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A GENERAL EQUILIBRIUM ANALYSIS OF THE SWEDISH TAX REFORMS 1989-1991

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1. INTRODUCTION

This paper presents a relatively small computable or applied general equilibrium model that can be used to analyze medium and long run structural issues. One of the main motives behind the construction of the model was a desire to complement the calculations of distributional effects of the Swedish tax reform, implemented during 1990-91, that were based on tax-benefit models. Although these models replicate the tax system in great detail they only capture impact effects since they do not incorporate any economic behavior. Our model, on the other hand, concentrates on the economic behavior and tries to assess the long run effects, after wages and prices have fully adjusted to a new equilibrium. The cost of this more sophisticated economic analysis is that we are forced to model the tax reform in a very stylized fashion through a small number of effective tax rates. Thus, the two model approaches should be seen as complements rather than substitutes in analyzing the tax reform.

Although the model is primarily designed for the purpose of evaluating the Swedish tax reform we will not pursue that analysis here. Instead we concentrate on a general description of the model and its properties. What kind of effects can we expect to investigate in our framework? In general, this type of model focuses on sectoral allocation of factors of production, labor supply and consumption patterns, in response to a change in economic policy. Given that we have data on different household categories it is possible to compute quantitative measures of efficiency as well as distributional effects.

The model belongs to the tradition of static computable general equilibrium models.[1] Thus, the time dimension is not explicitly modelled and there are no truly intertemporal decision problems of the agents to solve. This means that savings and investment decisions are treated in an ad-hoc manner. It is assumed that households save a constant fraction of their income. However, savings has no effects upon production capacity nor future consumption. Instead of an explicit demand for investment over time we define the demand for capital as the difference between the desired long run capital stock and the actual capital stock.

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[1] For a comprehensive treatment of a typical (static) CGE model see Ballard et.al. [1985].

The model includes four types of agents; producers, households, a government sector and a sector representing the rest of the world. There are two types of labor; skilled and unskilled, both of which are assumed to be perfectly mobile between the sectors of the domestic economy. Households are endowed with labor and capital stocks, including household capital. We make a distinction between old or sector specific and new or mobile capital. The sector specific capital stocks as well as the total amount of new capital are exogenously given. The return to old capital stocks takes the form of quasi rent. Production employing old capital, whether it takes place in the business or in the household sectors, continues as long as the quasi rent is non-negative. In contrast to old capital, we assume that new capital can be freely allocated between the production and household sectors. Thus, the net return of new capital must be equalized across sectors.

There are a number of reasons for dividing capital into the categories old and new. First, by altering the relation between old and new capital we can simulate different degrees of capital mobility. In the very short run all capital can be considered to be of the old type with no mobility at all, whereas in the long run the entire capital stock is mobile.[2] Secondly, substitution possibilities between factors of production are greater ex-ante than ex-post. Thirdly, new technologies are often embodied in new investment. These facts can be incorporated into the model by interpreting new capital as capital that has not yet been installed for a specific use. Lastly, the distinction between existing and new capital is also useful from a tax perspective.

The production sectors of the economy are divided into three tradeable and four non-tradeable sectors. The tradeable sectors are defined in terms of factor intensities; capital, skilled labor and unskilled labor intensive. In these sectors the output prices are determined by the world market. The non-tradeable sectors consist of a owner-occupied housing sector, other real estate, private services and public production. Households have preferences over consumption of goods and leisure, which means that labor supply is endogenous. There are two alternatives for the households to employ its labor supply; it can be offered for sale on the regular labor market or it can be used together with household capital in the household production process. A reason for explicitly

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[2] This distinction between old and new capital is adopted from Haaland [1987], [1991]. See also Devarajan and Offerdahl [1989] and Fullerton [1983] for a discussion about the role of different assumptions regarding capital mobility in CGE models.

modelling household production is that those activities are not subject to taxation, which induces substitution between taxable and non-taxable employment of the resources of households.

There are two channels through which the rest of the world affects the domestic economy. Firstly, the output prices of the tradeable sectors, which are classified in terms of factor proportions of primary factors, are determined in the world markets and can thus be regarded as exogenous to the domestic producers. Secondly, we assume that the interest rate is determined in the international capital market. Hence, it too can be regarded as exogenous to the domestic economy. The availability of an international capital market implies that domestic supply and demand for new capital need not be equal in equilibrium. If demand for new capital exceeds supply, at a given interest rate, the difference is supplied from abroad. The government sector collects taxes and given the exogenous public expenditures and savings, distributes transfers to households such that it balances its budget.

The model solves for the allocation of labor and new capital among the production and household sectors, which in turn determines the output of different goods. For each household category, we determine the supply of labor, the allocation of its endowment of new capital between business production sectors and household capital and the expenditures among different consumption goods. In addition we determine the amount of foreign supplied new capital. Finally, the distribution of income is given by the equilibrium factor prices and the endowment of factors of production.

The outline of the paper is as follows. In Section 2 we discuss the tax reform and its implementation in the model. Section 3 describes the behavioral assumptions of the agents in our model. The simulation results are presented in Section 4 and some conclusions are offered in Section 5. The notation used, a complete list of the model equations, data sources and the calibration procedure are provided in Appendices 1-4.

2. THE TAX REFORM

Before we discuss the actual implementation of the tax reform in our model we shall very briefly describe the main ingredients of the reform and the goals that it is supposed to achieve. A number of revisions of the Swedish tax system have taken place since the end of the late eighties and still continue. For the purpose of our investigation "the tax reform" is defined as the substantial revisions of the tax system undertaken during 1990 and 1991.[3]

The previous Swedish tax system was characterized by very high statutory income tax rates. Since these high rates were combined with rather narrow tax bases the outcome resulted in allocative inefficiencies as well as an inequitable distribution of the tax burden. The Swedish reform process followed the international pattern with lower tax rates, especially marginal rates, and broader tax bases. Due to the principle of a uniform taxation and the subsequent broadening of tax bases it becomes possible to reduce tax rates and at the same time keep total tax revenues almost unchanged.

One can identify two major goals that one hope to achieve through the new tax system. The first is to provide a more efficient financing of public expenditures i.e. to minimize the allocational costs of distorting taxes, given an unchanged level of public expenditures. The second purpose focuses on horizontal equity with a uniform taxation of labor and capital income. In this paper we will only try to evaluate the former aim since we are not considering different subgroups of the household sector.

Since the purpose of our investigation is to analyze the impact of different tax structures i.e. different sets of tax rates and not the average level of taxation it is necessary to keep real government expenditures constant. Otherwise it would be impossible to separate the effects of different tax structures from the effects of different levels of average taxation. In other words, we are comparing equilibria with different tax structures, where we have imposed the requirement of equal-yield revenue. This restriction is more fully dealt with in Section 4.3 below where we

[3] The following description draws heavily on the survey of the Swedish tax reform 1990-91 published by the Ministry of Finance [1991].

consider different ways of fulfilling the equal-yield requirement. It should be noted that the equal-yield requirement does not constitute any limitation of our study since the tax reform was implemented under the explicit restriction that the tax revenue should stay the same as before the reform. Total tax revenue in Sweden equals approximately 56 per cent of gross domestic product. The extent of the reform and its structure is described in Table 2.1 below.

Table 2.1 - *The Tax Reform in Budgetary Terms, 1991 prices*

Budget losses	**Billions of SEK**	**Per cent**
Reductions of state income tax rates	89.1	92.0
Distributional measures	8.2	8.0
Total:	97.3	100.0
Financing		
Broader base, employment income	12.7	13.0
Broader base, capital income and property taxes	38.6	41.0
VAT and other indirect taxes	28.4	30.0
Corporate income taxes	1.2	1.0
Other revenues	9.2	10.0
Effects attributable to allocative gains	5.0	5.0
Total:	95.1	100.0

There are two major reallocations of the tax burden. The most important is the shift from earned income to capital income and capital. The second characteristic feature is a switch from taxes on income to consumption through increased indirect taxes. Note also that certain distributional measures such as increased child allowances, minimum pensions and local rental allowances, have been undertaken in order to achieve an acceptable outcome of vertical equity.

After the reform there are three types of income; employment income, capital income and business income. The taxes applied are described in Table 2.2. The sum of employment income and unincorporated business income constitutes earned income, which is subject to state and municipal income tax. If the taxable income does not exceed 170.000 SEK (1991) only the municipal income tax is applicable at an average rate of 31 per cent. A taxable income greater than 170.000 SEK is subject to an additional state income tax of 20 per cent. The dominant part of the Swedish social security system is financed through payroll taxes. For income that does not entitle to social security benefits a special salary tax is levied. Capital income, which is taxed separately from earned income, is subject to a proportional state income tax rate of 30 per cent. Corporations are also liable to a flat state income tax of 30 per cent. Dividends and capital gains are taxed twice since they are also taxed as personal capital income. Finally, there is also a general value added tax with a tax rate of 23.46 per cent defined on an exclusive basis.

Table 2.2 - *Classes of Income*

Class of Income	Subject to
Employment income	State and municipal tax (31/51 per cent)
	Social security contributions / salary tax (28/18 per cent)
Capital income	State tax (30 per cent)
Business income	
Unincorporated	State and municipal tax (31/51/ per cent)
	Social security contributions / salary tax (25/18 per cent)
Incorporated	State tax (30 per cent)

2.1 Modelling the Tax Reform

It is not a trivial task to translate the actual tax reform proposals into a form that is compatible with the model. The way we depict the tax system in the model is through a number of effective tax rates. Needless to say it is necessary to make several simplifying assumptions and not every aspect of the tax reform can be adequately represented, but hopefully some of the main features can be properly described and analyzed. The values for the effective tax rates used in the simulations are presented in Table 2.3 below. (All effective tax rates are defined on an exclusive basis).

Here we will limit ourselves to some general comments about the tax rates used. A detailed description of the computation is given in Appendix 3. The distinction between a broadened tax base and an increase in rate of taxation is not explicit in the model. Instead, both of these features are reflected in the computation of the effective tax rates. Although the statutory corporate tax rate is proportional, in the model we make a distinction between the average and the marginal corporate tax rate. The reason behind this is that we make a distinction, in the model, between old or sector specific capital and new or mobile capital. The return to old capital takes the form of a quasi-rent which is taxed at the average corporate tax rate. New capital, on the other hand, is mobile between all domestic sectors as well as between the domestic economy and the rest of the world. We consider the addition of new capital to the existing old capital stock as an investment, which is taxed at the marginal corporate tax rate.

In this context it should be pointed out that we distinguish between the housing sector and the household production sector. The former is treated in the same manner as the other ordinary business production sectors. This means that the output of the housing sector, housing services, is sold on a market at a uniform price. Furthermore, labor employed in the housing sector is taxed at the prevailing payroll tax rate and output is subject to indirect taxation. In the household production sector the capital stock consists of consumer durables, which together with labor services produce household services to be consumed only within the household. Thus, there is no market with a uniform market price for household services or put differently there is one internal market for each household. In contrast to the housing sector, the employment of labor as well as the consumption of household services are not taxed.

The payroll tax rate is applied at the same rate to both categories, skilled and unskilled, of labor and to all production sectors, including the housing sector as mentioned above. It should be noted that we consider the entire payroll expenditure to be a tax. One might very well argue that part of it is not a tax since it is directly connected to pension benefits received later in life. Our reason for treating the housing sector as an ordinary business sector and to consider the entire payroll cost as a tax is governed by the fact that changing these definitions would involve a number of somewhat arbitrary modifications of our data set in order to maintain the consistency of the social accounting matrix (see Section A3.5 in Appendix 3).

Household capital income is taxed at the average or the marginal rate depending on whether it is the return on old or new capital. Consumption goods, including housing services, are subject to indirect taxation. Out of eleven consumption good tax rates only four are changed; food and various services. In order to take into account of both the corporate and the household capital income tax let us define the following combined tax rates.

$$\tau_{Fhj} = \tau_{Cj} + (1-\tau_{Cj})\cdot\tau_{Kh} \qquad (2.1)$$

$$\tau^{m}_{Fhj} = \tau^{m}_{Cj} + (1-\tau^{m}_{Cj})\cdot\tau^{m}_{Kh} \qquad (2.2)$$

Full income of households, equation (3.3) below, depends partly on the after-tax value of labor endowment. Labor endowment is valued by the price of leisure, which equals one minus the marginal rate of the labor income tax times the gross wage rate according to equation (3.1) below. Since total labor income taxes paid equals the average tax rate times gross labor income we need to define a labor income tax function that relates the average and the marginal tax rates.

$$\tau_{Yh} = \tau^{m}_{Yh} + \frac{B_{Yh}}{\sum_{b} W_b \cdot \left(L_h - \sum_{v} LD_{hv}\right) \cdot q_{bh}} \qquad (2.3)$$

where, W_b is the wage rate for labor category b and the expression within parenthesis equals total labor supply L_h minus the labor services used in household production LD_{hv}. The parameter q_{bh} denotes the fixed proportion of each skill category coming from a given household. Hence, the inclusion of B_{Yh} in equation (3.3) below, the definition of household income.

Table 2.3 - *Effective Tax Rates*

Tax Rate	Description	Before reform	After reform
τ_{Cj}	average corporate tax rate, except housing	0.20	0.20
	average capital tax rate for the housing sector	0.057	0.177
τ_{Cj}^{m}	marginal corporate tax rate, except housing	-0.05	0.01
	marginal capital tax rate for the housing sector	0.167	0.291
τ_{Lj}	payroll tax rate in the capital intensive sector	0.4269	0.4155
	payroll tax rate in the skilled labor intensive sector	0.4289	0.4174
	payroll tax rate in unskilled labor intensive sector	0.4184	0.4072
	payroll tax rate in sheltered sector	0.3602	0.3506
	payroll tax rate in public sector	0.3612	0.3515
	payroll tax rate in estate sector	0.3653	0.3555
	payroll tax rate in housing sector	0.3649	0.3551
τ_{Yh}	average tax rate on household labor income	0.368	0.290
τ_{Yh}^{m}	marginal tax rate on household labor income	0.577	0.422
τ_{Kh}	average tax rate on household capital income	0.058	0.066
τ_{Kh}^{m}	marginal tax rate on household capital income	0.370	0.292
τ_{Sl}	sales tax rate on food	0.2657	0.2971
	sales tax rate on spirits and tobacco	2.8037	2.8037
	sales tax rate on non-durable goods	0.3328	0.3328
	sales tax rate on clothing and footwear	0.4337	0.4337
	sales tax rate on health- and medical care	-0.4171	-0.4171
	sales tax rate on furniture and household articles	0.3184	0.3184
	sales tax rate on dwelling services	0.0382	0.1198
	sales tax rate on other services	0.0098	0.0558
	sales tax rate on transportation services	0.5145	0.6019
	sales tax rate on recreational and cultural services	0.1293	0.1566
	sales tax rate on private non-profit organization output	0.0983	0.0983

What kind of effects can we expect from the changed tax structure? First, we would expect that the employment of new capital, investment, in business sectors, especially in the housing sector, will diminish due to the increased marginal tax rate on capital. If there is no international capital movements this means that more of the new capital will be allocated to the household production sector. A counteracting force is the lowering of the marginal tax rate on labor income which makes the price of leisure to go up. Labor supply will increase and make capital employed in the business sectors more productive. If we instead assume that there is an international capital market, we would anticipate an outflow of capital. Finally, the consumption pattern of the household sector will change as it substitutes away from services in response to the change in indirect taxation.

2.2 Limits of the Analysis

Before we discuss the simulation results we need to say a few words about what effects of the tax reform we are able to analyze within the present model structure. Obviously, there are a number of aspects of the tax reform that cannot be investigated in our framework. That is a characteristic which we share with every other model since it is always necessary to focus on just a few aspects. However, three limitations should be mentioned.

The first is the lack of distributional effects on different household groups since we are employing data for an aggregate household sector. A second limitation is due to the fact that the model is essentially static, which precludes a rigorous analysis of saving and investment. We can analyze the allocation between different sectors of a given total capital stock, but we are unable to determine the level itself of savings and investment.

Third, we do not explicitly deal with the vast and complicated transfer system that is closely connected with the tax system. Transfers to the household sector are simply treated as a lump sum transfer. Since we are not analyzing any distributional impacts of the tax reform this is not serious limitation. Furthermore, the calculation of the effective marginal tax rate on labor income incorporates partially the dependence of transfers on income.

There are at least three advantages of the use of a numerical simulation model. First, we can analyze the impact of indirect effects, due to the interdependence of markets, when prices and wages have adjusted to the new tax system and established a new equilibrium. Secondly, we are able to determine the sectoral allocation of production factors between taxed and non-taxed activities i.e. between business and household production. Given this division we can further analyze the allocation of labor and capital between the different business sectors, especially between tradeable and non-tradeable sectors. The effect on labor supply can be studied since it is endogenous and responds to a change in the marginal rate of income taxation. The pattern of private consumption can be analyzed. Third, we compute welfare measures of excess burden or dead-weight loss due to the tax system.

3. THE MODEL

3.1 The Household Sector

Each household sector is comprised of two sub sectors; a consumption and a production sector. In the former we analyze a representative household in its role as a consumer, i.e. it demands market goods, household services, leisure and supplies labor. The second sub sector describes household production. Household services are supplied and labor and household capital are demanded. One can interpret the household production sector as the informal sector in the economy. There are two mechanisms which govern the allocation of resources between the formal and the informal sector in the model. Labor income taxes is the first one. The household first decides how to allocate its labor endowment between leisure and labor supply and then further divides its labor supply into one part going to the regular labor market and another part which is channelled to household production. Thus, note that we distinguish between leisure and time devoted to work in household production. In addition the household has to pay capital income taxes, but only on that proportion of its endowment of capital which is allocated to the business production sectors. Consequently, the household can avoid part of the capital income tax by employing capital in its household production.

3.1.1 Consumption Demand and Labor Supply

Each household is endowed with labor services, LE_h, old stocks of household capital, KD_{ho} and business production capital, K_{jo} and new capital AS_h. As mentioned before there are two skill categories of labor used in the production sectors. In order to connect the skill and household types we assume that each household h is endowed with skill category b in the fixed proportion q_{bh} of its total labor endowment. For future convenience let us define the price of leisure as the gross wage rate, W_b, times one minus the marginal labor income tax rate summed over the labor categories.

$$PF_h = \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \tag{3.1}$$

The stocks of production capital are rented by the producers. The household can allocate its endowment of new capital, AS_h, between household capital, KD_{hn}, used in household production and production capital, SF_h, employed in the business sectors. That part of new capital which is allocated to household capital is derived through the demand for consumption services generated by household capital, which in turn implies a desired stock of household capital. The difference between the desired and the actual stock of household capital constitutes the demand for new household capital. In a similar way the demand for new production capital is derived from the consumption demand of outputs from the business sectors. Thus, the following accounting identity must be satisfied.

$$AS_h = SF_h + KD_{hn} \tag{3.2}$$

Expanded or full income equals the value of labor endowment, old and new capital income, depreciation and government net transfers minus income taxes.

$$Y_h = PF_h \cdot LE_h - B_{Yh} + \beta_h \cdot \sum_j (1-\tau_{Fhj}) \cdot RK_j + RD_h + r_W \cdot P_K \cdot AS_h + DEP_h + TR_h \tag{3.3}$$

The first two terms on the right hand side equals one minus the average labor income tax rate times the labor endowment, where B_{Yh} is the intercept in the household tax function. The third term equals the household profit share, β_h, times the after tax value of the quasi-rent accruing to old capital, RK_j, summed over all business sectors. The tax rate τ_{Fhj} takes into account both corporate and personal capital income taxes. The fourth term denotes the quasi-rent accruing to the stock of old household capital, RD_h, which is not subject to taxation. The fifth term is equal to the international rate of interest, r_W, times the price of the capital good, P_K, times the endowment of new capital or gross income from new capital. It is assumed that the household receives the amount of depreciation of both business and household capital, DEP_h, as represented by the sixth term. Finally, the last term, TR_h, represents government net transfers to the household.

The household has preferences over consumption of market goods and services, C_{hi}, non-market household services, C_{Dh}, produced and consumed within the household and leisure, F_h. We assume that the household maximizes utility, U_h, subject to its total income. Utility is specified as a two-stage nested CES-function. Non-market and market consumption goods are aggregated in the lower level into a composite consumption good which is then combined with leisure in the top-level to form utility. The household decision problem is.

$$\textit{Maximize} \qquad U_h = U_h(C_{h1}, \ldots, C_{hn}, C_{Dh}, F_h) \qquad \textit{subject to}$$

$$Y_h = \sum_{i \neq D} PC_i \cdot C_{hi} + PC_{Dh} \cdot C_{Dh} + PF_h \cdot F_h + S_h + \tau^m_{Kh} \cdot r_W \cdot P_K \cdot SF_h + EX_{Ch} \tag{3.4}$$

The first two terms on the right hand side of the budget constraint are the consumption expenditures on market goods and on household services respectively. The third term equals the value of leisure and S_h denotes household gross savings. The fourth term equals the capital income taxes incurred by allocating part of the new capital to the business sectors. Finally, there is an exogenous demand component EX_{Ch}.

Since there is no explicit intertemporal decision problem we instead assume that households save a constant fraction, s_{Yh}, of its income.

$$S_h = s_{Yh} \cdot Y_h \tag{3.5}$$

By solving the decision problem of the household we get the Marshallian demand functions of market goods, household services, and leisure as functions of market good prices including sales tax, PC_i, the price of household services, PC_{Dh}, which are specific for each household type, net-of-tax wage rates and income.

$$C_{hi} = C_{hi}(PC_i, PC_{Dh}, PF_h, Y_h) \tag{3.6}$$

$$C_{Dh} = C_{Dh}(PC_i, PC_{Dh}, PF_h, Y_h) \tag{3.7}$$

$$F_h = F_h(PC_i, PC_{Dh}, PF_h, Y_h) \tag{3.8}$$

$$L_h = LE_h - F_h \tag{3.9}$$

In the last equation above labor supply, L_h, is defined as the difference between household labor endowment and the demand for leisure.

3.1.2 Household Production

The stock of household capital generates a flow of household services, C_{Dh}, to the household. This flow might vary, for a given stock, with intensity of use or more generally with the employment of other inputs like labor. When analyzing household production it is convenient to distinguish between production processes utilizing old and new household capital. The production function is specified as CES-function for both processes. Since the stock of old household capital is fixed for each household the production process is subject to diminishing returns. We assume that the household as a producer of household services using old capital acts as if it is maximizing the quasi rent to the fixed factor. Formally the decision can be written as.

$$\textit{Maximize} \qquad PC_{Dh} \cdot XD_{ho} - PF_h \cdot LD_{ho}$$

$$\textit{subject to} \qquad XD_{ho} = XD_{ho}(LD_{ho}, KD_{ho}) \tag{3.10}$$

where, XD_{ho} is the output of household services, using labor, LD_{ho}, and the fixed stock of old household capital, KD_{ho}. Next, we derive the short run or restricted profit function $RD_h(PC_{Dh}, PF_h, KD_{ho})$ and compute the supply function and the demand for labor by applying Hotelling's lemma.

$$XD_{ho} = XD_{ho}(PC_{Dh}, PF_h, KD_{ho}) \quad (3.11)$$

$$LD_{ho} = LD_{ho}(PC_{Dh}, PF_h, KD_{ho}) \quad (3.12)$$

Since old household capital is a fixed factor, we need to recognize the possibility that household production, using old household capital, will continue only as long as variable costs are covered. More formally, this can be expressed as.

$$\left[PC_{Dh} - PF_h \cdot (LD_{ho} / XD_{ho})\right] \cdot XD_{ho} \geq 0 \quad (3.13)$$

After subtracting for depreciation we get the net return to old household capital.

$$RD_h = PC_{Dh} \cdot XD_{ho} - PF_h \cdot LD_{ho} - P_K \cdot \delta_{Do} \cdot KD_{ho} \quad (3.14)$$

The production process using new household capital is characterized by constant returns to scale, which implies that the actual output is determined by the utility structure or demand conditions. Thus, in this case we instead assume that households minimize costs for a given output of household services. The decision problem for the household now becomes.

$$\textit{Minimize} \quad PF_h \cdot LD_{hn} + PD_{hn} \cdot KD_{hn}$$

$$\textit{subject to} \quad XD_{hn}\left(LD_{hn}, KD_{hn}\right) = \overline{XD}_{hn} \quad (3.15)$$

The solution to this problem is summarized by a unit cost function, $UC_{Dh}(PF_h, PD_{hn})$, which has as arguments net-of-tax wage rates and the rental price of new household capital. If unit cost is greater than price there is no production, using new capital, taking place. On the other hand, if production is positive we know that unit cost must be equal to price. The decision whether new capital should be used or not is described by the following Kuhn-Tucker conditions.

$$PC_{Dh} - UC_{Dh} \leq 0$$

$$\left(PC_{Dh} - UC_{Dh}\right) \cdot XD_{hn} = 0 \qquad (3.16)$$

$$XD_{hn} \geq 0$$

The demand for labor and new household capital is obtained by applying Shephard's lemma.

$$LD_{hn} = LD_{hn}\left(PF_{h}, PD_{hn}, XD_{hn}\right) \qquad (3.17)$$

$$KD_{hn} = KD_{hn}\left(PF_{h}, PD_{hn}, XD_{hn}\right) \qquad (3.18)$$

The rental price of new household capital is defined as.

$$PD_{hn} = \left(\delta_{Dn} + r_{w}\right) \cdot P_{K} \qquad (3.19)$$

This relationship results from representing the price of capital goods as the discounted value of future rentals. Note that the rental price of new household capital does not depend on any tax rates since the return on household capital is not subject to taxation.

3.2 The Business Sectors

Production of value added in each business sector is governed by a two-stage CES production function, where skilled and unskilled labor are aggregated to a composite labor input in the first stage. Next, this composite labor input is combined with old or new capital to produce value added. Finally, intermediate inputs are used according to a fixed-coefficient technology to form domestic gross output X_{vj}. Total gross output, in each sector, is the sum of output from production processes using old and new capital. Thus, the output from the two processes are perfect substitutes. Since old capital is assumed to be sector specific the return to old capital, quasi-rent, might differ between sectors. If the demand for output is large enough or the output price is sufficiently high there is a positive demand for new capital. In order to attract new capital the rate of return to capital must be at least as high as the opportunity cost or the world market interest rate. The production function for the process using old capital exhibits decreasing returns to scale since the old capital stock is fixed. In the process using new capital the production function is characterized by constant returns to scale.

Due to the different technologies available it is analytically convenient to distinguish between old and new processes in exactly the same way as we did for household production. The decision problem for a producer using old capital is.

$$\textit{Maximize} \qquad PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b WP_{bj} \cdot L_{bjo}$$

$$\textit{subject to} \qquad X_{jo} = X_{jo}\left(L_{bjo}, K_{jo}\right) \tag{3.20}$$

where, WP_{bj} is the wage cost for the producer and equals the wage rate times one plus the payroll tax rate. By solving this decision problem we can derive the short run or restricted profit function, $RK_j(PX_j, WP_{bj}, K_{jo})$, as a function of output prices, PX_j, wage costs and the fixed capital stock. The supply function of gross output and the demand for labor is obtained by applying Hotelling's lemma.

$$X_{jo} = X_{jo}\left(PX_j, WP_{bj}, K_{jo}\right) \tag{3.21}$$

$$L_{bjo} = L_{bjo}\left(PX_j, WP_{bj}, K_{jo}\right) \tag{3.22}$$

Only if the quasi-rent is non-negative will old capital be used and production continued. Thus, the following condition must be satisfied.

$$\left[PX_j - \sum_i PX_i \cdot a_{ij} - \sum_b WP_{bj} \cdot \left(L_{bjo} / X_{jo}\right)\right] \cdot X_{jo} \geq 0 \tag{3.23}$$

The net return to old business capital, which is subject to taxation, is defined as.

$$RK_j = PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b WP_{bj} \cdot L_{bjo} - P_K \cdot \delta_{jo} \cdot K_{jo} \qquad (3.24)$$

Since the technology of new processes exhibits constant returns to scale the profit function is not well defined. We assume instead that new firms minimize costs for a given output. Thus, the decision problem for a producer employing new capital is.

$$\textit{Minimize} \quad \sum_b WP_{bj} \cdot L_{bjn} + PK_{jn} \cdot K_{jn} + \sum_i PX_i \cdot a_{ij} \cdot X_{jn}$$

$$\textit{subject to} \quad X_{jn} \left(L_{bjn}, K_{jn}\right) = \bar{X}_{jn} \qquad (3.25)$$

Just as with household production we describe the solution by a unit cost function, $UC_{Xj}(WP_{bj}, PK_{jn})$ with wage costs and the rental price of new production capital as its arguments. As in the case of household production the decision whether new capital should be used or not is described by the Kuhn-Tucker conditions.

$$PX_j - UC_{Xj} \leq 0$$

$$\left(PX_j - UC_{Xj}\right) \cdot X_{jn} = 0 \qquad (3.26)$$

$$X_{jn} \geq 0$$

The demand for primary factors of production is obtained by applying Shephard's lemma.

$$L_{bjn} = L_{bjn}\left(PX_j, WP_{bj}, PK_{jn}, X_{jn}\right) \qquad (3.27)$$

$$K_{jn} = K_{jn}\left(PX_j, WP_{bj}, PK_{jn}, X_{jn}\right) \qquad (3.28)$$

Demand for intermediate goods is equal to.

$$I_j = \sum_i a_{ji} \cdot \sum_v X_{iv} \tag{3.29}$$

The capital good is defined as a composite good, consisting of fixed proportions of the gross output of different sectors. The rental price of one unit of new production capital is the sum of the exogenous rate of depreciation, δ_{jn}, and the gross return to new capital multiplied by P_K, the price of the capital good.

$$PK_{jn} = \left(\delta_{jn} + \frac{r_w}{(1-\tau^m_{Cj})}\right) \cdot P_K \tag{3.30}$$

where, $\tau_{Cj}{}^m$ is the marginal corporate tax rate for sector j. The payment to old capital in each sector is defined residually after payments to labor and intermediate inputs. Total factor rewards is therefore, by definition, equal to total value added created. According to Euler's theorem this also holds for the new production processes, providing that factors are paid according to their marginal products.

3.3 The Foreign Sector

When modelling foreign trade we follow the approach taken by Haaland [1987], [1991] and Haaland et.al. [1987]. This involves abandonment of the Armington assumption of product heterogeneity and instead adopting an assumption of product homogeneity among different countries. We will not here further dwell on the relative merits of the approaches but refer to the discussion in the above mentioned sources.[4] Given our assumption of exogenous world market prices, PW_{td}, for tradeables we can determine net exports, Z_{td}, only.

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[4] See also Whalley and Yeung [1984] for a discussion about different external sector specifications with respect to foreign export demand and import supply, especially in the context of model closure.

$$PX_{td} = ER \cdot PW_{td} \tag{3.31}$$

$$Z_{td} = \sum_{v} X_{td,v} - I_{td} - C_{td} - INV_{td} - G_{td} - EX_{td} \tag{3.32}$$

where, ER is the exchange rate, C_{td} is private consumption demand, INV_{td} denotes investment demand, G_{td} represents government demand and EX_{td} is an exogenous demand. We define the trade balance as follows.

$$TB = \sum_{td} PX_{td} \cdot Z_{td} \tag{3.33}$$

The existence of an international capital market makes it possible for the demand of new business capital of the domestic producers to deviate from the aggregate domestic supply. If excess demand is positive, part of the stock of new business capital is owned by foreign investors, whereas a negative excess demand indicates that some of the domestic endowment of new capital is invested abroad, at the world market interest rate. Thus, the foreign stock of new capital is equal to.

$$KF = \sum_{j} K_{jn} - \sum_{h} SF_{h} \tag{3.34}$$

By using the definition of the trade balance we can express the current account as the difference between the value of net exports and interest payments to foreign capital.

$$CC = TB - r_{W} \cdot P_{K} \cdot KF \tag{3.35}$$

3.4 The Government Sector

We divide the non-private sector into a public production sector and an institutional sector, which we denote government. The public production sector employs labor and capital in order to produce gross output in the same way as private production sectors as described above in Section 3.2. It is assumed that the government sector is the sole demander of the output of the public production sector. Obviously, in reality households and firms are the main consumers of public goods and services. However, the main point to be made here is that we would like to keep public production constant, regardless of who consumes it, in order to evaluate changes in the tax structure rather than changes in the average level of taxation. The government sector collects taxes and distributes transfers to the private sector. We have the following sources of tax revenue:

(i) Labor employed in the business sectors, L_{bjv}, are taxed at the rate τ_{Lbj}, whereas labor employed in household production, LD_{hv}, is not taxed at all.

$$TX_L = \sum_b \sum_j \sum_v \tau_{Lbj} \cdot W_b \cdot L_{bjv} \qquad (3.36)$$

(ii) The average corporate tax rate, τ_{Cj} applied to the net return of old business capital gives the following tax revenues.

$$TX_{OC} = \sum_j \tau_{Cj} \cdot RK_j \qquad (3.37)$$

(iii) The return to new business capital is taxed at the marginal corporate tax rate τ_{Cj}^{m}.

$$TX_{NC} = \sum_j \tau_{Cj}^{m} \cdot \left(\frac{r_W}{1-\tau_{Cj}^{m}} \right) \cdot P_K \cdot K_{jn} \qquad (3.38)$$

(iv) Consumption goods except, household services, are taxed at rate τ_{Si}.

$$TX_S = \sum_h \sum_{i \in D} \tau_{Si} \cdot C_{hi} \cdot \sum_j m_{ji} \cdot PX_j \tag{3.39}$$

where, m_{ji} is an element in a matrix that converts the demand for consumer goods into a demand for gross output of the production sectors.

(v) Household labor income are taxed at the average tax rate τ_{Yh}.

$$TX_Y = \sum_b \sum_h \tau_{Yh} \cdot W_b \left(L_h - \sum_v LD_{hv} \right) q_{bh} \tag{3.40}$$

where, the expression within parentheses equals the difference between total labor supply and what is employed in household production.

(vi) After old business capital has been taxed at the corporate level it is also subject to a personal capital income tax at the rate τ_{Kh}.

$$TX_{OK} = \sum_h \sum_j \tau_{Kh} \cdot \beta_h (1 - \tau_{Cj}) \cdot RK_j \tag{3.41}$$

(vii) After the return to new business capital has been taxed at the marginal corporate tax rate, it is in addition subject to personal capital income taxes at the marginal rate τ_{Kh}^m.

$$TX_{NK} = \sum_h \tau_{Kh}^m \cdot r_W \cdot P_K \cdot SF_h \tag{3.42}$$

Government revenue consists of total tax revenue and an exogenous revenue component *EXGOV*. The government purchases the gross output from the public production sector, G_{pub}, which includes investment as well as consumption goods. In addition the government spends its revenue on transfers, *TR*, to the households. We assume that government savings, *GSAV*, is exogenous. Then the government sector budget constraint can be written as.

$$TX_L + TX_{OC} + TX_{NC} + TX_S + TX_Y + TX_{OK} + TX_{NK} + EXGOV =$$

$$= TR + PX_{pub} \cdot G_{pub} + GSAV \qquad (3.43)$$

As can be seen from the budget constraint, total transfers to the households are determined as the difference between total tax revenues and the exogenously given government expenditures and savings. Since we treat the household sector as an aggregate sector we do not have to specify how the transfer to each household, TR_h, is determined from the total amount of transfers available TR. In our case the two are equal.

3.5 Model Closure

The closure rule used in this model refers to the mechanism employed for equilibrating savings and investment. Aggregate gross savings is the sum of household savings, S_h, foreign savings, $FSAV$, and government savings, $GSAV$, of which the two latter are exogenous.

$$TSAV = \sum_h S_h + FSAV + GSAV \qquad (3.44)$$

The model is savings driven in the sense that aggregate gross investment demand is assumed to adjust passively to aggregate gross savings. Real investment demand by sector of origin, INV_j, is determined by applying fixed investment shares, k_j, to the total amount of savings.

$$INV_j = k_j (TSAV / PX_j) \qquad (3.45)$$

In order to avoid misunderstandings we need to clearly distinguish between investment demand and capital stocks. Investment demand INV_j is a flow variable and does not affect the productive capacity of the economy but only serves as a demand component of aggregate goods demand aimed at the production sectors. The demand for new production capital, K_{jn}, on the other hand, is a stock variable and constitutes a part of the productive capacity of the production sectors. There is, in the model, no link between investment demand and the demand for new capital. In an intertemporal model investment demand would be directly derived from the long run demand for capital. The fixed proportions, k_j, are computed solely by using benchmark data, which by definition does not contain any amount of new capital. A long run interpretation of the shares k_j would be to relate them to the total amount of capital demanded by the business sectors, but this has not been implemented in the present version of the model.

3.6 Equilibrium Conditions

A competitive equilibrium is a set of prices for nontradeables, PX_{nt}, wage rates, W_b, prices of household services, PC_{Dh}, and an exchange rate, ER, such that the following conditions are satisfied:

(i) Supply equals demand for each category, b, of labor.

$$\sum_h L_h \cdot q_{bh} = \sum_j \sum_v L_{bjv} + \sum_h \sum_v LD_{hv} \cdot q_{bh} \tag{3.46}$$

where, the left-hand side equals the total labor supply and the first term on the right-hand side is the labor demanded by the business sectors and the second term is the amount demanded by household production.

(ii) Supply equals demand on each market, nt, of non-tradeable goods.

$$\sum_v X_{nt,v} = I_{nt} + C_{nt} + INV_{nt} + G_{nt} + EX_{nt} \tag{3.47}$$

where, the left-hand side equals gross output and the terms on the right-hand side are demand for intermediate goods, private consumption, investment good demand, government demand and exogenous demand respectively.

(iii) Supply equals demand for every household, h, of household services.

$$\sum_{v} XD_{hv} = C_{Dh} \tag{3.48}$$

where, the left-hand side equals gross output and the right-hand side equals consumption demand for household services. Note that there are one market for each household.

(iv) Supply equals demand for foreign exchange.

$$CC + FSAV = FORREV \tag{3.49}$$

where, the current account and foreign saving constitute the supply of foreign exchange while the exogenous component *FORREV* equals the demand.

3.7 The Numeraire

Since there is no financial sector in the model there is no mechanism through which the absolute price level is determined. As is customary in these kind of models, only relative prices are determined. A numeraire must therefore be selected against which all price changes are to be measured. We have chosen the exchange rate as the numeraire and sets its value equal to one.

$$ER = 1 \tag{3.50}$$

4. RESULTS

General equilibrium models make it possible to perform a logically consistent analysis, which takes into account direct or impact effects as well as indirect effects due to the economic behavior of economic agents. In a conventional partial analysis one studies only one market at a time and abstracts from the interaction between different markets in the economy.

The effects of the Swedish tax reform makes a good illustration of the application of general equilibrium analysis. Since the tax reform directly affects several markets simultaneously, both households and firms will be influenced in a number of different and sometimes counteracting ways. In certain cases it is possible to determine, on theoretical grounds, the likely outcome of changing a particular tax instrument and in yet other cases there are even empirical studies indicating the order of magnitude of these effects. However, even if we had reliable empirical estimates for all major economic relationships affected by the tax reform, the combined or overall effect of these partial analyses still remains to be determined.[5]

Suppose that the tax rate on good *X* is increased. The initial effect is to raise the price of good *X* relative to other goods and thereby causing demand to decrease. Apart from this impact effect, additional adjustments or indirect effects takes place since the relative prices and incomes change. A diminished demand for good *X* in turn causes a reduced demand for the factors of production used in this sector. These repercussions cause still another round of adjustments and so on until a new equilibrium, induced by the changed tax rate, has been established. In comparison one can note that so called tax-benefit models, especially used for distribution studies, represents the tax system in great detail but only takes into account impact effects. Thus, these models abstract from the indirect and more long run effects in their evaluation of e.g. tax reforms. However, it is important to view the two approaches as complements rather than substitutes, each analyzing different aspects of a tax reform.

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[5] See e.g. Whalley [1975] for a comparison of the welfare effects of a distortionary tax on capital income between a partial and a general equilibrium analysis. His conclusion is that the partial analysis seems to be an unreliable approximation of the true changes in the economy.

4.1 Dynamic Links

Although the model is essentially static let us introduce a few simple dynamic elements. We denote the benchmark year, for which we have data, by t_0 and the solution year by T. By varying the time period T-t_0 we can simulate, in a very crude way, the evolution of the economy over time. Below we augment the model, presented in Section 3, with the equations needed to introduce some dynamic effects. First of all, old business and household capital stocks depreciate at a fixed rate and at time T there are only fractions of the initial old capital stocks left.

$$K_{jo}(T) = (1-\delta_{jo})^{T-t_0} \cdot K_{jo}(t_0) \tag{4.1}$$

$$KD_{ho}(T) = (1-\delta_{Do})^{T-t_0} \cdot KD_{ho}(t_0) \tag{4.2}$$

The old, now smaller, capital stocks are still fixed in each business (household) sector, but they now constitute a less binding constraint for those sectors that cannot profitably employ their old capital stock.[6] During the time span between the benchmark and the solution year we assume that the economy accumulates real savings, which we denote new capital or in our model notation, AS_h. If we assume that household income grows at the rate of g_{Yh} per year and households save a constant fraction, s_{Yh}, of their income we have the following domestic supply of new capital at the solution year.

$$AS_h(T) = s_{Yh} \cdot (1+g_{Yh})^{T-t_0} \cdot Y_h(t_0) \ / \ P_K(t_0) \tag{4.3}$$

The absolute amount of new capital that we endow the economy with in a given year is exogenous, but by choosing different values for the solution year, T, we can alter the relative magnitudes between old and new capital. In this manner we can represent an economy in the short run by requiring that only a small proportion of the total capital stock is of the new mobile type, whereas the long run can be depicted by letting all or almost all capital be mobile. Taking into account both the endowment of new capital and the depreciation of the old capital stocks, the percentage net

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[6] A similar model is used by Fullerton [1983], who analyzes how limited capital mobility affects the welfare gains from reforming the U.S. corporate income tax.

addition to the aggregate capital stock in period T equals.

$$\Delta K(T) = \frac{\sum_h AS_h(T) - \left[\sum_j (K_{jo}(t_0) - K_{jo}(T)) + \sum_h (KD_{ho}(t_0) - KD_{ho}(T))\right]}{\sum_j K_{jo}(t_0) + \sum_h KD_{ho}(t_0)} \tag{4.4}$$

When we increase the aggregate capital stock over time, it seems reasonable that we also allow the endowment of labor to increase. This can be interpreted as a growth in the population. If we assume that the annual growth rate of household labor endowment equals g_{Lh}, the labor supply at the solution year is equal to.

$$L_h(T) = (1+g_{Lh})^{T-t_0} \cdot LE_h(t_0) - F_h(T) \tag{4.5}$$

Finally, we assume that there is technical progress embodied in new capital. The rate of technical progress is of the Hicks-neutral type and pertains to business as well as to household capital. We denote the annual rate of technical progress in the production sectors by g_{Xj} and in the households by g_{Dh}. Thus, the production functions, employing new capital, in the business and the household sectors take the following form in the solution year.

$$VA_{jn}(T) = (1+g_{Xj})^{T-t_0} \cdot A_{jo} \cdot \left[\alpha_j \cdot AL_{jn}(T)^{\frac{\eta_{jn}-1}{\eta_{jn}}} + (1-\alpha_j) \cdot K_{jn}(T)^{\frac{\eta_{jn}-1}{\eta_{jn}}}\right]^{\frac{\eta_{jn}}{\eta_{jn}-1}}$$

$$XD_{hn}(T) = (1+g_{Dh})^{T-t_0} \cdot \Lambda_{Dho} \cdot \tag{4.6}$$

$$\cdot \left[\alpha_{Dh} \cdot LD_{hn}(T)^{\frac{\lambda_{Dhn}-1}{\lambda_{Dhn}}} + (1-\alpha_{Dhn}) \cdot KD_{hn}(T)^{\frac{\lambda_{Dhn}-1}{\lambda_{Dhn}}}\right]^{\frac{\lambda_{Dhn}}{\lambda_{Dhn}-1}} \tag{4.7}$$

Thus, equations 4.1-4.7 constitute the dynamic block in the model.

4.2 Simulation of the Tax Reform

During the construction of the model to be used for the analysis of the tax reform, we have also built a few simpler models that are special cases of the more general one. Altogether there are four different model versions, but all with the same general structure. Apart from being a natural model building strategy the different models are dictated by their respective data requirements. The simplest model, *BENCH*, does not have any household production sector and no new capital to allocate between sectors. Thus, the capital stocks are fixed in each business production sector and there is no substitution possible between market and non-market activities. The next model, in order of complexity, is *DUR*, which is the same model as *BENCH* but incorporates a household production sector. By adding the quasi dynamic relationships 4.1-4.7 and assuming no international capital flows we get model version *CLOSED*. In this case we have an exogenous amount of new capital that can be allocated between business and household sectors. The rate of interest is endogenous and is determined such that demand and supply for new capital are equated. Finally, by introducing an international capital market which supplies new capital at the world market interest rate we arrive at *FLOW*. In Table 4.1 we compare the simulation results of each model version for some aggregate variables.

Before we discuss the results in Table 4.1 let us explain how they are obtained. By construction the aggregate capital stock of the economy, i.e. old and new as well as business and household capital, differs between the various model versions. In order to make the results of Table 4.1 more comparable we have imposed the restriction that the total amount of capital, before the tax reform, is the same for all models. This is done in the following way. We start with model *CLOSED* and choose a solution year T such that the percentage net addition to the aggregate capital stock, $\Delta K(T)$, equals 20 per cent. There will now be old fixed capital stocks in all sectors, business and household, as well as new capital in some sectors. Denote the corresponding aggregate capital stock by K^{*}. We then perform the comparative static exercise and get the results of column three in table 4.1. Since the amount of new capital is fixed in this model version the rate of return on new capital is endogenous. Next, we employ model *FLOW* which has an international capital market. We fix the international rate of interest at the pre-reform level of model *CLOSED* such that these two models now have identical pre-reform equilibria, especially they both have an aggregate capital stock that equals K^*. Then we simulate the tax reform for model *FLOW* and the results are shown in the appropriately named column in table 4.1.

Table 4.1 - *Tax reform effects of different models*

	Model			
Percentage change in variable	**BENCH**	**DUR**	**CLOSED**	**FLOW**
Aggregate real value added - $\Sigma_j \Sigma_v v_j X_{jv}$ [7]	4.1	4.1	4.0	-2.2
Net national income [8]	7.4	7.5	5.2	4.9
Price of composite consumer good - UC_{Bh}	9.3	14.0	7.3	7.4
Average wage rate [9]	-2.7	-2.7	-8.9	-11.2
Real composite consumption goods - CB_h	5.5	3.2	3.4	2.0
Labor supply to market - LM_h	6.3	6.4	12.0	11.8
Labor supply to household production - LD_h	-	-4.4	-9.1	-8.5
Utility - U_h	1.7	1.4	1.7	0.6
Equivalent variation, per cent of GDP	1.4	1.3	1.9	0.7

Models *DUR* does not possess any new mobile capital. Therefore we take the allocation of K^* between sectors, comprised of old and new capital, as consisting entirely of old capital. That leaves the size of the aggregate capital stock unchanged but now there is no new capital in the economy. The same procedure is adopted for model *BENCH*, with the exception that there is no household production sector so we have to scale up the fixed capital stocks in the business sectors to the extent that the aggregate capital stock remains at K^*. However, it must be emphasized that models *DUR*

[7] Note that we adhere to the usual definition of gross domestic product and do not include any production of the household sector.

[8] Net national income is equal to gross wage payments plus the return to old and new business capital, summed over all business sectors. In model terms net national income is defined as $\Sigma_b \Sigma_j \Sigma_v WP_{bj} L_{bjv} + \Sigma_j RK_j + P_K \min\{\Sigma_h SF_h / \Sigma_j K_{jn}, 1\} \Sigma_j [K_{jn} r_w / (1-\tau_{Cj}^m)] - \min\{KF, 0\} P_K r_w$.

[9] The average wage rate is calculated as a weighted average of the wage rates for skilled and unskilled labour, with the weights being set equal to the relative quantities of aggregate skilled and unskilled labour demanded in the business sectors.

and *BENCH* are not strictly comparable to models *CLOSED* and *FLOW* since the former have been recalibrated with the new capital larger fixed stocks.

Let us first compare *CLOSED* and *FLOW*. The main difference is that there is an outflow of capital, in response to higher marginal corporate tax rates, in model *FLOW*. Thus, gross domestic product declines but net national income is about the same for the two model specifications. However, there is a marked difference in welfare gains. In the more detailed discussion of the results below we will retain the two model versions *CLOSED* and *FLOW* in order to compare the results corresponding to different assumptions about the integration of international capital markets. This is especially pertinent for a small open economy as the Swedish one.[10] This issue is discussed further below in Section 4.3 dealing with sensitivity analysis.

Next let us compare *DUR* and *BENCH*. The reduction in the marginal tax rate on labor income induces a substitution away from household into labor market employment in the former case. This causes a decline in the production of household services and a subsequent sharp price rise of household services. By comparing the two models with only fixed capital to those which also includes mobile capital we see that the possibility of reallocating capital induces a greater increase in labor supply. These greater substitution possibilities cause the price of the composite consumer good to rise less rapidly.

The model contains seven business sectors, one household sector, a government and a foreign sector, three mobile and six sector specific factors of production. A possible drawback of using a simulation model with a large number of variables is that the intuition behind the results can be lost in the complex structure of the model. Instead of increasing our understanding the model becomes a black box. In order to reduce that risk and gain some understanding of the properties of the model it might be instructive to examine the effects of changing only one tax rate at the time. In Tables 4.2-4.6 below each column is associated with a change of a specific tax rate(s) corresponding to the pre- and post-reform values of the effective tax rates of Table 2.3. The rows represent some of the endogenous variables in the model and the figures are expressed as

[10] An alternative would be to treat domestic and foreign capital as imperfect substitutes and construct a composite capital good as e.g. given by a CES-function.

percentage changes between the pre- and post-reform equilibrium. The first column shows the results when the average and the marginal corporate tax rates are changed, keeping all other tax rates constant. Similarly, the second column shows the effects of a change in the consumption tax rates, the third corresponds to a change in the average and marginal labor income tax rate and finally the last column measures the impact when all tax rates are changed simultaneously or in other words when the entire reform is implemented. We do not report the results of separately changing the payroll tax rates and the personal capital income tax rates since their partial effects are negligible. They are, however, included in the final column representing the complete tax reform.

4.2.1 Business Production Effects

We first discuss the effects on business production and its demand for factors of production, which are presented in Table 4.2 below. The main effect of the change in corporate taxation (col.1) is to raise the pre-tax return on new business capital such that the after-tax return, which is internationally determined, is unchanged. Here we can see the dramatic differences between the two models concerning the assumption of international capital mobility. In the *FLOW* case the amount of new capital employed domestically is reduced. Since total domestic supply of new capital is exogenous it will to a greater extent be invested abroad. There is a very slight reallocation of domestic new capital away from household to business capital (row 3) but that is in no way sufficient to compensate for the outflow of capital. In an open economy, the major effect of increased personal capital income taxation is to reduce domestic savings but leave domestic investment demand unchanged. A larger proportion of the domestic capital stock will be owned by foreigners. In our model personal capital income taxes do not even affect domestic savings, since it is assumed exogenous. The only result is a pure income effect. The decline in the employment of new capital is especially pronounced in the housing sector (not shown in the table) due to the large increase of its marginal corporate tax rate. Housing output, however, is reduced to a lesser extent since there is a substitution of labor for capital taking place. The effect on the trade balance reflects the imposed requirement that net exports must be large enough to pay for the return on foreign owned capital employed domestically. Column two shows the result of the change in indirect taxation. The effects on production are relatively minor. In the *FLOW* case there is a however a considerable decrease in the production of tradeables.

The effects of reduced marginal as well as average labor income tax rates are reported in column three. Labor supply to the business sectors increases by roughly 13 per cent in both cases. In the *FLOW* case this large increase in labor supply is accompanied by a substantial increase in the demand for new business capital. Most of this demand is satisfied by a huge inflow of foreign capital. In order to finance the foreign capital net exports must increase in proportion. Finally, the last column shows the total effects of changing all tax rates simultaneously i.e. simulating the entire tax reform. Note that in the total effect is included personal capital income and payroll taxes. The combined outcome shows an almost exact additive relationship with respect to the separate effects.

4.2.2 Household Production Effects

Next, let us look at the allocation effects between market and non-market activities. These are reported in Table 4.3. Not surprisingly, the largest effects are found when the labor income tax rates are reduced as can be seen from column three. The price of leisure increases by over 35 per cent which makes it less profitable to employ labor in the household sector. In order not to reduce the output of household services too much there is a substitution towards more capital intensive production methods in the household sector. In the case of higher corporate taxation some of the domestic new capital is diverted from household to business production. As more capital is invested abroad some of the released labor is now employed in household production. The increased indirect taxation makes market consumer goods relatively more expensive which induces a substitution between consumption of market goods and household services, but it has only minor effects on household production.

Table 4.2 - *Business Production Effects due to Tax Reform*

Percentage change in	Model version	Tax rate(s) being changed: corporate tax [11] (1)	consumer goods tax (2)	labor income tax (3)	all taxes (4)
Gross domestic	Flow	-22.4	-2.4	33.4	-2.2
product: $\Sigma_j\Sigma_v v_j X_{jv}$	Closed	0.0	-0.1	4.0	4.0
Domestic demand for new	Flow	-55.9	-6.2	71.2	-19.6
business capital: $\Sigma_j K_{jn}$	Closed	-1.0	-0.4	-2.5	-4.1
Domestic supply of new	Flow	1.5	-0.1	-5.7	-3.3
business capital: $\Sigma_h SF_h$	Closed	-1.0	-0.4	-2.5	-4.1
Foreign capital, per cent of	Flow	-42.9	-4.5	57.6	-12.2
domestic new capital: KF [12]	Closed	-	-	-	-
Labor supply to market:	Flow	-2.2	-0.8	13.9	11.8
$\Sigma_h LM_{hh}$	Closed	-0.3	-0.7	12.7	12.0
Gross output of tradeable	Flow	-70.3	-7.2	95.6	-16.7
sectors: $\Sigma_{td}\Sigma_v X_{td,v}$	Closed	0.3	0.2	2.3	2.9
Gross output of non-	Flow	-13.6	-1.5	22.3	0.5
tradeable sectors: $\Sigma_{nt}\Sigma_v X_{nt,v}$	Closed	0.0	-0.1	4.3	4.4
Gross output of housing	Flow	-9.1	-3.2	11.6	-3.6
sector: $\Sigma_v X_{hou,v}$	Closed	-3.3	-2.6	4.1	-1.9
Labor demand of tradeable	Flow	-16.3	-2.3	30.9	34.2
sectors: $\Sigma_{td}\Sigma_v AL_{td,v}$	Closed	-1.4	-2.5	36.2	32.6
Labor demand of non-	Flow	-0.8	-0.7	12.3	9.6
tradeable sectors: $\Sigma_{nt}\Sigma_v AL_{nt,v}$	Closed	-0.1	-0.5	10.4	10.0
Labor demand of housing	Flow	14.9	0.0	0.2	17.6
sector: $\Sigma_v AL_{hou,v}$	Closed	5.7	-0.8	9.6	15.2

[11] By corporate tax rates (τ_{Cj}, τ_{Cj}^{m}) we mean the tax on capital use in all business sectors i.e. including the public and the housing production sectors.

[12] A negative number indicates an outflow of capital.

Table 4.3 - Household ***Production Effects due to Tax Reform***

Percentage change in	Model version	Tax rate(s) being changed: corporate tax (1)	consumer goods tax (2)	labor income tax (3)	all taxes (4)
Gross output of household services: $\Sigma_v XD_{hv}$	Flow	-2.3	0.4	7.8	4.1
	Closed	1.8	0.8	2.6	5.4
Demand for new household capital: KD_{hn}	Flow	-4.3	0.4	17.0	9.9
	Closed	3.0	1.2	7.5	12.2
Demand for labor: $\Sigma_v LD_{hv}$	Flow	2.3	0.3	-11.1	-8.5
	Closed	-0.7	0.1	-8.3	-9.1
Capital income: RD_h + $P_K r_W KD_{hn}$	Flow	-0.9	0.4	13.2	5.9
	Closed	-3.8	0.6	9.9	6.7

4.2.3 Price and Income Effects

The results in Table 4.4 mostly reflects the effects on economic activity as reported in Table 4.2. As can be seen from column one, the *FLOW* case exhibits a substitution of capital for labor income. A larger proportion of domestic new capital is now invested abroad generating capital income and at the same time depressing wages and labor demand at home. As a result of the decreased supply of factors of production, domestically, the price of composite consumer goods rises sharply. Increased indirect taxes, column two, predictably forces the price of the composite consumer good up with very small effects on wages and income.

Table 4.4 - *Price and Income Effects due to Tax Reform*

Percentage change in	Model version	Tax rate(s) being changed: corporate tax (1)	consumer goods tax (2)	labor income tax (3)	all taxes (4)
Net national income:	Flow	4.9	-0.5	4.9	4.9
	Closed	1.7	-0.4	3.8	5.2
Price of composite consumer good: UC_{Bh}	Flow	6.5	3.1	1.9	7.4
	Closed	1.7	3.1	2.3	7.3
Gross labor income:	Flow	-6.7	-0.8	13.6	-0.6
	Closed	0.3	0.2	0.8	2.1
Net labor income:	Flow	-6.7	-0.8	27.6	11.6
	Closed	0.3	0.2	13.3	14.7
Gross capital income:	Flow	12.3	-0.1	-2.7	7.0
	Closed	-0.3	-0.8	5.8	4.9
Net capital income:	Flow	7.6	-0.1	-2.3	8.0
	Closed	-4.5	-0.8	6.3	5.9
Wage rate of skilled labor: W_{sl}	Flow	-3.9	0.1	-0.7	-11.1
	Closed	0.5	0.9	-10.5	-8.8
Wage rate of unskilled labor: W_{ul}	Flow	-4.8	0.0	-0.2	-11.2
	Closed	0.5	0.9	-10.5	-8.9

The effects of reduced labor income taxation, column three, again highlights the difference between the two models. Now the effects are almost completely reversed compared to column one. Reduced income taxation, average and marginal, causes an increase in labor supply which in turn generates a large inflow of foreign capital. The result is a considerable increase in gross as well as net labor income. The reason for the decline in capital income, given that the net return to capital is exogenous in the *FLOW* model, is that a larger proportion of domestic new capital is devoted to household production. Note the large difference in the development of the real wage rate. In both cases the labor supply is increased by roughly the same amount, but when a foreign capital inflow is allowed for the marginal productivity of labor does not decline as much as when the total amount of capital is fixed. Finally, the last column shows that the overall results are quite similar for the two model versions, despite the fact that there are large differences in the partial responses as demonstrated by the results of columns one and three. It seems that the separate strong effects of model *FLOW* are to a large degree offset against each other.

4.2.4 Tax Revenue Effects

Again, the tax revenue effects shown in Table 4.5 are mirror images of the underlying real effects of Table 4.2. The results are very much what one would expect. However, a few comments are worth making. Column one shows that the increase in corporate taxation, mainly on housing, diminishes the tax base on new capital to such an extent that there is a reduction in tax revenues from this source. Although, there is a decrease in new corporate tax revenues in both models the underlying causes differ markedly. In the *FLOW* case there is an outflow of new capital, whereas in the *CLOSED* case the rate of return on new capital goes down. In both cases the result is a smaller tax base. However, this loss is compensated for by a surge in tax revenue arising from old capital employed. Note also that since the return on new capital is reduced in the *CLOSED* version the tax revenues from household capital income decrease. We also see the relatively strong repercussions of increased corporate taxation, in the *FLOW* case, on payroll and labor income tax revenues.

A higher taxation of consumer goods affects mainly its own tax base. Reduced labor income taxation, column three, cause the tax revenues from this source to drop since the larger labor supply is not enough to offset the reduction in tax rates. However, the increased activity in the economy increases payroll and sales tax revenue such that nominal tax revenues are approximately unchanged. Revenues from personal new capital income is reduced, when there is an inflow of capital, since foreign investors do not pay any personal capital income taxes in Sweden. The greatest increase shows corporate taxes on new capital.

Table 4.5 - *Tax Revenue Effects due to Tax Reform*

Percentage change in	Model version	Tax rate(s) being changed: corporate tax (1)	consumer goods tax (2)	labor income tax (3)	all taxes (4)
Corporate tax revenue from old capital: TXOC	Flow	122.2	-0.1	1.6	119.2
	Closed	95.6	-1.1	15.5	114.3
Corporate tax revenue from new capital: TXNC	Flow	-133.4	-5.6	55.9	-185.9
	Closed	-191.9	11.5	-19.3	-203.0
Payroll tax revenue: TXL	Flow	-6.9	-0.8	13.9	-3.0
	Closed	0.3	0.2	1.2	-0.4
Labor income tax revenue: TXY	Flow	-6.7	-0.8	-10.5	-21.7
	Closed	0.3	0.2	-20.5	-19.5
Capital income revenue from old capital: TXOK	Flow	10.5	0.0	0.7	23.7
	Closed	-2.4	-0.7	9.5	21.1
Capital income revenue from new capital: TXNK	Flow	4.1	-0.1	-5.7	-24.8
	Closed	-6.9	-0.7	1.4	-26.1
Consumer goods tax revenue: TXS	Flow	0.4	25.0	11.5	33.3
	Closed	1.0	25.6	5.6	35.0
Total tax revenue: TX	Flow	6.0	4.8	1.2	5.7
	Closed	6.5	5.1	-1.7	6.9
Government transfers: TR	Flow	15.8	10.4	2.2	21.0
	Closed	13.7	10.3	4.2	21.8
Real total tax revenue: TX / UC_{Uh}	Flow	1.9	2.3	-7.2	-4.3
	Closed	5.1	2.5	-7.7	-3.7

Finally, the overall effects on tax revenue are reported in column four. Tax revenues from different sources are affected in about the same magnitude for both models, except for corporate and personal capital income taxes as might be expected given the different assumptions about new capital mobility. It is interesting to note that the change in tax revenues from labor income are affected quite similarly, even though the partial responses are very different. Changes in total tax revenue, both nominal and real, are of the same order of magnitude in both cases.

4.2.5 Welfare Effects

Before looking at Table 4.6 which reports the welfare effects, let us define a few measures of welfare. Let us begin by defining the Laspeyere and Paasche cost-of-living indices, for household h, in terms of the variables used in the model.

$$\textit{Laspeyere index} = \frac{\sum_{i \neq D} PC_i^1 \cdot C_{hi}^0 + PC_{Dh}^1 \cdot CD_h^0 + PF_h^1 \cdot F_h^0}{\sum_{i \neq D} PC_i^0 \cdot C_{hi}^0 + PC_{Dh}^0 \cdot CD_h^0 + PF_h^0 \cdot F_h^0} \tag{4.8}$$

$$\textit{Paasche index} = \frac{\sum_{i \neq D} PC_i^1 \cdot C_{hi}^1 + PC_{Dh}^1 \cdot CD_h^1 + PF_h^1 \cdot F_h^1}{\sum_{i \neq D} PC_i^0 \cdot C_{hi}^1 + PC_{Dh}^0 \cdot CD_h^1 + PF_h^0 \cdot F_h^1} \tag{4.9}$$

where, superscript *1* indicates the state of the economy after the tax reform and superscript *0* represents the initial or pre-reform equilibrium. If preferences are homothetic, the Laspeyere and the Paasche indices are bounded by the following inequality.

$$PI_h \leq \frac{UC_h^1}{UC_h^0} \leq LI_h \tag{4.10}$$

Assume that we would like to compare two states of the economy which can adequately be represented by a price vector P and a measure of income Y. A measure of welfare change involved in moving from state *0*, (P^0, Y^0), to another state *1*, (P^1, Y^1), is the difference in indirect utility. Thus, we can write the change in utility due to the tax reform for household h as.

$$\Delta U_h = V_h(P^1, Y_h^1) - V_h(P^0, Y_h^0) \quad (4.11)$$

Next, let us define the following function.

$$\mu(q: p, y) = e(q, V(p, y)) \quad (4.12)$$

where, e is the expenditure function and the function μ measures how much income the consumer would need at prices q to be as well off as he would be facing prices p and income y. Using this definition we can now express the welfare change for household h as.

$$\Delta U_h = \mu(q: P^1, Y_h^1) - \mu(q: P^0, Y_h^0) \quad (4.13)$$

It remains to choose the reference price vector q. There are two obvious choices; $\mathbf{P^0}$ or $\mathbf{P^1}$. By choosing the prices corresponding to the initial state *0* we get an expression for the equivalent variation.

$$EV_h = \mu(P^0: P^1, Y_h^1) - \mu(P^0: P^0, Y_h^0) = \mu(P^0: P^1, Y_h^1) - Y_h^0 = (U_h^1 - U_h^0) \cdot UC_h^0 \quad (4.14)$$

Thus, the equivalent variation takes the initial income and prices and calculates the change in income needed to achieve the utility level corresponding to the new equilibrium. Equipped with these definitions let us discuss the results of Table 4.6. First of all, we note that consumption of the composite goods, the utility index and the EV_h all rank the different cases in the same order. The is not true for the measure of leisure since some of the welfare gains are achieved at the expense of reduced leisure consumption. By looking at cost-of-living indices we see that in the first column there are much greater increases for the *FLOW* case since a considerable amount of new capital is used abroad and hence the supply of domestic factors of production are cut back. The even bigger increase in the cost-of-living indices shown in column three is mainly due to the higher price of leisure.

Table 4.6 - *Welfare Effects due to Tax Reform*

Percentage change in	Model version	Tax rate(s) being changed: corporate tax (1)	consumer goods tax (2)	labor income tax (3)	all taxes (4)
Consumption of composite good: CB_h	Flow	-4.8	-1.2	10.5	2.0
	Closed	-0.3	-0.7	4.4	3.4
Consumption of dwelling services $C_{h,dwelling}$	Flow	-9.4	-3.4	11.5	-4.2
	Closed	-3.5	-2.8	3.9	-2.5
Leisure: F_h	Flow	0.3	0.4	-4.5	-4.0
	Closed	0.6	0.3	-4.5	-4.0
Utility: U_h	Flow	-3.7	-0.8	6.8	0.6
	Closed	-0.1	-0.5	2.3	1.7
Laspeyere cost-of-living-index:	Flow	1.0414	1.0247	1.0947	1.1061
	Closed	1.0144	1.0264	1.0667	1.1121
Ideal cost-of-living index:	Flow	1.0401	1.0244	1.0902	1.1042
	Closed	1.0141	1.0262	1.0651	1.1099
Paasche cost-of-living index:	Flow	1.0388	1.0242	1.0861	1.1023
	Closed	1.0137	1.0260	1.0635	1.1077
EV as a percentage of gross domestic product:	Flow	-4.0	-0.9	7.4	0.7
	Closed	-0.1	-0.5	2.5	1.9
EV as a percentage of net national income:	Flow	-4.7	-1.1	8.6	0.8
	Closed	-0.2	-0.6	2.9	2.2
EV as a percentage of total tax revenue:	Flow	-8.6	-2.0	15.8	1.5
	Closed	-0.3	-1.1	5.3	4.0

The last three rows give an indication of the potential welfare gains of the tax reform. It is the reduction in labor income taxes that is by far the dominant contributor to the welfare gains. The total gains involved amount to somewhat less than one per cent of pre-reform gross domestic product for the *FLOW* specification and to roughly two per cent for the *CLOSED* version.

4.3 Sensitivity Analysis

Sensitivity analysis can be performed at several different levels. First of we have to make a choice of the specification of the model; what we assume about factor mobility, adjustment of prices, level of aggregation etc.. In our case we reported our results, in Tables 4.1-4.6 above, for two different specifications with regard to the international mobility of capital. As we have seen the results differ markedly for some parameter changes and thus have different implications for tax policy in a small open economy. On the next level we decide what functional forms to use when describing the technology and preferences in our model. Finally, we must specify numerical values for various elasticities. It is of course preferable to estimate the model econometrically, but in our case this has not been possible within the time constraints of our project. When the model is not econometrically estimated it is even more important to perform sensitivity analysis. In this section we will restrict ourselves to two kinds of sensitivity analyses. In Section 4.3.1 we exogenously specify different values for the elasticity of substitution between consumption and leisure for the household sector and solve the model for each new value and compare the results. Second, we analyze different assumptions about how to keep the real amount of taxes collected constant. This is done in Section 4.3.2.

4.3.1 The Elasticity of Substitution

There are a number of elasticities in the model, namely the elasticity of substitution between; labor and leisure for the consumer (1), different consumer goods (1), labor and capital in household production (2), skilled and unskilled labor in business sectors (7) and composite labor and capital in business production (14). Thus, even with an aggregate household sector there in principle no less than 25 different elasticities of substitution that need to be specified. There are of course other parameters as well that can be subjected to sensitivity analysis. Due to this dimensionality problem it will not be practically possible to perform a sensitivity analysis with respect to all elasticities or parameters.

We will limit ourselves to the probably most crucial parameter in the model i.e. the elasticity of substitution between leisure and consumption in the household utility function. This parameter governs the elasticity of labor supply with respect to the price of leisure and vice versa. In other words there is a one-to-one relationship between the two. So, if there is an estimate of the elasticity of labor supply available we can use it to derive a numerical value for the elasticity of substitution between leisure and consumption. A detailed derivation of this relationship is given in Section A3.7 in Appendix 3. We present our results for different values of the elasticities in Table 4.7 below. Remember that for each value we have recalibrated the model and then performed the comparative static exercise of simulating the tax reform. All other parameters are unchanged. As our base case i.e. the results reported in Tables 4.1-4.6 above we have used the value of 0.50 for the elasticity of substitution.

As expected, the larger the elasticity of substitution (elasticity of labor supply) the larger the magnitudes of the effects of the tax reform. For all variables and for both model versions there is an almost exact linear relationship between the magnitude of the parameter and the magnitude of the effects on the variables. Thus, it seems that the relative magnitudes between variables stay roughly the same and that the main effect is to scale up or down the absolute size of the effects.

4.3.2 Different Equal-Yield Requirements

As previously mentioned it is important to keep real government expenditures constant so that the impact of a changed tax structure can be isolated from a changed level of average taxation. This can be done in several different ways. In our model the only variable government expenditure item is transfers to the household sector as can be seen from the government budget constraint which is reproduced here.

Table 4.7 - *Sensitivity Analysis w.r.t. the Elasticity of Substitution*

Percentage change in		Elasticity of Labor Supply					
		0.34	0.40	0.46	0.52	0.57	0.69
		Elasticity of Substitution					
		0.3	0.4	0.5	0.6	0.7	0.9
EV as per cent of gross domestic product:	Flow	-0.3	0.2	0.7	1.2	1.6	2.6
	Closed	1.3	1.6	1.9	2.1	2.3	2.7
EV as per cent of tax revenue:	Flow	-0.6	0.4	1.5	2.5	3.5	5.6
	Closed	2.9	3.5	4.0	4.5	4.9	5.7
Gross domestic product:	Flow	-5.5	-3.9	-2.2	-0.5	1.2	4.6
	Closed	3.5	3.8	4.0	4.3	4.5	4.9
Net national income:	Flow	4.4	4.7	4.9	5.2	5.5	6.0
	Closed	4.6	4.9	5.2	5.4	5.6	6.0
Utility: U_h	Flow	-0.2	0.2	0.6	1.1	1.5	2.4
	Closed	1.2	1.5	1.7	1.9	2.1	2.5
Composite consumer good: CB_h	Flow	0.6	1.3	2.0	2.8	3.5	5.0
	Closed	2.4	2.9	3.4	3.9	4.3	5.1
Supply to labor market: LM_{hh}	Flow	10.4	11.1	11.8	12.6	13.3	14.8
	Closed	10.1	11.1	12.0	12.8	13.6	14.9

$$TX + EXGOV = TR + PX_{pub} \cdot G_{pub} + GSAV \qquad (4.15)$$

where, *TX* is equal to total tax revenue. We see from Table 4.5 above that real tax revenues decline, which implies that real household transfers must also decline. In order to keep real government expenditures or equivalently real government tax revenues constant they need to be raised to their pre-reform level. What we are really interested in is to keep the real resources that are used up by the government sector constant. Let us therefore define real tax revenues as nominal tax revenues deflated by the unit price of utility.

$$REALTX = TX \,/\, UC_{Uh} \tag{4.16}$$

In our base case simulation, presented in Tables 4.1-4.7 above, we have kept *REALTX* constant by reducing household lump sum transfers or in other words by levying a lump sum tax on the household sector. Another possibility to increase real tax revenues to their pre-reform level is to increase one or several tax rates. This would entail an excess burden cost compared to the case where additional tax revenue is raised through lump sum taxation. Assume that we instead of a lump sum tax raise the labor income tax such that real tax revenues are kept at their pre-reform level. Since real tax revenues are fixed we must let the tax rate on labor income become a variable. We perform a new simulation with the following two equations added to the model.

$$REALTX = \left(TX \,/\, UC_{Uh}\right)^0 \tag{4.16}$$

$$\tau^*_{Yh} = \theta_Y \tau_{Yh} \quad and \quad \tau^{m*}_{Yh} = \theta_Y \tau^m_{Yh} \tag{4.17}$$

where, the superscript *0* indicates the pre-reform state of the economy and the superscript * that the tax rate is variable. As can be seen we require that both the average and the marginal labor tax rate are changed (increased) by the same factor of proportionality θ_Y. In the same manner we can define variable tax rates for the other tax instruments in the model. In Table 4.8 below, we report the equivalent variation, expressed as a percentage of gross domestic product, varies according to how the additional tax revenue is raised.

The figures for the lump sum case in row one are same as those in row one in table 4.7. It turns out, in our model, that changing the tax rate on household capital income has no allocative effects at all. The only effect is an income effect. Remember that the total amount of capital is exogenous and the allocation of it depends on relative factor costs which in turn are independent on taxation of capital income. Thus, we get the same results as for the lump sum case.

Let us first look at model *FLOW*. In terms of efficiency, as measured by the equivalent variation in relation to gross domestic product, the costliest way to obtain the extra revenue necessary is through increased taxation on labor. Instead of a welfare gain equal to 1.3 per cent of gross domestic product, there will be loss of over 4 per cent. The least inefficient way to collect the additional tax is by raising the corporate tax rate. This result may seem somewhat surprising in the light of the strong adverse effects reported above when only the corporate tax rate was increased. The can probably be explained by the fact that the initial levels of the corporate tax rates are relatively low compared to the other tax rates. As is well known the excess burden rises more than proportionate to the rise in the tax rate(s). It should be noted that all alternatives of raising the tax revenues for model *FLOW*, except the lump sum tax, results in a net loss.

Table 4.8 - *Different Equal-Yield Requirements*

Mode of Taxation		Percentage change in EV[13]	Proportional increase in tax rate(s)
Lump sum:	Flow	0.7	1.0
	Closed	1.9	1.0
Labor income:	Flow	-3.8	1.276
	Closed	1.0	1.158
Payroll:	Flow	-2.0	1.472
	Closed	1.3	1.307
Consumer goods:	Flow	-1.6	1.537
	Closed	0.5	1.410
Corporate income:	Flow	-1.5	1.704
	Closed	0.4	1.692
Household capital income:	Flow	0.7	1.259
	Closed	1.9	1.229

For model *CLOSED*, on the other hand, the costliest way to finance government expenditures is through consumer goods taxation and the most efficient way, excluding lump sum taxation, is to

[13] EV is expressed as a percentage of gross domestic product.

raise payroll taxes. It is only the consumer goods taxation case that produces a welfare loss. Although lump sum taxation is unrealistic it can be interpreted as an upper bound of the welfare gains obtainable.

5. CONCLUSIONS

The computable general equilibrium model that has been presented in this paper is primarily intended to be used in the evaluation of the Swedish tax reforms during 1990 - 1991. Especially, it will be used as a complement to tax-benefit models that restrict their analysis to the impact effects of policy changes.

In this paper we have used data for an aggregate household sector which precludes any distributional issues to be analyzed. Instead the analysis has focused on the allocation between different production sectors of the economy and between market and non-market activities. We have calculated a number of welfare measures intended to summarize the overall efficiency aspects of the tax reform. It is found that the reform improves allocative efficiency, mainly due to lower taxation of labor income. In particular the effective marginal tax rate on labor income is reduced from 57 per cent to 42 per cent.

Are the results reasonable? The results of every model are of course dependent upon the model specification, data used and the numerical values specified for certain key parameters. On the basis of the results and the sensitivity analysis presented in section four it is our impression that the qualitative results are compatible with accepted theory as well as with general intuition. The fact that our two model versions gave rather different results for certain tax experiments should not be taken as evidence that one can obtain any result one desires, but should rather be interpreted as a systematic way of analyzing different assumptions regarding the behavior of the economy.

Our next step is to disaggregate the household sector into different socioeconomic groups in order to analyze the some of the distributional effects of the 1989-91 tax reform in Sweden. For that purpose a complete social accounting matrix, with a disaggregated household sector has been constructed.

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RESUMÉ

Syfte och Bakgrund

Huvudsyftet med denna uppsats är att utvärdera de långsiktiga effekterna av den svenska skattereformen 1990-91 med avseende på aggregerad välfärd och effektivitet. Ett delsyfte har också varit att komplettera de beräkningar som gjorts med sk "tax-benefit" modeller. Dessa modeller är konstruerade så att de avbildar skattesystemet med stor nogrannhet och detaljrikedom, men på bekostnad av att det ej finns något ekonomiskt beteende inkorporerat. Detta innebär att endast impact-effekter kan analyseras med denna modellansats. Vår modell, å andra sidan, har sin styrka i att ett explicit ekonomiskt beteende modelleras för de olika agenterna i ekonomin. Modellansatsen är sådan att det är de mera långsiktiga effekterna som undersöks. Lång sikt i detta sammanhang betyder att vi analyserar effekterna av skattereformen efter det att priser och löner har anpassat sig till ett nytt jämviktsläge.

Eftersom den nuvarande modellversionen endast innehåller en aggregerad hushållssektor, så medför det att vi ej kan analysera fördelningsmässiga aspekter av reformen. Vi inriktar i stället analysen på hur allokeringen av produktiva resurser mellan olika produktionssektorer samt mellan näringslivet och hushållsproduktion påverkas.

Skattesystemet i Sverige, före reformen, präglades av höga formella inkomstskattesatser. Eftersom dessa höga skattesatser delvis var en följd av relativt smala skattebaser, så resulterade denna kombination i såväl allokeringsmässig ineffektivitet som en orättfärdig fördelning av skattebördan. Den svenska reformprocessen följde det internationella mönstret bland sina föregångare genom att föreslå lägre skattesatser, speciellt marginalskattesatser, tillsammans med en vidgning av skattebaserna. Principen om enhetlig beskattning och basbreddning gör det möjligt att sänka skattesatserna utan att nämnvärt minska de totala skatteintäkterna. Man kan identifiera två huvudmål som man hoppas kunna uppnå genom det nya skattesystemet. Det första är att kunna effektivisera finansieringen av de offentliga utgifterna dvs att minimera "excess burden" av snedvridande skatter, givet att nivån på de offentliga utgifterna är oförändrad. Det andra målet består i att kunna upprätthålla en horisontell rättvisa genom en enhetlig beskattning av arbete och kapital. I denna uppsatsen diskuteras enbart det förra målet eftersom vi ej behandlar olika hushållsgrupper.

Analysmetod - Modellbeskrivning

För att undersöka de långsiktiga effekterna av skattereformen, så konstruerar vi en "computable general equilibrium" simuleringsmodell. Modellen är huvudsakligen statisk, eftersom tidsdimensionen ej modelleras explicit och agenterna löser därmed ej några genuint intertemporala beslutsproblem. Detta inebär att sparande och investeringar behandlas på ett ad-hoc mässigt sätt. Vi antar att hushållssektorn sparar en konstant andel av sin inkomst. Sparandet påverkar vare sig den produktiva kapaciteten eller den framtida konsumtionen. När det gäller investeringarna, så vore det önskvärt att explicit modellera investeringsefterfrågan utsträckt över tiden. Men i stället så definierar vi efterfrågan på nytt kapital som skillnaden mellan den optimala långsiktiga kapitalstocken och den faktiska.

Modellen innehåller fyra typer av ekonomiska agenter; producenter, en representativ konsument, en offentlig sektor och en utländsk sektor. Hushållssektorn har ett initialt innehav av tid (arbete) och kapital. Vi särskiljer två typer av arbetskraft; hög- och lågutbildad, vilka båda antages vara fritt rörliga mellan inhemska produktionssektorer. Beträffande kapital skiljer vi mellan gammalt eller sektorsspecifikt och nytt eller rörligt. De sektorsspecifika kapitalstockarna liksom den totala inhemska nya kapitalstocken är exogent givna. Ersättningen till gammalt kapital utgår i form av en kvasiränta som i allmänhet skiljer sig åt mellan sektorerna. Så länge som kvasiräntan är icke-negativ så används gammalt kapital i produktionen. Nytt kapital däremot, kan fritt omallokeras till dess att nettoavkastningen efter skatt utjämnats mellan de olika sektorerna som använder nytt kapital.

Produktionssektorerna är indelade i tre konkurrensutsatta och fyra skyddade sektorer. De konkurrensutsatta sektorerna är definierade i termer av faktorintensiteter; kapitalintensiv, intensiv i hög- respektive lågutbildad arbetskraft. Priset på output i dessa sektorer är givet av världsmarknaden. De skyddade sektorerna består av; en sektor för egna hem, övrig fastighetsförvaltning, privata tjänster and offentlig produktion. Hushållens nytta är en funktion av deras konsumtion av varor och fritid, vilket innebär att arbetskraftsutbudet är endogent. Arbetsutbudet kan i sin tur delas upp i två komponenter. Det kan antingen kanaliseras till produktionssektorerna via den "ordinarie" arbetsmarknaden, eller kan det användas internt inom hushållssektorn i dess produktion av hushållstjänster. Produktion inom hushållssektorn kan tolkas som den informella sektorn av ekonomin. Olika skatter påverkar därmed allokeringen av resurser mellan den formella och den informella delen av ekonomin.

Den inhemska ekonomin är kopplad till den internationella via två kanaler. Som tidigare nämnts så är priserna för de konkurrensutsatta sektorerna givna från världsmarknaden. För det andra, så antar vi att det existerar en internationell kapitalmarknad som bestämmer världsmarknadsräntan. Detta medför att det inhemska utbudet av och efterfrågan på nytt kapital ej behöver överensstämma i jämvikt. Skillnaden utgörs av ett kapitalin(ut)flöde. Den offentliga sektorns uppgifter består i att samla in skatter och dela ut transfereringar till hushållssektorn. Eftersom såväl offentliga utgifter som sparande är exogent givna, så kommer kravet på en offentligt balanserad budget att bestämma transfereringsutgifterna.

Resultat

För att kunna undersöka känsligheten av resulten med avseende på olika antaganden om kapitalets internationella rörlighet så presenteras resultaten för två olika modellversioner. I den första versionen (*CLOSED*) antar vi att kapitalet ej kan flyttas utanför den inhemska ekonomin dvs ekonomin är sluten med avseende på kapitalrörelser. Därmed kommer räntan att bestämmas av inhemska utbuds- och efterfrågeförhållanden på nytt kapital. Den andra versionen (*FLOW*) antar däremot att kapitalet kan röra sig helt fritt mellan den inhemska och den internationella kapitalmarknaden. Medan räntan nu är exogent given för de inhemska producenterna, så kommer andelen utländskt kapital att bestämmas endogent.

Vi presenterar result dels med avseende på att hela reformen genomförs i ett enda steg, dels med avseende på partiella reformer som endast ändrar en typ av skattesats i taget. Låt oss först undersöka effekterna av att enbart ändra skatten på använt kapital (bolagsskatten). I *CLOSED* versionen så är effekterna i stort sett försumbara. Däremot, när vi tillåter kapitalrörlighet över gränserna så medför en höjning av bolagsskatten, främst inom bostadssektorn, att kapital strömmar ut från landet vilket i sin tur medför att produktionen minskar. Detta är ett exempel på bolagsskattens olika effekter i en sluten respektive en liten öppen ekonomi.

Antag nu att vi ändrar arbetsinkomstskatten, medan övriga skattesatser hålls oförändrade. Även i detta fall skiljer sig effekterna markant åt i de två modellerna. I båda fallen så ökar arbetsutbudet. När vi tillåter kapitalrörlighet, så åtföljs en ökning i arbetsutbudet av en inströmmning av kapital som medför en väsentlig ökning av produktionen. I *CLOSED* versionen däremot, så medför en ökning av arbetsutbudet framför allt att lönerna sänks med liten effekt på produktionen.

När vi simulerar hela reformen, så tar de ovan beskrivna deleffekterna i *FLOW* fallen nästan ut varandra, så att nettoeffekterna för de två modellerna blir ganska lika, dock med att par notabla undantag. Den huvudsakliga skillnaden mellan modellerna är att produktionen (BNP) är mindre i *FLOW* versionen, eftersom en del av kapitalet placeras utomlands. Däremot så är nettonationalinkomsten ungefär lika stor i båda fallen.

Vi presenterar ett antal välfärdsmått som är ämnade att ge ett sammanfattande mått på den allokeringsmässiga effektiviteten. Vi finner då att reformen ökar effektiviteten i ekonomin. Det är framför allt reduktionen av marginalskatten på arbetsinkomster som ger upphov till den aggregerade välfärdsökning. Den effektiva marginalskatten på arbetsinkomster sänks genom reformen från 57 procent till 42 procent. Den total välfärdsökningen, uttryckt i procent av BNP före reformen, uppgår i *FLOW* versionen till knappt en procent och i *CLOSED* fallet till ungefär två procent.

Är resultaten rimliga? Resultaten som fås från en viss modell är naturligtvis alltid beroende av modellspecifikationen, data och de speciella värden som man har ansatt vissa nyckelparametrar. Utifrån de resultat vi erhållit och den känslighetsanalys vi utfört är det vår uppfattning att de kvalitativa resultaten stämmer överens med såväl etablerad teori som allmän intuition. Det faktum att våra två modellversioner producerade markant avvikande resultat för vissa partiella skatteexperiment bör ej tas som intäkt för att vilka resultat som helst kan erhållas, utan ska i stället tolkas som ett systematiskt sätt att analysera olika viktiga antaganden om ekonomins funktionssätt.

APPENDIX 1 - LIST OF VARIABLES

Symbol	Index Variables	Set
b	labor category	skilled, unskilled
j	production sector	capital intensive, skilled labor intensive, unskilled labor intensive, sheltered, public, real estate and housing
td	tradeable sectors	capital intensive, skilled labor intensive and unskilled labor intensive
nt	non-tradeable sectors	sheltered, public, real estate and housing
v	capital vintage	old, new
h	household category	aggregate household sector
i	consumption good	food, spirits and tobacco, non-durable goods, clothing and footwear, health- and medical care, furniture and household articles, dwelling services, transportation services, recreational and cultural services, other services, private non-profit organization output and household services

Symbol	Endogenous Price Variables
W_b	wage rate
WP_{bj}	wage cost for the producer
PF_h	price of leisure
UC_{Lj}	unit cost of composite labor
PK_{jv}	rental price of business capital
PD_{hv}	rental price of household capital
UC_{Xj}	unit cost of new gross output
UC_{Dh}	unit cost of new output from household production
PX_j	price of gross output from business sectors
P_K	price of capital good
PC_i	price of market consumption goods
PC_{Dh}	price of household services
UC_{Bh}	unit cost of composite consumption good
UC_{Uh}	unit cost of utility
ER	exchange rate

Symbol	Endogenous Quantity Variables
SF_h	supply of new business capital
KD_{hn}	new household capital
U_h	utility
V_h	indirect utility function
C_{Bh}	composite consumption good
F_h	leisure
L_h	labor supply
C_{hi}	market consumption good
C_{Dh}	household services
C_j	aggregate household demand for producer good
AL_{jv}	composite labor
L_{bjv}	demand for labor in business sectors
LD_{hv}	demand for labor in household production
K_{jn}	demand for new business capital
VA_{jv}	value added
X_{jv}	gross output in business sectors
XD_{hv}	gross output or value added of household production
I_j	intermediate goods
INV_j	investment demand by sector of origin
Z_{sd}	net exports
KF	foreign stock of new capital
REALTX	total real tax revenue

Symbol	Endogenous Value Variables
Y_h	after tax full income
S_h	household gross savings
B_{Yh}	intercept in labor income tax function
DEP_h	depreciation
RK_j	after-tax net return to old business capital
RD_h	net return to old household capital
TR	total government net transfers to households
TR_h	government net transfers to household
TX_L	labor tax revenue
TX_{OC}	tax revenue from use of old business capital
TX_{NC}	tax revenue from use of new business capital
TX_S	consumption tax revenue

TX_Y	tax revenue from labor income
TX_{OK}	tax revenue from income of old business capital
TX_{NK}	tax revenue from income of new business capital
TX	total tax revenue
EV_h	equivalent variation
TB	trade balance
CC	current account
TSAV	total gross savings

Symbol	Exogenous Variables
AS_h	endowment of new capital
ΔK	total net addition of capital
s_{Yh}	household gross savings ratio
g_{Xj}	growth rate of Hicks-neutral technical progress in business sectors
g_{Lh}	growth rate of labor endowment
g_{Dh}	growth rate of Hicks-neutral technical progress in household production
PW_{td}	world price of tradeables
r_W	world rate of interest
K_{jo}	endowment of old business capital
KD_{ho}	endowment of old household capital
G_j	government demand for goods
FSAV	foreign savings
FORREV	foreign revenue
GSAV	government savings
EXGOV	government revenue
EX_j	exogenous demand for gross output
EX_{Ch}	exogenous household expenditure
β_h	household share of return to old business capital
δ_{jv}	rate of depreciation of business capital
δ_{Dv}	rate of depreciation of household capital
LE_h	labor endowment
m_{ji}	element of the transition matrix between producer and consumer goods
q_{bh}	element of the transition matrix between labor categories and households
a_{ij}	input-output coefficients
v_j	share of value added in gross output in business sectors
k_j	share in capital composition vector

Symbol	Effective Tax Rates
τ_{Lj}	payroll tax rate
τ_{Cj}	average corporate tax rate
τ_{Cj}^{m}	marginal corporate tax rate
τ_{Yh}	average labor income tax rate
τ_{Yh}^{m}	marginal labor income tax rate
τ_{Kh}	average household capital income tax rate
τ_{Kh}^{m}	marginal household capital income tax rate
τ_{Fhj}	$\tau_{Cj} + (1-\tau_{Cj})\tau_{Kh}$
τ_{Fhj}^{m}	$\tau_{Cj}^{m} + (1-\tau_{Cj}^{m})\tau_{Kh}^{m}$
τ_{Si}	tax rate on consumer goods

Symbol	Functional Parameters
Σ_h	efficiency parameter in utility function U_h
λ_{Ch}	distribution parameter in utility function U_h
σ_h	elasticity of substitution parameter in utility function U_h
Φ_h	efficiency parameter in subutility function C_{Bh}
λ_{hi}	distribution parameter in subutility function C_{Bh}
λ_{Dh}	distribution parameter in subutility function C_{Bh}
ϕ_h	elasticity of substitution parameter in subutility function C_{Bh}
A_{jv}	efficiency parameter in production function X_{jv}
α_j	distribution parameter in production function X_{jv}
η_{jv}	elasticity of substitution parameter in production function X_{jv}
Γ_j	efficiency parameter in labor aggregation function AL_{jv}
γ_j	distribution parameter in labor aggregation function AL_{jv}
ϵ_j	elasticity of substitution in labor aggregation function AL_{jv}
Λ_{Dhv}	efficiency parameter in household production function XD_{hv}
α_{Dh}	distribution parameter in household production function XD_{hv}
η_{Dhv}	elasticity of substitution parameter in household production function XD_{hv}

APPENDIX 2 - LIST OF EQUATIONS

Table A2.1 - *Factor Demand and Goods Supply Equations*

number of equations

Production function:

$$X_{jv} = \left(\frac{A_{jv}}{v_j}\right) \cdot \left[\alpha_j \cdot AL_{jv}^{\frac{\eta_{jv}-1}{\eta_{jv}}} + (1-\alpha_j) \cdot K_{jv}^{\frac{\eta_{jv}-1}{\eta_{jv}}}\right]^{\frac{\eta_{jv}}{\eta_{jv}-1}}$$

Labor aggregation function:

$$AL_{jv} = \Gamma_j \cdot \left[\sum_b \gamma_{bj} \cdot L_{bjv}^{\frac{\epsilon_j-1}{\epsilon_j}}\right]^{\frac{\epsilon_j}{\epsilon_j-1}}$$

Old gross output:

$$X_{jo} = \frac{\partial \Pi_j(PX_j,\ WP_{bj},\ K_{jo})}{\partial PX_j} \qquad (j)$$

Quasi-rent accruing to old business capital:

$$\left(PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b WP_{bj} \cdot L_{bjo}\right) \cdot X_{jo} \geq 0$$

Demand for old composite labor:

$$AL_{jo} = -\frac{\partial \Pi_j(PX_j,\ WP_{bj},\ K_{jo})}{\partial UC_{Lj}(WP_{bj})} \qquad (j)$$

Demand for new composite labor:

$$AL_{jn} = \left(\frac{\partial UC_{Xj}(PX_j,\ WP_{bj},\ PK_{jn})}{\partial UC_{Lj}(WP_{bj})}\right) \cdot X_{jn} \qquad (j)$$

Kuhn-Tucker conditions:

$$PX_j - UC_{Xj} \leq 0$$

$$\left(PX_j - UC_{Xj}\right) \cdot X_{jn} = 0 \qquad \text{(j)}$$

$$X_{jn} \geq 0$$

Demand for labor:

$$L_{bjv} = \left(\frac{\partial UC_{Lj}(WP_{bj})}{\partial WP_{bj}} \right) \cdot AL_{jv} \qquad \text{(b·j·v)}$$

Demand for new business capital:

$$K_{jn} = \left(\frac{\partial UC_{Xj}(PX_j,\ WP_{bj},\ PK_{jn})}{\partial PK_{jn}} \right) \cdot X_{jn} \qquad \text{(j)}$$

Demand for intermediate goods:

$$I_j = \sum_i a_{ji} \cdot \sum_v X_{iv} \qquad \text{(j)}$$

Price of capital good:

$$P_K = \sum_j k_j \cdot PX_j \qquad \text{(1)}$$

Rental price of new business capital:

$$PK_{jn} = \left(\delta_{jn} + \frac{r_w}{(1 - \tau_{Cj}^{m})} \right) \cdot P_K \qquad \text{(j)}$$

Wage cost for the producer:

$$WP_{bj} = W_b \cdot (1 + \tau_{Lj}) \qquad \text{(b·j)}$$

Price of leisure:

$$PF_h = \sum_b W_b \cdot (1-\tau^m_{Yh}) \cdot q_{bh} \qquad \text{(h)}$$

Marginal or unit cost of composite labor:

$$UC_{Lj} = \Gamma_j^{-1} \cdot \left[\sum_b \gamma_{bj}^{\epsilon_j} \cdot WP_{bj}^{1-\epsilon_j} \right]^{\frac{1}{1-\epsilon_j}} \qquad \text{(j)}$$

Marginal or unit cost of new value added:

$$UC_{Vj} = A_{jn}^{-1} \cdot \left[\alpha_j^{\eta_{jn}} \cdot UC_{Lj}^{1-\eta_{jn}} + (1-\alpha_j)^{\eta_{jn}} \cdot PK_{jn}^{1-\eta_{jn}} \right]^{\frac{1}{1-\eta_{jn}}} \qquad \text{(j)}$$

Marginal or unit cost of new gross output:

$$UC_{Xj} = v_j \cdot UC_{Vj} + \sum_i a_{ij} \cdot PX_i \qquad \text{(j)}$$

Table A2.2 - *Goods Demand and Factor Supply Equations*

number of equations

Utility function:

$$U_h = \Sigma_h \cdot \left[\lambda_{Ch} \cdot C_{Bh}^{\frac{\sigma_h - 1}{\sigma_h}} + (1-\lambda_{Ch}) \cdot F_h^{\frac{\sigma_h - 1}{\sigma_h}} \right]^{\frac{\sigma_h}{\sigma_h - 1}} \qquad \text{(h)}$$

Consumer goods aggregation function:

$$C_{Bh} = \Phi_h \cdot \left[\sum_{i \in D} \lambda_{hi} \cdot C_{hi}^{\frac{\phi_h - 1}{\phi_h}} + \lambda_{Dh} \cdot C_{Dh}^{\frac{\phi_h - 1}{\phi_h}} \right]^{\frac{\phi_h}{\phi_h - 1}}$$

Net return to old business capital:

$$RK_j = PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b WP_{bj} \cdot L_{bjo} - P_K \cdot \delta_{jo} \cdot K_{jo} \qquad \text{(j)}$$

Depreciation:

$$DEP_h = \beta_h \cdot P_K \cdot \sum_v \sum_j \delta_{jv} \cdot K_{jv} + P_K \cdot \sum_v \sum_h \delta_{Dv} \cdot KD_{hv} \qquad \text{(h)}$$

Household after-tax full income:

$$Y_h = PF_h \cdot LE_h - B_{Yh} + \beta_h \cdot \sum_j (1-\tau_{Fhj}) \cdot RK_j + RD_h + r_W \cdot P_K \cdot AS_h + DEP_h + TR_h \qquad \text{(h)}$$

Household gross saving:

$$S_h = s_{Yh} \cdot Y_h \qquad \text{(h)}$$

Household budget constraint:

$$Y_h = \sum_{i \in D} PC_i \cdot C_{hi} + PC_{Dh} \cdot C_{Dh} + PF_h \cdot F_h + S_h + r_W \cdot \tau^m_{Kh} \cdot P_K \cdot SF_h + EX_{Ch}$$

Demand for composite consumer good:

$$C_{Bh} = - \frac{\partial V_h \left(PC_i,\ PC_{Dh},\ PF_h,\ Y_h\right) \ / \ \partial UC_{Bh}}{\partial V_h \left(PC_i,\ PC_{Dh},\ PF_h,\ Y_h\right) \ / \ \partial \left(Y_h - S_h - EX_{Ch}\right)} \qquad \text{(h)}$$

Demand for leisure:

$$F_h = - \frac{\partial V_h \left(PC_i,\ PC_{Dh},\ PF_h,\ Y_h\right) \ / \ \partial PF_h}{\partial V_h \left(PC_i,\ PC_{Dh},\ PF_h,\ Y_h\right) \ / \ \partial \left(Y_h - S_h - EX_{Ch}\right)} \qquad \text{(h)}$$

Labor supply:

$$L_h = (1+g_{Lh})^T \cdot LE_h - F_h \qquad \text{(h)}$$

Marginal or unit cost of utility:

$$UC_{Uh} = \Sigma_h^{-1} \cdot \left[\lambda_{Ch}^{\sigma_h} \cdot UC_{Bh}^{1-\sigma_h} + (1-\lambda_{Ch})^{\sigma_h} \cdot PF_h^{1-\sigma_h}\right]^{\frac{1}{1-\sigma_h}} \qquad \text{(h)}$$

Marginal or unit cost of composite consumer good:

$$UC_{Bh} = \Phi_h^{-1} \cdot \left[\sum_{i \neq D} \lambda_{hi}^{\phi_h} \cdot PC_i^{1-\phi_h} + \lambda_{Dh}^{\phi_h} \cdot PC_{Dh}^{1-\phi_h} \right]^{\frac{1}{1-\phi_h}} \qquad \text{(h)}$$

Demand for market consumer goods:

$$C_{hi} = \left[\frac{\partial UC_{Bh}(PC_i,\ PC_{Dh},\ PF_h)}{\partial PC_i} \right] \cdot C_{Bh} \qquad \text{(h}\cdot\text{(i-1))}$$

Demand for household services:

$$C_{Dh} = \left[\frac{\partial UC_{Bh}(PC_i,\ PC_{Dh},\ PF_h)}{\partial PC_{Dh}} \right] \cdot C_{Bh} \qquad \text{(h)}$$

Aggregate household demand for producer goods:

$$C_j = \sum_h \sum_{i \neq D} m_{ji} \cdot C_{hi} \qquad \text{(j)}$$

Price of market consumer goods:

$$PC_i = (1 + \tau_{Si}) \cdot \sum_j m_{ji} \cdot PX_j \qquad \text{(i-1)}$$

Household portfolio of new capital:

$$AS_h = SF_h + KD_{hn} \qquad \text{(h)}$$

Table A2.3 - *Household Production Equations*

number of equations

Production function:

$$XD_{hv} = \Lambda_{Dhv} \cdot \left[\alpha_{Dh} \cdot LD_{hv}^{\frac{\lambda_{Dhv}-1}{\lambda_{Dhv}}} + (1-\alpha_{Dhv}) \cdot KD_{hv}^{\frac{\lambda_{Dhv}-1}{\lambda_{Dhv}}} \right]^{\frac{\lambda_{Dhv}}{\lambda_{Dhv}-1}}$$

Supply of old household services:

$$XD_{ho} = \frac{\partial \Pi_{Dh}(PC_{Dh}, PF_h, KD_{ho})}{\partial PC_{Dh}} \qquad \text{(h)}$$

Quasi-rent accruing to old household capital:

$$(PC_{Dh} \cdot XD_{ho} - PF_h \cdot LD_{ho}) \cdot XD_{ho} \geq 0$$

Demand for old household labor:

$$LD_{ho} = - \frac{\partial \Pi_{Dh}(PC_{Dh}, PF_h, KD_{ho})}{\partial PF_h} \qquad \text{(h)}$$

Kuhn-Tucker conditions:

$$PC_{Dh} - UC_{Dh} \leq 0$$

$$(PC_{Dh} - UC_{Dh}) \cdot XD_{hn} = 0 \qquad \text{(h)}$$

$$XD_{hn} \geq 0$$

Demand for new household labor:

$$LD_{hn} = \left[\frac{\partial UC_{Dh}(PF_h, PD_{hn})}{\partial PF_h} \right] \cdot XD_{hn} \qquad \text{(h)}$$

Demand for new household capital:

$$KD_{hn} = \left[\frac{\partial UC_{Dh}(PF_h, PD_{hn})}{\partial PD_{hn}}\right] \cdot XD_{hn} \qquad \text{(h)}$$

Rental price of new household capital:

$$PD_{hn} = (\delta_{Dn} + r_w) \cdot P_K \qquad \text{(h)}$$

Marginal or unit cost of new household services:

$$UC_{Dh} = \Lambda_{Dhn}^{-1} \cdot \left[\alpha_{Dh}^{\lambda_{Dhn}} \cdot PF_h^{1-\lambda_{Dhn}} + (1-\alpha_{Dh})^{\lambda_{Dhn}} \cdot PD_{hn}^{1-\lambda_{Dhn}}\right]^{\frac{1}{1-\lambda_{Dhn}}} \qquad \text{(h)}$$

Quasi-rent accruing to old household capital:

$$RD_h = PC_{Dh} \cdot XD_{ho} - PF_h \cdot LD_{ho} - P_K \cdot \delta_{Do} \cdot KD_{ho} \qquad \text{(h)}$$

Table A2.4 - *The Foreign Sector Equations*

number of equations

Output prices of tradeable goods:

$$PX_{td} = ER \cdot PW_{td} \qquad \text{(td)}$$

Net exports:

$$Z_{td} = \sum_{v} X_{td,v} - I_{td} - C_{td} - INV_{td} - G_{td} - EX_{td} \qquad \text{(td)}$$

Trade balance:

$$TB = \sum_{td} PX_{td} \cdot Z_{td} \qquad \text{(1)}$$

Foreign capital:

$$KF = \sum_j K_{jn} - \sum_h SF_h \tag{1}$$

Current account:

$$CC = TB - r_W \cdot P_K \cdot KF \tag{1}$$

Table A2.5 - *Government Sector Equations*

number of equations

Tax function for labor income:

$$\tau_{Yh} = \tau_{Yh}^m + \frac{B_{Yh}}{\sum_b W_b \cdot \left(L_h - \sum_v LD_{hv}\right) \cdot q_{bh}} \tag{h}$$

Payroll tax revenue:

$$TX_L = \sum_b \sum_j \sum_v \tau_{Lbj} \cdot W_b \cdot L_{bjv} \tag{1}$$

Tax revenue from use of old business capital:

$$TX_{OC} = \sum_j \tau_{Cj} \cdot RK_j \tag{1}$$

Tax revenue from use of new business capital:

$$TX_{NC} = \sum_j \tau_{Cj}^m \cdot \left(\frac{r_W}{1-\tau_{Cj}^m}\right) \cdot P_K \cdot K_{jn} \tag{1}$$

Consumption tax revenue:

$$TX_S = \sum_h \sum_i \tau_{Si} \cdot C_{hi} \cdot \sum_j m_{ji} \cdot PX_j \qquad (1)$$

Labor income tax revenue:

$$TX_Y = \sum_b \sum_h \tau_{Yh} \cdot W_b \left(L_h - \sum_v LD_{hv} \right) q_{bh} \qquad (1)$$

Tax revenue from old business capital income:

$$TX_{OK} = \sum_h \sum_j \tau_{Kh} \cdot \beta_h (1 - \tau_{Cj}) \cdot RK_j \qquad (1)$$

Tax revenue from new business capital income:

$$TX_{NK} = \sum_h \tau^m_{Kh} \cdot \tau_W \cdot P_K \cdot SF_h \qquad (1)$$

Government budget constraint:

$$TX_L + TX_{OC} + TX_{NC} + TX_S + TX_Y + TX_{OK} + TX_{NK} + EXGOV =$$

$$= TR + PX_{pub} \cdot G_{pub} + GSAV \qquad (1)$$

Table A2.6 - *Closure Equations and the Numeraire*

number of equations

Total gross saving:

$$TSAV = \sum_h S_h + GSAV + FSAV \qquad (1)$$

Closure rule:

$$INV_j = k_j (TINV \,/\, PX_j) \qquad (j)$$

Numeraire:

$$ER = 1 \tag{1}$$

Table A2.7 - *Equilibrium Equations*

	number of equations

Labor market:

$$\sum_h L_h \cdot q_{bh} = \sum_j \sum_v L_{bjv} + \sum_h \sum_v LD_{hv} \cdot q_{bh} \qquad \text{(b)}$$

Market for non-tradeable goods:

$$\sum_v X_{nt,v} = I_{nt} + C_{nt} + INV_{nt} + G_{nt} + EX_{nt} \qquad \text{(nt)}$$

Market for household services:

$$\sum_v XD_{hv} = C_{Dh} \qquad \text{(h)}$$

Market for foreign exchange:

$$CC + FSAV = FORREV \qquad \text{(1)}$$

APPENDIX 3 - DATA

A3.1 Production Sectors

The level of aggregation regarding the production sectors is governed by the number of factors of production that are specified in the model. Instead of defining the output of the sectors in terms of the characteristics of the goods, we define the sectors according to relative factor intensities. Table A3.1 below shows how the non-household production sectors in the model are defined in terms of more disaggregated sectors, which are classified according to the revised code of classification by kind of activity in the Swedish national accounts (SNR).

Table A3.1 - *Classification of Production Sectors*

Production Sector according to Swedish National Accounts	SNR code
Capital Intensive Sector	
Iron ore mining	2100
Non-ferrous ore mining	2200
Other mining	2900
Beverage and tobacco manufactures	3130
Manufacture of pulp	3410
Manufacture of paper and paperboard	3420
Manufacture of industrial chemicals, incl. plastic materials	3510
Petroleum refineries and manufacture of products of petroleum and coal	3530
Iron and steel basic industries	3710
Non-ferrous metal basic industries	3720
Skilled Labor Intensive Sector	
Manufacture of other chemical products	3520
Manufacture of machinery and equipment	3820
Manufacture of electrical machinery, apparatus, appliances and supplies	3830
Manufacture of transport equipment, except ship building	3840
Manufacture of professional, scientific, measuring equipment etc.	3850
Ship building and repairing	3860

Unskilled Labor Intensive Sector	
Import-competing food manufacturing	3120
Textile, wearing apparel and leather industries	3200
Saw mills and planing mills	3310
Manufacture of pulp, paper and paperboard products	3430
Manufacture of rubber products	3550
Manufacture of plastic products	3560
Manufacture of fabricated metal products, except machinery and equipment	3810
Other manufacturing	3900
Sheltered Sector	
Agriculture	1100
Forestry and logging	1200
Fishing	1300
Protected food manufacturing	3110
Other wood industry	3320
Printing, publishing and allied industries	3440
Manufacture of non-metallic mineral products, except products of petroleum and coal	3600
Electric light and power, steam and hot water supply	4100
Gas manufacture and distribution	4200
Water works and supply, incl. sewage disposal	4300
Construction	5000
Wholesale and retail trade	6100
Restaurants and hotels	6300
Transport and storage	7100
Communication	7200
Financial institutions	8100
Insurance	8200
Business services	8320
Sanitary and similar services, except sewage disposal	9200
Social and related community services	9300
Recreational and cultural services	9400
Repair services not elsewhere classified	9510
Other personal services	9520
Real Estate Sector	
Other real estate	8312
Housing Sector	
One- and two-family houses and leisure houses	8311

In Table A3.2 we present a summary description of the business sectors in the model. First of all we notice that the foreign trade sectors are rather small both with respect to value added and employment of factors. A very large percentage of their gross output is going to net exports. Obviously, these shares would be even higher if we used gross export figures but the relevant variable in the model is net exports. Except for the skilled labor intensive sector, the sheltered sectors employ a higher proportion of skilled labor than the export sectors. The extremely high capital labor ratios in the real estate and the housing sectors are due to special nature of these sectors, which use very little labor but have large capital stocks. Among the other sectors the most capital intensive production methods are found, as expected, in the capital intensive sector.

Table A3.2 - *Supply and Factor Demand Structure of Model Sectors, billions of SEK and hours*

Sector	Value added	Hours worked	Capital stock	Skilled labor share	Capital labor ratio [14]	Export share [15]
Capital intensive	49.001	17.565	255.395	6 %	14.5	37 %
Skilled labor intensive	88.061	45.054	160.668	9	3.6	52
Unskilled labor intensive	49.563	24.459	109.790	5	4.5	21
Sheltered	468.857	220.185	1430.905	10	6.5	0
Real estate	21.147	2.285	636.752	9	278.6	-1
Housing	90.567	2.778	1309.149	9	471.3	0
Public	209.121	137.446	736.438	8	5.4	-5

In Table A3.3 below we display the same information as in table A3.2 but instead of absolute values we show the sectoral structure in percentage shares. Thus, each column sums to 100. Again, we see that the sectors exposed to foreign trade are small with regard to both output and employment of factors of production. They only account for one fifth of gross domestic product and only about ten per cent of the capital stock.

[14] measured in 1000 SEK per hour worked.

[15] measured as net exports divided by gross output.

Table A3.3 - *Supply and Factor Demand Structure of Model Sectors, percentage Shares*

Sector	Value added	Hours worked	Capital stock	Skilled labor	Net exports
Capital intensive	5 %	4 %	6 %	3 %	33 %
Skilled labor intensive	9	10	3	10	61
Unskilled labor intensive	5	5	2	3	16
Sheltered	48	49	31	53	0
Real estate	2	1	14	0	0
Housing	9	1	28	1	0
Public	22	30	16	30	-10
Total	100	100	100	100	100

A3.2 Labor Categories

Data on the distribution of different categories of labor between business sectors are taken from Statens Industriverk (SIND) [1991]. Altogether this source contains 12 kinds of labor, distinguished with respect to their formal educational status. There is one level corresponding to elementary school, five high school categories and six university degrees including post-graduate training. We define skilled labor as labor with a university degree irrespective of the field. For industry and all business sectors taken as a whole, skilled labor constitutes seven and nine per cent respectively of the total labor force.

In order to compute the share of skilled labor for the model sectors, defined in Table A3.1 above, we multiply the share of skilled labor for each individual sector of the model sector by its relative wage share within the model sector to get a weighted share of skilled labor. The share of skilled labor for the model sector is obtained by summing the weighted shares over the individual sectors comprising the model sector. The share of skilled labor in the public sector is taken from Nordström [1990]. Since our definition of skilled labor differs from that used by Nordström the absolute numbers are not comparable. In order to overcome this difficulty we have computed the ratio of the share of skilled labor in the public sector to the share of skilled labor in total industry from the figures in Nordström. Next, we multiply this ratio with our share of skilled labor in total industry to obtain our estimate of the share of skilled labor in the public sector. The percentage share of skilled labor for our model sectors are given in Table A3.2 above.

A3.3 Factor Prices

In the model there are altogether 11 different factors of production. There are two labor categories; skilled and unskilled. We have eight old fixed capital stocks, including the household production sector and one type of new mobile capital. Factor prices are defined as total labor costs, including social security contributions, for the producer per hour worked and capital cost per unit of physical capital. In Table A3.4 below report the relative wage rate, the gross operating surplus to old capital and depreciation rates for old and new capital for each sector.

The first column in Table A3.4 shows the wage costs, wages plus social security contributions, for the different sectors. For each individual sector we divide the total compensation of employees, wages plus social security contributions, by the total number of hours worked, to get the hourly wage cost. A weighted hourly wage cost for each model sector is obtained by multiplying the individual hourly wage costs by the relative shares of hours worked for each individual sector comprising the model sector. The different levels of wage costs across sectors could be explained by a number of factors. One reason could be that the composition of the labor force with respect to different skill categories might differ between sectors. Another reason might be that in reality there are a whole range of different skill categories, not only the two distinguished in our model. Still other factors are differences in work environments such as safety and working time, age composition etc.. These differences could be compatible with equilibrium in the labor markets if they are merely compensating differentials. Column three shows the relation between the hourly wage cost for skilled and unskilled workers. For the capital intensive sector we see that, on average, the hourly wage cost is 67 per cent higher for skilled than for unskilled labor. The average ratio for the model sector is computed as a weighted average of the ratios for each of the individual sectors that comprise the model sector with the weights being equal to their relative share of hours worked.

Table A3.4 - *Factor Prices*

Sector	Hourly wage costs, SEK	Share of skilled labor	Premium skilled wage cost	Skill-adjusted wage costs	Sector-specific cost diff.	Cost of old capital
Capital int.	124.9	6.0 %	67 %	127.0	39 %	9.0 %
Skilled labor int.	116.2	9.4	66	115.7	27	12.4
Unskilled labor int.	100.8	4.8	76	103.4	13	12.5
Sheltered	91.9	9.8	62	91.3	0	10.5
Real estate	89.2	8.9	63	89.1	-2	2.8
Housing [16]	89.2	8.9	63	89.1	-2	6.6
Public	108.5	8.0	65 [17]	109.0	19	1.5
Household production	-	-	-	-	-	19.5

Since we know the share of skilled labor, α_j, and the relative hourly wage cost, β_j, for each model sector we can calculate the hourly wage cost for unskilled (and skilled) labor from the following relation.

$$col.1 = \alpha_j \cdot \beta_j \cdot WP_{uj} + (1-\alpha_j) \cdot WP_{uj} \tag{A3.1}$$

As can be seen from column three, the relative wage cost is roughly the same across sectors. The average ratio between skilled and unskilled hourly wage cost equals 1.65 for the entire economy and the average share of skilled labor is 0.0875. Let us denote these averages by β^* and α^* respectively. If we assume that all sectors employ the same share, α^*, of skilled labor and that the average ratio β^* prevails and use the computed wage costs from (A3.1), we can compute the skill-adjusted hourly wage cost WP^*_j as follows.

[16] The hourly wage cost, the share of skilled labour and the relative skilled wage cost for the housing sector are set equal to those for the real estate sector since these two sectors are not separately reported in SIND [1991].

[17] Since the public production sector is not included in SIND [1991], we set the ratio between skilled and unskilled hourly wage costs equal to the average of the industrial sectors.

$$WP_j^* = \alpha^* \cdot \beta^* \cdot WP_{uj} + (1-\alpha^*) \cdot WP_{uj} \tag{A3.2}$$

After the adjustment made for different shares of skilled labor employed in the sectors we get, in column four, the sector specific wage cost differences. In column five we normalize the values in column four by setting the wage cost for the sheltered sector equal to one. We then notice that the remaining differences are rather substantial. The hourly wage cost for the capital intensive sectors is approximately 40 per cent higher than in the sheltered sector. However, despite these relatively large differences in hourly labor cost across sectors we will in the specification of our model assume away these sector specific differentials. Our justification for doing so is that we are interested in the long run effects of the tax reform and introducing an ad hoc restriction on the relative wage pattern, based on data for a single year does not seem warranted. If one would like to incorporate and analyze compensating wage differentials into the model this should be done in a much more rigorous way than just imposing an exogenous wage structure in an otherwise intrinsically long run model.

Next, let us turn to the cost of capital. We need to distinguish between the return to old capital which takes the form of quasi-rent accruing to the fixed factor and the return to new mobile capital. The cost of old capital, PK_{jo}, is computed from our benchmark data set (social accounting matrix) as the gross operating surplus divided by the old capital stock.

$$PK_{jo} = \textit{gross operating surplus of sector } j \;/\; K_{jo} \tag{A3.3}$$

Using the model notation we get the following expression for the cost of old capital

$$PK_{jo} = \frac{RK_{jo} + P_K \cdot \delta_{jo} \cdot K_{jo}}{K_{jo}} \tag{A3.4}$$

where, RK_{jo} is the pre-tax net return to old capital. The actual values are shown in the rightmost column of Table A3.4. Two comments are needed here. First, the figure for the public production sector does not include any net operating surplus since it is not reported by the national accounts and we have not made any adjustment for it. Since we are more or less keeping public production constant during our simulations, this does not seem to of any great importance. Secondly, the net return to old household capital has been set equal to the average of the net return to consumer durables during 1980-86 as computed by Berg [1988]. Thus, we have the following expression for the cost of old household capital.

$$PD_{ho} = \left(\delta_{Do} + \textit{average net return to consumer durables}\right) \cdot P_K \tag{A3.5}$$

The cost of new capital for the business sectors, PK_{jn}, and the household sector, PD_{hn}, are defined by the following equations

$$PK_{jn} = \left(\delta_{jn} + \frac{r_w}{(1-\tau_{Cj}^m)}\right) \cdot P_K \tag{A3.6}$$

$$PD_{hn} = \left(\delta_{Dn} + r_w\right) \cdot P_K \tag{A3.7}$$

where, r_W is the net return to new capital and τ_{Cj}^{m} is the corporate tax rate. Since new capital is mobile we assume that the net return is equalized across sectors, including the household production sector. In our model version *CLOSED*, r_W is endogenous whereas it is the exogenous world market rate of interest in *FLOW* the model version with international mobility of capital. The numerical value of the cost of new capital depends, in our model, on the endowment of new capital as described by equation (4.4) in Section 4.1 above.

A3.4 Producer and Consumer Goods

Since in practice the classification of consumer and producer goods are different we need to convert the demand for consumer goods into demand for producer goods. This is accomplished with the use of a transition matrix, M_{ij}, whose elements, m_{ij}, denote the amount of producer good j needed in order to produce one unit of consumer good i. The transition matrix is derived from the data of the social accounting matrix (see Section A3.5 below). We construct element m_{ij} in the following way. The purchases by consumer good i from sector j is divided by total expenditures on consumer good i minus the value of its imports and indirect taxes. The result is given in Table A3.5 below.

Table A3.5 - *Conversion Matrix for Consumer and Producer Goods*

	Capital int.	Skilled labor int.	Unskill. labor int.	Shelt.	Estate	Housing
Food	0.03	0.00	0.12	0.85	0.00	0.00
Spirits and tobacco	0.57	0.00	0.00	0.43	0.00	0.00
Non-durable goods	0.09	0.17	0.15	0.59	0.00	0.00
Clothing and footwear	0.00	0.00	0.16	0.84	0.00	0.00
Health- and medical care	0.00	0.16	0.00	0.84	0.00	0.00
Furniture	0.00	0.05	0.11	0.84	0.00	0.00
Dwelling services	0.01	0.00	0.00	0.13	0.00	0.86
Other services	0.00	0.00	0.00	1.00	0.00	0.00
Transport services	0.07	0.20	0.00	0.70	0.03	0.00
Recreation services	0.00	0.02	0.02	0.87	0.00	0.09
Non-profit output	0.01	0.01	0.02	0.80	0.16	0.00

Thus, we have the following relation for transforming the household demand for consumer goods into aggregate household demand for producer goods.

$$C_j = \sum_h \sum_i m_{ij} \cdot C_{hi} \tag{A3.8}$$

The price of consumer goods that consumers meet includes the consumer goods tax rate τ_{Si} and is defined in terms of the producer output prices, PX_j, as follows.

$$PC_i = (1+\tau_{Si}) \cdot \sum_j m_{ij} \cdot PX_j \qquad \textit{where,} \qquad \sum_j m_{ij} = 1 \tag{A3.9}$$

A3.5 Social Accounting Matrix

Below we present the data for the model in the form of a social accounting matrix (SAM), which is a square matrix in which each element represents a transaction, price times quantity, between two accounts. These accounts represents sectors or agents in the economy. For each account, its expenditures are given in the column whereas income is recorded in the corresponding row. If budget constraints, for each sector or agent, are satisfied the row and column sum for each account must balance. As in the case of Walras law, if all accounts but one balance, then the remaining account must also balance.

The data used in the benchmark is based on the study by Karlsson and Roström [1992], which presents a complete social accounting matrix for Sweden 1988. Since this study is very detailed containing 45 production sectors and a number of other accounts that are not directly used in our model we need to make the following adjustments to get a condensed model social accounting matrix.

1) The government sector in the model consists of the federal government, the local government and the social security accounts in the original SAM.

2) The aggregate household sector in the model is comprised of the household, the non-financial and the financial enterprise accounts in the original SAM. In other words, what we label as the household sector in the model is the private sector of the economy.

3) The capital (savings) account of the model is made up of the gross investment, changes in stocks, purchases and sales, and financial saving accounts in the original SAM.

4) We aggregate the business sectors of the original SAM according to the classification in Table A3.1 above.

5) The sheltered sector in the model consists of the sectors shown in table A3.1 plus the accounts of other producers, the residual and unallocated items in the original SAM.

6) We net out interest payments, dividends and transfers between the household, the government and the rest of the world accounts. Interest payments from the household and the government accounts to the rest of the world (21.177) are transferred directly to the rest of the world account instead of first going to the interest account.

7) Direct taxes paid by the rest of the world to the government sector (189) is netted against transfers from the government to the rest of the world (7.019).

8) Indirect taxes from the accounts of other producers (420), public consumption (6.152) and unallocated items (-11.411) are transferred to the account of indirect non-commodity taxes (icke-varuanknutna indirekta skatter).

9) Social security contributions are regarded as revenues for the government sector instead of the household sector. To compensate for this government transfers to the household sector increase by the same amount.

10) Net indirect taxes is computed as: import duties (tull) plus commodity taxes excluding value added taxes (särskilda varuskatter) plus value added taxes (moms) minus commodity subsidies (varuanknutna subventioner) plus indirect non-commodity taxes (icke-varuanknutna indirekta skatter) minus non-commodity subsidies (icke-varuanknutna subventioner. Government expenditures for subsidies (48.919) are netted out. Indirect taxes, net, computed as described above are transferred directly to the government.

11) Net exports for the business sectors equal exports minus imports. The import content of exports is netted out.

12) Wage payments are divided into skilled and unskilled wage payments.

13) We treat net indirect taxes paid by the business sectors as an intermediate good purchased by the business sectors and the capital account from the public sector. Indirect taxes, net, paid by the export account is treated as an exogenous demand component purchased from the public sector.

14) Imports purchased by the public sector (10.798) is subtracted from public sector gross output and from purchases by the export account from the public sector. Gross output from the public sector is then equal to 286.809 - 10.798 = 276.011. The value of government demand from the public production sector is computed as the gross output of the public production sector (276.011) minus intermediate goods (29.169) minus exogenous demand (-13.120) minus investment demand by the capital account (14.801) which equals 245.161.

After these adjustments of the original social accounting matrix for Sweden for 1988 have been made we arrive at the model social accounting matrix that we use as our benchmark data set. This matrix is presented below in Table A3.6 below. An asterisk (*) after an element in the matrix indicates an exogenous transaction. The first five columns (rows) are factor accounts. The payment to labor is divided between wage payments to skilled and unskilled labor and social security contributions paid by the employers to the government. A small exogenous portion of payments to skilled labor is paid to the rest of the world sector. Gross return to capital is broken down into depreciation and the net, before taxes, return to capital. The proportions of depreciation and net return to capital that accrue to the government are exogenous. The value of the gross domestic product is given by adding the sums of the first five columns. The next three columns represent the institutional sectors; the government, the aggregate household and the rest of the world sector. Government and household transfers to the rest of the world are exogenous. Government expenditures on goods purchased from the public production sector as well as saving of the government and the rest of the world sectors are exogenous. Next, we have two tax accounts. Direct taxes include corporate taxes, household labor and capital income taxes, whereas indirect taxes are taxes levied on consumer goods. The columns labelled capint-house represent the business production sectors. The sum of the column representing production sector *j* which equals the value of gross output is comprised of the value added, the sum of the first five rows, plus the value of intermediate goods used. The intersection of the columns representing the business sectors and the

Table A3.6 - *Social Accounting Matrix for Sweden 1988, millions of SEK*

		sl	ul	socsec	deprec
sl	wages, skilled labor				
ul	wages, unskilled labor				
socsec	social security contributions				
deprec	depreciation				
osnet	net operating surplus				
state	government sector			177641	14077 *
hh	aggregate household sector	66687	408596		113758
world	rest of the world sector	842 *			
dirtax	direct taxes				
indtax	indirect taxes				
capint	capital intensive sector				
slint	skilled labor intensive sector				
ulint	unskilled labor intensive sector				
shelt	sheltered sector				
estate	real estate sector				
house	housing sector				
public	public consumption				
pricon	private consumption				
food	food				
spir	spirits and tobacco				
nond	non-durable goods				
clot	clothing and footwear				
medi	health- and medical care				
furn	furniture and household articles				
dwel	dwelling services				
serv	other services				
tran	transportation				
cult	recreation and cultural services				
pnpo	private non-profit org. consumption				
import	imports				
export	exports				
capital	savings				
sum	account sum	67259	408596	177641	127835

	osnet	state	hh	world	dirtax	indtax	capint	slint
sl							1728	6650
ul							16511	40999
socsec							7787	20436
deprec							9494	9176
osnet							13481	10800
state	6070 *				270131	92201		
hh	188645	233619						
world		16225 *	13644 *					
dirtax			270131					
indtax								
capint							24473	11031
slint							3339	15940
ulint							5719	10416
shelt							33728	35012
estate							419	524
house								
public		245161 *					3978	2769
pricon			589272					
food								
spir								
nond								
clot								
medi								
furn								
dwel								
serv								
tran								
cult								
pnpo								
import								
export				137928				
capital		65113 *	138260	12375 *				
sum	194715	560118	1011307	150303	270131	92201	120657	163753

	ulint	shelt	estate	house	public	pricon	food	spir
sl	2006	36110	337	410	20287			
ul	23236	198167	2080	2528	125076			
socsec	10562	84395	883	1072	52506			
deprec	5547	62814	5707	23845	11252			
osnet	8212	87371	12140	62712				
state								
hh								
world								
dirtax								
indtax							23194	18465
capint	10150	19908	76	91	1370		2336	3766
slint	2174	16951	134	160	6933			
ulint	11368	27688	186	228	2656		10548	
shelt	30453	314181	10387	25361	32543	11652 *	74404	2820
estate	365	20029	3		7363			
house								
public	682	9502	-1265	-2523	16026			
pricon								
food						119149		
spir						25821		
nond						10844		
clot						42636		
medi						8726		
furn						31833		
dwel						131251		
serv						17683		
tran						83641		
cult						99870		
pnpo						6166		
import							8667	770
export								
capital								
sum	104755	877116	30668	113884	276012	589272	119149	25821

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	nond	clot	medi	furn	dwel	serv	tran	cult
sl								
ul								
socsec								
deprec								
osnet								
state								
hh								
world								
dirtax								
indtax	1955	8633	-4122	6038	4799	172	23146	9393
capint	543				877		3055	78
slint	973		1589	864	26		8850	1473
ulint	890	3252		2055	85		89	1608
shelt	3469	16655	8293	16044	16605	17499	31516	63182
estate							1473	
house					108052			6276
public								
pricon								
food								
spir								
nond								
clot								
medi								
furn								
dwel								
serv								
tran								
cult								
pnpo								
import	3014	14096	2966	6832	807	12	15512	17860
export								
capital								
sum	10844	42636	8726	31833	131251	17683	83641	99870

	pnpo	import	export	capital	residual	sum
sl					1	67529
ul					-1	408596
socsec						177641
deprec						127835
osnet					-1	194715
state					-2	560118
hh					2	1011307
world		119592 *				150303
dirtax						270131
indtax	528					92201
capint	42		45150	-2288	-1	120657
slint	59		84673	19616	-1	163753
ulint	110		21919	5934	4	104755
shelt	4288		130 *	128893	1	877116
estate	873		-381 *			30668
house			-443 *		-1	113884
public			-13120 *	14801	-2	276012
pricon						589272
food						119149
spir						25821
nond						10844
clot						42636
medi						8726
furn						31833
dwel						131251
serv						17683
tran						83641
cult						99870
pnpo						6166
import	266 *			48792 *	1	119592
export						137928
capital						215748
sum	6166	119592	137928	215748	0	

corresponding rows make up the input-output system. The column for aggregate private consumption shows how aggregate consumption is divided between the various consumer goods plus an exogenous component purchased directly from the sheltered sector, which represents consumption by non-household organizations which is included in aggregate private consumption by the household sector according to the national accounts. The following 11 columns and their intersections with the rows of the business sectors make up the transition matrix between consumer and producer goods. Note that the we treat the import content of each consumer good as exogenous. The import column records the value of the exogenous aggregate consumer good imports. The next column shows the net exports of the business sectors, of which net exports of the non-tradeable sectors are considered exogenous. The row of the capital account shows the savings of the institutional sectors, whereas the column shows investment demand by sector of origin including an exogenous demand directed at the foreign sector. Final demand for producer good *j* consists of the intersection of the columns of government (public consumption), the consumer goods (private consumption), exports (foreign demand) and capital (investment demand) with the rows of the business sectors. Finally, the residual column is due to rounding errors when all entries in the matrix are given by integers.

A3.6 Household Production

There are three variables we need to estimate for the household production sector; the amount of time spent or labor services employed, the stock of household capital, excluding housing, in household production and the rate of return on old household capital. According to an updated version of the estimate given in Berg [1988], the stock of consumer durables for the household sector, measured in current prices, equals 641.186 millions of SEK. From the same source we compute the rate of net return from household capital, excluding housing, as the average during the period 1980-86, which equals 4.52 per cent.

For the amount of labor devoted to household production we use the information contained in Statistics Sweden [1988] and in chapter 10 of Industriens Utredningsinstitut [1990]. In the former survey, the total time available for households is divided into necessary, contracted, committed and free time. Necessary time consists of sleep, meals and personal health care. Contracted time is regular work and travel time to an from work. Committed time includes work done in the household. Some of the work done within the household can be substituted for market goods and services. We assume that half of the time devoted to household time can be substitutable between market and non-market activities. It is of course difficult to get a precise estimate of this proportion but 50 per cent seems to be a conservative approximation. From diagram 1 on page 29 and diagram 2 on page 31 in Statistics Sweden [1988] we get the following average time shares for an entire week: free time 21%, household work 16%, studies 1%, regular work 20% and necessary time 41%. If we disregard the study time proportion and count half of the household work, the ratio between free and regular working time equals 1.05 and the ratio between household and regular working time equals 0.40. Since we have observations on the amount of working time we can compute the free and household time as follows. Total hours per week equals 168 (24 hours per day). We assume that the average working time per week equals 40 hours. Then, free time equals $1.05 \cdot 40 = 42$ and household time equals $0.40 \cdot 40 = 16$ hours per week. By subtracting regular working time, household time and free time from the total hours available per week we arrive at 70 hours of necessary time per week or 10 hours per day.

A3.7 Parameter Values

One choice that has to be made when implementing the model for numerical simulations is the functional form of production and utility functions. The simplest choice would be a Cobb-Douglas function which has the properties that both price- and income elasticities are equal to one, which implies that the budget shares are constant. This is far too restrictive. A somewhat more general specification is the constant elasticity of substitution (CES) function, which allows the budget shares to vary systematically with the prices. However, at given prices, the expenditures on each commodity are proportional to income or the income elasticities are unity. This is still not very satisfactory. Thus, there is a need for a still more general formulation. On the demand side, one such alternative is the linear expenditure system which permits richer possibilities for income and price elasticities.

However, despite its shortcomings we employ the CES specification for all production, utility and aggregation function in our model. A major reason for this choice is that we are not econometrically estimating the demand and production functions and therefore need to economize on the number of parameters specified. Instead, we using a calibration procedure described in Appendix four. A high priority in future work is to use more flexible functional forms and to econometrically estimate the model parameters.

Some of the parameters cannot be calibrated, by only using the benchmark data set, but must instead be assigned numerical values. In Table A3.7 below we report the values that have been used in our base case simulations.

One of the key parameters is the elasticity of substitution between consumption and leisure, σ_h, which affects the labor supply. There are a wealth of numerical estimates for the elasticity of labor supply but very few estimates of the elasticity of substitution parameter itself. It is, however, possible to derive a one-to-one relationship between the two parameters such that if we know the value of the elasticity of labor supply we can thereby compute the corresponding value of the elasticity of substitution. Let us begin by defining the elasticity of labor supply, ϵ_L, with respect to the price of leisure.

$$\epsilon_L = \frac{\partial(LE_h - F_h)}{\partial PF_h} \cdot \frac{PF_h}{(LE_h - F_h)} = - \frac{\partial F_h}{\partial PF_h} \cdot \frac{PF_h}{LE_h - F_h} \qquad \textbf{(A3.10)}$$

Given this definition we can write the elasticity of leisure, ϵ_F, with respect to the price of leisure as follows.

$$\epsilon_F = - \epsilon_L \left[\frac{1}{LE_h \,/\, \sum_b LM_{bh} - 1} \right] \qquad \textbf{(A3.11)}$$

The demand for leisure, according to the specification in the model, equals

$$F_h = Y_h^* (UC_{Uh} \cdot \Sigma_h)^{\sigma_h - 1} \cdot \left[\frac{1 - \lambda_{Ch}}{PF_h} \right]^{\sigma_h} \qquad \textbf{(A3.12)}$$

Table A3.7 - *Parameter Values*

Parameter	Description	Value
σ_h	elasticity of substitution between leisure and a composite good	0.50
ϕ_h	elasticity of substitution between different consumer goods	0.50
$\eta_{D,h,old}$	elasticity of substitution between labor and old household capital	0.50
$\eta_{D,h,new}$	elasticity of substitution between labor and new household capital	1.10
$\eta_{td,old}$	elasticity of substitution between labor and old business capital	0.70
$\eta_{nt,old}$		0.60 [18]
$\eta_{td,new}$	elasticity of substitution between labor and new business capital	1.40
$\eta_{nt,new}$		1.20[19]
ϵ_{td}	elasticity of substitution between skilled and unskilled labor in the business sectors	1.20
ϵ_{nt}		0.90[20]
$g_{X,td}$	Hicks-neutral technical progress in the business sectors	0.015
$g_{X,nt}$		0.005
$g_{D,h}$	Hicks-neutral technical progress in the household production	0.010
$g_{L,h}$	growth rate of labor endowment	0.003
$\delta_{capint,v}$	depreciation rate on physical capital (old and new) for the capital intensive sector	3.7 / 5.5 %
$\delta_{slint,v}$	depreciation rate on physical capital (old and new) for the skilled labor intensive sector	5.7 / 5.5
$\delta_{ulint,v}$	depreciation rate on physical capital (old and new) for the unskilled labor intensive sector	5.1 / 5.5
$\delta_{shelt,v}$	depreciation rate on physical capital (old and new) for the sheltered sector	4.4 / 5.5
$\delta_{estate,v}$	depreciation rate on physical capital (old and new) for the real estate sector	0.9 / 1.4
$\delta_{house,v}$	depreciation rate on physical capital (old and new) for the housing sector	1.8 / 1.4
$\delta_{public,v}$	depreciation rate on physical capital (old and new) for the public sector	1.5 / 5.5
$\delta_{D,v}$	depreciation rate on physical capital (old and new) for the household production sector	15.0 / 15.0

[18] For a survey of estimates of the elasticity of substitution between labour and capital, see Mansur and Whalley [1984]. Nordström [1990] uses the values 0.80 for tradeable, 0.60 for non-tradeable and 0 for the public sector.

[19] Haaland [1987] employs the value 0.20 for old and 1.20 for new processes.

[20] Nordström [1990] uses the values 1.60 for tradeable and 1.20 for non-tradeable sectors.

where, $Y_h^* = Y_h - S_h$ is treated as a constant. Income is considered exogenous in accordance with most empirical studies of labor supply. The derivative of the leisure demand function with respect to the price of leisure is equal to

$$\frac{dF_h}{dPF_h} = \frac{\partial F_h}{\partial PF_h} + \frac{\partial F_h}{\partial UC_{Uh}} \cdot \frac{\partial UC_{Uh}}{\partial PF_h} \tag{A3.13}$$

where,

$$\frac{\partial F_h}{\partial PF_h} = -\sigma_h \cdot Y_h^* \cdot (UC_{Uh}\Sigma_h)^{\sigma_h-1} (1-\lambda_{Ch})^{\sigma_h} \cdot PF_h^{-\sigma_h-1} = -\sigma_h \cdot \frac{F_h}{PF_h} \tag{A3.14}$$

$$\frac{\partial F_h}{\partial UC_{Uh}} = Y_h^* \cdot \Sigma_h^{\sigma_h-1} (\sigma_h-1) \cdot UC_{Uh}^{\sigma_h-2} \left[\frac{1-\lambda_{Ch}}{PF_h}\right]^{\sigma_h} = (\sigma_h-1) \cdot UC_{Uh}^{-1} \cdot F_h \tag{A3.15}$$

$$UC_{Uh} = \Sigma_h^{-1} \cdot \left[\lambda_{Ch}^{\sigma_h} \cdot UC_{Bh}^{1-\sigma_h} + (1-\lambda_{Ch})^{\sigma_h} \cdot PF_h^{1-\sigma_h}\right]^{\frac{1}{1-\sigma_h}} \tag{A3.16}$$

$$\frac{\partial UC_{Uh}}{\partial PF_h} = \Sigma_h^{\sigma_h-1} \left[\frac{UC_{Uh}}{PF_h}\right]^{\sigma_h} (1-\lambda_{Ch})^{\sigma_h} \tag{A3.17}$$

Using the expressions in (A3.14)-(A3.17) we can rewrite A3.13 as.

$$\frac{dF_h}{dPF_h} = -\sigma_h \cdot \frac{F_h}{PF_h} + (\sigma_h-1) \cdot \frac{F_h}{UC_{Uh}} \cdot \Sigma_h^{\sigma_h-1} \left[\frac{UC_{Uh}}{PF_h}\right]^{\sigma_h} (1-\lambda_{Ch})^{\sigma_h} \tag{A3.18}$$

Let us express (A3.18) in terms of the elasticity of leisure.

$$\epsilon_F = -\sigma_h + (\sigma_h-1) \cdot \frac{PF_h \cdot F_h}{Y_h^*} \tag{A3.19}$$

Finally, by substituting (A3.11) into (A3.19) we get the following relation between the elasticity of labor supply and the elasticity of substitution.

$$\epsilon_L = \frac{\left[\frac{PF_h \cdot F_h}{Y_h^*} - \sigma_h\left(\frac{PF_h \cdot F_h}{Y_h^*} - 1\right)\right]}{\left[\frac{1}{LE_h \,/\, \sum_b LM_{bh} - 1}\right]} \qquad \text{(A3.20)}$$

Based upon the formula in (A3.20) we report in Table A3.8 the partial elasticities of labor supply with respect to the price of leisure that correspond to different values of the elasticity of substitution between consumption and leisure. We consider two different definitions of labor supply. In the first row we define labor supply as that amount of labor which is not retained by the household as leisure or the total labor supply including supply to the household production sector. The second row restricts labor supply to the labor market. As can be seen the magnitudes differ substantially, with the elasticity of the regular labor supply being roughly half of that for total labor supply. One should keep in mind that these estimates of the elasticity of labor supply, given a value for the elasticity of substitution, are only approximations to the values computed from labor supply studies. Our specification i.e. the demand function for leisure is a major simplification of the much more elaborate specifications used in the labor supply studies.

Table A3.8 - *Elasticity of Substitution and Elasticity of Labor Supply*

	Elasticity of Substitution					
	0.30	**0.40**	**0.50**	**0.60**	**0.70**	**0.90**
Elasticity of total labor supply: $LM_{bh}+LH_h$	0.34	0.40	0.46	0.52	0.57	0.69
Elasticity of labor supply to labor market: LM_{bh}	0.66	0.78	0.89	1.00	1.11	1.33

The rate of depreciation of old business capital, for each sector, is computed as the amount of depreciation given by the social accounting matrix divided by the corresponding capital stock, whereas the rate of depreciation of new business capital is taken from Södersten [1991]. According to Berg [1988], that part of consumer durables which is not made up of cars has a depreciation rate equal to 15 per cent. Based on this estimate we set the depreciation rates for old and new household capital equal to 15 per cent.

A3.8 Effective Tax Rates

In Table 2.3 we reported the effective tax rates that represent the pre- and post-reform tax system. In this section we present detailed calculations or sources, in those cases we have utilized the calculations of others, of these tax rates.

(i) Calculation of taxes on labor income:

The average effective income tax rate (τ_{Yh}) is calculated as the sum of national income tax (statlig inkomstskatt) plus local income tax (kommunal inkomstskatt) minus a minor deduction (skattereduktion hemmamake) divided by total net income (sammanräknad nettoinkomst). For 1988 the average effective tax rate on labor income equals 36.8% [=(69.670 + 168.996 - 0.512) / 647.170]. The figures within parenthesis are expressed in billions of SEK. For 1991 the average effective tax rate on labor income equals 29.9% [=(18.449 + 236.992) / 885.787]. The major reason for the decline in the average tax rate is due to the fact that after the reform most income earners only pay a proportional local income tax, whereas the progressive national income tax mainly affects high income groups. The figures have been supplied by the Ministry of Finance.

The average or aggregate marginal income tax rate on labor income (τ_{Yh}^m) that we use have been calculated by the Ministry of Finance. Certain transfers and fees received or paid by the household vary according to their income. This marginal effect of transfers is included in our measure of the effective marginal tax rate on labor income. For 1988 the marginal tax rate equals 57.7% of which

2.1% constitutes the marginal effect of transfers. The figures for 1991 are respectively 40.1% and 2.1%. Thus, there is a substantial decrease in the marginal tax rate of labor income.

It should be noted that the total marginal effect on labor income, taking into account payroll, income and indirect taxes is very high in Sweden, although it decreased markedly after the reform. If we assume that the labor cost for the producer increases by one SEK, then the amount that is disposable for the household or individual after all taxes have been paid equals 27.1% for 1988 and 37.0% for 1991. We define the total marginal effect as 1 - [(1-ta)·(1-tm-tb)·(1-ti)], where, ta is the payroll tax, tm is the marginal income tax, tb is the marginal transfer effect and ti is the indirect tax rate.

(ii) Calculation of taxes on labor use:

The effective tax rate on labor use (τ_{Lj}) is defined as total social security contributions divided by the actual wage payments to labor. Thus, in the social accounting matrix in Section A3.5, for each sector, we divide row three by the sum of rows one and two. This tax rate differs slightly between the different sectors. It should also be noted that we count the entire social security contribution as a tax in this context. According to calculations by the Ministry of Finance, the tax part equals 18.6% for 1988 and 18.1% for 1991. The rest can be considered payments for related pension benefits. As can be seen from Table 2.3 our calculation gives an effective tax rate on labor use of approximately 40%. Despite the large absolute difference between these two measures we adhere to considering the entire social security contribution as a tax for two reasons. Firstly, this tax is hardly affected by the tax reform and it is the changes in tax rates that we are primarily interested in. Given the tax rates for 1988, calculated in our way, we have multiplied each tax rate with the ratio of the tax rates calculated by the ministry of finance i.e.(0.186/0.181) in order to get our estimates of the tax rates for 1991. Secondly, since the entire social security contribution is included in value added it would have been necessary to define an exogenous component of value added in order to preserve the consistency of our social accounting matrix.

(iii) Calculation of taxes on consumer goods:

The effective tax rate on consumer goods for 1988 is computed, for each consumer good category, as the ratio between indirect taxes net of subsidies to the total market value of the consumer good minus the indirect tax and minus the value of imports. The import content of consumer goods is treated as exogenous in the model. Using our social accounting matrix we divide, for each consumer good category, the row of indirect taxes with the corresponding column total minus the rows for indirect taxes and imports. In order to calculate the changes in the rates affecting consumer goods we are using the calculations in Statens Pris- och Konkurrensverk (SPK) [1989], [1990]. In Table A3.9 below we reproduce part of the data contained in table 6 in report R 1986:16 and table 3.7 in report R 1990:7 of SPK [1989], [1990].

Column one corresponds to those categories of consumer goods in the model that are affected by the reform. Except for some food items the main increase in indirect taxation is levied upon services of different kinds, in particular dwellings services. The data in column two and three are taken directly from SPK [1989], [1990]. In column four we show the share, expressed as a percentage, that each individual good in column two constitutes of the model category in column one. The data are taken from Karlsson and Roström [1992]. Column five is just the product of column three and four and the last column is the sum of the percentage point changes of the individual goods comprising each model consumer good. Note that the value added tax on new owner-occupied housing is treated as an investment tax on new housing as explained more fully in section (iv) below.

(iv) Calculation of corporate taxes:

The average and marginal effective corporate tax rates are taken from Södersten [1991]. From the same source we also collect the average and marginal effective tax rates applicable to an investment in owner-occupied housing. Since a detailed description of the computation of the effective tax rates is available in Södersten [1991] there is no need to repeat it here. However, a few comments are in order in the present context.

Table A3.9 - *Price Effects on Consumer Goods of Changed Indirect Taxation*

Model good	Consumer good	Estimated price change	Share of model good	Price change	Total price change
Food	matserveringstjänster [21]	9.4 %	17.2 %	1.62 %	3.14 %
	mjölk	25.3	6.0 [22]	1.52	
Other services	frisörtjänster [23]	21.2	21.7	4.60	4.60
Cultural services	hotelltjänster	9.4	2.6	0.24	2.73
	teletjänster	19.0	6.8	1.29	
	biljett till dansrestaurang [24]	23.5	2.2	0.52	
	campingtjänster	18.8	0.3	0.06	
	järnvägsresor	15.8	1.3	0.21	
	inrikes flygresor	21.5	0.6	0.13	
	inrikes båtresor [25]	18.5	0.3	0.06	
	taxi	16.4	0.9	0.15	
	båtbensin	33.0	0.2	0.07	
Transport	bilbensin [26]	33.0	22.3	7.36	8.74
	dieselolja [27]	23.5	1.2	0.28	
	kollektivtrafik [28]	3.3	4.8	0.16	
	kontrollbesiktning	19.3	1.9 [29]	0.37	
	garage [30]	13.9	4.1	0.57	
Dwelling services	hyres- och bostadsrätt	19.2	42.5 [31]	8.16	8.16

[21] Interpreted as category "utemåltider".

[22] Share calculated as the ratio between categories "mjölk" and "matserveringstjänster" times the share for "matserveringstjänster" in row one.

[23] Interpreted as the category "hårvård".

[24] Interpreted as the category "scenframträdanden, dans".

[25] Interpreted as 0.5 times the category "buss, båt".

[26] Interpreted as 0.95 times the category "drivmedel".

[27] Interpreted as 0.05 times the category "drivmedel".

[28] Interpreted as the category "lokalresor".

[29] Share computed as the ratio between 0.5 times the category "skatt, besiktning" and the category "lokalresor" times the share of category "kollektivtrafik" in the row above.

[30] Interpreted as the category "övrigt".

The tax on existing owner-occupied housing takes into account the property tax and the deductibility of nominal interest expenses. It does not however incorporate the value added tax, since it is not levied on the purchase or possession of existing houses. The same applies for the corporate tax with regard to the value added tax. On the other hand, the marginal tax rate for an investment in new owner-occupied housing includes, among other things, the value added tax on building materials, which is interpreted as an investment tax.

For an investment in the corporate sector or alternatively in the owner-occupied housing sector we have the following pre-tax rate of return

$$\frac{r_W}{1 - \tau_{Cj}^m} \tag{A3.21}$$

where, r_W is the exogenous rate of interest and τ_{Cj}^m is the marginal effective tax rate that applies to investment in corporate assets as well as to owner-occupied housing. After corporate and personal taxes have been paid we get the net return on the investment

$$\left(\frac{r_W}{1 - \tau_{Cj}^m}\right)\left(1 - \tau_{Cj}^m\right)\left(1 - \tau_{Kh}^m\right) = r_W\left(1 - \tau_{Kh}^m\right) \tag{A3.22}$$

where, τ_{Kh}^m is the marginal effective personal capital income tax rate. Thus, we see that the net return is the same regardless of where the investment takes place (as it should in equilibrium). Note however that with more than one household the net return will generally differ between different household groups if their respective marginal tax rates on capital income differ.

(v) Calculation of personal capital income taxes:

The marginal effective personal capital income tax rate is taken from Södersten [1991]. It is computed using data from household surveys. It is assumed that a part of household saving is

[31] Computed as one minus the share of owner-occupied dwellings, taken from SPK [1989], [1990].

channeled through different tax-exempt institutions and insurance companies, which has the effect of reducing the actual tax rate. Furthermore, an inflation rate of five per cent is assumed when calculating the effective tax rates.

When calculating the average effective tax rate of personal capital income we employ to a large extent the methodology used by Hansson [1984]. In Table A3.10 we present the steps and data for the calculation of the tax rate. Corresponding to each row there is a comment immediately following the table.

Table A3.10 - *Calculation of the Average Effective Tax Rate for Personal Capital Income, billions of SEK*

		1988	1991
1.	net national product excl. housing	736.850	887.253
2.	estimated share for labor earnings	0.885	0.858
3.	aggregate capital income excl. housing	87.489	131.066
4.	corporate income tax	36.346	32.076
5.	average personal income tax rate	0.368	0.290
6.	taxable personal capital income	13.792	29.676
7.	average effective personal income tax rate	0.058	0.066

1. NNP for 1988 (billions of SEK) equals GDP at factor values (976.316) minus consumption of fixed capital (127.835) minus value added of the housing and real estate sectors (111.631). The corresponding for 1991 were not available so we used the figures for 1990 instead.

2. Aggregate capital income must be estimated, due to the inclusion of entrepreneurs labor earnings in operating surplus. For this purpose the share for labor earnings for employees and entrepreneurs is estimated using data for SNI-sectors 2-4. From the labor force surveys (AKU Årsmedeltal 1988, table 18) we compute the ratio between the total number of hours worked and the hours worked by employees only, which equals 1.053 for 1988. From this we estimate the share of labor earnings as follows (excluding housing and real estate).

$$1.053 \cdot \left(\frac{\textit{total wages and social security contrib.}}{\textit{value added} - \textit{depreciation}} \right) \qquad \text{(A3.23)}$$

3. Since national accounts do not include income arising from government capital, we calculate it, X, implicitly from the following expression.

$$\frac{X}{(1 - \textit{labor share}) \cdot (\textit{NNP} + X)} = \frac{\textit{gov. sector capital}}{\textit{total capital}} \qquad \text{(A3.24)}$$

From this expression we solve for X which equals 23.923 billions of SEK. Aggregate capital income can now be computed as (1-0.885)·(736.850+23.923)=87.489.

4. The figures for corporate tax payments were supplied by the Ministry of Finance.

5. The calculation of the average effective personal income tax rate was discussed in section A3.8 (i) above.

6. Taxable personal capital income for 1988 was calculated as income from capital (inkomst av kapital) plus 25 per cent of taxable income from agriculture (inkomst av jordbruk) and trade and professions (inkomst av rörelse) plus 25 per cent of income from incidental earnings (capital gains) minus deficits in different income sources. For 1991 there is only one type of capital income (see chapter 2).

7. The average effective personal capital income tax rate is calculated as row 5 times row 6 divided by row 3.

APPENDIX 4 - CALIBRATION

Our benchmark equilibrium data set is expressed in value terms. In order to separate the transactions into a price and a quantity component we need to adopt a unit convention. Mobile factors will be allocated between sectors, in equilibrium, such that their returns net of taxes and gross of subsidies are equalized. We follow Mansur and Whalley [1984] in adopting the following definition of physical units for mobile factors of production: "That amount of a factor that can in equilibrium earn a reward of one currency unit net of taxes and before receipt of subsidies in any of its alternative uses". Units for commodities are similarly defined as the amounts that in equilibrium sell for one currency unit net of all sales taxes and subsidies.

A4.1 Labor Aggregation Function

Our specification of the labor aggregation function is as follows.

$$AL_{jv} = \Gamma_j \cdot \left[\sum_b \gamma_{bj} \cdot L_{bjv}^{\frac{\epsilon_j - 1}{\epsilon_j}} \right]^{\frac{\epsilon_j}{\epsilon_j - 1}} \tag{A4.1}$$

The value of the elasticity of substitution, ϵ_j must be supplied from outside our benchmark data set but the efficiency parameter, Γ_j, and the share parameters, γ_{bj}, can be determined from the benchmark data set through the following calibration procedure. From the first-order conditions of the decision problem of a producer using old business capital we get the following expression for the share parameter.

$$\gamma_{sj} = \frac{1}{1 + \left[\frac{(W_u \cdot (1 + \tau_{Lj}))}{(W_s \cdot (1 + \tau_{Lj}))} \right] \cdot \left(\frac{L_{ujo}}{L_{sjo}} \right)^{1/\epsilon_j}} \tag{A4.2}$$

$$\gamma_{uj} = 1 - \gamma_{sj} \tag{A4.3}$$

We get the last equation by normalizing the share parameters such that their sum equals one. Using the definition that $W_b=1$ in the benchmark equilibrium data set and given the assigned value of the elasticity of substitution, the observed quantities of skilled and unskilled labor inputs used and the observed tax rates for labor we can calibrate a value for the share parameter. Next, we can calibrate the efficiency parameter, given the calibrated value of the share parameters as follows.

$$\Gamma_j = \frac{\sum_b L_{bjo}}{\left[\sum_b \gamma_{bj} \cdot L_{bjo}^{1-1/\epsilon_j}\right]^{\frac{\epsilon_j}{\epsilon_j - 1}}} \tag{A4.4}$$

The calibrated values of the distribution and efficiency parameters enable us to compute the unit cost function for composite labor.

$$UC_{Lj} = \Gamma_j^{-1} \cdot \left[\sum_b \gamma_{bj}^{\epsilon_j} (W_b (1+\tau_{Lj}))^{1-\epsilon_j}\right]^{\frac{1}{1-\epsilon_j}} \tag{A4.5}$$

A4.2 Production Function

Our specification of the production function is as follows.

$$VA_{jv} = A_{jv} \cdot \left[\alpha_j \cdot AL_{jv}^{\frac{\eta_{jv}-1}{\eta_{jv}}} + (1-\alpha_j) \cdot K_{jv}^{\frac{\eta_{jv}-1}{\eta_{jv}}}\right]^{\frac{\eta_{jv}}{\eta_{jv}-1}} \tag{A4.6}$$

The value of the elasticity of substitution, η_{jv} must be supplied from outside our benchmark data set but the efficiency parameter, A_{jv}, and the share parameter, α_j, can be determined from the benchmark data set through the following calibration procedure. From the first-order conditions of the decision problem of a producer using old business capital we get the following expression for the share parameter.

$$\alpha_j = \frac{1}{1 + \left(\frac{PK_{jo}}{UC_{Lj}}\right) \cdot \left(\frac{K_{jo}}{AL_{jo}}\right)^{1/\eta_{jo}}} \tag{A4.7}$$

The calibrated value of the unit cost function of composite labor, the quasi-rent accruing to old business capital, the assigned value of the elasticity of substitution and the observed quantities of total labor and capital input are sufficient to enable us to compute a value for the share parameter. Given the calibrated value of the share parameter and the observed quantity of value added produced we determine the efficiency parameter as follows.

$$A_{jo} = \frac{VA_{jo}}{\left[\alpha_j \cdot AL_{jo}^{1-1/\eta_{jo}} + (1-\alpha_j) \cdot K_{jo}^{1-/\eta_{jo}}\right]^{\frac{\eta_{jo}}{\eta_{jo}-1}}} \tag{A4.8}$$

The corresponding parameters for the production function using new business capital cannot be calibrated, since by definition there is no new capital in the benchmark data set. Instead we make the following assumption.

$$A_{jn} = (1+g_{Xj})^{T-t_0} \cdot A_{jo} \tag{A4.9}$$

where, g_{Xj} is the exogenous growth rate of Hicks-neutral technical progress, t_0 denotes the benchmark year and T is the solution year. Note that the share parameters are assumed to be the same for old and new production processes.

A4.3 Consumer Goods Aggregation Function

Our specification of the function aggregating different consumption goods into a composite consumption good is as follows.

$$C_{Bh} = \Phi_h \cdot \left[\sum_{i \in D} \lambda_{hi} \cdot C_{hi}^{\frac{\phi_h - 1}{\phi_h}} + \lambda_{Dh} \cdot C_{Dh}^{\frac{\phi_h - 1}{\phi_h}} \right]^{\frac{\phi_h}{\phi_h - 1}} \quad \text{(A4.10)}$$

The value of the elasticity of substitution, ϕ_h must be supplied from outside our benchmark data set but the efficiency parameter, Φ_h, and the share parameters, λ_{hi} and λ_{Dh}, can be determined from the benchmark data set through the following calibration procedure. From the first-order conditions of the household decision problem we get the following expression for the share parameters.

$$\lambda_{hj} = \lambda_{hi} \left(\frac{PC_j}{PC_i} \right) \cdot \left(\frac{C_{hj}}{C_{hi}} \right)^{1/\phi_h} \qquad \lambda_{Dh} = \lambda_{hi} \left(\frac{PC_{Dh}}{PC_i} \right) \cdot \left(\frac{C_{Dh}}{C_{hi}} \right)^{1/\phi_h} \quad \text{(A4.11)}$$

We also know that the share parameters sum to one. After some algebraic manipulations we can solve for the share parameter as follows.

$$\lambda_{hi} = \frac{1}{1 + \sum_{j \neq i} \left(\frac{PC_j}{PC_i} \right) \cdot \left(\frac{C_{hj}}{C_{hi}} \right)^{1/\phi_h}} \quad \text{(A4.12)}$$

$$\lambda_{Dh} = \frac{1}{1 + \sum_{j \neq i} \left(\frac{PC_j}{PC_{Dh}} \right) \cdot \left(\frac{C_{hj}}{C_{Dh}} \right)^{1/\phi_h}} \quad \text{(A4.13)}$$

Using the definition of PC_i and the convention that $PX_j = 1$ in the benchmark data set, the assigned value of the elasticity of substitution, the observed quantities of market consumption goods and household services and the consumption tax rates we can compute the values for the share parameters. Given the calibrated values of the share parameters we next determine the efficiency parameter as follows.

$$\Phi_h = \frac{\sum_{i \neq D} C_{hi} + C_{Dh}}{\left[\sum_{i \neq D} \lambda_{hi} \cdot C_{hi}^{1-1/\phi_h} + \lambda_{Dh} \cdot C_{Dh}^{1-1/\phi_h}\right]^{\frac{\phi_h}{\phi_h - 1}}} \tag{A4.14}$$

The calibrated values of distribution and efficiency parameters enable us to compute the unit cost function for the composite consumption good.

$$UC_{Bh} = \Phi_h^{-1} \cdot \left[\sum_{i \neq D} \lambda_{hi}^{\phi_h} \cdot PC_i^{1-\phi_h} + \lambda_{Dh}^{\phi_h} \cdot PC_{Dh}^{1-\phi_h}\right]^{\frac{1}{1-\phi_h}} \tag{A4.15}$$

A4.4 Household Production Function

Our specification of the production function in household production is as follows.

$$XD_{hv} = \Lambda_{Dhv} \cdot \left[\alpha_{Dh} \cdot LD_{hv}^{\frac{\lambda_{Dhv}-1}{\lambda_{Dhv}}} + (1-\alpha_{Dhv}) \cdot KD_{hv}^{\frac{\lambda_{Dhv}-1}{\lambda_{Dhv}}}\right]^{\frac{\lambda_{Dhv}}{\lambda_{Dhv}-1}} \tag{A4.16}$$

The value of the elasticity of substitution, λ_{Dhv} must be supplied from outside our benchmark data set but the efficiency parameter, Λ_{Dhv}, and the share parameter, α_{Dh}, can be determined from the benchmark data set through the following calibration procedure. From the first-order conditions of the decision problem of households employing old household capital we get the following expression for the share parameter.

$$\alpha_{Dh} = \frac{1}{1 + \left(\frac{PD_{ho}}{PF_h}\right) \cdot \left(\frac{KD_{ho}}{LD_{ho}}\right)^{1/\lambda_{Dho}}} \tag{A4.17}$$

Provided that we have observations or can estimate the amount of old household capital, the labor input in household production, the price of leisure and defining the price of household services to be equal to one we can compute the share parameter. Given the calibrated value of the share parameter we determine the efficiency parameter as follows.

$$\Lambda_{Dho} = \frac{XD_{ho}}{\left[\alpha_{Dh}\cdot LD_{ho}^{1-1/\lambda_{Dho}} + (1-\alpha_{Dh})\cdot KD_{ho}^{1-1/\lambda_{Dho}}\right]^{\frac{\lambda_{Dho}}{\lambda_{Dho}-1}}} \tag{A4.18}$$

The corresponding parameters for the production function using new household capital cannot be calibrated, since by definition there is no new household capital in the benchmark data set. Instead we make the following assumption.

$$\Lambda_{Dhn} = (1+g_{Dh})^{T-t_0}\cdot\Lambda_{Dho} \tag{A4.19}$$

where, g_{Dh} is the exogenous growth rate of Hicks-neutral technical progress. Again the share parameters are assumed to be the same for old and new production processes.

A4.5 Utility Function

Our specification of the utility function is as follows.

$$U_h = \Sigma_h\cdot\left[\lambda_{Ch}\cdot C_{Bh}^{\frac{\sigma_h-1}{\sigma_h}} + (1-\lambda_{Ch})\cdot F_h^{\frac{\sigma_h-1}{\sigma_h}}\right]^{\frac{\sigma_h}{\sigma_h-1}} \tag{A4.20}$$

The value of the elasticity of substitution, σ_h must be supplied from outside our benchmark data set but the efficiency parameter, Σ_h, and the share parameter, λ_{Ch}, can be determined from the benchmark data set through the following calibration procedure. From the first-order conditions of the household decision problem we get the following expression for the share parameter.

$$\lambda_{Ch} = \frac{1}{1 + \left(\frac{PF_h}{UC_{Bh}}\right) \cdot \left(\frac{F_h}{\sum_i C_{hi}}\right)^{1/\sigma_h}} \qquad \text{(A4.21)}$$

Using the expression for the unit cost function of composite consumption, the assigned value of the elasticity of substitution, the observed quantities of total consumption of market goods and household services and the amount of leisure enable us to compute a value for the share parameter. Leisure is of course not directly observable but can be computed as the difference between the assumed labor endowment and the observed quantity of labor supply. The amount of household services are given from the calibration procedure in Section A4.4 above. Given the calibrated value of the share parameter we determine the efficiency parameter as.

$$\Sigma_h = \frac{\sum_i C_{hi} + F_h}{\left[\lambda_{Ch}\left(\sum_i C_{hi}\right)^{1-1/\sigma_h} + (1-\lambda_{Ch})\cdot F_h^{1-/\sigma_h}\right]^{\frac{\sigma_h}{\sigma_h-1}}} \qquad \text{(A4.22)}$$

APPENDIX 5 - WALRAS LAW

In this appendix we will show that the equilibrium conditions or excess demand equations in (3.47) - (3.50) are not independent equations. For simplicity we assume that the exogenous variables EX_{Ch}, EX_j, $EXGOV$ and $FORREV$ are equal to zero. We start by summing the budget constraints, given in (3.3) and (3.4), over all households.

$$\sum_h PF_h \cdot LE_h + \sum_h B_{Yh} + \sum_h \sum_j \beta_h \cdot (1-\tau_{FHj}) \cdot RK_j + \sum_h RD_h +$$

$$+ \sum_h TR_h + \sum_h DEP_h + \sum_h r_W \cdot P_K \cdot AS_h =$$

$$= \sum_h \sum_{i \neq D} PC_i \cdot C_{hi} + \sum_h PC_{Dh} \cdot C_{Dh} + \sum_h S_h + \sum_h PF_h \cdot F_h + \sum_h \tau_{Kh}^m \cdot r_W \cdot P_K \cdot SF_h \quad \text{(A5.1)}$$

Next, we subtract the value of leisure from both sides of (A5.1) and use the definition of the price of leisure PF_h, (3.1), and the definition of the price of consumer goods, (A3.2), to rewrite (A5.1) as.

$$\sum_h \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \cdot L_h + \sum_h B_{Yh} + \sum_h \sum_j \beta_h \cdot (1-\tau_{FHj}) \cdot RK_j + \sum_h RD_h +$$

$$+ \sum_h TR_h + \sum_h DEP_h + \sum_h r_W \cdot P_K \cdot AS_h =$$

$$= \sum_h \sum_{i \neq D} \sum_j PX_j \cdot (1+\tau_{Sj}) \cdot m_{ij} \cdot C_{hi} + \sum_h PC_{Dh} \cdot C_{Dh} + \sum_h S_h + \sum_h \tau_{Kh}^m \cdot r_W \cdot P_K \cdot SF_h \quad \text{(A5.2)}$$

By using the definition of the return to old business capital RK_j, (3.24), and to old household capital RD_h, (3.14), we can rewrite (A5.2) as.

$$\sum_h \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \cdot L_h + \sum_h B_{Yh} + \sum_h TR_h + \sum_h DEP_h + \sum_h r_W \cdot P_K \cdot AS_h +$$

$$+ \sum_h \sum_j \beta_h \cdot (1-\tau_{Fhj}) \left[PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b W_b \cdot (1+\tau_{Lj}) \cdot L_{bjo} - P_K \cdot \delta_{jo} \cdot K_{jo} \right] +$$

$$+ \sum_h \left[PC_{Dh} \cdot XD_{ho} - \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \cdot LD_{ho} - P_K \cdot \delta_{Do} \cdot KD_{ho} \right] =$$

$$= \sum_h \sum_{i \neq D} \sum_j PX_j \cdot (1+\tau_{Si}) \cdot m_{ij} \cdot C_{hi} + \sum_h PC_{Dh} \cdot C_{Dh} + \sum_h S_h + \sum_h \tau_{Kh}^m \cdot r_W \cdot P_K \cdot SF_h \qquad \textbf{(A5.3)}$$

Since the production employing new capital in business production sectors as well as households is characterized by constant returns to scale the value of output equals the value of inputs if they are paid according to their respective marginal revenue product.

$$PC_{Dh} \cdot XD_{hn} = \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \cdot LD_{hn} + PD_{hn} \cdot KD_{hn} \qquad \textbf{(A5.4)}$$

$$PX_j \cdot X_{jn} = \sum_b W_b \cdot (1+\tau_{Lj}) \cdot L_{bjn} + PK_{jn} \cdot K_{jn} + \sum_i PX_i \cdot a_{ij} \cdot X_{jn} \qquad \textbf{(A5.5)}$$

If we substitute the definitions of PK_{jn} and PD_{hn} into (A5.4) and (A5.5) and sum over all households and business sectors we get.

$$\sum_h PC_{Dh} \cdot XD_{hn} = \sum_h \sum_b W_b \cdot (1-\tau_{Yh}^m) \cdot q_{bh} \cdot LD_{hn} + \sum_h (\delta_{Dn} + r_W) \cdot P_K \cdot KD_{hn} \qquad \textbf{(A5.6)}$$

$$\sum_j PX_j \cdot X_{jn} = \sum_j \sum_b W_b \cdot (1+\tau_{Lj}) \cdot L_{bjn} + \sum_j \left(\delta_{jn} + \frac{r_W}{1-\tau_{Cj}^m} \right) \cdot P_K \cdot K_{jn} +$$

$$+ \sum_j \sum_i PX_i \cdot a_{ij} \cdot X_{jn} \qquad \textbf{(A5.7)}$$

Let us solve for the net return to business and household capital before taxes.

$$\sum_h r_W \cdot P_K \cdot KD_{hn} = \sum_h PC_{Dh} \cdot XD_{hn} - \sum_b \sum_h W_b \cdot (1-\tau^m_{Yh}) \cdot q_{bh} \cdot LD_{hn} -$$

$$- \sum_h P_K \cdot \delta_{Dn} \cdot KD_{hn} \qquad \textbf{(A5.8)}$$

$$\sum_j \left(\frac{r_W}{1-\tau^m_{Cj}}\right) \cdot P_K \cdot K_{jn} = \sum_j PX_j \cdot X_{jn} - \sum_i \sum_j PX_i \cdot a_{ij} \cdot X_{jn} -$$

$$- \sum_b \sum_j W_b \cdot (1+\tau_{Lj}) \cdot L_{bjn} - \sum_j P_K \cdot \delta_{jn} \cdot K_{jn} \qquad \textbf{(A5.9)}$$

Using the portfolio identity, (3.2), and the definition of foreign capital, (3.34), we can write the net return to total domestic new capital as.

$$\sum_h r_W \cdot P_K \cdot AS_h = \sum_h r_W \cdot P_K \cdot KD_{hn} + \sum_j \left(\frac{r_W}{1-\tau^m_{Cj}}\right) \cdot P_K \cdot K_{jn} -$$

$$- \sum_j \left(\frac{\tau^m_{Cj}}{1-\tau^m_{Cj}}\right) \cdot r_W \cdot P_K \cdot K_{jn} - r_W \cdot P_K \cdot KF \qquad \textbf{(A5.10)}$$

Next, we substitute (A5.8), (A5.9) and (A5.10) into the aggregate household budget constraint, (A3.3), to get the following expression.

$$\sum_h \sum_b W_b \cdot (1-\tau^m_{Yh}) \cdot q_{bh} \cdot L_h + \sum_h B_{Yh} + \sum_h TR_h + \sum_h DEP_h +$$

$$+ \sum_h \sum_j \beta_h \cdot (1-\tau_{Fhj}) \cdot \left[PX_j \cdot X_{jo} - \sum_i PX_i \cdot a_{ij} \cdot X_{jo} - \sum_b W_b \cdot (1+\tau_{Lj}) \cdot L_{bjo} - P_K \cdot \delta_{jo} \cdot K_{jo}\right] +$$

$$+ \sum_h \left[PC_{Dh} \cdot \sum_v XD_{hv} - \sum_b W_b \cdot (1-\tau^m_{Yh}) \cdot q_{bh} \cdot \sum_v LD_{hv} - P_K \cdot \sum_v \delta_{Dv} \cdot KD_{hv} \right] +$$

$$+ \sum_j \left[PX_j \cdot X_{jn} - \sum_i PX_i \cdot a_{ij} \cdot X_{jn} - \sum_b W_b \cdot (1+\tau_{Lj}) \cdot L_{bjn} - P_K \cdot \delta_{jn} \cdot K_{jn} \right] -$$

$$- \sum_j \left(\frac{\tau^m_{Cj}}{1-\tau^m_{Cj}} \right) \cdot r_W \cdot P_K \cdot K_{jn} - r_W \cdot P_K \cdot KF =$$

$$= \sum_h \sum_{i \in D} \sum_j PX_j (1+\tau_{Si}) \cdot m_{ij} \cdot C_{hi} + \sum_h PC_{Dh} \cdot C_{Dh} + \sum_h S_h + \sum_h \tau^m_{Kh} \cdot r_W \cdot P_K \cdot SF_h \qquad \textbf{(A5.11)}$$

By substituting (3.36)-(3.42) into the government budget constraint, (3.43) we get the following expression for the government sector budget constraint.

$$\sum_b \sum_j \sum_v \tau_{Lj} \cdot W_b \cdot L_{bjv} + \sum_h \sum_{i \in D} \sum_j \tau_{Si} \cdot C_{hi} m_{ji} \cdot PX_j + \sum_b \sum_h \tau_{Yh} \cdot W_b \cdot \left(L_h - \sum_v LD_{hv} \right) \cdot q_{bh} +$$

$$+ \sum_h \tau^m_{Kh} \cdot r_W \cdot P_K \cdot SF_h + \sum_j \tau^m_{Cj} \left(\frac{r_W}{1-\tau^m_{Cj}} \right) \cdot P_K \cdot K_{jn} + \sum_h \sum_j \tau_{Fhj} \cdot \beta_h \cdot RK_j =$$

$$= \sum_h TR_h + \sum_j PX_j \cdot G_j + GSAV \qquad \textbf{(A5.12)}$$

By adding the budget constraint of the household sector, (A5.3), and the government sector, (A5.12), and using the relation between the average and the marginal labor income tax rates, (2.3), and the definition of DEP_h, we can cancel out depreciation, transfer and tax payments. Thus, we have the following budget constraint for the domestic economy.

$$\sum_b \sum_h W_b \cdot \left(L_h - \sum_v LD_{hv}\right) \cdot q_{bh} + \sum_j \sum_v \left[PX_j \cdot X_{jv} - \sum_i PX_i \cdot a_{ij} \cdot X_{jv} - \sum_b W_b \cdot L_{bjv}\right] +$$

$$+ \sum_h \sum_v PC_{Dh} \cdot XD_{hv} - r_W \cdot P_K \cdot KF =$$

$$= \sum_h \sum_{i \in D} \sum_j PX_j \cdot m_{ij} \cdot C_{hi} + \sum_h PC_{Dh} \cdot C_{Dh} + \sum_h S_h + \sum_j PX_j \cdot G_j + GSAV \qquad \textbf{(A5.13)}$$

The closure rule, (3.45) and (3.46), can be written as follows.

$$\sum_j PX_j \cdot INV_j - FSAV = \sum_h S_h + GSAV \qquad \textbf{(A5.14)}$$

Total purchases of intermediate goods can be rewritten as.

$$\sum_i \sum_j \sum_v PX_i \cdot a_{ij} \cdot X_{jv} = \sum_i \sum_j \sum_v PX_j \cdot a_{ji} \cdot X_{iv} =$$

$$= \sum_j PX_j \cdot \sum_i \sum_v a_{ji} \cdot X_{iv} = \sum_j PX_j \cdot I_j \qquad \textbf{(A5.15)}$$

The expression for the value of aggregate private consumption can be simplified as follows.

$$\sum_h \sum_{i \in D} \sum_j PX_j \cdot m_{ij} \cdot C_{hi} = \sum_j PX_j \cdot \sum_{i \in D} \sum_h m_{ij} \cdot C_{hi} = \sum_j PX_j \cdot C_j \qquad \textbf{(A5.16)}$$

Using (A5.14)-(A5.16) and rearranging the terms we arrive at the following expression for the aggregate budget constraint.

$$\sum_b W_b \cdot \left[\sum_h \left(L_h - \sum_v LD_{hv}\right) \cdot q_{bh} - \sum_j \sum_v L_{bjv}\right] + \sum_{nt} PX_{nt} \cdot \left(\sum_v X_{nt,v} - I_{nt} - C_{nt} - INV_{nt} - G_{nt}\right) +$$

$$+ \sum_{td} PX_{td} \cdot \left(\sum_{v} X_{td,v} - I_{td} - C_{td} - INV_{td} - G_{td}\right) - r_{W} \cdot P_{K} \cdot KF + FSAV +$$

$$+ \sum_{h} PC_{Dh} \left(\sum_{v} XD_{hv} - C_{Dh}\right) = 0 \qquad \textbf{(A5.17)}$$

Lastly, be employing the definitions of the trade balance, (3.33), and the current account, (3.35), we can write the final expression for the aggregate domestic budget constraint.

$$\sum_{b} W_{b} \left[\sum_{h} \left(L_{h} - \sum_{v} LD_{hv}\right) \cdot q_{bh} - \sum_{j} \sum_{v} L_{bjv}\right] + \sum_{nt} PX_{nt} \cdot \left[\sum_{v} X_{nt,v} - I_{nt} - C_{nt} - INV_{nt} - G_{nt}\right] +$$

$$+ \sum_{h} PC_{Dh} \left[\sum_{v} XD_{hv} - C_{Dh}\right] + (CC + FSAV) = 0 \qquad \textbf{(A5.18)}$$

If all labor and goods markets clear the expressions within the square brackets in (A5.18) equal zero. One implication of Walras Law, providing that all prices and wages are positive, is that if all but one market clear then the remaining market must also clear. As can be seen from (A5.18), this implies that if the labor and goods market clear then the expression within the last parenthesis must be zero. But the expression within the last parenthesis is nothing but the equilibrium condition for the foreign exchange market. Thus, we have shown that the equilibrium conditions or excess demand functions are not independent of each other.

A5.1 Numerical Solution of the Model

For the actual numerical solution of the model we have employed version 2.05 of the GAMS computer program.[32] We have to make sure that there exists a solution to the model and that the solution is unique.

(i) First let us count the number of equations and variables (b=2, h=1, i=12, nt=3, td=4 j=nt+td and v=2).

From the equilibrium conditions we compute the following endogenous prices: W_b, PX_{nt}, PC_{Dh}, and ER. Given these prices we can derive the following additional endogenous prices: WP_{bj}, PF_h, UC_{Lj}, PK_{jn}, PD_{hn}, UC_{Xj}, UC_{Dh}, PX_{td}, P_K, PC_i, UC_{Bh}, and UC_{Uh}. The total number of endogenous price variables equals b + b·j + 6h + (i-1) + 5j + 2 = 70.

We have the following endogenous quantities: SF_h, KD_{hn}, U_h, C_{Bh}, F_h, L_h, C_{hi}, C_{Dh}, C_j, AL_{jv}, L_{bjv}, LD_{hv}, K_{jn}, X_{jv}, XD_{hv}, I_j, INV_j, Z_{td}, and KF. The number of endogenous quantity variables equals b·j·v + 7h + h·(i-1) + 2h·v + 4j + 2j·v + td + 1 = 110.

We have the following endogenous value variables: Y_h, S_h, B_{Yh}, DEP_h, RK_j, RD_h, TR, TX_L, TX_{OC}, TX_{NC}, TX_S, TX_Y, TX_{OK}, TX_{NK}, TB, CC and $TSAV$. The number of endogenous value variables equals 5h + j + 11 = 23.

Thus, the total number of endogenous variables equals 203. If we sum all the equations in Appendix 2 we see that the total number of equations equals b + b·j + b·j·v + 22h + h·(i-1) + (i-1) + nt + 2td + 13j + 15 = 204. However, according to Walras' law one of the excess demand equations is redundant, as was shown above. Thus, the number of variables and independent equations are equal. Of course, this equality of the number of equations and variables does not in itself guarantee that there is a unique solution to the system of non-linear equations that the model is comprised of.

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[32] See Brooke et.al. [1988].

(ii) We can also investigate the uniqueness of the solution through model simulations. Regardless, whether we maximize or minimize a given objective function the same value of the objective function should be obtained and all real quantities should be unaffected. This does not, of course, prove that there is a globally unique solution but can nevertheless provide one simple check that the model is logically consistent. Another simple test is to maximize or minimize different objective functions and make sure that the same prices and quantities are obtained as the solution in each case.

(iii) Multiplying the numeraire with a positive scalar should leave all quantities unchanged and change all prices proportionately. In other words the model is homogeneous of degree zero in all quantities. Any nominal variable can be chosen as numeraire in the model. This implies that regardless of the particular numeraire chosen all real variables should be unaffected.

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