5. Production and input-output

The chapter describes the determination of values and volumes for production, intermediate consumption and gross value added in the industries of ADAM. We also discuss the input-output-based price determination, which concerns the prices of demand components based on prices of imports and Danish production. Common to both value volume and price calculation is that they ensure the mutual consistency of the behavioural equations in ADAM by linking supply and demand.

5.1 Supply and demand

Equilibrium in the goods market

The starting point for ADAM's determination of production and gross domestic product is the simple equilibrium condition for goods markets found in textbooks:

(5.1) $$Y + M = C + I + E$$

i.e. gross domestic product, Y, plus imports, M, equals the sum of consumption, C, investments, I, and exports, E, all at current prices.

However, for use in ADAM condition (5.1) is slightly reformulated. Firstly, it is important to divide the GDP into product taxes, Sv, and the rest, which is gross value added, Yf, so that $Y=Yf+Sv$. Secondly, in ADAM the equilibrium condition is formulated for production value, X, i.e. production calculated inclusive of the input of materials in production. The input of materials comprises goods and services used for intermediate consumption in industries. If V denotes total intermediate consumption, production can be written $X=Yf+V$.

Using these definitions, the equilibrium condition can be rewritten as

(5.2) $$X + M + Sv = V + C + I + E$$

The left hand side of (5.2) is the total *resources* (supply) of goods and services at market prices, and it comes from either Danish production or imports incl. imposed taxes. The right hand side of (5.2) is total use (demand) of goods and services, and it consists of the total intermediate consumption, V, plus the three basic components of final demand: consumption, investment, and exports. Uses and resources must be equal to each other.

Not one, but many equilibria

ADAM contains not only one of these equilibrium conditions, but many. In principle, there is an equilibrium condition for each good. The introduced combination of three resources and four uses in (5.2) can be arranged as an input-output table:

(5.3)

$$X = X_V + X_C + X_I + X_E$$
$$M = M_V + M_C + M_I + M_E$$
$$Sv = Sv_V + Sv_C + Sv_I + Sv_E$$

where e.g. X_V represents Danish-produced input of materials, M_I is imports of capital goods, and Sv_C is taxes on consumption. The total equilibrium condition (5.2) is still valid and can be retrieved by summing the equations in (5.3).

Input-output table

The structure of the goods part in the input-output table is reflected by the right hand side of (5.3). There is a row for each resource, e.g. $[X_V\ X_C\ X_I\ X_E]$ for Danish production, and a column for each use, e.g. $[X_C\ M_C\ Sv_C]$ for consumption. The row for X shows the structure of demand for Danish production, i.e. the distribution on input of materials, consumption, investment, and exports. Column *C* shows the cost structure of consumption, i.e. the distribution on Danish production, imports and taxes.

To complete the picture, the goods part of the input-output table is often supplemented by gross value added at the bottom. Thus, the column for an industry will add up to its total gross production instead of its total inputs in production. In such a row of value added for industries, there are zeros in the cells of *C*, *I* and *E*.

Table 5.1 provides an overview of the 12 industries in ADAM. The entire input-output table for ADAM is shown in tables 5.A-5.C placed at the end of the chapter. Tables 5.A-5.C divide the gross value added of the 12 industries into gross profits, wages, and other taxes, as will be discussed in connection with equation (5.12).

Table 5.1 **Production value and employment in 12 industries, 2009**

	Variable	Production value X	Employment Q
		DKK mio.	1.000 persons
Agriculture	*a*	68 544	81
Extraction of hydrocarbons etc.	*e*	44 493	3
Oil refineries	*ng*	21 327	0,71
Electricity, gas and heating	*ne*	58 227	16
Food processing	*nf*	133 310	62
Manufacturing	*nz*	412 739	293
Construction	*b*	195 622	174
Housing	*h*	160 653	16
Sea transport	*qs*	137 608	19
Financial services	*qf*	160 226	85
Private services	*qz*	1 027 401	1 262
Public services	*o*	500 317	801

5.2 Model

Groupings in ADAM

ADAM distinguishes between 12 different industries of production, 10 types of imports, 3 types of product taxes, 9 types of consumption, 4 types of investments and 7 types of exports. Thus, in practice the input-output table is much larger (25 rows and 32 columns), but the principle is exactly the same as in the small input-output table in (5.3).

Names

The input-output table is used for forming input-output coefficients. Such i-o coefficients are variables in ADAM, and their names follow a simple notation: for examples, the variable *aXnf_Cf* denotes the i-o coefficient for supplies of Danish manufactured food, *Xnf,* into food consumption, *Cf*, and *aM01_E01* is the coefficient of re-exports of food products, i.e. of SITC groups 0 and 1. A few input-output cells are variables in mio. DKK, for example *Spp_Cf* is excise duty on food consumption.

Input-output koefficients

The i-o coefficient for the supply from imports of cars to private consumption of cars, e.g., is defined as

(5.4)

$$aM7b\_Cb = \frac{M7b\_Cb}{pm7b \cdot fCb}$$

i.e. the i-o cell is deflated to a quantity measure using the general import price of the row, and the i-o coefficient is the ratio of this cell quantity to the total column quantity, private consumption of cars.

5 basic principles

There are five basic principles for the determination of i-o cells:

- Demanded volume is provided immediately, either as Danish production or as import.
- The split-up between Danish production and imports reflects the price-sensitive market shares determined in the import equations. In the short term, production is often more sluggish while import reacts more quickly to demand fluctuations cf. the estimated short-term import demand elasticity above 1.
- Price changes on resource components are passed on fully in the price of uses.
- As a starting point, the volume distribution in the column for a given use is assumed to remain unchanged from the previous year. Thus, for example, if car consumption increases by 1 per cent in volume, the car imports and the car-sale-related services will both grow by 1 per cent, and the i-o coefficients will be constants.
- As a starting point, prices in the row for a given resource are assumed to change proportionally from the previous year. Thus, for example, if the gasoline price increases by 1 per cent, the price of gasoline consumption will increase by 1 per cent for both households and industries.

Constant i-o coefficients

Though the i-o coefficients are basically considered constant, they are endogenous variables in ADAM. In the simplest case, for example:

(5.5)

$$aM7b\_Cb = aM7b\_Cb_{-1}$$

Volumes

The total volume of a resource is determined as the sum of the contributions of all demand components using the i-o coefficients of the resource component as weights. Again using car imports as an example:

(5.6)

$$fM7b = aM7b\_xa \cdot fXa + \ldots + aM7b\_Cb \cdot fCb + \ldots + aM7b\_im \cdot fIm + \ldots + aM7b\_E7 \cdot fE7$$

Similar equations determine the volume of the other import components and of the production in industries, fX_i.

Prices

For all use components, i.e. demand components in ADAM, the net price (net of indirect taxes) is calculated as the sum of the contributions from all resource prices using the i-o coefficients of the demand components as weights. For example, the net price of car consumption is given by:

(5.7)

$$pncb = pxa \cdot aXa\_cb + \ldots + pm7b \cdot aM7b\_Cb + \ldots + pms \cdot aMs\_Cb$$

The summation embraces all production industries and import components.

When the net price is determined, the market price of the demand component is found by adding taxes. For example, the price of food consumption is given by:

(5.8)

$$pcf = (pncf + tpcf) \cdot (1 + btgcf \cdot tg)$$

where *tpcf* is the rate of excise duty on food consumption, *tg* is the general VAT rate, and *btgcf* indicates the VAT load on food consumption. See chapter 8 on public finances for further discussion on the role of indirect taxes.

Similar equations determine the prices on the rest of the consumption components as well as on inputs of materials, pv_j, investments, pi_j, and exports, pe_j.

Special industries

It should be noted that some industries do not follow the normal principle that production adjusts to demand.

Production in agriculture, *Xa*, and the related food production, *Xnf*, are either exogenous or a function of the ratio between the exogenous food price and Danish costs. Thus, they do not respond to changes in food demand. Instead, it is food exports that adapt when there are changes in the food demand or agricultural production.
Extraction of hydrocarbons etc., *Xe*, is an exogenous production.

Production in housing, *Xh*, is proportional to the stock of houses, and is therefore slow to adjust to the housing demand. In the short term, it is rather the price of existing dwellings, which responds to demand. In the long term, housing stock and hence housing production are determined by housing demand, cf. the discussion of the housing model in chapter 3.

Production of public services, *Xo*, is determined by the exogenous employment of the public industry, and both public employment and production are seen as politically determined, see Chapter 8 on public finances.

For the special industries just listed, it is necessary to adjust the determination of input-output cells in various ways.

On import substitution

For products produced in both Denmark and abroad, it is necessary to modify the simple determination of i-o coefficients shown in (5.5). This is because changes in Danish competitiveness, i.e. changes in the relative price of Danish production and imports, affect the market share of imports determined in the import equations of the model. This mechanism must be reflected in the i-o coefficients.

As an example, we take the i-o coefficient for imports of food to consumption of food, *am01_cf*. The equation for this coefficient corresponds to the simple equation (5.5) with a correction for the change in the market share:

(5.9) $$aM01\_Cf = aM01\_Cf_{-1} \cdot kfmz01$$

The correction factor, *kfmz01*, expresses the growth in the market share of food imports, *M01*, measured in volumes. This market share is determined by the import equation for food, and if the market share increases by 1 per cent, *kfmz01* equals 1.01. Note that the change in the market share of *M01* is assumed to have the same proportional effect on all cells in the *M01* row.

When the import share is changed, the share of domestic production must be changed in the opposite direction. Thus, the total market is not affected by a shift in import share; the gain of one market share is the loss of the other.

Food imports are competing with the production of the Danish food industry, *Xnf*. Consequently, when food imports rise because of a higher market share, the additional imports are deducted in the food production. This means that the coefficient equation for food production delivered to food consumption is modified to:

(5.10) $$aXnf\_cf = aXnf\_Cf_{-1} - aM01\_Cf_{-1} \cdot (kfmz01 - 1)\frac{pm01_{-1}}{pxnf_{-1}}$$

If the import market share is unchanged, i.e. *kfmz01*=1, the equation works as the simple cell equation in (5.5). But if the import market share increases by, e.g. 1 per cent, the import cell *M01_Cf* will increase by 1 per cent, cf. (5.9), while the Danish production cell in (5.10) will decrease by the same amount at previous years' prices. Thus, the sum of the two cells will remain unchanged.

Gross value added

When the production and the input of intermediate consumption are determined, gross value added, GVA, can be determined as production minus intermediate consumption:

(5.11)

$$Yf_i = X_i - V_i$$

"Other taxes on production"

A part of gross value added goes to the public sector in the form of other net taxes on production, *Spz,* (net means net of subsidies). These production taxes are distributed across industries. For example, agriculture pays property tax and receives EU subsidies, while the housing industry pays property tax and receives housing subsidies, see also the chapter on public finances.

Gross surplus

Finally, the "gross operating surplus and mixed income" for short the residual income, can be determined by:

(5.12)

$$Yr_i = Yf_i - Spz_i - Yw_i$$

That is to say: Gross value added minus other net taxes on production and minus wages. Residual income covers capital costs and profit.

Totals for *Yf*, *Spz* and *Yw* are made by a summation taking place over the 12 industries.

5.3 Properties

In the case of a positive demand shock, ADAM's total output and employment will increase in the short term and thereafter decrease in the long term, reverting to the baseline. This is the general effect on the total economy. In contrast, production and employment in individual industries will not necessarily return to the starting point.

If the public purchase of goods and services increase by 1 per cent, the accompanying wage increase will be instrumental in crowding out exports, but the higher wage increases the purchasing power of households, so both public and private consumption will increase in the long term. It is primarily manufacturing that produces the exported goods, so in the long term value added and employment will be smaller in manufacturing. On the other hand, the private service industries mainly produce for the domestic market, so these industries will be larger in the long term. Figures 5.1 and 5.2 illustrate the effects on gross value added and employment in the manufacturing industries,

specifically the *n*-industries *nz*, *nf*, *ng* and *ne*, as well as in the service industries *qz*, *qs* and *qf*.

Figure 5.1 **Public purchase + 1%, effect on gross value added**

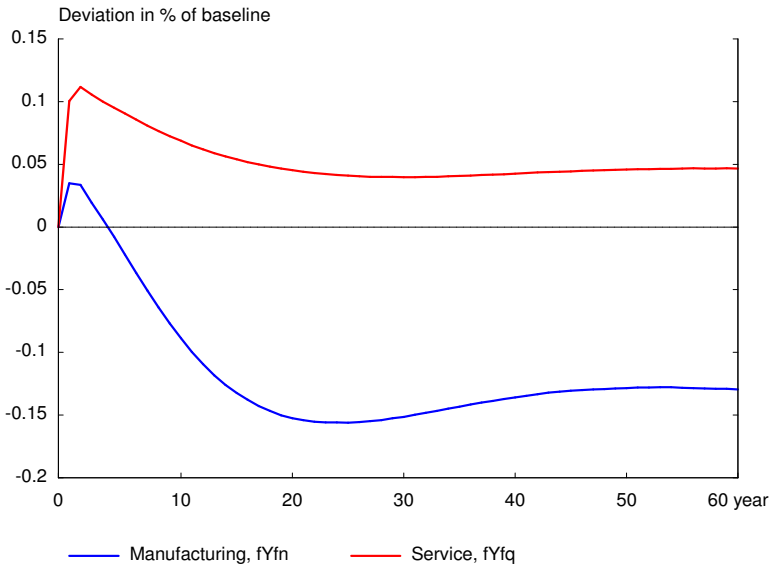
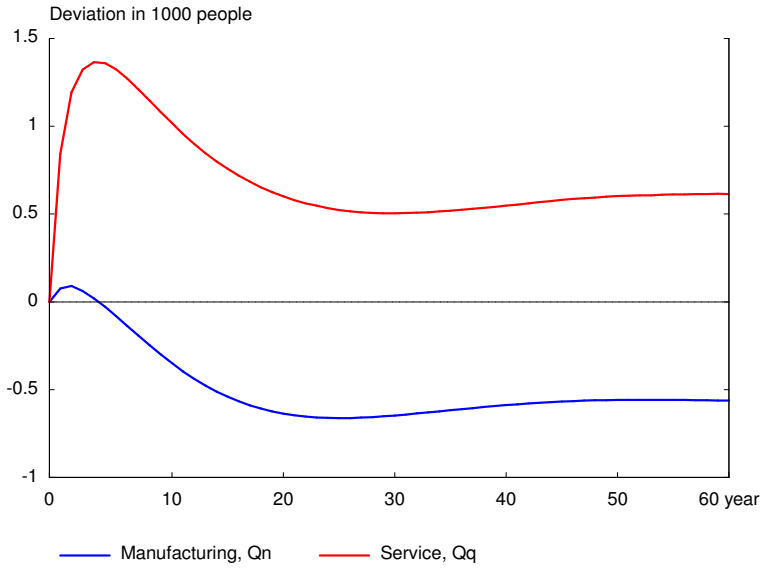


Figure 5.2 **Public purchase + 1%, effect on employment**



Box 5.1 Adjusting in the input-output system

It is not easy to make adjustments in the equations of the input-output system without running the risk of difficulties with the many definitional relations that must apply.

In general, adjustments to the input-output cells must be made so that either the row or column sum remains unchanged: If one cell is adjusted upwards, another cell must be adjusted downwards.

If the column sum remains unchanged as in the example of import substitution, the adjustment will affect the distribution of a given demand component on resource components, such as imports and Danish production.

If instead the row sum remains unchanged, the adjustment will affect the distribution of a given resource price on demand components. The problem may be that a price increase of Danish production is expected to have an impact on domestic prices, but not on the export price. This can be obtained by entering the row of the production industry in question and in this row we adjust upwards a domestic cell and downwards an export-cell by the same amount.

This kind of adjustment in the pass-through of resource prices is, in practice, the most frequent intervention in the input-output system, and a mechanism for price adjustment has been specified in the input-output equations. More specifically, special adjustment terms have been specified for the net price of every demand component, e.g. *Jdpncf* for the net price on food consumption. These adjustment terms are located in cells with input from the service industry (*qz*), for example supply to food consumption, and a change in the adjustment term can be interpreted as a change in trading profit (wholesale and retail trade). The sum of the special adjustment terms is automatically offset in the price of inventory investment, *pnil*, to ensure that the row identity for the *qz* industry holds, also when the problem is ignored by the model user. Obviously, the drawback of the automatic adjustment is that the price of inventory investment becomes difficult to interpret.

ADAM's input-output system is further discussed in a number of model group papers on *dst.dk/adam*.

Table 5.A Input-output table, input to industries. 2007

	Xa	Xe	Xng	Xne	Xnf	Xnz	Xb	Xqz	Xqs	Xqf	Xh	Xo	**Total**
	DKK bn..												
Xa	8	0	0	1	38	0	2	1	0	0	0	2	**51**
Xe	0	1	20	11	0	1	1	0	0	0	0	0	**34**
Xng	2	0	1	0	0	1	1	4	0	0	0	0	**9**
Xne	1	0	0	4	2	5	0	8	0	0	0	3	**24**
Xnf	9	0	0	0	13	1	0	8	0	0	0	1	**33**
Xnz	3	1	0	1	5	85	45	33	2	2	0	6	**184**
Xb	1	1	0	4	1	2	2	21	0	2	19	5	**58**
Xqz	10	2	1	3	16	73	56	294	3	15	1	65	**538**
Xqs	0	0	0	0	0	0	0	7	0	0	0	1	**7**
Xqf	5	0	0	1	1	3	2	16	2	23	13	2	**69**
Xh	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Xo	0	0	0	0	0	1	0	6	0	1	0	11	**20**
M01	4	0	0	0	15	1	0	6	0	0	0	1	**27**
M2	1	0	0	0	4	6	2	0	0	0	0	0	**14**
M3k	0	0	-	3	0	0	-	0	-	-	0	0	**3**
M3r	-	-	6	-	-	-	-	-	-	-	-	-	**6**
M3q	1	0	0	1	0	1	1	6	27	0	0	0	**39**
M59	3	0	1	0	6	109	25	31	2	1	0	13	**190**
M7b	-	-	-	-	-	0	-	-	-	-	-	-	**0**
M7y	-	-	-	-	-	0	0	0	-	-	-	0	**1**
Ms	1	2	0	1	5	17	3	81	117	6	1	8	**241**
Mt	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Spm	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Spp+Spr	1	2	0	0	1	2	2	9	0	0	4	2	**23**
Spg	0	0	0	0	0	1	0	14	0	4	5	21	**45**
Spz	- 6	- 0	- 0	0	- 0	- 1	0	1	- 0	3	4	- 3	**- 1**
Yw	9	2	0	6	22	122	64	370	6	49	4	275	**929**
Yr	14	55	1	22	9	50	17	168	13	30	99	31	**507**
Total	**70**	**66**	**31**	**57**	**139**	**481**	**223**	**1 084**	**172**	**135**	**150**	**446**	**3 054**

Note: The last three rows, *Spz*, *Yw* and *Yr* distribute value added in the industry on production taxes, wages, and gross operating surplus.

Table 5.B **Input-output table, input to consumption and investments. 2007**

	Cf	Cv	Ce	Cg	Cb	Ch	Cs	Ct	-Et	Co	Im	Ib	It	Il	**Total**
	DKK bn.														
Xa	2	1	0	-	-	-	0	-	-	1	0	-	- 0	1	**5**
Xe	0	0	-	-	-	0	0	-	-	-	0	-	-	2	**3**
Xng	0	0	1	4	-	-	0	-	-	-	0	-	-	1	**7**
Xne	-	0	19	-	-	2	0	-	-	-	0	-	-	0	**22**
Xnf	28	1	-	-	-	-	0	-	-	0	0	-	-	1	**30**
Xnz	0	14	0	- 0	0	1	2	-	-	1	36	-	-	7	**61**
Xb	-	0	-	-	-	4	0	-	-	7	0	153	-	-	**164**
Xqz	34	74	2	2	9	7	142	-	-	31	49	13	-	2	**365**
Xqs	-	0	-	-	-	-	1	-	-	-	0	-	-	-	**1**
Xqf	-	0	-	-	-	-	56	-	-	0	3	-	-	-	**60**
Xh	-	0	-	-	-	150	0	-	-	-	0	-	-	-	**150**
Xo	-	0	-	-	-	-	30	-	-	393	1	0	-	-	**424**
M01	19	1	-	-	-	-	-	-	-	0	-	-	- 0	0	**20**
M2	0	1	1	-	-	0	-	-	-	-	0	-	-	1	**3**
M3k	-	0	0	-	-	-	-	-	-	-	-	-	-	0	**0**
M3r	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**
M3q	-	0	1	3	-	-	-	-	-	-	-	-	-	- 0	**4**
M59	0	38	-	0	1	1	2	-	-	5	50	-	-	8	**104**
M7b	-	-	-	-	17	-	-	-	-	0	8	-	-	0	**26**
M7y	-	0	-	-	-	-	-	-	-	-	5	-	-	1	**7**
Ms	-	1	-	-	-	0	4	-	- 36	0	5	0	-	0	**- 26**
Mt	-	-	-	-	-	-	-	38	-	-	-	-	-	-	**38**
Spm	0	1	0	0	0	0	0	-	-	0	0	-	- 0	0	**1**
Spp+Spr	11	0	12	10	15	1	- 3	-	-	0	10	2	-	0	**58**
Spg	22	31	9	5	6	2	20	-	-	2	9	26	-	-	**131**
Spz	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Yw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Total	**116**	**163**	**46**	**24**	**47**	**168**	**255**	**38**	**- 36**	**440**	**177**	**194**	**- 0**	**25**	**745**

Table 5.C Input-output table, input to exports. 2007

	E01	E2	E3	E59	E7y	Es	Et	**Total**	**Total uses**
	DKK bn.								
Xa	7	6	-	-	-	0	-	**11**	**70**
Xe	-	1	28	0	-	1	-	**29**	**66**
Xng	-	0	15	0	-	-	-	**15**	**31**
Xne	-	-	11	-	-	-	-	**11**	**57**
Xnf	68	4	-	2	-	2	-	**75**	**139**
Xnz	0	3	0	224	2	7	-	**237**	**481**
Xb	-	-	-	-	-	1	-	**1**	**223**
Xqz	10	7	0	46	0	117	-	**181**	**1 084**
Xqs	-	-	-	-	-	163	-	**163**	**172**
Xqf	-	-	-	0	-	6	-	**6**	**135**
Xh	-	-	-	-	-	-	-	**-**	**150**
Xo	-	-	-	-	-	2	-	**2**	**446**
M01	9	-	-	-	-	-	-	**9**	**56**
M2	-	2	-	-	-	-	-	**2**	**19**
M3k	-	-	0	-	-	-	-	**0**	**4**
M3r	-	-	0	-	-	-	-	**0**	**7**
M3q	-	-	7	-	-	-	-	**7**	**49**
M59	-	-	-	88	-	-	-	**88**	**381**
M7b	-	-	-	4	-	-	-	**4**	**30**
M7y	-	-	-	-	3	-	-	**3**	**11**
Ms	-	-	-	-	-	3	36	**38**	**253**
Mt	-	-	-	-	-	-	-	**-**	**38**
Spm	0	0	0	1	0	-	-	**1**	**3**
Spp+Spr	- 1	0	- 0	- 0	-	-	-	**- 1**	**80**
Spg	-	-	-	-	-	-	-	**-**	**176**
Spz	-	-	-	-	-	-	-	**-**	**-1**
Yw	-	-	-	-	-	-	-	**-**	**929**
Yr	-	-	-	-	-	-	-	**-**	**507**
Total	**94**	**23**	**61**	**365**	**5**	**302**	**36**	**885**	**5 595**