Chapter 9

Data sources and calibration

For computable general equilibrium models like DREAM calibration is the procedure which assigns numerical values to the parameters and exogenous variables of the model. DREAM employs a number of different data sources in the calibration process. The exogenous variables of the model are in some cases taken directly from external sources (e.g. base year GDP and many other NA variables). In other cases, data are combined or modified in order to conform to DREAM standards (a simple modification is the aggregation of production sectors to those used in DREAM), or relevant model equations are used to produce initial levels of variables which do not have a counterpart in external data (e.g. utility levels).

Parameters fixed a priori

In the case of the parameters of the model, some are calculated during the calibration process, whereas others are determined a priori. The reason is that the DREAM model contains more parameters than equations. Hence, some parameters have to be fixed in advance. The general principle in DREAM as in other CGE models is to fix those parameters a priori that are particularly important for the marginal properties of the model. Ideally, the value of these should be decided from empirical studies of the Danish economy. However, in practice in quite a few cases there exists only little empirical evidence (or none at all) for the value of a particular parameter, neither from Denmark nor comparable countries. In these situations, the choice of value necessarily must be made by the model builders on the basis of common-sense judgements of what creates sensible results.

9.1 Technique of the calibration process

Technically, the calibration of DREAM is divided into two stages: Static calibration and dynamic calibration. The static calibration is similar to the process of many non-dynamic CGE models which assume that the economy is in a steady state in the base year. Also in the static calibration of DREAM, it is assumed that the data from the Danish economy in the base year is in a steady state. This implies manipulating the data for intertemporal activities like savings and investment. Clearly, the static calibration results in unaccurate parameter values for intertemporal parameters like the mark-up values (which influence investment) or the parameters determining household savings. However, this does not matter as all parameters which influence intertemporal decisions are recalculated during the dynamic calibration anyway. Hence for the user interested in understanding what determines the values of the parameters and some initial values of variables in the actual projections made by DREAM, the dynamic calibration is the relevant process to understand.

Why then preserve the static calibration step at all? Firstly, some parameters which have no intertemporal significance are determined finally already during the static calibration. Secondly, the steady-state values of the model variables produced by the static calibration process are used as a useful starting point for the dynamic calibration. Thirdly, static calibration is used during the process of model development for conducting various consistency checks and other tests; errors or inconsistencies when updating data or changing the model structure are often caught during the static calibration. The static calibration also serves didactic purposes as it gives an understanding of the basic model structure for the model users.

9.1.1 Static calibration

Static calibration is performed for three time periods: t1 (the base year), t2 (the following year) and t0, which is an artificial "year" created in order to be able to calculate those data for t1 which depend upon pre-determined values from the preceding year (i.e. various stock variables). Hence, t0 should NOT be interpreted as a historical year - data are quite hypothetical. Also, in the static calibration values for t2 are the same as for t1 when adjusted for exogenous inflation and productivity growth because of the assumption that the economy is in its steady state.

9.1.2 Dynamic calibration

In the dynamic calibration, all exogenous variables for the total time horizon of the model (presently 115 periods, i.e. from 2003 to and including 2117) are used together with the parameters determined finally during the static calibration and the values for the initial year of the endogenous variables. This is used to generate values of the remaining model parameters. The important changes in the dynamic calibration compared to static calibration are:

1) Depreciation rates are recalculated to replicate the actual capital stock

2) The rate of foreign transfers to households $o_t^{F,H}$ is recomputed in order to give the actual balance of payments in the calibration year (whereas in the static calibration $o_t^{F,H}$ is residually determined to secure a constant foreign debt).

3) LD, ATP and SP and pension funds and once-and-for-all pensions are adjusted.

4) Because of the recalibrated depreciation rates, also the profit correction term for the government sector k^{Depr} is recalibrated as well as the two tax rates $t_{j,t}^{P,Weight}$ and $t_{j,t}^{P,Land}$ which are levied on capital stocks.

5) LD is closed down in 2029 when the youngest member reaches the age of 65.

6) The government debt and primary budget is recalculated to obtain the actual figures, and the correction term of source taxation is recalculated as well. Also the values of book capital in the initial year are recalculated because of the new depreciation rates.

7) Some anticipated policy changes are also introduced into the dynamic calibration. The principle is that future policy changes which were known but not yet implemented in the base year are still assumed to influence the forward-looking behaviour of the agents and are consequently also incorporated into the calibration process.

8) Parameters concerning the intertemporal allocations of households, e.g. the preference for leaving bequests, are recalculated.

9.1.3 Dynamic calibration and the base-line scenario

Even though the dynamic calibration process results in a full model projection, this result is not identical to the actual base-line projection which is used afterwards as the background to which various policy experiments and other shocks are compared. The main reason is that the calibration year is usually some years old, and it may be advantageous to incorporate more recent information, for instance changes in taxes or other policy rules announced after the calibration year. For that reason the base-line scenario is constructed as a shock (or possibly several consecutive shocks, one for each year after the calibration year in which such changes have been announced) to the calibration projection. In the present projection, 2003 is the calibration year and new shocks take place in 2004 as well as in 2005.

9.2 Procedure and Results

The exposition of the calibration procedure and the various data sources used which follows below ignores the distinction between static and dynamic calibration, instead presenting the main issues of the final calibration process for the variables and parameters in question, whether their actual determination takes place during static or dynamic calibration.

9.2.1 Population

Population data are taken from the annual population projection of DREAM, cf. Koch et al. (2004). Some manipulations are performed in order to make the population consistent with the model: Firstly, the population data are mediofied so that the DREAM population in the initial year (2003) is the average of the population as of January 1st, 2003 and January 1st, 2004, etc. Secondly, in DREAM, people cannot be older than 101 years, so that the people which are aged 102 years or more are excluded from the model population. In the population, there are about 100 people aged 102+ years initially, rising to about 2000 people in the projection in 2100 because of the increasing projected life-times.

9.2.2 Labour market

The number of people in the labour force for each age, gender and ethnical group in the base year is taken from the RAS data-base at Statistics Denmark. The main rule for the projection of the labour force in future years (which is made in a premodel and hence exogenous to the main DREAM model itself) is that the participation rate is constant for each particular age-, gender- and ethnically distributed group. There are two exceptions to this, however: Firstly, certain government policies are assumed to change participation rates, i.e the phasing out of leave allowances and bridging benefits and the reduction of the old-age pensions entitlement age from 67 to 65 years during 2005-06. Secondly, in the case of immigrants, there is empirical evidence that for immigrants of a given age, gender and origin area, participation rates will also depend on the number of years they have been resident in Denmark. For the two immigrant groups, participation rates consequently also depends on the average number of years of residence in Denmark for persons of a given age or gender.

Unemployment as well as numbers of hours worked for each individual in the labour force is endogenous in DREAM's projection, but in the initial year age-, gender- and origin-specific unemployment rates are taken from the RAS data-base. As these do not completely yield the official over-all unemployment rate when aggregated, they are all scaled to this over-all rate as taken from Statistics Denmark[1]. Age-, gender- and origin-specific average working hours per week are taken from the labour market data base IDA at Statistics Denmark and used to transform the number of people on the labour market into full-time equivalents.

For people in employment, their productivity (ρ_t) is age-, gender- and origin-specific. These productivity profiles are taken from the Law Model.

In the present projection, the annual working time determined by collective agreements is scheduled to fall slightly during the first years after the initial calibration year. Data for the calculated fall in negotiated annual working hours are received from the Ministry of Finance.

[1] Statistiske Efterretninger: Arbejdsmarked.

Calibration of labour supply parameters

The hypothetical full-employment labour supply $L^{Max}_{o,s,a,t}$ and actual labour supply $L^{S}_{o,s,a,t}$ are determined in (5.55) and (5.57). They depend upon the general wage level, various tax rates, unemployment benefits and the consumer price index, which are commented on below, and on the labour-supply elasticities γ and γ^{LFull} and the scale parameters $\eta_{o,s,a}$ and $\zeta_{o,s,a}$. γ is set to 0.1 following Danish estimations, cf. Frederiksen et al. (2001). The hypothetical γ^{LFull} by construction is restrained to be smaller and is accordingly set to 0.08. Then $\eta_{o,s,a}$ and $\zeta_{o,s,a}$ can be calibrated residually by reversing the equations.

9.2.3 Capital stocks and depreciation rates

Building and machinery capital stocks in the base year are taken from the ADAM data bank. There exist two alternative measures of the capital stock: gross and net values. The gross capital stock is the value of all capital goods evaluated at replacement prices (prices of new investment goods) and consequently corrects for physical decay (only). The net capital stock takes remaining lifetimes into account and consequently also corrects for economic decay. Broadly speaking, the gross capital stock is the best measure of production capacity and therefore the most relevant one for purposes of production functions, whereas the net capital stock is the best measure of wealth. In case of a constant physical depreciation rate, the two concepts are identical because physical and economic decay then coincide. As DREAM has constant depreciation rates, only one concept of capital is possible in the model, so a choice must be made between the two. DREAM uses the net capital stock because top priority is given to measuring the wealth of households accurately. At the same time, the resulting misspecification in the production function is considered not to be very important. The reason is that in any case, the production function should ideally be specified with the services of the capital stock as input. As such data are non-existent, the capital stock is used as input alternatively, assuming that the services are proportional to the stock. At a given point in time, measuring the stock inaccurately simply amounts to redefining the factor of proportionality.

Depreciation rates

The depreciation rates of machinery capital in the various sectors are calculated from the figures for depreciation $Depr^{P,M}_{t1,j}$, investment $I^{K,M}_{t1,j}$ and end-of-year capital stocks $K^{P,M}_{t1,j}$ of the base year in the national accounts:

$$\delta^{P,M}_j = \frac{Depr^{P,M}_{t1,j}}{K^{P,M}_{t1,j} + Depr^{P,M}_{t1,j} - I^{K,M}_{t1,j}}, \qquad j \in \{P, C, G\}.$$

The denominator replicates the start-of-year capital stock. For building capital, the equation is quite similar. The resulting values are shown in table X:

Parameter	Sector	Value
$\delta^{P,M}$	P	0.1566
$\delta^{P,M}$	G	0.1750
$\delta^{P,M}$	C	0.1597
$\delta^{P,B}$	P	0.0381
$\delta^{P,B}$	G	0.0428
$\delta^{P,B}$	C	0.0368
$\delta^{P,B}$	D	0.0288

9.2.4 Production

The input-output-table in DREAM

The input-output-table of DREAM is a central part of the model which gives a picture of production, factor incomes and demand of the whole economy. The input-output table fundamentally builds upon an aggregated version of the input-output table of the national accounts, but with some modifications which are relevant for the modelling in DREAM. Out of the 25 rows of the table, the first 5 rows represent provision of goods (from 4 domestic production sectors including dwelling services plus imports) measured at factor prices except that imports include net customs tax payments. The next 16 rows represent the payments of the 16 different kinds of production taxes and subsidies distinguished in the model. The final rows show renumeration of the tree kinds of primary inputs (wages, capital income and the special resource rent from the North Sea) and of installation costs in the two private production sectors.

The 17 columns represent the categories of economic activity distinguished in DREAM: intermediate inputs into the four production sectors plus 13 kinds of final use: private consumption, government consumption, machinery investments in three sectors and building investments in four sectors, exports, inventory investments and finally installation costs in the two private production sectors. The table consequently gives total production value for each sector, total value for all final demand categories, total value of all production taxes and subsidies, and total value of renumeration of factor inputs.

Construction of the input-output-table

There are two main data sources for constructing the I-O table. The ADAM data bank, which contains preliminary input-output data for the calibration year, supplies the majority of row and column totals and the cell values for indirect taxes and primary inputs. The remaining cell values are constructed from the row and column totals using coefficients from the last final year of the input-output tables from Statistics Denmark. Hence, these coefficients are from a previous year than the totals, and the resulting cell values are not directly derivable from the input-output tables of the ADAM data bank used by various other institutions. This approach is more suitable for DREAM's purposes, cf. Sørensen (2003). A RAS procedure secures internal consistency between the various figures of the table.

The values for installation costs are constructed by DREAM and represent resources used up in the installation process. Consequently, they are additional to official production figures and should be subtracted before GDP, etc. are calculated from the table. The special North Sea resource rent is also calculated specifically by DREAM. For a more detailed explanation of the calculation of both installation costs and resource rents, see below.

	Fp	Fc	Fd	Fg	c	g	IMp	IMc	IMg	IBp	IBc	IBd	IBg	X	Res	IncM	IncB	Total
Yp	601.419	69.442	-	58.874	224.172	23.673	53.346	3.266	3.919	1.985	0.053	4.590	0.264	594.009	0.948	4.672	0.632	1645.3
Yc	37.986	27.599	-	4.943	18.324	5.507	-	-	-	54.047	1.474	39.295	13.281	-	0.035	0.456	0.018	203.0
Yd	-	-	-	-	91.325	-	-	-	-	-	-	-	-	-	-	-	-	91.3
Yg	15.361	0.476	-	9.259	16.028	309.300	-	-	-	-	-	-	-	0.231	-	-	-	350.7
Partial sum	654.8	97.5	-	73.1	349.8	338.5	53.3	3.3	3.9	56.0	1.5	43.9	13.5	594.2	1.0	5.1	0.6	2290.2
Mp	233.156	30.602	-	13.592	157.530	3.286	60.137	5.856	3.118	-	-	-	-	-	0.327	-	-	507.6
TREmp	1.867	0.219	-	0.939	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0
TRLand	7.755	-	6.901	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.7
TRWeight	1.389	0.241	-	0.092	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7
TRW	3.939	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.9
TRRes	0.402	0.059	-	0.084	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5
SRDwe	-5.706	-1.876	-	2.169	-	-	-	-	-	-	-	-	-	-	-	-	-	-5.4
SRGRes	-8.567	-1.253	-	-1.781	-	-	-	-	-	-	-	-	-	-	-	-	-	-11.6
SRSetASide	-0.548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.5
SREURes	-0.811	-0.119	-	-0.169	-	-	-	-	-	-	-	-	-	-	-	-	-	-1.1
TRReg	-	-	-	-	8.214	-	3.674	0.636	0.244	-	-	-	-	-	-	-	-	12.8
TRVAT	15.498	1.353	-	14.578	74.338	1.508	4.122	0.047	1.258	3.004	-	10.197	2.646	-	-	-	-	128.5
TRDuty	23.798	2.240	-	2.091	35.772	-0.0003	-0.034	-0.003	-0.003	0.176	0.004	0.430	-0.007	-	-0.100	-	-	64.4
SRGSpe	-9.037	-	-	-	-1.220	-	-	-	-	-	-	-	-	-1.376	-	-	-	-11.6
SRRural	-4.614	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-4.6
SRSpe	-0.623	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.6
SRExp	-	-	-	-	-	-	-	-	-	-	-	-	-	-1.999	-	-	-	-2.0
Partial sum	24.74	0.86	6.90	18.00	117.10	1.51	7.76	0.68	1.50	3.18	0.00	10.63	2.64	-3.37	-0.10	-	-	192.0
NSea	10.290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.3
W	463.565	60.646	-	219.284	-	-	-	-	-	-	-	-	-	-	-	-	-	743.5
Cap	253.440	12.862	84.424	26.698	-	-	-	-	-	-	-	-	-	-	-	-	-	377.4
Partial sum	727.30	73.51	84.42	245.98	-	-	-	-	-	-	-	-	-	-	-	-	-	1131.2
IncM	4.672	0.456	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.1
IncB	0.632	0.018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6
Total	1645.3	203.0	91.3	350.7	624.5	343.3	121.2	9.8	8.5	59.2	1.5	54.5	16.2	590.9	1.2	5.1	0.6	4126.8

Input-output-table in billion DKK, 2003.

Installation costs Installation costs are determined according to (4.11) and (4.12) as the square of investment relative to the existing capital stock, scaled by the parameters $k_j^{I,P,M}$ and $k_j^{I,P,B}$. These are each set to 0.2.

Resource rent from the North Sea The special resource rent from the North Sea is calculated using data for energy production in the North Sea from the Danish Energy Authority. To get from energy production to pure resource rents an estimation of the relationship between energy production and resource rents from the Ministry of taxation[2] is used which suggests that the extraction of 100 million m3 oil corresponds to a resource rent of DKK 34,957 million in 2001.

The value of the resource rent is subtracted from ordinary capital income for the manufacturing sector to respect the over-all identity income.

[2] Rapport fra Kulbrinteskatteudvalget, 2001

Prices

According to the Harberger convention, units of measurements of all real goods are defined so that all net prices (market prices net of all production taxes and subsidies) are equal to one in the calibration year. The price (more precisely, price index) levels used in DREAM, however, are market prices including excise taxes and subsidies. Consequently, they are modified accordingly with the relevant taxes. For instance, the price (index) of government consumption in the initial year is

$$P^{C,G} = 1 + t_{t1}^{G,Reg} + t_{t1}^{G,VAT} + t_{t1}^{G,Duty,V} + t_{t1}^{G,Duty,Q} - s_{t1}^{G,G,Dwe} - s_{t1}^{G,G,Spe} - s_{t1}^{EU,G,Spe} = 1.0044. \quad (9.1)$$

That is, the price index of government consumption in the calibration year is equal to one plus the tax rates of registration duties, VAT and excise duties minus the subsidy rates of dwelling subsidies and product-specific government- and EU-financed subsidies.

$P^{C,G}$	Government consumption price index
$P_k^{C,G,1}$	Government consumption price index for intermediate goods
$P_{k,c}^{C,G,2}$	Government consumption price index for goods
$P_e^{C,H}$	Consumer price index
$P_{e,k}^{C,H,1}$	Consumer price index for intermediate goods
$P_{e,k,c}^{C,H,2}$	Consumer price index for goods
P_j^{H}	KL price index
$P_j^{I,P,B}$	Price index for IPB
$P_{j,k}^{I,P,B,1}$	Price index for IPB1
$P_{j,k,c}^{I,P,B,2}$	Price index for IPB2
$P_j^{I,P,M}$	Price index for IPM
$P_{j,k}^{I,P,M,1}$	Price index for IPM1
$P_{j,k,c}^{I,P,M,2}$	Price index for IPM2
$P_D^{K,H,B}$	Household residential buildings price
$P_D^{K,H,B,User}$	User costs of residential buildings
$P_D^{K,H,L}$	Household residential land price
$P_D^{K,H,L,User}$	User costs of residential land
P_j^{M}	Price index for M
$P_{j,k}^{M,1}$	Price index for M1
$P_{j,k,c}^{M,2}$	Price index for M2
P_j^{O}	Marginal revenue optimization price
P_j^{Y}	Net output price index producer price

An exception to the Harberger convention are the user-cost prices of residential buildings and land $P_D^{K,H,B,User}$ and $P_D^{K,H,L,User}$. $P_D^{K,H,B,User}$ represents the user cost of possessing one unit of residential building for one year and is calculated as

$$P_D^{K,H,B,User} = (t^{Dwe} + k^{User} + i^H)P_{D,t-1}^{I,P,B} + \delta_D^{P,B} P_D^{I,P,B} - (P_{D,t}^{I,P,B} - P_{D,t-1}^{I,P,B}).$$

The first term represents tax payments on owner-occupied dwellings and the alternative interest on the value of the building (which includes the calibration term k^{User}). The second term represents depreciation of the building, and the third term potential capital gains.

$P_D^{K,H,L,User}$ is calculated after the same principle, but it is taken into account that there is also a property tax on land; on the other hand, land does not depreciate:

$$P_D^{K,H,L,User} = (t^{Dwe} + t^{H,Land} + k^{User} + i^H)P_{D,t-1}^{K,H,L} - (P_{D,t}^{K,H,L} - P_{D,t-1}^{K,H,L}).$$

Mark-up values

The mark-up factors for the firms in the two private production sectors are determined residually during the final multi-equation calibration procedure. Their values are around 1-2 per cent, cf. table. For a comparison with Danish estimated values, Hylleberg and Jørgensen (1998) find markup ratios in the range from 0 to 0.25. DREAMs calibrated values are consequently in the lower end of the range.

Parameter	Value
$markup_{C,t1}$	0.0108
$markup_{P,t1}$	0.0213

Parameters of the production function

The production functions contain several parameters which are either substitution elasticities between inputs or distribution parameters. Substitution elasticities are determined a priori, as far as possible following literature surveys of existing empirical evidence. The substitution elasticity between labour and capital σ^H, and the substitution elasticity between the capital-labour aggregate and materials σ^Y, are taken from the Danish static CGE model GESMEC, cf. Frandsen et al. (1995). The elasticity of substitution between materials from the manufacturing, construction and government sectors σ^M, on which there exists scarce empirical evidence, is assumed to take the very moderate value of 0.1. For the elasticity of substitution between buildings capital and machinery capital σ^K in the capital aggregate and between inputs to building investments from the construction sector and the manufacturing sector $\sigma^{I,P,B}$ empirical figures are also not well-known. In the first case, substitution is considered to be at the same level as σ^H ($\sigma^H = \sigma^K = 0.6$). In the second case, again the very moderate value of 0.1 implying almost no substitution has been chosen.

The elasticities of substitution between domestic and imported goods as regards materials (σ^{M1}) and machinery investment ($\sigma^{I,P,M1}$) are assumed to take the value of 5 parallelly to the export price elasticity and all other foreign trade elasticities. This value is higher than in empirical estimates for Denmark. In the Danish macro-economic model MONA the long-run export price elasticity is found to be 2, cf. Danmarks Nationalbank (2003), and in SMEC it is 3, cf. Bocian et al. (1999). Nielsen (Heino, 2002?) also reports an export price elasticity of 3. However, there are strong theoretical reasons for expecting the foreign trade elasticities of a small open economy to be large in the very long run, and it can be conjectured that empirical estimates on time series covering around 30 years underestimate the elasticities in the very long-run perspective relevant here. For this reason all foreign trade elasticities in DREAM are given the numerical value of 5.

All the results are seen in the table below.

σ^Y	Elasticity of substitution (M-H) in production function	0.25
σ^M	Elasticity of substitution (C-P-G) in production function	0.1
σ^H	Elasticity of substitution (L-K) in production function	0.6
σ^{M1}	Elasticity of substitution (D-F) in production function (materials)	5
σ^K	Elasticity of substitution (B-M) in production function (capital)	0.6
$\sigma^{I,P,B}$	Elasticity of substitution (C-P) in production function (investment)	0.1
$\sigma^{I,P,M1}$	Elasticity of substitution (D-F) in production function (mach. investment)	5

Distribution parameters are calibrated residually in single-equation calculations by reversing the relevant demand equations. For instance, μ_j^M is determined by reversing equation (4.82) to give

$$\mu_j^M = \left(\frac{P_{j,t1}^M}{P_{j,t1}^O}\right)\left(\frac{M_{j,t1}}{Y_{j,t1}^{Gross}}\right)^{\frac{1}{\sigma_j^Y}}. \tag{9.2}$$

When the prices $P_{j,t1}^M$ and $P_{j,t1}^O$ are already determined, cf. above, $M_{j,t1}$ and $Y_{j,t1}^{Gross}$ are known from the input-output-table and σ_j^Y is chosen above, this equation determines uniquely μ_j^M.

9.2.5 Final demand

Private consumption

The level of the various components of total private consumption in the initial year are given from the IO table. As was the case for the production functions, the various elasticities of substitution in the nested utility function are determined in advance, as can be seen in the table below, whereas the distribution parameters can be calibrated residually in single equations like 9.2. The substitution of elasticity between housing and non-housing σ_C^C has taken its value of 1.1 from the Norwegian CGE model MSG6 which again builds on estimations of Norwegian consumer demand documented in Holtsmark and Aasness (1995). This is identical to the value of the elasticity of substitution between goods from the government and from the private manufacturing sector σ_N^C, although this elasticity is independently calculated using the long run uncompensated own price elasticity of services in private consumption of -1.06, cf. Dam (1996). As most of the governmentally produced good in private consumption consists of services, we assume that the own price elasticity of this good is -1.06. The elasticity of substitution is then found using the ordinary formula linking uncompensated own price elasticities and substitution elasticities, i.e.:

$$\sigma_N^C = \frac{\varepsilon_{G,G} + S_G}{S_G - 1} = \frac{-1.06 + 0.046}{0.046 - 1} \approx 1.1,$$

where $\varepsilon_{G,G}$ is the uncompensated own price elasticity of the governmentally produced good and S_G is the cost share of that good which is calculated from the IO table.

For the elasticities of substitution between the repair good and dwellings and again between residential buildings and land we do not know any estimations, but assume that the substitutability is low. Both these elasticities are consequently awarded the value of 0.2.

σ_C^C	Elasticity of substitution (H-N) in household consumption bundle	1.1
σ_H^C	Elasticity of substitution (D-R) in household consumption bundle	0.2
σ_N^C	Elasticity of substitution (G-P) in household consumption bundle	1.1
$\sigma^{K,H}$	Elasticity of substitution (B-L) in household consumption bundle	0.2
σ^{C1}	Elasticity of substitution (D-F) in household consumption bundle	5

Government consumption

The level of government consumption is taken from the IO table. Like private consumption, elasticities of substitution for government consumption are determined in advance (and their values are assumed to be identical to those of private consumption) and the distribution parameters are calibrated residually in single equations.

$\sigma^{C,G}$	Elasticity of substitution (C-P-G) in government consumption bundle	1.1
$\sigma^{C,G1}$	Elasticity of substitution (D-F) in government consumption bundle	5

Investment

Investment levels are taken directly from the IO table.

Exports

There are two exporting sectors: the manufacturing sector and the government production sector. Export levels are taken from the IO table. Equation (8.1), which governs exports, additionally contains various taxes which are accounted for above and the parameters ε_i and μ_i^X. As mentioned above, the price elasticity of export demand ε_i like all other foreign trade elasticities is set to 5, after which the scale parameter μ_i^X can be calibrated residually by reversing (8.1).

9.2.6 Government finances

In general, data for government revenues and other incomes are taken from ADAM's databank. Data for indirect tax revenues in particular are calculated when computing DREAM's input-output table, cf. above. Data for tax revenues of middle-bracket and top-bracket taxes and for the tax on owner-occupied dwellings (which are subsets of the source tax revenue) are supplied from the Ministry of taxation. For two particular taxes the revenue is not calibrated to the actual revenues of the base year: the tax on yields of pension scheme assets (TR^{Pens}) and the category Other personal income taxes (TR^{CapPen}). The reason is that the model-generated tax revenue is supposed to reflect a long-run steady-state revenue better than actual revenues which may vary considerably from year to year. Total tax revenues are calibrated to actual tax revenues, however, and the discrepancy in each year caused by the special treatment of these two taxes is caught by the calibrated lump-sum transfer $o_t^{H,G,LumpRev}$.

Data for initial government debt and for government expenditures also are taken from ADAM or (concerning the subdivision of government consumption or transfers to households into their constituent sub-categories) from Statistics Denmark[3].

Calculation of indirect and direct tax rates

In DREAM as in other aggregate CGE models, actual tax revenues usually differ from the revenue obtained when multiplying a particular tax base from the model with the corresponding official tax rate. There may be various reasons for this: Errors in the original data used, lack of consistency between various data sources, or modelling decisions which ignore certain rules of the existing tax system such as tax exemptions and allowances, etc. When determining the size of tax rates used in the model, CGE modellers consequently generally have to choose one of two possibilities: Either the official (statutory) tax rates can be used, or effective tax rates (actual revenue divided by the corresponding tax rate) can be calculated. This choice contains a trade-off. The last possibility naturally most accurately and easily replicates the actual revenue. On the other hand, statutory tax rates normally are the relevant ones for marginal decisions influencing the behaviour of the central agents. As the use of statutory tax rates generates a wrong amount of revenue, it is however necessary to introduce various correction terms which are then calibrated to replicate the government budget of the base year.

As a main rule, in DREAM statutory tax rates are used for direct taxes and effective tax rates for indirect taxes. From the input-output table, the indirect tax rates for VAT, motor vehicle registration duties, excise duties, property (i.e. land) taxes, motor vehicle weight duties (for both firms and households, even though the last mentioned is considered a direct tax in NA connections) and the residual tax rate $t_t^{P,Res}$ in the initial year are computed by dividing the revenue from the relevant cell with the corresponding tax base from the corresponding cells. For instance, VAT tax rates for household consumption are calculated as

$$t_{e,t}^{H,VAT} = \frac{74.338}{349.8 - 91.325 + 157.53} = 0.1787 \qquad , e \in \{R, G, P\},$$

where the figures can be found from table IO: DKK billion 74.338 is the total VAT revenue from private consumption, 349.8 is total private consumption delivered from domestic sectors, 91.325 is the imputed value of dwelling consumption (which is subtracted as it is not subject to VAT), and 157.53 is the value of imports for private consumption. The resulting effective VAT

[3] Statistiske Efterretninger: Offentlig forvaltning og service, and statistikbanken.dk: Offentlig sektors finanser 2003, realøkonomisk fordeling og sektor.

rate of 17.87 per cent is used uniformly across the tax liable categories of private consumption.

Customs tax rates

Unlike the other indirect tax rates treated above, we do not have data for sector-specific customs tax revenues. Instead, the total customs tax revenue divided by total imports net of customs taxes is used to determine the customs tax rates $t_t^{G,Cus}$, $t_{d,t}^{H,Cus}$, $t_{j,t}^{I,B,Cus}$, $t_{j,t}^{I,M,Cus}$ and $t_{j,t}^{M,Cus}$ (which are all equal to 0.0045).

Direct taxes

Concerning direct taxes, the statutory values for t_t^{Cou}, t_t^{Mun}, t_t^{Chu}, t_t^{Bot}, t_t^{Mid}, t_t^{Top}, t_t^{EITC}, $t_t^{Payroll}$, t_t^{Cor} and t_t^{Z} are taken from the official figures of the Danish Ministry of Taxation. t_t^{Dwe} in DREAM is set to 1.1 per cent, which reflects the statutory rate for most dwellings of 1 per cent plus an assumed supplement of 0.1 per cent reflecting the progressive rate of 3 per cent for very highly-valued dwellings.

The tax rates for personal capital income $t_t^{H,Int}$, $t_t^{H,Div}$ and $t_t^{H,Gain}$ are calculated in a pre-model, cf. Knudsen (2001). The same is true for $t^{EITCEff}$ and r^{EITC} and for the age-dependent parameters used to determine middle-bracket and top-bracket tax revenues $k_{a,t}^{Mid1}$, etc. The variables k_t^{Mid} and k_t^{Top} are determined residually during dynamic calibration as the values which make (5.8) and (5.9) reproduce the actual tax revenues of the calibration year.

Calculation of per capita government transfers

For most income-replacing government transfer arrangements, the per capita amount in the base year is simply given as the average amount received per person. For instance, for the post-employment wage, the calibration equation becomes:

$$o^{G,H,PEW} = \frac{OR^{rPEW}}{\sum\sum\sum N^{Ind,r^{PEW}}}, \tag{9.3}$$

where OR^{rPEW} is the total amount of post-employment wage transfers paid out. This formulation ignores the fact that the actual post-employment wage paid out may differ according to the age when entering the arrangement, pensions savings, etc. The following table shows the value of all the government transfers which are calculated in the same way:

Name of transfer	Value, DKK	Description
$o^{G,H,AB}$	125.346	Activation benefits
$o^{G,H,AP}$	126.760	Anticipatory pensions
$o^{G,H,BB}$	130.374	Bridging benefits
$o^{G,H,CA}$	125.346	Cash assistance
$o^{G,H,CS}$	26.907	Civil servants' pension
$o^{G,H,IB}$	62.673	Introductory benefits
$o^{G,H,LA}$	82.079	Leave allowance
$o^{G,H,MB}$	173.178	Maternity benefits
$o^{G,H,OAP}$	88.657	Old-age pensions
$o^{G,H,OAPBase}$	55.233	Old-age pensions, base amount
$o^{G,H,OAPAdd}$	33.424	Old-age pensions, additional amount
$o^{G,H,PEW}$	133.729	Post-employment wage
$o^{G,H,S}$	28.143	Student allowances
$o^{G,H,SB}$	169.776	Sickness benefits

Note that in DREAM civil servants' pensions are paid to *all* citizens over the eligible age unlike the other transfers. Concerning old-age pensions, the total amount paid by the government in the base year is divided between the base rate and the additional pension according to micro simulations carried out by the DREAM group.

Tax depreciation rates

The value of $\delta_{j,t}^{P,M,Book}$ is taken from ADAM's data bank and is equal to 0.25 for all sectors. The value of $\delta_{j,t}^{P,B,Book}$ is 0.05, which is the central statutory depreciaton rate for buildings allowed by Danish tax laws. Note that in both these cases, these values are larger than the calibrated real depreciation rates listed on page 257.

Book values of capital stock

For lack of any data, $K_{j,t0}^{P,M,Book}$ and $K_{j,t0}^{P,B,Book}$ are calculated as if the economy was in a long-run steady-state in the calibration year. The accumulation equation for $K_{j,t}^{P,M,Book}$ is (4.14), reproduced here for convenience:

$$K_{j,t}^{PMBook} = (1 - \delta_{j,t}^{P,MBook}) K_{j,t-1}^{PMBook} + p_t^{PIM} I_{j,t}^{M}. \tag{9.4}$$

In steady state, the value of book capital grows with the product of productivity growth and exogenous inflation, the (real) capital stock grows with the productivity growth rate, and net investment must equal state-steady capital growth:

$$K_{j,t}^{PMBook} = (1+g_t)(1+g_t^P)K_{j,t-1}^{PMBook}, \quad (9.5)$$

$$K_{j,t}^{PM} = (1+g_t)K_{j,t-1}^{PM}, \quad (9.6)$$

$$I_{j,t}^{M} - \delta_{j,t}^{P,M} K_{j,t-1}^{PM} = g_t K_{j,t-1}^{PM} \Longleftrightarrow I_{j,t}^{M} = (\delta_{j,t}^{P,M} + g_t)\frac{K_{j,t}^{PM}}{1+g_t}. \quad (9.7)$$

Inserting these three equations above yield the steady-state result

$$K_{j,t}^{PMBook} = \frac{1-\delta_{j,t}^{P,MBook}}{(1+g_t)(1+g_t^P)} K_{j,t}^{PMBook} + p_t^{PIM} \frac{(\delta_{j,t}^{P,M}+g_t)}{1+g_t} K_{j,t}^{PM}, \quad (9.8)$$

Rearranging this for period 1 and again using the steady-state relations (9.5) and (9.6), we achieve the single-equations

$$K_{j,t0}^{PMBook} = \frac{p_{t1}^{PIM}(\delta_{j,t1}^{P,M}+g_{t1})(1+g_{t1}^P)}{\delta_{j,t1}^{P,MBook} + g_{t1} + g_{t1}^P + g_{t1}g_{t1}^P} K_{j,t0}^{PM}, \quad (9.9)$$

which determines $K_{j,t0}^{PMBook}$ as a function of $K_{j,t0}^{PM}$. A set of similar equations determines $K_{j,t0}^{P,B,Book}$.

9.2.7 Growth, inflation and interest rates and the risk premium of shares

The labour-augmenting (Harrod-neutral) annual rate of productivity growth in DREAM is 2 per cent. 2 per cent is close to the historical average of many Western countries (including Denmark) of annual growth in GDP per capita since the industrial revolution. However, though GDP per capita rises with the productivity growth rate in steady state, the two concepts are not identical, and the productivity growth rate should be determined on the basis of growth accounting. In Jensen et al. (2002, NØT) the annual multifactorproductivity growth rate for Denmark from 1966-98 is reported to be between 1.2 and 1.6 per cent, depending on the exact specification and the treatment of educational changes in the labour force. Bearing in mind that multifactorproductivity should be divided by labour's production share to translate into labour-augmenting productivity growth rates, these figures are consistent with a Harrod-neutral productivity growth rate of around 2 per cent[4].

[4] According to the IO table, labour's production share is 0.657. $\frac{1.2}{0.657} \approx 1.8$, whereas $\frac{1.6}{0.657} \approx 2.4$.

The foreign inflation rate is 1.75 per cent. This figure is not based on historical averages because past monetary history is considered to be influenced by several regime shifts (the latest being the establishment of the EMU in 1999) so that earlier inflation records are not judged to be very reliable indicators of future inflation. Instead, it it assumed that the inflation target of the EMU of an inflation not exceeding 2 per cent annually will be adhered to in future (and that the non-EMU trading partners of Denmark will experience similar long-run inflation rates or alternatively a corresponding trend in exchange rate adjustments), resulting in an average inflation rate slightly under 2 per cent, i.e. 1.75 per cent.

The nominal bond interest rate in DREAM is 4.75 per cent. This figure is found as the rate of foreign inflation plus a real interest rate of 3 per cent annually. According to Abildgren (2005), the historical average real return to long-term Danish government bonds from 1875 to 2003 was 3.1 per cent, and the average real short-run interest rate during the same period was 2.9 per cent.

The risk premium of shares of 0.041 is taken from the study of the equity premium of Danish shares compared to Danish government bond yields from 1924-99 performed by Nielsen and Risager (2001), p. 75.

9.2.8 Labour-market pension funds, private pensions, ATP, SP and LD funds

LD

The initial wealth of the LD Fund is taken from the annual report of The Danish Financial Supervisory Authority (Finanstilsynet). Total payments from the fund in the base year are taken from ADAM's data bank (the variable TPLDU) and distributed between all non-disabled persons at the eligible age, i.e. the retirement age a^{OAP}.

$$b^{LD}_{aOAP,t1} = \frac{TPLDU/1000}{\sum_{s \in S} N^{Able}_{s,aOAP,t1}}.$$

For all future years an alternative principle is used: The benefits are kept constant in growth- and inflation-corrected units and calculated so that the net present value of total payments for all years until 2031 are equal to the initial wealth. In 2031, the fund is assumed to pay out its last assets after which it is discontinued.

Labour market pension funds and private pensions

The figures for aggregate wealth in the labour market pension funds and the private pensions is taken from the annual report of The Danish Financial Supervisory Authority (Finanstilsynet). The distribution on individual generations in the pension fund follows data collected from the relevant pension institutions during 2004-05, as does the division between wealth reserved for retirement, disablement and spouse pensions. Total contributions to the pension fund in the base year is taken from ADAM's data bank and used to calculate q^{ZF}. Concerning private pensions, data for the generational wealth distribution and for the age distribution of contributions have been constructed by the Danish Economic Council, cf. Pedersen and Stephensen (1999).

SP and ATP

Total SP wealth is taken from ADAM and total ATP wealth from The Danish Financial Supervisory Authority (Finanstilsynet). Base-year contributions for both SP and ATP are from the annual report of The Danish Financial Supervisory Authority. Payments from the funds to the households are endogenous, even in the base year.

9.2.9 Household wealth and savings

The distribution of initial household wealth across generations is determined by the parameter wWealth_a, which sums to 1 across all generations from 17-year-old people until and including the generation aged 76 years. It is calculated from data for residential and financial household wealth in the base year from the Law Model. (figur).

The fraction of financial household wealth which consists of shares w^{Assets} is set to be $1/3$. The corporate debt share of the replacement value of capital $D^P_{j,t}$ is set to 0.6, following Schultz Møller (1993).

Household savings are indirectly given by the Keynes-Ramsey rule, which again contains three important parameters: ν, θ and χ. The intertemporal elasticity of substitution ν is set to 0.6. This is within the range of estimates from foreign (mostly American) studies which find values from practically zero to around two, with the majority being less than 1. Gruber (2006) provides a recent overview over these studies and methodological problems connected with estimating the intertemporal elasticity of substitution. Also for the rate of time preference θ Danish empirical evidence is scarce. θ is set to 0.01, which again is considered within the range of estimates in the international literature. Frederick et al. (2002) and Møller (2003) provide critical reviews of several empirical investigations, including results that range from zero to very large, as well as various attacks on the notion of a constant rate of time preference altogether.

The preference for leaving bequests χ is calculated residually during the multi-equation dynamic calibration process and presently has the value 187.0921.

9.2.10 Foreign assets

Net foreign assets at the end of the calibration year are taken from ADAM's data bank, as is the value of the current account of the calibration year.