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MULTIMAC IV : A Disaggregated Econometric Model of the Austrian Economy

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Introduction

MULTIMAC IV is the current stage of the input-output based macroeconomic model of WIFO (Austrian Institute of Economic Research). Former versions of the model have been laid down in Kratena (1994) and Kratena and Wüger (1995). This version (MULTIMAC IV) is characterized by a full description of quantity and price interactions at the disaggregated level.

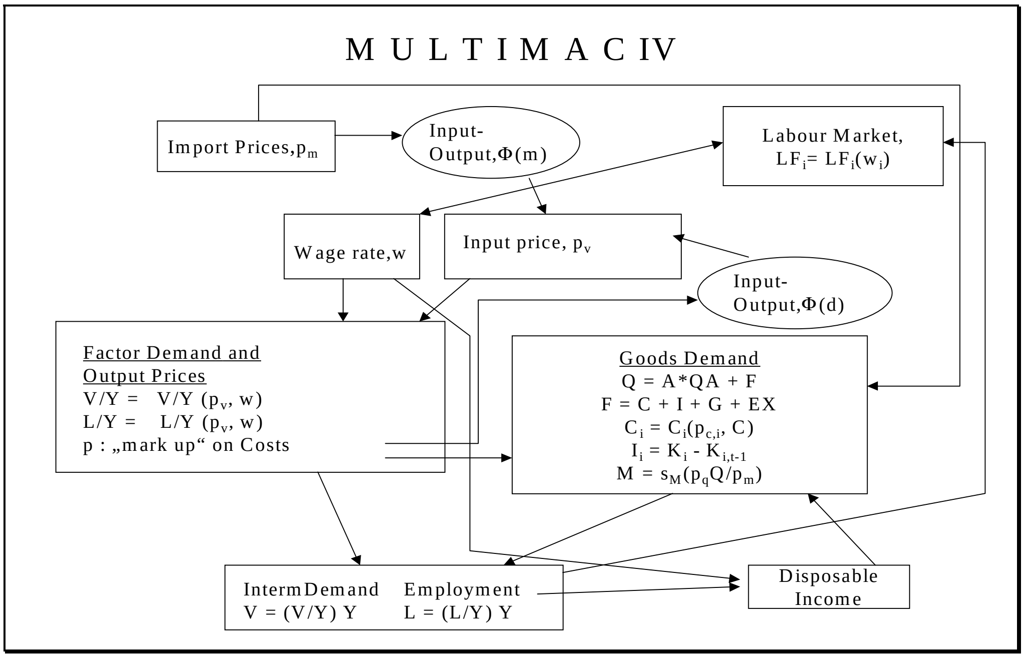
MULTIMAC IV is input – output based at a medium aggregation level of 36 industries and combines econometric functions for goods and factor demand, prices, wages and the labour market with the input-output accounting framework. In that sense MULTIMAC IV is oriented along the same lines as other large scale macroeconomic input-output based models like the INFORUM model family (Almon (1991)) and the European multiregional model E3ME (Barker, et. al. (1999)). Compared to these fully specified models MULTIMAC IV has important shortcomings in the modelling of external trade, where exports are fully exogenous and only import functions exist. MULTIMAC IV shares with the two mentioned models the emphasis on econometrics, i.e. on parameter values derived by using historical data in statistical methods opposed to the CGE philosophy of restricting parameters and calibrating for some base year.

On the other hand an important advantage of CGE models is the consistent derivation of functional forms from microeconomic theory, which implies certain restrictions concerning the links between variables. This is for example the case for factor demand and output prices, where CGE models usually start from production or cost functions in a certain market form (usually but not necessarily perfect competition), from which factor demand and output prices can be derived simultaneously.

MULTIMAC IV tries to combine the advantages of econometric techniques with consistent microeconomic functional forms and uses specifications derived from well known microeconomic concepts. In general the functional forms chosen in MULTIMAC IV from microeconomic theory are those with a minimum of necessary *a priori* restrictions.

MULTIMAC IV consists of three main blocks for factor demand, goods demand and the labour market. In between these model blocks some small model elements are built in for the intermediate demand prices and for income generation. Input – output analysis plays an important role at the price side as well as on the goods demand side and in both cases the phenomenon of changing input – output structures is treated with.

Figure 1: The block structure of MULTIMAC IV



1. The Database of MULTIMAC IV

In order to provide a brief overview of the database of MULTIMAC IV, this section deals with the following three aspects. First the sources and compilation methods for the time series data in the model will be described. This is followed by the introduction of the Input-Output(IO)-table incorporated in the model. And finally the derivation of the devices that link these two data bases, mainly bridge matrices, is outlined. The level of industrial classification adopted in the model comprises 36 sectors plus one sector capturing statistical differences (e.g. between National Accounts and the Input-Output table). The classification along with the corresponding 2-digit NACE industries (respectively ÖNACE, which is the slightly modified NACE classification used by Statistics Austria) can be taken from table 1 below.

Table 1: The 36 industry structure of MULTIMAC IV

	Model Industry	NACE 2-digits
1	Agriculture, Forestry and Fishing	1,2,5
2	Mining of Coal and Lignite	10
3	Extraction of Crude Petroleum and Natural Gas	11
4	Gas Supply	
5	Manufacture of Refined Petroleum Products	23
6	Electricity, Steam and Hot Water Supply	40
7	Collection, Purification and Distribution of Water	41
8	Ferrous & Non Ferrous Metals	27
9	Non-metallic Mineral Products	13, 14, 26
10	Chemicals	24
11	Metal Products	28
12	Agricultural and Industrial Machines	29
13	Office Machines	30

14	Electrical Goods	31, 32
15	Transport Equipment	34,35
16	Food and Tobacco	15, 16
17	Textiles, Clothing & Footwear	17, 18, 19
18	Timber & Wood	20
19	Paper	21
20	Printing Products	22
21	Rubber & Plastic Products	25
22	Recycling	37
23	Other Manufactures	33, 36
24	Construction	45
25	Distribution	50, 51, 52
26	Hotels and Restaurants	55
27	Inland Transport	60
28	Water and Air Transport	61, 62
29	Supporting and Auxiliary Transport	63
30	Communications	64
31	Bank, Finance & Insurance	65, 66, 67
32	Real Estate	70, 71
33	Software & Data Processing	72
34	R&D, Business Services	73, 74
35	Other Market Services	92, 93, 95
36	Non-market Services	75, 80, 85, 90, 91
37	Statistical Differences	

1.1 Time Series Data

A notable difference between MULTIMAC IV and its predecessors is that the data base of the time series in MULTIMAC IV complies with the new standards of the ESA 1995. The first annual data at the industry level satisfying the new standards became available by Statistics Austria (St.At.) (2000b). These time series comprise various economic indicators and run from 1988 through 1999. Most of them are available on a 55 industry level (roughly corresponding to the 2-digits of the NACE classification), although there are some important exceptions, as will be outlined below. Clearly, the compilation of an econometric model such as MULTIMAC would not be feasible with time series featuring only 12 observations. Whenever possible the time series were extended back to 1976, mainly with the help of series from former versions of the model based on National Accounts for Austria according to the concept of ESA 1979.

The variables of interest for MULTIMAC IV, their sources and the various adjustments applied to those series are briefly described in the following subsections.

1.1.1 Data on GDP, Value Added, Intermediate Demand, Wages and Employment

This section will explore the derivation of the most detailed time series available for the computation of MULTIMAC IV. The data on *GDP*, *Value Added* and *Intermediate Demand* that comply with the standards of ESA 1995, all are available on a 55 industry level from 1988 through 1999 for both nominal and real values (at constant prices of 1995). Moreover, for all these variables time series of previous versions of MULTIMAC IV in the old system of ESA 1979 exist over the time period of 1976 to 1997 based on a former data base of National Accounts from St.At. but also in 55 NACE based classification .

The growth rates of new and old data on the series under consideration were used to extend the former back from 1988 to 1976. In order to keep aggregation-biases as low as possible, the computations were undertaken on the 55 industry level and aggregation to the 36 industries of the model was accomplished thereafter. These computations were conducted for both nominal and real values of the series, which in addition enabled the derivation of the respective price indices (with 1995 as their base year).

Time series on *employment* and *wages/salaries* at the industry-level underwent the same procedure that was just outlined as far as enlargement of the time series back to 1976 is concerned. The series of these data from 1976 to 1997 were in the former industrial classification of Austrian statistics (Betriebssystematik 1968) and in a first step had to be converted into NACE classification. This was done using the full census of the Austrian economy for 1995 (Nicht-Landwirtschaftliche Bereichszählung) with data in both classifications for NACE 3 digit industries and special studies by Austrian Social Security (Hauptverband der Sozialversicherungsträger) on data in both classifications for the base year 1995.

Time series on *unemployment* by industries are available from Unemployment Insurance Offices and were used to calculate sectoral *labour force* and *unemployment rates*. These data range from 1987 to 2000 and had also to be converted from former industrial classification of Austrian statistics (Betriebssystematik 1968) to NACE.

1.1.2 Data on Imports, Exports, and Investment

As opposed to the first block of data described above, the situation with data on foreign trade and investment is less favourable.

The most comprehensive database available for *imports and exports* is maintained by the WIFO itself, and is based on the External Trade Statistics (Außenhandelsstatistik 1988 – 1995). The 6 digit commodities of external trade had been converted to PRODCOM and the further to NACE to arrive at time series from 1989 to 1999 for values and volumes. Given this information, unit values of imports and exports were computed based on the 3-digit level in order to derive the corresponding price index of the nominal series[1]. Aggregating up to the classification maintained in MULTIMAC IV resulted in an approximation for the series of nominal and real imports and exports as well as the corresponding price indices for the manufacturing sectors.

[1] Note that the computation of the unit values is conducted on the 3-digit level and is therefore necessarily imprecise since we are assuming here that each 3-digit good has the same weight. During the computation-process a correction for outliers has been performed.

For services currently no time series are available on a disaggregated level. Hence we applied the overall growth rates of imports and exports of service goods (which is available from National Accounts) uniformly to every service sector based on the disaggregated values of the IO-table 1990 to arrive at least at a rough approximation of those series. Information on import prices was completely unavailable, so those had to be approximated by the corresponding domestic price index[2].

The situation for *investment* is slightly different than the one for foreign exchange data in that there are time series from 1988 to 1999 for a total of 12 sectors available. Those sectors correspond roughly to the one-digit industries of ÖNACE 1995, which essentially means that services on the one hand are well captured but that manufacturing one the other hand is treated as a single sector only. The time series are readily available for both nominal and real values, hence a corresponding price index (base 1995) is easily computable. The investment data have been used together with the estimated sectoral capital stock by WIFO for 1987 to construct capital stock data following the perpetual inventory method (s.: Czerny, et.al. (1997)). For this purpose the following parameters had to be chosen: (i) the sectoral depreciation rate and (ii) the long term ('equilibrium') growth rate of investment. That allows to calculate the active and the reserve capital stock starting from a given value in t = 0.

Besides the fact that data on both foreign trade and investment are not available for each sector of MULTIMAC IV, it must also be noted, that at the moment there are no possibilities to extend those time series backward (as was the case with data described in the first section above). Therefore MULTIMAC IV has to deal with very short series in these groups which is a considerable shortcoming of the model in its current version.

1.1.3 Public and Private Consumption

Data on *public consumption* on the industry-level are not available for the time being. Hence we proceeded along the lines described earlier in connection with foreign trade data for

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[2] Note, however, that - as will be described later - imports of service good swill remain exogenous in MM IV, and import prices are only used to re-base the IO-table of 1990 to prices of 1995.

service sectors. That is, the sectoral values of the IO-table for 1990 (in 1995 prices) are updated using the aggregate growth rate of real public consumption as given by the National Accounts. This results in a series of real public consumption ranging from 1988 to 1999 for three distinct sectors (since there are only three sectors in the classification of MULTIMAC IV that provide public goods) plus the statistical difference between the IO-table and National Accounts. Since public consumption is treated as exogenous in MULTIMAC IV, it enters the model solely when it comes to determine total real final consumption, and hence no nominal values or price indices are needed.

The most recent data on *private consumption* are taken from National Accounts which provides annual values from 1988 through 1999 on a 5-digit level (corresponding to 225 different types of consumption goods) of the respective classification. Again, those time series could be extended backward making use of older series from the ESA 1979. However, the classification code of National Accounts has changed with the introduction of the ESA 1995, complicating the comparison of the two classifications below the 2-digit level (which comprises 12 groups). The most disaggregate level achievable for applying the growth rates turned out to be 21 groups. Eventually it was decided to incorporate 20 groups within MULTIMAC IV which can be taken from table 2 below.

Table 2: Consumption Categories in MULTIMAC IV

1 Food, Drink and Tobacco
2 Clothing and Footwear
3 Gross Rent and Water
4 Transport
- 4.1 Cars
- 4.2 Petrol,
- 4.3 Public transport
- 4.4 Other transport

5 Communication
6 Other Services
- 6.1 Medical Care
- 6.2 Entertainment
- 6.3 Education
- 6.4 Restaurants, Hotels

7 Other Goods and Services
8 Heating
- 8.1 Electricity
- 8.2 Gas

8.3 Liquid Fuels
8.4 Coke
8.5 Biomass
8.6 District Heating
9 Furniture

Since both nominal and real data are available we can compute a price index and end up with time series from 1976 to 1999.

1.1.4 Other data

Other data utilized in MULTIMAC IV comprise the following series.

- Total disposable income in real terms as given by National Accounts
- Population, subdivided in both male and female population
- Labour force, in total and in the disaggregation of the labour market – block of the model (see section 6 for a description of those sectors)
- Variables taken from DAEDALUS, the energy-model of WIFO, which are treated as exogenous in MULTIMAC IV
- Data on housing stock
- Data on the depreciation rates of capital stock the 12 sectors for which investment data are available

All these series are treated as exogenous in MULTIMAC IV (disposable income is 'quasi-exogenous' in that it depends on an exogenous fraction of total value added) and are therefore given for the entire historical time period as well as the forecasting period of the model (i.e. from 1976 to 2010).

1.1.5 Variables derived via definitional equations

Given the stock of data from sections 1.1 to 1.4, it is possible to compute a large set of variables using definitional equations. Among those variables are total demand (domestic demand plus imports), wage rates, total final demand and many more.

Note that whenever time series of shorter length (such as data on foreign trade) are involved in the computation of the variables just mentioned also the compounds will be running over the short period only, which of course limits the capability to use these series in regression equations.

1.2 The Input-Output Table 1990

At the time of the preparation of the database of MULTIMAC IV the most recent Input-Output table published for Austria dated back to the year 1990 (Statistics Austria (2000a)). The IO-table for 1995 became available by Statistics Austria in July 2001, its incorporation in the model is left over for future versions of the model. The 1990–table in use in the current version of the model is in NACE classification and is therefore – at least as far as the sectoral classification is concerned - directly compatible to the time series data used in the model. It must be noted however, that this table is not fully consistent with the ESA 1995 (which is for the first time achieved in the IO-table 1995). The table itself is set up according to the Make-Use framework and distinguishes between imported and domestic goods in the intermediate consumption and in the final demand matrix.

In order to incorporate the IO-table in the model two steps had to be carried out. First, the table had to be based on prices of 1995, the base year of MULTIMAC IV. This was accomplished at the most disaggregated level possible given the various constraints on prices, which in most cases were available for 55 industries (as opposed to 73 industries in the IO-table).

The second step involved the aggregation of the IO-table on the 36 industries structure of our model. Statistical differences between the values of the resulting IO-table and data from

National Accounts are absorbed by an additional sector 37. In this way the complete Input-Output framework is made consistent with the data from National Accounts.

1.3 Bridge matrices linking the IO-table with National Accounts data

In order to link the time series of National Accounts data with the IO-table two ‘bridge matrices’ for consumption and investment had to be set up.

To illustrate this more thoroughly, consider the modelling block of private consumption. As will be described in section 5.1, the demand from the 20 categories of private consumption is modelled using simultaneous models or single equations and the groups are then summed up to nine main categories. The task is then to determine which sectors of the economy satisfy this demand. To be able to do this, one has to ‘translate’ the demand of the nine consumption categories (a classification that follows the National Accounts) into demand for goods of the 36 sectors of the model. For the case of private consumption, this is achieved by setting up a matrix that links the nine consumption categories with the 36 sectors of the model such that multiplying the consumption vector with this matrix yields the demand for goods in the 36 industry-structure of MULTIMAC IV.

These matrices are usually computed by using information from the year 1990, since in that year private consumption is available in both the 36 industry structure as well as the 9 groups of National Accounts, that is in 1990 we have information on the column and row sums of the matrix we wish to create. Further information to fill in the cells of the bridge matrix from input – output statistics comprise trade and transport margins and effective value added tax rates by commodity. Due to a lack of data, the structure of this matrix has to be kept the same throughout the entire time period if MULTIMAC IV and treated as constant.

In finishing the description of that database a brief prospective of future efforts dealing with the extension of the database can be made. First and foremost the shortage of the time series of foreign trade turned out to cause problems in several modelling steps, since it restricted the length of some very important variables that are derived from definitional equations. This is especially true when it comes to update the Input-Output coefficients via an equation for total intermediate demand, as will be described in section 4 below. Secondly the incorporation of the new IO-table 1995 into MULTIMAC will be an issue in the near future.

2. Input Demand and Output Prices

Industrial organizations literature generally treats price setting behaviour of firms in an overall model of goods and factor markets. The seminal paper for this approach is Appelbaum (1982), a recent empirical application for various industrial sectors in Austria can be found in Aiginger, Brandner and Wüger (1995). Besides that, numerous studies that deal with factor demands derived from cost functions additionally include a price equation, which is estimated simultaneously with the factor demand equations in one system.

Important examples for this line of research mainly using the flexible cost functions ‚Translog' and ‚Generalized Leontief' are Berndt and Hesse (1986), Morrison (1989, 1990), Meade (1998) and Conrad and Seitz (1994). The price setting equations combined with the factor demand equations differ in these studies. Some start from the assumption of perfect competition, so that prices equal marginal costs as is the case in Berndt and Hesse (1986), Morrison, (1988, 1990) and Meade (1998). An example for a ‚mark up pricing' equation combined with factor demand corresponding to the market form of monopolistic competition can be found in Conrad - Seitz (1994).

Especially for the Generalized Leontief – cost function, which was first proposed by Diewert (1971), different concepts to allow for both technical progress variables and fixed factors have been developed. Morrison (1989, 1990) suggested an extension by technical progress and fixed factors with variable factors and the fixed factor capital, which has been proposed for the US INFORUM model by Meade (1998). Empirical results from estimations of Generalized Leontief – cost functions for several Austrian industries including technical progress as well as capital as a fixed factor can be found in Kratena (2000).

In MULTIMAC IV a simple form with only an extension for technical progress is chosen where the variable factors are the inputs of intermediate demand of an industry, V, with price p_v and labour input L with wage rate w, and a deterministic trend t representing technical progress. The price p for gross output QA shall be determined by a constant mark up μ n variable costs as in Conrad and Seitz (1994), which corresponds to the model of monopolistic competition in the markets. At perfect competition the price would equal marginal costs (p=MC) like in Berndt and Hesse (1986) and Meade (1998). Starting point is the (short term) cost function for variable costs G:

$$(1) \qquad G = QA\left[\sum_i \sum_j a_{ij}\left(p_i p_j\right)^{\frac{1}{2}} + \sum_i d_{it} p_i t^{\frac{1}{2}} + \sum_i g_{tt} p_i t\right],$$

with p_i, p_j as the input prices of the variable factors.

Applying Shephard's Lemma we can derive factor demands, since the partial derivatives of (1) with respect to factor prices (p_v, w) yield the input quantities (V, L) :

$$(2) \quad \frac{V}{QA} = \alpha_{VV} + \alpha_{VL}\left(\frac{w}{p_V}\right)^{\frac{1}{2}} + \gamma_{Vt} t^{\frac{1}{2}} + \gamma_{tt} t\,,$$

$$(3) \quad \frac{L}{QA} = \alpha_{LL} + \alpha_{VL}\left(\frac{p_V}{w}\right)^{\frac{1}{2}} + \gamma_{Lt} t^{\frac{1}{2}} + \gamma_{tt} t\,.$$

During estimation of (2) and (3) we assume symmetry concerning α_{VL} (i.e., $\alpha_{VL} = \alpha_{LV}$) and restrict one of the parameter for technical progress (γ_{tt}) to be the same in both factor demand equations. Due to data limitations the demand for total intermediates (i.e. from domestic and imported sources) is treated here as one input demand equation, which is an important shortcoming of MULTIMAC IV. The assumption of perfect competition in the markets would imply that prices equal marginal costs ($p = \partial G/\partial QA$). Instead a fixed mark up μ on marginal costs is introduced representing the model of monopolistic competition. As an alternative one could work with a variable mark up μ set on marginal costs implicitly including the ‚conjectural variations' of the oligopolistic model (see e.g. Aiginger, Brandner and Wüger (1995)). This variable mark up then would depend on the competitive price (which is usually approximated by the import price p_m) and the input prices p_v and w. Marginal costs $\partial G/\partial X$ for our case are given as:

(4) $$\partial G/\partial QA = \alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{½} + \delta_{vt}p_v t^{½} + \delta_{Lt}wt^{½} + \gamma_{tt}(p_v + w)t$$

Hence, when applying a fixed mark up we get the following output price equation:

(5) $$p = [1 + \mu]\,[\alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{½} + \delta_{vt}p_v t^{½} + \delta_{Lt}wt^{½} + \gamma_{tt}(p_v + w)t\,].$$

This completes the system of equations – composed of (2), (3), and (5) – that will be applied in estimation. From the Generalized Leontief – cost functions one can derive cross- and own price elasticities. As microeconomic theory states that the compensated price elasticities must sum up to zero, we get for our 2 factor model: ε (LL) = - ε(LV) and ε(VV) = - ε(VL). Elasticities can be directly derived from the input – output equations (2) and (3), where the inputs of V and L are functions of input prices w and p_v. This gives for cross- and own - price elasticities:

(6) $$\varepsilon(LL) = -(\alpha_{VL}/2)\,(Y/L)\,(p_v/w)^{½}$$

$$\varepsilon(VV) = -(\alpha_{VL}/2)\,(Y/V)\,(w/p_v)^{½}$$

$$\varepsilon(VL) = (\alpha_{VL}/2)\,(Y/V)\,(w/p_v)^{½}$$

$$\varepsilon(LV) = (\alpha_{VL}/2)\,(Y/L)\,(p_v/w)^{½}$$

Using the seemingly unrelated regression (SUR) estimation procedure, systems of equations as specified in (2), (3), and (5) have been etimatedor all industries of MULTIMAC IV except the energy sectors 2 through 6 (see section 1, table 1 for a description of the model's industrial classification). For 6 industries, however, we were not able to derive significant negative own price elasticities out of the system estimates and therefore unrestricted and freely specified functions similar to (2), (3), and (5) were applied to those sectors. Table 3 shows the resulting own price elasticities for both factor demands, where elasticities derived from freely specified models are marked with an asterisk (cross price elasticities are simply minus the own price elasticities, as both have to sum up to zero). Note, however, that the cross price was not included in the estimation of the freely specified industries and that hence the summation restriction of own and cross price elasticities does not hold for those sectors.

All of the elasticities in table 3 are evaluated at the sample means, whenever dynamic models were estimated (which can only be the case for the freely specified sectors) the long-run elasticities are reported in table 3. The results show important differences concerning the impact of factor prices on factor demand across industries. The sample mean of the time varying elasticities turns out to be in general rather low and significantly below unity. The exceptions are Mining of Coal and Lignite, Software&Data Processing and Other Market Services where factor demand is very elastic.

This model block of MULTIMAC IV determines labour demand and total intermediate demand for given input prices of both factors and for a given output level. Employment therefore changes uniformly with output, if no changes in input prices occur. Feedback mechanisms are built in by changes in the intermediate demand price through output price changes and by wage rate adjustments due to changes in the labour market.

Table 3: Own Price Elasticities of Factor Demand (Intermediates(V) and Labour(L))

	Model Industry	Intermediates	Labour
1	Agriculture and Forestry	-0,7303*	0*
2	Mining of Coal and Lignite	-1,0104*	exogenous
3	Extraction of crude Petroleum and Natural Gas	0*	exogenous
5	Manufacture of refined petroleum products	0*	exogenous

6	Electricity, Gas, Steam and hot Water supply	-0,1336*	exogenous
7	Collection, Purification and Distribution of Water	-0,2031*	exogenous
8	Ferrous & Non Ferrous Metals	-0,4909	-0,1928
9	Non-metallic Mineral Products	-0,3483	-0,1829
10	Chemicals	-0,1288	-0,0426
11	Metal Products	-0,3973	-0,2464
12	Agricultural & Industrial Machines	-0,515	-0,2824
13	Office Machines	-0,346	-0,0879
14	Electrical Goods	-0,3299	-0,1937
15	Transport Equipment	-0,6767	-0,2315
16	Food and Tobacco	-0,2244*	0*
17	Textiles, Clothing & Footwear	-0,7118	-0,3262
18	Timber & Wood	-0,1217	-0,0438
19	Paper	-0,131	-0,0381
20	Printing Products	-0,616	-0,3844
21	Rubber & Plastic Products	-0,0051	-0,0023
22	Recycling	-0,2538*	0*
23	Other Manufactures	-0,4832	-0,2836
24	Construction	-0,2229	-0,1503
25	Distribution	-0,3426	-0,3367
26	Hotels and Restaurants	-0,2934*	0*
27	Land Transport	-0,0462	-0,0743
28	Water and Air Transport	-0,6810*	0*
29	Supporting and Auxiliary Transport	-0,5872*	0*
30	Communications	-0,0014	-0,0054
31	Bank, Finance & Insurance	-0,2401	-0,3593
32	Real Estate	-0,667	-0,1214
33	Software & Data Processing	-1,0346	-0,9698
34	R&D, Business Services	-0,1595	-0,1204
35	Other Market Services	-1,2129	-1,4132
36	Non-market Services	-0,0623	-0,1274

3. Import Prices and Input Prices

The price of intermediate demand an industry faces in MULTIMAC IV is determined by the output prices of the other industries in the home country and abroad as described in the traditional input – output price model. In the input – output price model for given technical coefficient matrices for domestic and imported inputs the vector of domestic prices (**p**) is determined by domestic output prices themselves (**p**) and the vector of import prices ($\mathbf{p_m}$):

$$(7) \qquad \mathbf{p} = \mathbf{p\,A(d)} + \mathbf{p_m\,A(m)} + \mathbf{w\,L/QA} + \mathbf{c}$$

where **c** is a vector of residual income and **w L/QA** is labour cost per unit of output as before in vector notation. Here the technical coefficients matrix is split up into a domestic (**A(d)**) and an imported (**A(m)**) matrix.

From input – output tables we know, that total intermediate demand of industry i, V_i , equals the sum of inputs produced by other domestic industries (V_{ji}(d)) and imported inputs (V_{ji}(m)):

Industry (i,j)

1 ....n

1

.

. V_{ji}

.

n

Σ V_1 ....V_n

The input coefficient along the column of an industry (V_i/QA_i), which was modelled in the last section with the help of the Generalized Leontief – function, is given as the total of the two column sums for *i* of technical coefficient matrices (derived from input – output tables) for domestic and imported goods (**A(d)** , **A(m)**).

From the traditional input – output – price model we can now write the intermediate input coefficient at current prices ($\mathbf{p_v V/QA}$) as a matrix multiplication of a row vector of domestic prices **p** and a row vector of import prices $\mathbf{p_m}$ with **A(d)** and **A(m)** to get the row vector $\mathbf{p_v V/QA}$:

$$(8) \qquad (\mathbf{p_v V/QA}) = (\mathbf{p_m\, A(m)} + \mathbf{p\, A(d)})$$

In analogy to that we can introduce the input – output level of disaggregation in the factor demand equations described in the last section by treating the column sum **V/QA** as a bundle of n inputs. Assuming a constant structure for the n inputs within **V/QA** given by matrices **Z** with elements Vji/Vi each for domestic (d) and imported (m) inputs, $\mathbf{p_v}$ becomes:

$$(9) \qquad \mathbf{p_v} = (\mathbf{p_m\, Z(m)} + \mathbf{p\, Z(d)})$$

This relationship now introduces the feedback of output price changes on output prices. Equation (9) solves exactly for the input – output years, in other years the price index of National Accounts for $\mathbf{p_v}$ may deviate from the value calculated with (9) using fixed matrices of the base year for **Z(m)** and **Z(d)**. With fixed matrices **Z** derived from the IO-table 1990 and time series (1976 – 1994) of the vectors **p** and $\mathbf{p_m}$ we constructed a 'hypothetical' vector of intermediate demand $\mathbf{p_v^H}$ according to (9). The actual price index of National Accounts ($\mathbf{p_v}$) and the price – index $\mathbf{p_v^H}$ intersect at t = 1990, and have different mean growth rates. This different growth rates simply reflect the actual change in matrices **Z** due to technical change.

Both series $\mathbf{p_v}$ and $\mathbf{p_v^H}$ are at least difference stationary and the question is, if a stable (long run) relationship between the first differences of both series exist. To implement that, the following simple regressions for first differences have been estimated with u_t as the residual with the usual statistical properties:

(10) $\Delta \mathbf{p_{v,t}} = a_0 + a_1 \Delta \mathbf{p^H_{v,t}} + u_t$

where Δ is the first difference operator. Including these equations in MULTIMAC IV gives an endogenous price of intermediate demand with exogenous import prices $\mathbf{p_m}$ and exogenous intermediate demand structures given by fixed matrices **Z**.

4. Total Demand and Input – Output Tables

The total goods demand vector **Q** is made up of the imports vector **M** and the vector of domestic output **QA**[3]**.** The input – output definition of the commodity balance is:

(11) $\mathbf{Q} = \mathbf{QA} + \mathbf{M} = \mathbf{QH} + \mathbf{F},$

where **QH** is the intermediate demand vector and **F** is the final demand vector. Introducing the technical coefficients matrix **A** (the sum of domestic and imported elements), **QH** can be substituted by the product of **A** and **QA**:

(12) $\mathbf{Q} = \mathbf{A} * \mathbf{QA} + \mathbf{F}.$

[3] MULTIMAC IV makes no distinction between industries and commodities (although Austrian input – output statistics does), but includes a row for transfers to take into account non-characteristic production by industries.

MULTIMAC IV treats energy transactions in a separate way, so that all matrices and vectors can be split into an energy (e) and a non-energy (ne) part. The commodity balance (12) for non-energy therefore becomes:

$$(13) \quad \mathbf{Q_{ne}} = \mathbf{A_{ne}} * \mathbf{QA} + \mathbf{F_{ne}}.$$

The technical coefficients matrix $\mathbf{A_{ne}}$ comprises the non-energy input in non-energy sectors as well as the non-energy input in energy sectors; **QA** is the total output vector (energy and non-energy).

The original matrix of technical coefficients in the current version of MULTIMAC IV stems from the 1990 input – output table of Austria and the issue of technical change in matrix **A** has to be considered. This includes at a first stage changes along the column as described in section 2. When the total input coefficient **V/QA** is determined, the sum of non-energy inputs (along the column) is given by:

$$(14) \quad \sum a_{ne} = V / QA - \sum a_e \, ,$$

where technical change in the sum of energy inputs $\sum a_e$ is described in the energy model DAEDALUS and is exogenously fit into MULTIMAC.

For explaining changes in technical coefficients along the row different methods are used in macroeconomic input-output models. One method dating back to Conway (1990) and Israilevich, et. al. (1996) consists of constructing a series of ‘hypothetical’ output $\mathbf{QA^H}$ using constant technical coefficients matrix of a base year ($\mathbf{A_0}$) and then estimating the relationship between hypothetical and true output. In our notation and omitting for the moment the fact, that energy sectors are treated exogenously, $\mathbf{QA^H}$ would then be computed via the following identity:

(15) $$\mathbf{QA_t^H} = \mathbf{A_0} * \mathbf{QA_t} + \mathbf{F_0} - \mathbf{M_0}.$$

As the notation in (15) indicates, this method usually assumes also constant structures of final demand and imports such that $\mathbf{A_0}$, $\mathbf{F_0}$, and $\mathbf{M_0}$ would become updated simultaneously and hence no inference could be made on any of these three matrices (vectors) alone. However, this assumption is not necessary in MULTIMAC IV, as final demand structures, imports, and GDP are modelled in econometric sub-models where only the structure of the bridge matrices is held constant. That is, there are equations in MULTIMAC that yield predictions of $\mathbf{F_{ne}}$, $\mathbf{M_{ne}}$, and $\mathbf{QA_{ne}}$ (denoted as $\mathbf{F_{ne}*}$, $\mathbf{M_{ne}*}$, and $\mathbf{QA_{ne}*}$ respectively):

(16a) $\mathbf{F_{ne}*} = g(\mathbf{F_{ne}})$

(16b) $\mathbf{M_{ne}*} = h(\mathbf{M_{ne}})$

(16c) $\mathbf{QA_{ne}*} = k(\mathbf{QA_{ne}})$.

where all these systems of stochastic equations have error terms that are assumed to be iid normal. Given (16a), (16b), and (16c) we can always compute a prediction for $\mathbf{QH_{ne}}$ ($\mathbf{QH_{ne}*}$) from the following identity:

(17) $$\mathbf{QH_{ne}*} = \mathbf{QA_{ne}*} - \mathbf{F_{ne}*} + \mathbf{M_{ne}*}.$$

This allows us to depart from the usual approach as applied by Conway (1990) and Israilevich et.al. (1996) and to use the following basic identity, thereby concentrating on **A** alone in order to derive a system of equations that update the IO-coefficients:

(19) $\mathbf{QH_{ne}} = \mathbf{A_{ne}} * \mathbf{QA},$

We begin by using actual data from the historical period 1989 – 1999 to calculate a series of hypothetical intermediate demand for the non-energy sectors ($\mathbf{QH_{ne,t}^{H}}$) from (19) above, assuming constant coefficients in $\mathbf{A_{ne}}$. Introducing time subscripts, we can write:

(20) $\mathbf{QH_{ne,t}^{H}} = \mathbf{A_{ne,90}} * \mathbf{QA_{t}}.$

Note that $\mathbf{QH_{ne,t}^{H}}$ as computed by (20) will by definition be equal to $\mathbf{QH_{ne,t}}$ in the year 1990, but that both series are very likely to differ from each other in all other years. This is because the variations in $\mathbf{QA_t}$ alone will not be able to explain all of the variation in $\mathbf{QH_t}$, due to changes in the coefficients of matrix $\mathbf{A_{ne,90}}$ at time t. The relationship of hypothetical and true intermediate demand can be stated as follows:

(21) $\mathbf{R_t} * \mathbf{QH_{ne,t}^{H}} = \mathbf{QH_t},$

where $\mathbf{R_t}$ is a diagonal matrix. Our aim is to alter (hence update) $\mathbf{A_{ne,90}}$ in such a way, that the entire variation in (20) is explained. Premultiplying both sides of (21) with $\mathbf{R_t}^{-1}$, inserting the result for $\mathbf{QH_{ne,t}^{H}}$ into (20) and rearranging yields

(22) $\mathbf{R_t} * \mathbf{A_{ne,90}} * \mathbf{QA_t} = \mathbf{QH_{ne,t}}$.

That is, matrix $\mathbf{A_{ne,90}}$ is updated at time t with a fixed factor along the rows derived from matrix $\mathbf{R_t}$. Note that this 'correction matrix' $\mathbf{R_t}$ corresponds to the correction matrix used in the well known RAS – approach of updating IO-coefficients (Stone and Brown, 1962). Interpreting this economically, we can say that because $\mathbf{R_t}$ pre-multiplies $\mathbf{A_{ne,90}}$, the unexplained variation from (20) is attributed to the *technology of producing the output* (row-wise multiplication with a constant).

In order to make this updating process operable in MULTIMAC, i.e. to estimate the elements of the main diagonal of $\mathbf{R_t}$, we introduce a block of econometric equations, that estimate a linear or log-linear relationship between $\mathbf{QH_{ne,t}}$ and $\mathbf{QH_{ne,t}^H}$:

(23) $\mathbf{QH_{ne,t}} = F(\mathbf{QH_{ne,t}^H})$.

The long term nature of this relationship can be characterised by increasing, decreasing or constant 'intensities' of intermediate demand for a certain commodity across all industries. So the two series might be co-integrated (constant intensity) or not and in the latter case might have common short term movements. For all three possible cases of changing 'intensity' of intermediate demand the relationship $\mathbf{QH_{ne,t}}/\mathbf{QH_{ne,t}^H}$ might be modelled, alternatively the difference in the slope of the two time series might be analysed by regressing $\Delta log(\mathbf{QH_{ne,t}})$ on $\Delta log(\mathbf{QH_{ne,t}^H})$:

(24) $\Delta log\ (\mathbf{QH_{ne,t}}) = \alpha_1 + \alpha_2\, \Delta log\ (\mathbf{QH_{ne,t}^H})$ or

$$\mathbf{QH_{ne,t}} / \mathbf{QH_{ne,t}^H} = \alpha_1 + \alpha_2\, (\mathbf{QH_{ne,t-1}} / \mathbf{QH_{ne,t-1}^H}),$$

where the α_i denote the parameters to be estimated. It should be noted finally, that the estimation of (24) has to be performed carefully keeping an eye on long run properties of the relationship, which is also due to the fact, that **QH** is only available in the short time period of 1988 to 1999 (due to scarcity in the data on foreign trade, see section 1). Hence one of the major goals in future modelling steps will be the incorporation of new data on foreign trade in order to base the estimation of the very influential system of equations (24) on more solid grounds.

This method of updating the coefficients of matrix $\mathbf{A_{90}}$ works accordingly in the forecasting – period of MULTIMAC IV, using the estimates of $\mathbf{F_{ne}}$, $\mathbf{M_{ne}}$, and **QA** as given by (16a) – (16c) (note here, that in order to get the full vector of **QA**, we must also implement the exogenous forecasts for the energy-sectors as obtained in DAEDALUS) to compute a forecast of $\mathbf{QH_{ne}}$, which in turn yields the desired adjustment factor via (24).

5. Final Demand and Imports

The final demand vector **F** is the sum of a vector of private consumption, **C**, a vector of gross capital formation, **I**, as well as a vector of exports, **EX,** and a vector of public consumption, **G**:

$$\mathbf{F} = \mathbf{C} + \mathbf{I} + \mathbf{G} + \mathbf{EX} \quad (25)$$

Exports and public consumption are treated as exogenous in MULTIMAC IV, whereas private consumption, gross capital formation and imports are modelled econometrically.

5.1 Private Consumption

In MULTIMAC IV we also treat private real consumption (**CR)** on a very disaggregated level. The model comprises 9 main groups, with three of them further subdivided summing up to 20 distinct groups in total. The main groups and subgroups can be taken from table 2 in section 1 above. In order to model these groups we follow a nested procedure which allocates total expenditure on the nine main groups first and then estimates the subgroups in a second step given the total expenditure of the corresponding main group[4]. Both single equation specifications and system estimation are used in the empirical application. The reason for this is threefold: first and foremost, our data do not allow the estimation of all nine main groups within a simultaneous demand system due to a lack of degrees of freedom. Secondly, some groups (especially Gross Rent and Water) need specific explanatory variables in order to be modelled satisfactorily. Fnally we wanted to make use of additional exogenous (energy) variables that can be forecasted using the energy model DAEDALUS, the energy-model of WIFO.

The main groups modelled via single equations comprise *Gross Rent and Water* (3), *Transport* (4), *Heating* (8), and *Furniture* (9).

The energy sectors *Transport* and *Heating* take an exceptional position - as already indicated above - since we make use of endogenous variables from DAEDALUS in their estimation. Among those variables are consumption of electricity, coke, gas, fuel oil, biomass, and long distance heating as well as total vehicle stock, and consumption of petrol and diesel fuel. The models for the subgroups of real consumption of transport goods (CR4) therefore take the following form:

ΔLOG(CR41) = ΔF(D(FA-FA(-1)), DUM)

LOG(CR42/FA) = F(PC42/PC43, CR42(-1)/FA(-1), AVBN, AVDS)

LOG(CR43/FA) = F(PC43/PC42, CR43(-1)/FA(-1), DUM)

LOG(CR44) = F(FA, PC44, DUM)

[4] Note that we have to assume the underlying utility function to be weakly separable when we want to apply this nested

where ΔLOG denotes that the dependent variable is transformed to logarithms and estimated in first differences. F is a log-linear function and ΔF is a function in difference-log-linear form. FA denotes stock of cars, AVBN and AVDS denote average consumption per kilometre for both petrol and diesel and DUM stands for various dummy variables that account for outliers in the data. A definitional equation is added summing up over the subgroups to give total consumption of transport goods (CR4).

For *Heating* (group 8) we model the expenditure on the main category and 5 of its 6 subgroups and derive the consumption on the remaining subgroup (CR81) as a residual to ensure additivity. All of the equations are estimated in log-difference form and explain the respective consumption expenditure by the amount of energy consumption of the respective good by households as modelled in DAEDALUS. That is for example, real expenditure on consumption of gas (CR82) is explained by total gas demand from the energy model.

Gross Rent and Water appeared to be modelled best without the use of both price and income variables which is most likely due to some statistical artefacts (i.e., imputed rents) contained in the time series. We therefore use the stock of housing (DW) and dummies to explain the annual change in consumption of that group:

$$\Delta LOG(CR3) = F(DW, DUM).$$

According to the estimated parameters, the annual change in consumption expenditure on CR3 will increase by 0,2% if the housing stock increases by 1%.

Consumption of *Furniture* (CR9) is estimated in a standard log-linear model that comprises both real income (YD/PC) and the lagged endogenous variables:

procedure.

LOG(CR9) = F(YD/PC, CR9(-1), DUM).

The short run income elasticity for CR9 is estimated to be 0,51, and goes up to 1,46 in the long run, clearly indicating that furniture is what is usually termed a luxury good.

Having obtained estimates for those four categories, the remaining fraction of total expenditure (after deduction of expenditure on the first 4 groups) is distributed among the remaining categories via a system of demand equations, more precisely, an Almost Ideal Demand System (AIDS). That is, in order to satisfy additivity over the entire consumption categories we compute total expenditure for the AIDS (denoted as CNAIDS) as a residual, such that the following identity holds:

(26) CNAIDS = CN – CN3 – CN4 – CN8 – CN9.

Here CN is total nominal consumption and CN3, CN4, CN8, and CN9 is nominal consumption of consumption groups 3, 4 8, and 9 respectively, which are obtained from real consumption (as estimated above) multiplied by the corresponding price index. Note that we are modelling nominal consumption within the system of equations, since the demand equations in the AIDS are stated in budget share form.

The AIDS, which was first proposed by Deaton and Muellbauer (1980), has been used extensively in the literature in a wide range of consumption studies ever since it’s first presentation. Deaton and Muellbauer depart from a PIGLOG cost function which they specify empirically by the use of a Translog and a Cobb-Douglas type function. Solving the dual optimisation problem by applying Shepard’s Lemma, they derive the well known budget share equations:

(27) $$w_i = \alpha_0 + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{CNAIDS}{P}\right),$$

where w_i denotes the budget share of good i, p_j is the price of good j, CNAIDS is total expenditure on all goods within the system and the Greek letters are the parameters to be estimated. P is a price index for the whole group, specified according to the following translog – function:

(28) $$\ln P = a_0 + \sum_{k=1}^{n} a_k \ln p_k + \frac{1}{2} \sum_{k=1}^{n} \sum_{j=1}^{m} \gamma^*_{kj} \ln p_k \ln p_j \ .$$

Note that in our case n (the amount of goods modelled within the AIDS) equals five. The relationship between γ_{ij} and γ^*_{ij} can be stated as

(29) $$\gamma_{ij} = ½(\gamma^*_{ij} + \gamma^*_{ji}).$$

To avoid non-linearities during the estimation process, we follow the usual approach of approximating P by the price – index of Stone, P^S, which is given by

(30) $$\ln P^S = \sum_k w_k \ln p_k \ ,$$

and we therefore estimate a so-called linear approximate AIDS model, often termed as LA-AIDS. Inserting (30) into (27) above yields our final model:

(31) $$w_i = \alpha_0 + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{CNAIDS}{P^S}\right)$$

The symmetry condition of the demand equations is satisfied by restricting the parameters of (31) to assure $\gamma_{ij} = \gamma_{ji}$.

In order to interpret the results from estimating the system of equations (31), we want to derive both expenditure and price elasticities. Following Green and Alston (1990) and drawing on Monte-Carlo simulations by Alston et. al. (1994) for the derivative of the Stone price index with respect to p_j, we can assume the uncompensated price elasticities for the LA-AIDS to be reasonably well approximated by

(32) $$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i} w_j .$$

The correct formula for expenditure elasticities in the LA-AIDS is given by equation 7 in Green and Alston (1991, p.874) which is a simultaneous system of equations. Very often, however, simply the elasticities from the AIDS model (with no approximation of the price index P) are computed for the LA-AIDS in the literature:

(33) $$\eta_{ix}^{AIDS} = 1 + \frac{\beta_i}{w_i} .$$

Comparing the true elasticities and the approximation from (33) we found very small differences, so for the sake of simplicity we will compute the expenditure elasticities according to (33) and hence assume

(34) $$\eta_{ix}^{AIDS} = 1 + \frac{\beta_i}{w_i} \approx \eta_{ix}^{LA-AIDS} .$$

Te subgroups of Other Services were estimated in log-linear form and Restaurants and Hotels were treated as residual in order to ensure adding up within group 6. Table 4 below depicts income and own-price elasticities for main groups and sub-groups as well as the estimated values of the β_i's. The expenditure elasticities of the subgroups are also stated to reflect changes in total expenditure (as opposed to expenditure on the corresponding main group only).

Table 4: Expenditure and Own Price Elasticities of Consumption Categories modelled in the AIDS

		Own Price	Total Expenditure
1	Food, Drink and Tobacco	-0,32	0,47
2	Clothing and Footwear	-2,41	0,56
5	Communication	-1,27	2,09
6	Other Services	-1,05	1,41
	6.1 Medical Care	0	1,38
	6.2 Entertainment	0	2,12
	6.3 Education	-0,46	1,58
	6.4 Restaurants and Hotels	Residual	0,84
7	Other Goods and Services	-0,76	1,40

In order to link the 9 main consumption categories with the 37 industry structure of private consumption in the IO table (**CIO**) we use a bridge matrix **BM(ij)** (see section 1.3) , such that

(35) $\mathbf{CIO} = \mathbf{BM}(ij) * \mathbf{CR}$.

In this bridge matrix *i* represents the 9 consumption categories and *j* the 37 industries of MULTIMAC IV.

The total sum of **CR** is given by an aggregate consumption equation with disposable household income as explaining variable:

(36) $\Delta CR_t = (\Delta(YD_t/PC_t), ECM)$

where ECM denotes an error correction mechanism.

In the current version of MULTIMAC IV we have to utilize a time-dependent coefficient to link disposable income to the sum of nominal value added, since data for income distribution are currently not available in National Accounts.

5.2 Gross Capital Formation

The vector of gross investment, **I**, given in the structure of the supplying sectors of the IO table, is divided up using fixed coefficients once the total sum of investment, $\Sigma_i \mathbf{J_i}$, in the structure of investing sectors, is determined:

(37) $\mathbf{I} = B(ji) * \Sigma_i \mathbf{J_i}$

with j and i being industries. Investment data in Austria are currently not supporting the disaggregated 37 industries structure of MULTIMAC IV. Instead, we have data on 10 sectors available, with manufacturing being treated as a single sector. To obtain the current capital stock for sector i ($K_{i,t}$) a starting value of an initial capital stock given from former Austrian National Account data is combined with assumptions on depreciation rates (δ) within the sectors, so that capital stock evolves as:

(38) $K_{i,t} - K_{i,t-1} = J_{i,t} - \delta K_{i,t-1}$.

Hence gross investment $J_{i,t}$ is given as the sum of the change in the capital stock and depreciation.

Making use of *stock adjustment* – models the time path of the actual capital stock is explained as an adjustment process to some 'desired' or 'optimal' capital stock. These models have been applied to investment in housing (see Egebo, et.al. (1990), Czerny, et al. (1997)) and are based on the work of Stone and Rowe (1957), assuming the following adjustment process of the current capital stock K to its desired level K* (Czerny, et.al., (1997), Appendix A):

(39) $$\frac{K_{i,t}}{K_{i,t-1}} = \left[\frac{K^*_{i,t}}{K_{i,t-1}}\right]^{\tau_1} \cdot \left[\frac{K^*_{i,t-1}}{K_{i,t-2}}\right]^{\tau_2}.$$

Taking logarithms in (39) we get the model in log-linear form:

(40) $\log(K_{i,t}) - \log(K_{i,t-1}) = \tau_1 [\log K^*_{i,t} - \log K_{i,t-1}] + \tau_2 [\log K_{i,t-1} - \log K_{i,t-2}]$.

with the necessary condition $\tau_1 < 0$.

The model is closed by explaining the desired capital stock K*. This desired capital stock could result from including a fixed factor capital in the Generalized Leontief - functions described in section 1 above, whenever *user costs* of capital are given.. The adjustment process then depends on the difference between user costs and the shadow price of capital given from the Generalized Leontief - functions. However, due to data limitations we assume in MULTIMAC IV that K* depends on the current level of output only. That is,

(41) $\log(K^*_{i,t}) = F[\log QA_{i,t}]$

Inserting K* into (40) above yields the stock adjustment equation, which is estimated for each of those 10 sectors, where investment data are available:

(42) $\log(K_{i,t}) - \log(K_{i,t-1}) = \alpha_K + \gamma_K \log(QA_{i,t}) - \tau_1 \log(K_{i,t-1}) + \tau_2 (\log(K_{i,t-1}) - \log(K_{i,t-2}))$

For the output variable different lag structures or averages as in Czerny, et. al. (1997) have been used. For the industries 'Banking, Finance & Insurance', 'Real Estate', and 'Non-Market Services' no useful specification was found and it was also for other reasons of model use decided to treat investment in these industries as exogenous. The estimation results in Table 5 show, that the full model of specification (42) with the first and the second adjustment term only turned out to be applicable in two of the 10 aggregated industries. The second adjustment term was significant in some other industries, but the magnitude of the two terms together led to instability in the long run behaviour of the capital stock in that cases, so that the second term was excluded. That did not deteriorate the equation fit in these cases.

Table 5: Parameter estimates of capital stock adjustment equations

Dependent Variable: $\log(K_t) - \log(K_{t-1})$			
	Log (QA)	**$\log(K_{t-1})$**	**$\log(K_{t-1}) - \log(K_{t-2})$**
Agriculture and Forestry	0,0227	-	-
Coal Mining & Crude Oil	0,0012	-0,0777	-
Energy	0,0289	-0,0529	-
Manufacturing	0,0817	-0,1614	0,2784
Construction	-	-	0,8941
Distribution	0,0644	-0,0709	-
Hotels and Restaurants	0,0334	-0,4613	-
Transport & Communication	0,0486	-0,1820	0,5605
Other Market Services	0,0201	-0,0717	-

5.3 Imports

Time series data on imports (starting from 1988) are readily available in Austria only for the primary and secondary sector. From National Accounts we get an aggregated series for nominal imports of services, whose annual growth rates are projected on the 1990 values of imports from the IO-table, to give at least an approximation for nominal imports of services at a more disaggregated level. For service imports we have to assume import prices equal to domestic prices, which clearly makes a sensible treatment and appropriate modelling impossible. In MULTIMAC IV we adopt a slightly modified AIDS to determine the imported and domestic fractions of total demand for goods of the primary and secondary sector. That is, total demand is split up into two components yielding two equations which are estimated simultaneously. A typical example of such a demand system is the import demand model of Anderton, Pesaran and Wren-Lewis (1992). As Kratena and Wüger (1999) have shown, the problems of regularity of the AIDS model, i.e. the boundedness of the shares within the [0,1] interval, become especially relevant in the two goods case, where a rising share with positive response to total expenditure is combined with a decreasing share with negative response to total expenditure. Therefore the AIDS model for import demand is likely to require some modifications, especially in dynamic applications such as MULTIMAC IV. For example one could follow the lines of Cooper and McLaren (1992) and derive a Modified AIDS model (MAIDS) or the Flexible Modified AIDS model proposed by Kratena, Wüger (1999). However, due to the non-linearity of both the MAIDS and flexible MAIDS and convergence problems in system estimation, we apply in the current version of MULTIMAC IV the model of Anderton, Pesaran and Wren-Lewis (1992), in which the shares are given as:

(43) $$\frac{mn_i}{qn_i} = \alpha_m + \gamma_{md} \log p_i + \gamma_{mm} \log p_{m,i} + \beta_m \log\left(\frac{QN_i}{PQ_i}\right) + \mu x \text{, and}$$

(44) $$\frac{qan_i}{qn_i} = \alpha_d + \gamma_{dm} \log p_i + \gamma_{dd} \log p_{d,i} + \beta_d \log\left(\frac{QN_i}{PQ_i}\right) + \mu x \text{.}$$

In (43) the fraction of imports of good i in total demand of that good is explained by both the domestic (p_i) and imported price ($p_{m,i}$), the proportion of total demand on i (QA_i) and an composite price index PQ_i, as well as a variable x which shall capture the gap between the individual level of the demand function (on which the cost and utility functions of the AIDS are based) and the actual empirical level of market demand functions, which are observed by the data (see Cooper and McLaren (1992) and Kratena and Wüger (1999)). In the case of private consumption information about the income distribution could be incorporated in the system through this variable. Here, we chose a measure of the openness of the economy as a proxy for a larger variety of goods from different sources that are available all over the world. This 'openness variable' is approximated by the share of total exports in total output (EX/VAN).

As in section 5.1 we avoid non-linearities in the estimation procedure by approximating PQ_i by the Stone price index PQ_i^S and restrict the parameters in order to satisfy symmetry (i.e. γ_{md}

= γ_{dm}). Since we are interested in modelling imports in this section, only elasticities from (43) will be tabulated below. As far as the derivation of those elasticities is concerned, the same formulas as in section 5.1 above are applied here.

Table 6: Output- and Own Price elasticities for imports

	Goods	Output elasticity	Own price elasticity
8	Ferrous & Non Ferrous Metals	1,38	-1,17
9	Non-metallic Mineral Products	1,32	-1,10
10	Chemicals	1,68	-1,24
11	Metal Products	1,43	-1,08
12	Agricultural & Industrial Machines	0,94	-0,99
13	Office Machines	0,83	-0,91
14	Electrical Goods	1,55	-1,16
15	Transport Equipment	1,11	-1,04
16	Food and Tobacco	3,02	-1,25
17	Textiles, Clothing & Footwear	1,79	-1,49
18	Timber & Wood	0,66	-0,97
19	Paper	1,03	-1,01
20	Printing Products	0,76	-0,95
21	Rubber & Plastic Products	1,49	-1,14
23	Other Manufactures	1,64	-1,21

The own price elasticities are all near the ‘normal case’ of –1, whereas for ‘output’ or better demand elasticity larger differences between the commodities exist. These differences are important for model simulation behaviour, because they show that demand increases in different sectors stimulate domestic output and imports in rather different ways across the industries.

6. Labour Markets and Wage Formation

The seminal work for disaggregated labour markets is Layard, Nickell, Jackman (1991). Large part of the labour market literature stresses the importance of disaggregation by skill groups or professions, as the stylised facts show that major changes in labour market variables (wages, unemployment) have occurred among groups of these classifications, whereas in the industry classifications less dynamics can be found (see Nickell (1997)).

In any case one starting point of a disaggregated labour market model are the labour demand functions for each industry, which are given by factor input equations. In the simple two sector case one could assume the labour input coefficient being a function of the wage rate (derived via Shephard´s Lemma from a cost function):

(45) $$\frac{L_1}{QA_1} = \alpha_1 \left(\frac{1}{w_1} \right) \quad ; \quad \frac{L_2}{QA_2} = \alpha_2 \left(\frac{1}{w_2} \right)$$

with $\alpha_1 > 0$ and $\alpha_2 > 0$ and $L_1 + L_2 = L$.

Employment demand of this type is given in MULTIMAC IV at a disaggregated level by the input demand equations from section 2:

(46) $$L = \left[\alpha_{LL} + \alpha_{VL}\left(\frac{p_V}{w}\right)^{\frac{1}{2}} + \gamma_{Lt} t^{\frac{1}{2}} + \gamma_{tt} t\right] QA$$

Total output *QA* could be assumed to be distributed to the sectors via demand shift parameters d_1 and d_2, which for the moment are assumed to be given:

(47) $$\frac{QA_1}{QA} = d_1 ; \qquad \frac{QA_2}{QA} = d_2$$

This model differs from the Layard, Nickell, Jackman model (1991) by explicitly defining sectoral labour demand for each sectoral output level and transferring the demand shift parameter to the goods market. In MULTIMAC IV the goods demand of type (46) is determined by the functions for final demand, intermediate demand and imports described in the last sections.

Defining a (full employment) productivity variable $X = Q/N$ the labour demand function of the theoretical model can be written as:

(48) $$w_1 = \alpha_1 \left[\frac{L_1}{N_1}\frac{N_1}{N}\right]^{-1} d_1 X \quad ; \quad w_2 = \alpha_2 \left[\frac{L_2}{N_2}\frac{N_2}{N}\right]^{-1} d_2 X$$

The equilibrium wage rate could be found in a competitive labour market model by labour supply reactions to changes in the consumer net wage, by an efficiency wage mechanism or by union wage bargaining. Assuming a bargaining mechanism the wage rate is the outcome of redistribution of the value of a job and a function of the unemployment rate and productivity:

(49) $$w_1 = \varphi_1\left[\frac{N_1}{L_1}\right] + \phi_1 X\,;\quad w_2 = \varphi_2\left[\frac{N_2}{L_2}\right] + \phi_2 X$$

with $\varphi_1 < 0$ and $\varphi_2 < 0$. The parameters φ and ϕ measure the ‚wage pressure' factors, which by themselves depend on union bargaining power.

Combining (48) and (49) we find equilibrium unemployment (u_i) and wage rates (w_i) for each sector at given demand shift parameters d_1, d_2 and given labour force shares N_1/N, N_2/N.

(50) $$u_1 = 1 - \frac{L_1}{N_1} = \frac{\varphi_1}{\phi_1} - \frac{\alpha_1 d_1}{\phi_1}\left(\frac{N_1}{N}\right)^{-1} + 1\,;\quad u_2 = 1 - \frac{L_2}{N_2} = \frac{\varphi_2}{\phi_2} - \frac{\alpha_2 d_2}{\phi_2}\left(\frac{N_2}{N}\right)^{-1} + 1$$

(51) $$w_1 = \varphi_1\left(\frac{\phi_1}{d_1\alpha_1\left(\frac{N_1}{N}\right)^{-1} - \varphi_1}\right) + \phi_1 X\,;\quad w_2 = \varphi_2\left(\frac{\phi_2}{d_2\alpha_2\left(\frac{N_2}{N}\right)^{-1} - \varphi_2}\right) + \phi_2 X$$

Most studies do not explicitly deal with labour mobility between the sectors. For the case where the sectors represent skilled and unskilled labour markets, mobility is restricted and incurs cost of training and moving to the skilled segment. The Layard, Nickell, Jackman (1991) study introduces costly movement between the labour market segments in a Harris, Todaro model of migration between the sectors. In such a setting (see Harris and Todaro (1970)) migration in the labour force is driven by differences in expected income, where the employment rate is used as a proxy for the probability to find a job in the other sector, so that the expected income differential is: $w_1(1 - u_1) - w_2(1 - u_2)$.

More recent studies on migration start from an equilibrium *stock* of migrants, which under certain conditions have been moving from one labour market to another. The idea is based on a study by Hatton (1995) and implies - as a recent study on East-West migration in an enlarged European Union points out (Boeri and Brücker (2000)) – that the total number of the migration potential of a society is limited. For each expected income differential a certain percentage of the total labour force is willing to migrate. The labour force in each segment can then be seen as comprising one constant part given by pure labour supply effects and one part of migrant stock from other labour market segments, which reacts to expected income differentials.

The total participation of the labour force in total population in working age could be a function of total economic activity as measured by total output and/or employment and the overall real wage rate (as in E3ME (Barker, et. al. (1999))):

(52) $(LF/POP) = \mathrm{F}\,(QA, w/PC, L)$

with *LF* as the MULTIMAC variable for the labour force. As in E3ME male and female labour force participation are treated separately.

The distribution of this total labour force among sectors is then guided by the constant describing the supply of certain skill levels, so that a change in the skill level of new entrants in the labour markets might shift the constant parts in the sectoral labour force equations. This shift is modelled by introducing an elasticity of sectoral labour forces to total labour force in a PIGLOG specification as in AIDS and simultaneously taking the wage differential elasticity into account:

(53) $LF_i/LF = a_1 + a_2 \log(LF) + a_2 \log(w_i/w)$

where *w* is the total wage rate.

The theoretical sectoral labour market model outlined here is commonly used at the level of regions, skill groups or occupations. In the case of a model in industries classification as MULTIMAC IV a link between skill groups or occupations could be introduced through the skills or occupations dimension at the industry employment side. Employment demand then becomes a two step procedure, where first the total labour input is determined and then in a second step is split up in different skill groups as in the general equilibrium approach in McGregor et. al. (1998). The relevant labour market classification then becomes skill groups and labour markets are linked to goods markets by the general equilibrium mechanisms. The disaggregated labour market in MULTIMAC IV tries a synthesis between working at the industry level with labour mobility across the industries and the use of skills and occupations data for describing segmented labour markets. This is done by aggregating the 37 industries of MULTIMAC into 3 industries with different average skill levels (high skilled, medium skilled, low skilled). The data base for this aggregation procedure is the industries * occupations employment matrix for 2000. The occupation groups are aggregated to a 8 stage level of ISCO, where they correspond broadly with skill levels and these 8 groups are then further integrated into 3 final skills/occupations groups.

The MULTIMAC IV industries are aggregated in the following way:

High skill industries:

3 Oil & Gas Extraction, 5 Manufactured Fuels, 6 Electricity & Heat, 7 Water Supply, 8 Ferrous & Non Ferrous Metals, 10 Chemicals, 11 Metal Products, 12 Agricultural & Industrial Machines, 13 Office Machines, 14 Electrical Goods, 15 Transport Equipment, 23 Other Manufactures, 28 Water and Air Transport, 30 Communications, 31 Bank, Finance & Insurance, 33 Software & Data Processing, 34 R&D, Business Services, 36 Non-market Services

Medium skill industries:

16 Food & Tobacco, 17 Textiles, Clothing & Footwear, 18 Timber & Wood, 19 Paper, 21 Rubber & Plastic Products, 24 Construction, 25 Distribution, 27 Inland Transport, 29 Other Transport Services, 35 Other Market Services

Low skill industries:

1 Agriculture, Forestry, Fishing; 9 Non-metallic Mineral Products, 20 Printing Products, 22 Recycling, 26 Hotels and Restaurants, 32 Real Estate

The treatment of labour force by industry allows us to work with unemployment rates by industries, ur_i, which are : $ur_i = (LF_i - L_i) / LF_i$

Union wage bargaining equations complement the model, which are again specified similar to E3ME (Barker, et.al. (1999)), but without external industry effects taking into account the interaction with the economy as a whole. Wage formation depends on consumer price changes, ΔPC, on productivity changes, $\Delta(QA_i/L_i)$, and on the level as well as on changes in the sectoral unemployment rate. The latter variables measure the influence of labour market performance in the target function of unions.

The wage equations for *wr* as the sectoral wage rate in MULTIMAC IV are specified with:

$$(54) \quad \Delta\log(wr_i) = a_1 + a_2\,\Delta\log(PC) + a_3\,\Delta\log(QA_i/L_i) + a_4\,\Delta\log(ur_i) + a_5\,\log(ur_i)$$

Table 7 shows results for the sectoral labour force equations and table 8 for the wage rate equations at the same aggregation level. Only the main parameter values are reported, the full specification including all lag structures is not shown here. The ‚total labour force elasticity‘

of the sectoral labour forces is in the PIGLOG specification given as the income elasticity in AIDS by $1 + a_2/(LF_i/L)$ (with a_2 as in (53)), so that we get ‚total labour force elasticities' below 1 for high and medium skilled workers and above 1 for low skilled workers. The relative wage parameters have the expected sign in the sectoral labour force equations, so that high and medium skilled sectors attract labour force dependent on the wage differential between their sectoral wage and the low skilled wage.

In the wage equations we found only consumer prices and unemployment rates as relevant variables and sectoral productivity growth proofed to have no impact.

Table 7: Parameter Estimates of Sectoral Labour Force Equations

Labour Force: LF(i)/LFTOT			
	High Skill (hs)	**Medium Skill (ms)**	**Low Skill (ls)**
Wage rates			
wr_hs/wr_ls	0,3248	-	
	(0,1900)		
wr_ms/wr_ls	-	0,0747	
		(0,0361)	
log (LFTOT)	-0,3306	-0,1065	0,0762
	(0,1879)	(0,0436)	(0,0071)
	(Standard Error in parenthesis)		

Table 8: Parameter Estimates of Sectoral Wage Equations

Wage rate: Δ log(wr)			
	High Skill	**Medium Skill**	**Low Skill**
	(hs)	**(ms)**	**(ls)**
Unemployment rates			
log(ur_hs)	-0,0447	-	-
	(0,0126)		
log(ur_ms)	-	-0,0284	-
		(0,0231)	
log(ur_ls)	-	-	-
Δ log(PC)	0,6207	0,8547	0,9879
	(0,1755)	(0,2916)	(0,2057)
	(Standard Error in parenthesis)		

The wage rates for the 36 industries are further explained in terms of the wage rate of the skill category industry to which they belong with:

(55) $\Delta\log(wr_j) = a_1 + a_2 \Delta\log(wr_i) + a_3 \Delta\log(QA_j/L_j)$

with *j* as 36 industries and *i* as the 3 skill category industries.

These estimation results as well as the estimation results for the participation rate equation are not shown here, but are available from the authors upon request.

Appendix A: Time Series Variables in MULTIMAC IV

Appendix A summarizes the time series variables of MULTIMAC IV along the structure maintained in the data describing section and gives the abbreviations used in the model.

Table A1: Data in the 37 industry structure

Description of the data	Abbreviation
Value added, nominal	van
Value added, real	va
GDP, nominal	qan
GDP, real	qa
Price of GDP	p
Intermediate demand by industry, nominal	sqhn
Intermediate demand by industry, real	sqh
Price for intermediate demand by industry	pqh
Wages and salaries	w
Dependent employment	l
Investment, nominal	jn
Investment, real	J
Price for investment	pj
Capital stock	k
Capital stock I	ki
Capital stock II	kii
Depreciation rate	s
Public consumption	g
Imports, nominal	mn
Imports, real	m
Price for imports	pm
Exports, real	ex

Table A2: Variables computed via identities

Description of the data	Abbreviation
Total demand, nominal	qn
Total demand, real	qn
Price for total demand	pq
Intermediate demand by commodity, real	qh
Price of intermediate demand by commodity	cqh
Final demand by commodity	f

Table 3A: Data in the labour market and on population

Description of the data	Abbreviation
Dependent employment by skill groups	Lhs, lms, lls
Labour force by industry	lf
Labour force by skill groups	Lfhs, lfms, lfls
Labour force by gender	lffem, lfmask
Wage rate by industry	wr
Unemployment rate by skill groups	u
Population by gender	popfem, popmask

Table 4A: Data in the categories of private consumption

Description of the data	Abbreviation
Private consumption, nominal	cn
Private consumption, real	cr
Price of private consumption	pc

Table A5: Variables in 37 industry classification, computed by multiplication with bridge matrices

Description of the data	Abbreviation
Private consumption	c
Investment	i

Table A6: Other variables

Description of the data	Abbreviation
Hypothetical output	qhhyp
Disposable income, nominal	yd
Housing stock	dw

Table 7A: Energy variables from DAEDALUS

Description of the data	Abbreviation
Petrol consumption	Bn_pkw
Fuel oil consumption	brent
Diesel consumption	ds_pkw
Stock of automobiles	fa
Biomass consumption	enbmhh
Liquid fuels consumption	endohh
Electricity consumption	enelhh
Gas consumption	engahh
Coke consumption	enkohh
District heating consumption	ensthh
Total energy consumption	entohh
Price of liquid fuels	pdo_dl
Price of petrol	pbn
Price of diesel	pds
Price of gas	pg_dl
Price of electricity	pel_dl
Price of coke	pko_dl

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