not suited for this type of analysis.

## Appendix 1: Sensitivity analysis

This section investigates the sensitivity of the evaluation of the total tax reform to the size of some of the parameters essential for the results, cf. the last remarks of the preceding section. Technically, changing one parameter necessitates changing at least one other parameter for the calibrated model to be able still to reproduce the benchmark data set exactly. In other words it implies a re-calibration of the model. In most cases the consequence is a change in a trivial parameter with little effects for the marginal properties of the model. For example changing the labor supply elasticity necessitates a corresponding change in the level-parameter,  $\gamma_1$ , of the labor supply function and changing an elasticity of substitution involves changing the distribution parameters of the CES function in question. However, changing one parameter in households' intertemporal utility function involves changing the other two and non-trivial intertemporal parameters because the intertemporal utility parameters are calibrated simultaneously.

Table 7 summarizes the outcome of the sensitivity analysis by listing the dynamic course in 6 key variables as a result of the total reform<sup>17</sup>. This is done both for the central calibration, referred to as the base case, and for 3 alternative parameter setups - namely, (i) double labor supply elasticity, (ii) double foreign trade elasticities, and (iii) a 5 per cent higher bequest parameter. The first row for each of the six variables put together reproduces table 1 of section 1.2, whereas the following rows state the percentage change compared to the initial stationary state for the base case and the 3 other simulations, respectively.

### 1. Double labor supply elasticity.

In this simulation the labor supply elasticity is assumed to be equal to 0.2 instead of the central calibration value of 0.1. Looking partially at the labor supply equation (2.2), this implies that the impact of a change in the real reward of working on the labor supply doubles. Table 7 shows accordingly that compared with the central calibration, the effect of the total tax reform on employment doubles right from the start as there are no intertemporal speculation in the supply of labor. In the longer run, as the capital stock adjusts downwards, the effect on unemployment disappears, just as in the central case. However, the equilibrium capital stock declines slightly less than in the central case. It falls by 1.7 per cent compared with a fall of 2.1 per cent in the central calibration. The larger input of the factors of production means that production falls less (from

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<sup>17</sup>Since the model is in 5-year intervals, all flows in the model are five times their annual amounts, while stocks are the same. In the table however, all flows are converted into their corresponding 1-year value.

-2.2 to -2.1 per cent), along with an increase in consumption (from 4.1 to 4.3 per cent) and wealth.

## **2. Double foreign trade elasticities.**

In this experiment the elasticities of substitution in the Armington specification of import demands are doubled from the central calibration range of 1.1-1.5 to 2.2-3.0, and the numerical export price elasticity is doubled from 1.4 to 2.8. This implies that increased net-supply of the domestic good to the foreign market which appear in the short run leads to a lower reduction of the price of the domestic good. Therefore the initial effect is a more rapid accumulation of wealth in the private sector, which appears as a significant improvement in the current account. The gradual contraction in domestic output which follows from the increased cost of capital does not imply the same increase in the domestic price level as in case of the low foreign price elasticities. Therefore the contraction does not generate the increase in the consumer real wages that followed from the reform in case of the low price elasticities. This reduces the increase in domestic consumption and activity in the long and almost offset the effect on consumption from the increased stock of assets. The fact that the reduced domestic production does not to the same extent generate a price increase on domestic products implies that future generations benefit less from the reform than in the base case. In fact the result is that future generations gain less than those currently alive and for those generations who enter the economy in the distant future there is approximately no effect. The positive long run effect of the reform therefore to a large extent depend upon the Armington specification and the price elasticities of foreign trade. The price elasticities used in the base long run estimates taken from Statistic Denmark's Macroeconometric model ADAM.

## **3. Bequest parameter 5 per cent higher.**

When performing central calibration, the rate of time preference is set to 1.25 per cent (0.25 per cent on an annual frequency). Given this, the intertemporal elasticity of substitution and the preference for bequest is calibrated endogenously to be 0.983 and 0.799 respectively. Equally one can fix the bequest parameter to 0.799 and calculate the rate of time preference and the intertemporal elasticity of substitution to 0.0125 and 0.983 respectively. The interpretation of the bequest parameter value is that in optimum, the utility of leaving 0.799 DKr. of bequest equalizes the utility of 1 DKr. worth of consumption in the last 5-year period of a household's life, i.e. the utility of bequest is equal to the utility of 3.995 years



of last year consumption<sup>18</sup>.

Increasing the bequest parameter with 5 per cent of its central calibration value now equates 1 Dkr. of bequest with 4.195 years of end period consumption. The corresponding values of the two other intertemporal utility parameters are 1.256 for the intertemporal elasticity of substitution and 0.035 for the rate of time preference (0.007 on an annual frequency). Increasing the bequest parameter increases the end of life assets and therefore it must increase the rate of time preference to stimulate savings, so that total assets can reproduce the benchmark values (to which the model is calibrated).

The effect of the increase in the intertemporal elasticity and the decrease in the rate of pure time preference both tend to imply that the optimal consumption path over the life cycle becomes steeper.. Therefore younger generations tend to increase their savings whereas older generations tend to reduce the savings. However as the bequest parameter is also increased the generation in question dies with a higher stock of financial wealth. In the short run these shifts in the structure of the life cycle demand have little effect on the economic activity. Gradually the effect on aggregate consumption is increasing. First of all due to the fact that younger generations receive a larger inheritance from their parents but also due to the increased tendency to save for younger persons which stimulates aggregate wealth and therefore also aggregate consumption. Future generations are therefore significantly better off after the tax reform with this new calibration than in the base line case. The difference, however does not appear in the macroeconomic performance before after 50 years.

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<sup>18</sup>Namely, 0.428 times an extra period of 5 years.

Billion Dkr.	Initial					New stationary
	stationary	5 years	10 years	25 years	50 years	
	state					
<b>Private consumption</b>	416	419	417	418	422	433
Base case		(0.7)	(0.2)	(0.5)	(1.4)	(4.1)
Double labor supply elasticity		(0.7)	(0.2)	(0.5)	(1.4)	(4.3)
Double foreign price elasticities		(0.4)	(-0.1)	(0.4)	(1.0)	(0.8)
Bequest parameter 5 percent higher		(0.4)	(-0.1)	(0.4)	(1.8)	(7.1)
<b>Real GDP</b>	830	834	832	820	813	812
Base case		(0.6)	(0.3)	(-1.2)	(-2.0)	(-2.2)
Double labor supply elasticity		(0.6)	(0.3)	(-1.2)	(-2.0)	(-2.1)
Double foreign price elasticities		(0.7)	(0.3)	(-1.5)	(-2.5)	(-2.9)
Bequest parameter 5 percent higher		(0.6)	(0.3)	(-1.2)	(-1.9)	(-1.9)
<b>Employment, index</b>	100.0	100.1	100.1	100.0	100.0	100.0
Base case		(0.1)	(0.1)	(0.0)	(0.0)	(0.0)
Double labor supply elasticity		(0.2)	(0.3)	(0.0)	(-0.1)	(0.0)
Double foreign price elasticities		(0.1)	(0.1)	(-0.1)	(-0.2)	(-0.2)
Bequest parameter 5 percent higher		(0.1)	(0.1)	(0.0)	(0.0)	(0.1)
<b>Capital stock</b>	2664	2640	2612	2563	2533	2527
Base case		(-0.9)	(-1.9)	(-3.8)	(-4.9)	(-5.2)
Double labor supply elasticity		(-0.9)	(-1.9)	(-3.8)	(-4.9)	(-5.1)
Double foreign price elasticities		(-1.1)	(-2.3)	(-4.5)	(-5.9)	(-6.4)
Bequest parameter 5 percent higher		(-0.9)	(-1.9)	(-3.7)	(-4.8)	(-4.7)
<b>Value of firms</b>	1489	1695	1714	1741	1763	1791
Base case		(13.9)	(15.1)	(16.9)	(18.4)	(20.3)
Double labor supply elasticity		(13.9)	(15.1)	(16.9)	(18.4)	(20.4)
Double foreign price elasticities		(13.3)	(14.0)	(15.1)	(15.7)	(15.8)
Bequest parameter 5 percent higher		(13.8)	(15.1)	(17.1)	(18.9)	(22.2)
<b>Foreign assets</b>	-259	-241	-211	-145	-82	45
Double labor supply elasticity		-241	-211	-143	-79	55
Double foreign price elasticities		-225	-175	-81	-30	-30
Bequest parameter 5 percent higher		-237	-203	-121	-32	208

Note: The numbers in parantheses are the percentage change compared to the initial stationary state

Table 7. Effects of the reform under alternative parameter values

In conclusion, the long run level of aggregate consumption seems to be the most volatile variable with respect to the parameter changes in the sensitivity analysis. This is so since consumption partly is determined by the accumulated stock of wealth, which is a consequence of a very long accumulation process in the present model. Changing parameters that affect the savings behavior in the

model therefore tend to have relatively large effects on long run consumption. In the sensitivity analysis this effect appears in case of the increase in the bequest parameter. In the case of the increase in the elasticity of foreign trade the reduction in consumption relative to the base case appear due to the lower stock of human capital, which is the second main determinant of aggregate consumption.

On the other hand the sensitivity analysis revealed that parameters that works through the supply side of the economy does not generate these accumulation effects. Doubling labor supply elasticities hardly affects the outcome of the economy. One should however bear in mind that even in the case of doubled elasticity the absolute value remains relatively low.

In all cases the reform entails a welfare improvement for both current and the future generations. In that respect this little sensitivity analysis shows that the results are somewhat robust to the values of the investigated parameters. On the other hand, the numbers also reveal that a more marked and still plausible change in some parameter values might produce a rather different outcome. For example, even in the alternative calibration with doubled foreign trade elasticities, they seem rather small numerically. Increasing them still further could change the results so that the welfare gain for future generations may turn to a welfare loss. Finally, changing several parameters simultaneously might produce more pronounced differences.

## Appendix 2: The Danish tax system and its implementation in DREAM

The contents of this Appendix 2 is twofold: First, it contains an overview of the Danish tax system both prior to and after the Tax Reform Act of 1993. Secondly, it describes the implementation of the reform in DREAM. The first subsection is devoted to a description of the taxation of personal and capital income. This is followed by a subsection describing the implementation of this taxation in DREAM. The final subsection describes the taxation of income from firm ownership.

### **The Danish personal and capital income tax system**

The Danish personal tax system is a piecewise linear progressive tax system and taxes are collected both by the State and the local government (i.e. municipality and county)<sup>19</sup>. Table 8 (on the next page) shows the tax rates imposed at different income levels as well as the income tax threshold and the basic allowances from 1993 - before the tax reform - until 1998, when the reform is to be fully implemented.<sup>20</sup> Prior to the reform personal income was defined as the sum of labor income, taxable social transfers and unemployment benefits. The reform introduces a distinction between income from employed persons and other types of personal income. Persons receiving income from employment now has to pay a labor market contribution, which acts as a gross tax on this type of income. No other parts of personal income are subject to this labor market contribution. As a result personal income after the tax reform is redefined as the sum of taxable social transfers, unemployment benefits and labor income net of labor market contributions.

Along with this step a significant reduction in the ordinary income tax rate is carried out. Further a new additional lower level income tax is introduced on all incomes above 130 900 Dkr. (Danish kroner) and the additional intermediate level income tax - known as the "6-percent tax" before the reform - is phased out over a 3-year period.

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<sup>19</sup>Note that income also is taxed by the Danish church, but as this contribution is voluntary, it is neither included in the presentation of the Danish income tax system nor in the tax parameters of the model.

<sup>20</sup>Note that all nominal terms in the table and the rest of this section are measured in 1995-prices. In the transformation from current prices to the 1995 level the "regulation number" is used. This number is growing at a rate equal to the growth rate (2 years earlier) in a weighted gross annual income for wage-earning and salaried employees corrected for changes in overtime, nuisance bonus, sickness absence, labor market pensions and the labor market contribution rate (in the present year). The calculation is based on the statistics of income from The Confederation of Danish Employers Association.

	1993	1994	1995	1996	1997	1998
	----- pct. -----					
<b>Average local government tax rates (municipal plus county tax)</b>	29.5	29.5	29.9	30.4	31.2	31.8
<b>Tax rate for State</b>						
Ordinary income tax	22.0	14.5	13.0	12.0	10.0	8.0
Additional income tax, lower level	0.0	4.5	5.0	5.0	6.0	6.0
Additional income tax, intermediate	6.0	5.0	3.0	0.0	0.0	0.0
Additional income tax, upper level	12.0	12.5	13.5	15.0	15.0	15.0
Marginal tax rate ceiling	68.0	65.0	63.5	62.0	60.0	58.0
Average marginal tax rate	67.8	64.7	63.2	61.6	59.9	58.0
<b>Labor market contribution</b>	0.0	5.0	6.0	7.0	8.0	8.0
	----- 1000 Dkr., 1995-prices -----					
<b>Personal reliefs</b>						
Local government tax	26.5	29.6	29.6	29.6	29.6	29.6
State tax	33.8	29.6	29.6	29.6	29.6	29.6
<b>Basic allowances</b>						
Lower limit for collecting additional income tax, lower level		130.9	130.9	130.9	130.9	130.9
Lower limit for collecting additional income tax, intermediate level	174.3	174.3	174.3			
Lower limit for collecting additional income tax, upper level	249.0	236.6	236.6	236.6	236.6	236.6

Table 8. Income tax rates and allowances, 1993-1998

The local government tax rate is chosen by individual local authorities and therefore this tax rate is not directly a part of the tax reform. The original ambition of the government however was to maintain the local government tax rate at the existing 1993-level, but this ambition has not been fulfilled and we observe an increase in this rate. In the simulation we allow for the increase in the local government tax rate so that the total tax burden is correct both in 1998 and in 1993. In this way the increase local government tax rate becomes part of the definition of the tax reform used in the present analysis.

Until 1993 the personal allowance increased with 3 percent of the personal income up to a maximum deduction of 4 100 Dkr.<sup>21</sup>. In 1994 the 3 percent extra deduction was abolished. Also up until 1993 the income tax threshold differed between local government and state taxation. A part of the tax reform was to unify these personal reliefs from 1994 and on. At the same time the lower limit for collecting additional income tax at the top level was reduced from 249 000 to 236 600 Dkr.

<sup>21</sup>Note that this does not appear in the table.

in 1994. All other basic allowances in force have remained constant.

Net capital income is added to the personal income and taxed according to the sum of the local government tax, the ordinary income tax and the lower level of additional income tax. Prior to the reform the positive part of the capital income was also exposed to the intermediate level of additional income tax, provided that the sum of the personal and the positive capital income exceeds the relevant allowance. After the reform was initiated all positive capital income is omitted from the tax basis of the intermediate level of additional income tax, but instead positive capital income exceeding 20 200 Dkr. enters into the tax basis of the upper level of additional income tax.

Observe from table 8 that the average local government tax rate, the ordinary income tax rate and the three additional income tax rates in every year sum to a rate above the marginal tax rate ceiling, which means that this ceiling becomes binding. The average top marginal rate of taxation is however below this rate, because the variation in local government tax rates shall be taken into account. Thus, for some municipalities the tax rate is low enough for the tax ceiling not to become binding. The average top marginal rate of taxation is therefore found as a weighted average of the total tax rate in these municipalities and the marginal tax rate ceiling in the others. The weights used is the ratio of municipal taxable income at the upper level to the total taxable income at the upper level.

To make the income tax reform more transparent one should look at the **effective** marginal tax rates, found by correcting for the labor market contribution<sup>22</sup>. A similar correction is also needed for the basic allowances (the corrected allowances are presented in table 9), since these deductions are directed to the personal income<sup>23</sup>. In 1993 the labor market contribution rate was zero, but to measure the effective taxation and allowances the 3-percent personal allowance must here be taken into account<sup>24</sup>. Table 9 illustrates this effective marginal taxation of

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<sup>22</sup>This is done simply by multiplying the marginal tax rate in question by one minus the labor market contribution rate and adding the result to the labor market contribution rate. Note that in the correction of the highest marginal tax rate, the calculated average top marginal tax rate is used instead of the marginal tax rate ceiling.

<sup>23</sup>The effective allowances are simply found by dividing the actual allowance by 1 minus the percent of labor market contribution for the year in question. For example the effective lower limit for collecting additional income tax at the upper level in 1995 is calculated as  $\frac{236.6}{1-0.06} = 251.7$ .

<sup>24</sup>This is done simply by multiplying the marginal tax rate by 0.97, since 3 percent of the income (as a result of the deduction) is not taxed. However this is only valid up to the limit of 134 900 Dkr, which is the 1993-limit of 130 000 Dkr. transformed into 1995-prices. Further the two personal reliefs are divided by 0.97, since taxation is first executed when 97 percent of the income exceeds the allowance, because of the 3-percent deduction.

gross income, as it shows the marginal tax rate of personal income before labor market contributions and before the 3-percent deduction (in 1993) for the relevant income brackets.

Income 1993		Income 1994		Income 1995		Income 1996		Income 1997		Income 1998	
brackets	%	brackets	%	brackets	%	brackets	%	brackets	%	brackets	%
0.0-27.3	0.00	0.0-31.2	5.00	0.0-31.5	6.00	0.0-31.8	7.00	0.0-32.2	8.00	0.0-32.5	9.00
27.3-34.8	28.62										
34.8-134.9	49.96	31.2-137.8	46.80	31.5-139.3	46.33	31.8-140.8	46.43	32.2-142.3	45.90	32.5-143.8	45.22
134.9-174.3	51.50	137.8-183.5	51.08	139.3-185.4	51.03	140.8-254.4	51.08	142.3-257.2	51.42	143.8-260.0	50.68
174.3-249.0	57.50	183.5-249.1	55.83	185.4-251.7	53.85						
249.0-	67.81	249.1-	66.45	251.7-	65.38	254.4-	64.24	257.2-	63.15	260.0-	61.78

Table 9. Effective marginal income tax rates, 1993-1998

### Personal and capital income taxation in DREAM

To capture the changes in the tax system in the simplified system of the model the average tax rates of an employed and an unemployed worker respectively and the average tax rate of capital income are calculated.

Income from employment is taxed with the tax rate of a full time employed worker in the model. It is assumed that a full time worker earns more than 130 900 Dkr., which corresponds to the allowance for collecting lower level additional income tax and approximately equals the maximum unemployment benefit. The average tax rate of income from employment have been calculated on the basis of the distribution of the personal income of Danish citizens whose income exceeded this limit of 130 900 Dkr. The data set contains the whole taxable population in 1995 and groups these people according to their level of personal income in income brackets for each 1.000 Dkr.

As the data set for 1995 has been used to calculate the average tax rate of an employed worker for every period, it has been assumed that the distribution of gross income does not change over time<sup>25</sup>. Furthermore it has been assumed that all personal income in the data set - when exceeding the limit of 130 900 - derives from labor income, and that deductible expenses are attached to personal income, i.e. not capital income.

<sup>25</sup>This means that the personal income data is first corrected for the labor market contribution rate for 1995 (6 percent.) to get a gross income (before any sort of taxation) and then the labor market contribution rate valid in each year is used to find the relevant personal income for the year in question.

First the average tax rate of wage income in each of the income brackets of the tax system starting from 130 900 Dkr. is calculated, where the capital income is omitted from the calculation. Using these results the (total) average taxation rate of an employed worker is defined as the weighted average of average tax rates for all brackets of the tax system. The weights used are the amounts of total income in each bracket (i.e. average income times the number of persons), relative to the total amount of personal income that is earned by persons earning more than 130 900 Dkr.

To determine the average tax rate on capital income the total tax as before is calculated for each income bracket, now however taking the capital income into account. The difference between this result and the total tax (found from the calculations referred to above) is then related to capital income, which in this residual manner results in the average capital income tax. The total average is again a weighted average for the different income brackets, but here all incomes above 29 600 Dkr. (this is the income tax threshold) is used, since the capital income is of relevance not only to people earning labor income. Each income bracket is divided into two groups containing persons with capital incomes below and above 20.200 Dkr. respectively. This is done in order to be able to account for the upper level of the additional income taxation. Furthermore the relevant weights are now calculated as the total numeric amount of capital income in the single income bracket relative to the sum of these numeric amounts for all the income brackets in question.

The calculation of the average taxation rates of *unemployed* workers is much simpler. For an unemployed worker starting from the maximum weekly unemployment benefit in the year in question measured in the 1995 price level, this is multiplied by 52. From here subscription to a labor union and unemployment fund for a full-time insured is deducted (in the amount below 130 900), and the income tax is calculated according to the current taxation rules and then related to the unemployment benefit yielding the average tax.

The calculated numbers are presented in table 10 below.



	1993	1994	1995	1996	1997	1998	(94-98)
Average taxation rate of an employed worker	45.1	43.3	42.7	42.3	42.1	41.5	42.4
Average taxation rate of an unemployed worker	35.7	31.4	30.6	30.0	29.2	28.1	29.9
Average taxation of capital income	51.5	49.3	48.7	48.2	48.0	46.7	48.2

Table 10. Average taxation rates, 1993-1998, percent

### The taxation of income from firm ownership

Transforming the tax system of firms in the Danish economy into the simplified tax system of the DREAM model involves several simplifying steps. The first major problem concerns the fact that all firms in the DREAM model are assumed to be joint-stock companies. As mentioned (in the main text) all firms are assumed to be owned by domestic citizens who are taxed according to the capital income tax system presented in the previous section of this appendix. However, a significant part of the bonds and share held by the private sector is in the hands of pension funds that are not subject to this taxation. Therefore the effects of changing tax rates in the capital income tax system is exaggerated in the present version of DREAM.

In the Danish economy a variety of different organizations of firms exists. Most importantly there is a large share of firms which are organized as non-incorporated firms and which are owned by the managers of the firm. These firms are typically small firms. Taxation of these firms has to be transformed into the taxation of joint-stock companies as these are the only type of firms in DREAM. To do this we interpret the taxes paid by the owners of these firms as dividend taxation in the model. This involves a reinterpretation of the tax rate of dividend,  $t_t^d$ . The following subsection describes the construction of the dividend tax rate.

The second major problem concerns the capital gain taxation. In the Danish tax system capital gains are taxed only on realization (both before and after the reform). In the model however, capital gains are taxed on accrual. To allow for this deferral of tax, the tax rate is converted into an effective accrued tax rate. The construction of this tax rate follows King & Fullerton (1984) but is adjusted to take account for special features of the Danish tax-system.

The construction of the effective accrued tax rate implies that the tax rate on accrued capital gains is identical to the discounted value of the tax rate on realized capital gains given that the assumptions of the pattern of realization are correct.

However, the timing of the tax revenue remains incorrect as the revenue is collected on accrual. The construction of the effective tax rate on accrued capital gains is presented in a subsection below.

### The effective marginal tax rate on dividends

The effective marginal tax rate on dividends,  $t_t^d$ , is calculated given the assumption that there exists both incorporated and non-incorporated firms. The hypothetical dividend tax rate of non-incorporated firms is constructed by means of two constructed tax rates, as the dividends are assumed to consist of both personal and capital income of the self-employees. An explanation of the calculation of these constructed tax rates is given below.

The starting point of the derivation is the dividend of the incorporated firms,  $D_t^s$ . The dividends of these joint-stock companies are given by

$$\begin{aligned} D_t^s = & (1 - t_t^c) \left( p_t Y_t^s - p_t^M M_t^s - (1 + t_t^a) W_t L_t^s - r_t B_{t-1}^{cs} \right) \\ & - p_t^I I_t^s + t_t^c \hat{\delta} \hat{K}_{t-1}^s + (B_t^{cs} - B_{t-1}^{cs}) \end{aligned} \quad (5.1)$$

Superscript  $s$  denotes joint stock companies. Observe, that this condition is of the same form as the definition of the overall dividend used in the model (see relation (4.3)). Similarly the arbitrage condition which defines the market value of the stock of shares of the incorporated sector is given as

$$r_t (1 - t_t^r) V_{t-1}^s = (1 - t_t^{ds}) D_t^s + (1 - t_t^g) (V_t^s - V_{t-1}^s) \quad (5.2)$$

which again has the same form as the overall arbitrage condition used in the model (see relation (4.1)).

Considering the non-incorporated firm, we define the sum of the personal income and capital income of the self employees as the cash flow after tax. Thus

$$\begin{aligned} D_t^w + D_t^k = & (1 - t_t^c) \left( p_t Y_t^p - p_t^M M_t^p - (1 + t_t^a) W_t L_t^p - r_t B_{t-1}^{cp} \right) \\ & - p_t^I I_t^p + t_t^c \left( \hat{\delta} \hat{K}_{t-1}^p + D_t^w + D_t^k \right) + (B_t^{cp} - B_{t-1}^{cp}) \end{aligned} \quad (5.3)$$

where  $D_t^w$  is personal income and  $D_t^k$  is capital income. Superscript  $p$  denotes personally owned firms. Observe that both personal income and capital income of the self employed is deductible in the corporate tax.

To determine the market value of the non-incorporated firms we assume that the self-employed is facing the following arbitrage condition

$$r_t (1 - t_t^r) V_{t-1}^p = (1 - t_t^W) D_t^w + (1 - t_t^r) D_t^k + (1 - t_t^g) (V_t^p - V_{t-1}^p) \quad (5.4)$$

where  $t_t^W$  is the relevant marginal rate of taxation of labor income.

Aggregation of dividends of the two types of firms i.e. of (5.1) and (5.3) implies that

$$\begin{aligned} D_t &\equiv (1 - t_t^c) D_t^w + (1 - t_t^c) D_t^k + D_t^s \\ &= (1 - t_t^c) \left( p_t Y_t - p_t^M M_t - (1 + t_t^a) W_t L_t - r_t B_{t-1}^c \right) \\ &\quad - p_t^I I_t + t_t^c \hat{\delta} \hat{K}_{t-1} + (B_t^c - B_{t-1}^c) \end{aligned} \quad (5.5)$$

which is the overall definition of dividends used in the model.

Summarily, aggregation of the market values of the different types of firms (sum of (5.2) and (5.4)) yields

$$\begin{aligned} r_t (1 - t_t^r) V_{t-1} &= (1 - t_t^W) D_t^w + (1 - t_t^r) D_t^k + (1 - t_t^{ds}) D_t^s \\ &\quad + (1 - t_t^g) (V_t - V_{t-1}) \end{aligned} \quad (5.6)$$

The fundamental assumptions with respect to the three different types of income from firm ownership may now be stated as

$$\begin{aligned} (1 - t_t^c) D_t^w &\equiv a D_t \\ (1 - t_t^c) D_t^k &\equiv b D_t \\ D_t^s &\equiv (1 - a - b) D_t \end{aligned} \quad (5.7)$$

Inserting this assumption into (5.6), we have that

$$r_t (1 - t_t^r) V_{t-1} = (1 - t_t^d) D_t + (1 - t_t^g) (V_t - V_{t-1}) \quad (5.8)$$

which is the overall arbitrage condition used in the model. This implies that the dividend tax rate,  $t_t^d$ , is defined as

$$t_t^d \equiv \frac{t_t^W - t_t^c}{1 - t_t^c} a + \frac{t_t^r - t_t^c}{1 - t_t^c} b + t_t^{ds} (1 - a - b) \quad (5.9)$$

The constructed tax rate of dividends,  $t_t^{ds}$ , is calculated on the basis of taxation of income from dividends. The tax reform implies a change in the taxation of dividends. In 1993, income from dividends that exceeded 32 900 Dkr. was taxed with a rate of 40 per cent, and income below the progression limit was taxed with 30 per cent<sup>26</sup>. The reform implies a change in the limit of progression, as certain

<sup>26</sup>In fact the tax rate of dividends less than 32 900 Dkr. was reduced from 45 per cent 40 per cent in 1993. This reduction could be argued to be a part of the tax reform. As we define the tax reform to be initiated in 1994, we assume that the 40 per cent rate was part of the initial tax system.

kinds of capital gains (see below) have to be added to the income from dividends, as this aggregate income is taxed as share income. The share income that exceeds 32 900 Dkr. is taxed with a rate of 40 per cent. Income below the progression limit is taxed with 30 per cent until 1996. From 1996 this rate is lowered to 25 per cent.  $t_t^{ds}$  is calculated as a weighted sum of the tax rates below and above the progression limit. The weights are assumed to be constant, even though the limit of progression has changed. The weights are calculated following OECD (1991).

The weights  $a$  and  $b$  are calculated as the ratios of the amount of personal income of self-employees to the amount of dividends, and the amount of capital income of self-employees to the amount of dividends, respectively<sup>27</sup>. Given these calculations the impact of the tax reform is modelled as a decrease in  $t_t^d$ , from  $t_{1993}^d = 36.2$  per cent to  $t_{1998}^d = 31.6$  per cent, which is due to the decrease in  $t_t^w$ ,  $t_t^r$  and the decrease in the taxation of share income below the progression limit.

### The effective accrued equivalent marginal tax rate on real capital gains

Prior to the tax reform, taxation of realized capital gains of households followed 3 basic rules

1. For shares which have been owned less than 3 years, realized capital gains are taxed as capital income.
2. For a *principal shareholder*, who has had ownership of the shares for 4 years, the realized capital gain from shares is taxed at a marginal rate of 50 per cent if the realized gain exceeds 67 400 Dkr. a year. For each year of ownership beyond the first 4 years the taxable realized gain is reduced by 10 per cent<sup>28</sup>. If the shares have been owned 8 years or more, then realized gain will be reduced by 50 per cent, and hence the effective marginal tax rate would be 25 per cent.
3. For a *minority shareholder*, who has had ownership of the shares for 3 years or more, realized capital gains are **not** taxed.

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<sup>27</sup>The split between personal income and capital income of self employees is calculated from "Skattepolitisk redegørelse 1996" (The Danish Ministry of Taxation). The split between joint stock companies and self employees is calculated from "Generel erhvervsstatistik og handel 1997:6" (Statistics Denmark).

<sup>28</sup>After 5 years - for instance -  $100 - 2 \times 10 = 80$  per cent of the realized capital gain is taxed at a marginal rate of 50 per cent corresponding to an effective marginal rate of  $0.8 \times 50 = 40$  per cent of the full capital gain.

After the initiation of the tax reform the distinction between principal and minority shareholders was replaced by a new split-up of people into two groups with capital gains above and below (respectively) a certain amount. Further a distinction between quoted and non-quoted shares was introduced. This can be summarized in the following 4 new rules

1. For shares which have been owned less than 3 year, realized capital gains are taxed as capital income.
2. For *quoted* shares that have a value less than 103 800 Dkr., and have been owned for 3 years or more, the realized capital gains are **not** taxed.
3. For *quoted* shares that exceed a value of 103 800 Dkr., and have been owned for 3 years or more, the realized capital gains are taxed at the rate of dividend taxation.
4. Realized capital gains from *non-quoted* shares that have been owned for 3 years or more are taxed at the rate of dividend taxation.

In the Danish tax system capital gains are taxed on realization. As mentioned taxation in the model is on accrued capital gains. Therefore the capital gain tax rate,  $t_t^g$  is calculated as an accrued equivalent marginal tax rate on real capital gains. It is assumed that all investors are households. Following King and Fullerton (1984),  $t_t^{g,i}$  is the present value of the stream of tax payment resulting per unit of capital gains accrued from period  $t-1$  to  $t$  for a shareholder of category  $i$ , where the categories reflects the different tax rules listed above (both before and after the reform was initiated).  $t_t^{g,i}$  is calculated using the formula

$$t_t^{g,i} = \lambda z_t^i \sum_{s=t}^{\infty} \left( \frac{1-\lambda}{1+r(1-t^r)} \right)^{s-t} = \lambda z_t^i \frac{1+r(1-t^r)}{\lambda+r(1-t^r)} \quad (5.10)$$

The present value is calculated assuming that the shareholder realizes a constant proportion,  $\lambda$ , of all shares per period<sup>29</sup>. It is assumed that  $\lambda$  equals 0.1 following King and Fullerton, implying that the average share is owned for 10 years.  $z_t^i$  is an average of the age dependent marginal tax rates (taking into account the age-structure of shares) that the shareholder of type  $i$  has to pay. It is calculated by

$$z_t^i = \sum_{v=1}^{\infty} z_{t,v}^i \lambda (1-\lambda)^{v-1} \quad (5.11)$$

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<sup>29</sup>The last equality follows as  $\frac{1-\lambda}{1+r(1-t^r)}$  must be less than 1 and the sum then is finite and can be simplified into a single fraction.

where  $z_{t,v}^i$  is the realized capital gain tax of the Danish tax system dependent on the number of years the share has been owned, i.e.  $v$  periods.  $\lambda(1-\lambda)^{v-1}$  is the share of all shares that have been held for exactly  $v$  years. Below  $t_t^{g,i}$  is calculated for the different categories of shareholders before and after the tax reform.

The tax rate **prior** to the tax reform,  $t_{1993}^g$ , is calculated using 3 assumptions

- 1) Non-principal shareholders do not realize any shares before the 3 years limit.
- 2) The realized capital gains of principal shareholder exceed 67 400 Dkr. a year.
- 3) 50 per cent of all shares are owned by principal shareholders<sup>30</sup>.

The first assumption implies that non-principal shareholders do not pay capital gain taxes:  $t_{1993}^{g,np} = 0$ . The second assumption implies that we can calculate the average tax rate,  $z_{1993}^p$  - given by (5.11) - for principal shareholders using the informations in tax rule (1). We get that  $z_{1993}^p = 36.7$  per cent. Substituting this into (5.10) yields  $t_{1993}^{g,p} = 30.3$  per cent. From the third assumption we have

$$t_{1993}^g = 0.5t_{1993}^{g,p} + 0.5t_{1993}^{g,np} = 15.1 \text{ per cent}$$

The tax rate,  $t_{1998}^g$ , **after** the tax reform is calculated using 4 assumptions

- 1) A shareholder, who owns a stock of quoted shares with a value less than 103 800 Dkr., will not realize any shares before the 3 years limit.
- 2) A shareholder, who owns a stock of quoted shares with a value above 103 800 Dkr., will have a realized capital gain that exceeds 32 900 Dkr. per year.
- 3) The realized capital gain of shareholders with non-quoted shares exceeds 32 900 Dkr. a year.
- 4) 50 per cent of the capital gains are capital gains from shares that are quoted on the stock exchange, and half of these capital gains originates from shares that are owned by shareholders with a stock of quoted shares that exceeds 103 800 Dkr.

There are three types of representative shareholders: shareholders owning a stock of quoted shares with a value less than 103 800 Dkr. ( $q1$ ), shareholders owning a stock of quoted shares with a value above 103 800 Dkr. ( $q2$ ), and shareholders owning non-quoted shares ( $nq$ ). According to the first assumption, the first type of shareholders will not pay any tax:  $t_{1998}^{g,q1} = 0$ . According to the second assumption, the second type of shareholders will pay the high tax rate on share income (40 per cent) for capital gains realized after 3 years. Knowing this we can calculate the average tax rate  $z_{1998}^{q2}$  given by (5.11):  $z_{1998}^{q2} = 41.5$  per cent. Substituting this into (5.10) yields  $t_{1998}^{g,q2} = 33.5$  per cent. For the same reason (and using assumption (3)) we know that  $t_{1998}^{g,nq} = 33.5$  per cent. Finally assumption

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<sup>30</sup>This assumption follows Lange (1997).

(4) implies that

$$t_{1998}^g = 0.5t_{1998}^{g,nq} + 0.25t_{1998}^{g,q^1} + 0.25t_{1998}^{g,q^2} = 25.1 \text{ per cent}$$

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