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Spatial Accounting Methods and the Construction of Spatial Social Accounting Matrices

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ABSTRACT *The paper examines modifications to Regional Accounts used to construct regional and interregional Social Accounting Matrices (SAMs). It is argued that as the size of the basic areal unit used in studies declines, more traditional accounting approaches are no longer satisfactory. A three-dimensional spatial approach (termed two-by-two-by-two) to the identification of fundamental dimensions (commodity and factor market; geographical; and social accounts) has been developed in contrast to the more traditional non-spatial approach (termed two-by-two). This involves a novel approach using the geographical concepts of place of production for production activities, place of residence for institutions, marketplace for commodities and marketplace for factors. The use of these concepts permits accounting balances to be calculated at the spatial level. The theoretical basis of the spatial regional accounting model is presented and an example of the construction of a Danish Interregional SAM (SAM-K) is examined. Particular attention is given to data requirements, showing that these are much more modest than generally assumed.*

KEY WORDS: Interregional SAM, spatial accounting, data requirements

1. Introduction

Developments in spatial accounting and modelling have in part at least, been driven by policy-makers' growing interest in regional and local economic performance and interactions with other regions and localities.[1] This has promoted increased interest in development of regional information systems, where the national accounts-based systems are of considerable importance. These systems include Regional Accounts (Eurostat, 1996: Chapter 13), regional versions of satellite accounts (United Nations, 1993: Chapter XXI) and interregional versions of Social Accounting Matrices (SAM) (United Nations, 1993: Chapter XX; Hewings and Madden, 1995; Round, 1995, 2003; Thorbecke, 1998). The aim of this paper is to examine the necessary adaptations to Regional Accounts in

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order to construct such extended national account based regional information systems. This includes a novel systematic approach to the treatment of geographical structures and relations. The paper also provides an example of the implementation of these adaptations in the case of Denmark.

In National Accounts, a *two-by-two* registration of economic activities is usually employed, using the basic division between supply and demand on one dimension and type of commodity and type of factor on the other, with the nation and Rest of the World as the geographical units (United Nations, 1993; Eurostat, 1996). If these production accounts are divided by industry, an input–output table can be constructed (United Nations, 1993: Chapter XV; Eurostat, 1996: Chapter 9). If there is a further division by type of institution, a Social Accounting Matrix (SAM) can be derived (United Nations, 1993: Chapter XX). These accounts are inherently non-spatial, although this is usually of little consequence, as the division between the nation and the Rest of the World is present, and economic dependence on activities in the Rest of the World is usually relatively limited as is the need for information about spatial structure in relation to the Rest of the World.

In Regional Accounts (Eurostat, 1996: Chapter 13), the basic geographical unit is the region rather than the nation and they have a structure which is similar to National Accounts, although more simple. A number of differences can be noted. First, the focus of interest is the supply side, where there is no regional supply and demand balance, although the sum of regional supply is consistent with national totals. Second, there is no division by commodity and factor. Third, Regional Accounts are limited to recording production activities by industry and account for some institutional sectors such as households. Regional Accounts are also non-spatial, though this now becomes a problem as external links are much more important. This means that two major extensions are necessary if interregional accounting is to be possible. The first extension is to construct commodity balances and factor balances at the regional level. Whilst this is non-spatial, it gives the Regional Accounts the same two-by-two structure as the National Accounts. The second extension is to create the spatial dimension, extending the commodity and factor balances to include origin (supply) and destination (demand). This in essence creates a *two-by-two-by-two* structure. Finally, the term regional is inappropriate as a number of questions (commuting and shopping for example) can only be properly dealt with at the sub-regional or local spatial level. In the following, the analysis is as relevant for the local as for the regional level. Therefore, it is perhaps more appropriate to use the term local rather than Regional Accounts.

In interregional Social Accounting Matrices, a spatial registration of activities can be made. Spatial registration implies that activities are registered by place of origin of inputs and by destination of the outputs. Whilst the step of creating spatial balances is a natural extension of the principles used in National Accounts to include the spatial dimension, in the following this spatial registration is based upon the new and systematic use of the concepts of (i) place of production for production activities where the activity takes place, (ii) place of residence for institutions, (iii) marketplace for commodities, and (iv) marketplace for factors.

In this paper, the methods used to set up an interregional SAM for Denmark are presented, developing ideas found in Madsen and Jensen-Butler (1999, 2002). Based upon the application of spatial registration of activities the procedure is examined including the use of the commodity and factor marketplaces. It is also shown that an

interregional Social Accounting Matrix can be set up for countries with limited data availability.

2. National and Regional Accounts

Regional Accounts are based upon the concepts and accounting principles used in National Accounts (United Nations, 1993: Chapter XIX; Eurostat, 1996: Chapter 13). However, for a number of reasons, the national accounting framework is inadequate for the registration of economic activities in small areas, where economic interaction between different areas is often intense and the degree of geographical specialisation is substantial. The national accounting framework is better suited to analyses based upon well-defined, coincident and relatively closed functional regions.

2.1. National Accounts and the Nation

The conceptual basis of the National Accounts is supply and use, subdivided by commodity. The mirror image of this concept is the institutional accounts, which are based upon ownership of the production of the nation, subdivided by type of institution. This gives a two-by-two structure, with supply and demand on the one dimension and commodities and factors on the other. The supply of commodities comes either from domestic production or from imports from abroad, and commodities are produced either by domestic or by foreign institutions. Demand for commodities is either domestic demand or foreign exports, and commodities are demanded either by domestic or foreign institutions. Domestic institutions are, on the one hand, either households or government, which generate final consumption, and on the other hand, production units which generate intermediate consumption, gross capital formation and changes in inventories.

Seen from both the demand and the production side, the geographical units used in National Accounts are the nation itself and the Rest of the World. A series of rules have been established to determine whether or not an institution belongs to the nation, in other words, what is the place of production of the institutional production unit and the place of residence of the demanding unit.

Using a terminology that is relevant in relation to Regional Accounts, the place of residence of institutions and, from a production point of view, the place of production of the institutions, are key concepts used here, which are derived from National Accounts. The National Accounts are one-dimensional, which means that an institution has one and only one geographical relation, this being whether the institution is resident or non-resident.

2.2. National Accounts and Geography

Normally, the concepts of place of residence and place of production are not used in National Accounts. However, in the context of regional economies they become important. The smaller the geographical scale, the more necessary it becomes to use the two concepts, as well as to introduce two new concepts, *marketplace for commodities* and *marketplace for factors.* The reason for this multi-dimensionality is that regions become more specialized as the areal unit for production, place of residence or marketplaces for

commodities and factors becomes geographically smaller. As the size of areal unit declines, fewer and fewer regions retain all of their functions on all four dimensions.

In National Accounts, this problem also exists, but on a more limited scale. A nation normally includes all four functions, being place of production, place of residence and marketplaces for commodities and factors. The transformation from place of production to place of residence is included in the double entry spatial accounting and is financed through the balance of payments: incomes from production activities abroad and from foreigners working inside the national territory (international commuting) are added to residential institutional incomes. Also, other incomes from abroad and paid abroad are included in the transformation from place of production to place of residence. This is not done in conventional National Accounts, where it is only included as a correction in national disposable income.

The transformation from marketplace for commodities to place of residence is included in the determination of demand by domestic institution, by subtracting foreign tourists' demand from total demand. Again, this is a deviation from the single entry principle, undertaken in order to estimate residential private consumption. Tourists' demand is included as part of exports, because it constitutes foreign demand inside the nation (see Eurostat, 1996: Chapter 3.142). Foreign tourism can be business tourism (treated as part of intermediate consumption), private tourism (treated as part of private consumption) and governmental tourism (treated as part of governmental consumption). Tourism is transformed into exports in two steps. First, the different types of consumption including tourism are accounted for. In this step the marketplace for commodities is the area in question. In the second step, tourists' demand is subtracted from total demand and is added to exports as one commodity. The demand that remains is, therefore, residential demand. Similarly, tourists' consumption abroad, being a separate commodity in private consumption, is subtracted from demand by type of commodity and added to imports from abroad. In this way, commodity balances in the first step are accounted for using the marketplace for commodities, and in the second step they are transferred to the foreign trade balance by adding domestic tourism abroad to foreign imports and adding residents' tourism to foreign exports. Although these problems are managed in the National Accounts, from the point of view of Regional Accounts this solution is not satisfactory. Here, an application of all four geographical concepts is necessary.

The introduction of the concept of *marketplace for commodities* and *marketplace for factors* changes and supplements the methods used to set up regional Social Accounting Matrices. Estimation of production by place of production and income by place of residence follows the guidelines set up by the European Union (Eurostat, 1996). However, estimation of demand in the marketplace for commodities, interaction between place of production and marketplace for commodities (intra- and interregional trade) and interaction between place of residence and marketplace for commodities (local private consumption and domestic tourism) extend the methods used in setting up regional Social Accounting Matrices. In addition, estimation of demand for production factors in the marketplace for production factors, including the transformation of demand for production factors from place of production to place of factor markets, and transformation of supply of production factors from place of residence to place of factor markets extend the methods used in setting up SAMs. This means that the *two-by-two* basic structure is extended to become *two-by-two-by-two*, including the origins (supply of commodities and factors of production) and destinations (demand for commodities and factors of

production). In the following, this spatial extension of the non-spatial framework is presented.

2.3. Regional Accounts and Spatial Registration of Economic Activities

In factor markets, supply and demand for production factors are to be found. Demand for production factors is determined by production at the place of production. In Figure 1, factor demand by sector is transformed into factor demand by type of production factor. On the supply side, supply of production factors by type of institution is transformed into supply by type of production factor. Supply of a production factor is related to the place of residence of the institution. The factor market is assigned geographically to the marketplace for factors.

In the case of labour, demand by sector can be transformed into demand by labour group defined using age, gender and education. Supply of labour is transformed from households

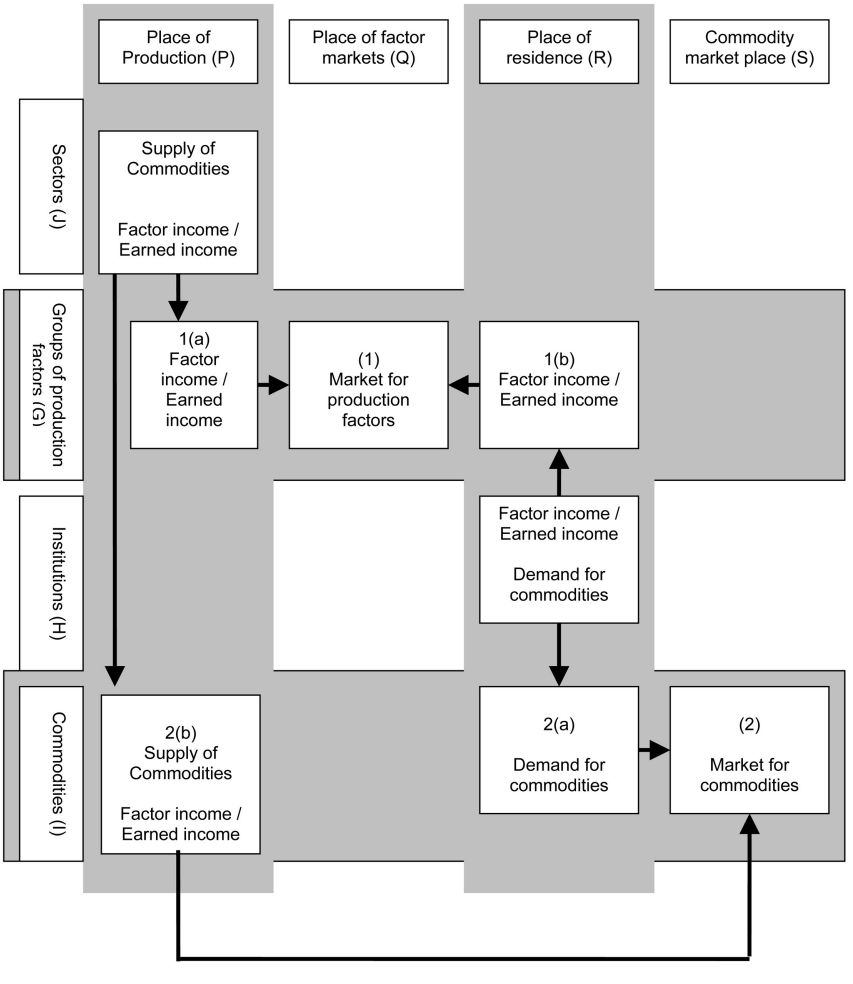

Figure 1. The conceptual basis of spatial social accounts

(institutions) to factor groups (such as age, gender and education). Geographically, the labour market links the place of production and the place of residence. In the real world, there are only a few examples of a pure spatially defined labour market, where the factor marketplace is separated from both the place of production and the place of residence. An example is the case where workers meet in the morning at a given location, where the employers hire manpower, and after negotiation, the workers are transported to the place of production. Normally, the link between place of production and place of residence is direct in a one-to-one relationship. From this point of view it cannot be determined whether the place of production or the place of residence is the labour marketplace. However, as the unemployed can be treated as an excess supply of labour, and unemployment by definition is only assigned to a place of residence, the labour market can be related to place of residence.

In the commodity market, there is a distinction between place of residence, the marketplace for commodities and place of production. The marketplace for commodities links the demand for the commodity (from the place of residence to the marketplace for commodities) to the supply of the commodity (from place of production to the marketplace for commodities). Before the transformation to the marketplace for commodities, the demand for commodities is transformed from income by institutional group to demand by commodity. On the supply side, production by sector is transformed from production by sector into production by commodity and then supply is related geographically to the marketplace for commodities.

2.4. Statistical Sources

One initial objection to this structure is its complexity. Requirements of simplicity have been behind development of the one-dimensional system. However, considering both data quality and existing data sources, it seems that this objection is no longer valid. By way of illustration, we show that data for two SAM elements (persons and commodities) are sufficient to establish the Regional Accounts.

First, by asking individuals, data on the supply side of the labour market (employment and earned income) can be obtained, as shown in block 1b in Figure 1. By asking firms or individuals, data on the demand side of the labour market (employment and earned income) can be obtained, as shown in block 1a. Second, by obtaining information on commodities from firms, data on the supply side of the commodity market (turnover) can be obtained, as shown in block 2b. Data on the demand side (turnover), can be obtained from individuals in the case of final consumption and from firms in the case of intermediate consumption, as shown in block 2a.

Individuals provide a good source of data, which with respect to block 1 are obtainable from a census. It is also possible that demand for factors (block 1a) can be obtained from surveys of firms. With respect to block 2, information is only exceptionally related directly to commodities, which would make it possible to obtain data. Instead, data have to be gathered either at the place of origin of the commodity (from producers at the place of production), at the marketplace for commodities (from retailers and wholesalers), or at the destination of commodities (from purchasers at the place of residence).

This simple model constitutes a good description of the statistical sources for the Regional Accounts – and shows why different transformations must be undertaken before the data can be used in the Regional Accounts. On the supply side, the production

account in the Regional Accounts is based upon information from the place of production. Production statistics will have the format of Make (sector by product) matrices. Statistics on the labour force, employment and unemployment by type of labour and by type of household are often based upon census data, sometimes supplemented by other relevant population data. Finally, demand is, in many cases, most effectively determined at the place of commodity demand. For example, estimation of private consumption by commodity is often based upon VAT statistics, which is related to the marketplace for commodities.

Before using these statistics in the Regional Accounts, a number of corrections must be made. In the production statistics, the share of factor income received by non-residential institutions must be subtracted in order to obtain factor income by place of residence, which is the key concept in the Regional Accounts. In the demand statistics, demand from non-residential actors should be subtracted in order to obtain residential demand for locally produced commodities.

3. Interaction and Regional Accounts

The concept of a balance is fundamental for data construction and accounting. In this section, the accounting model behind the concept of the commodity balance and the institutional balance is examined in its most general form. The model, with a few modifications, is applicable to both regional and national levels. The basic model is transformed into a *two-by-two-by-two* spatial model by incorporating the concepts of *place of production*, *place of residence, place of commodity market* and *place of the factor market.* This process also represents a transition from a commodity trade balance to an institutional balance, involving balance of payments and the concept of place of residence.

The accounting balances in a *two-by-two* non-spatial regional accounting framework are first presented. This is followed by a discussion of modifications of the general model with a subdivision into separate balances, these being the private sector balances and the governmental balances, which corresponds to the balance of payments for the region. The savings balances can be subdivided into sub-balances, all related to the place of residence. A discussion of price concepts in the two balances is included later. Finally, extension to the *two-by-two-by-two* registration of activities, where sub-balances are made interregional, is presented and a subdivision of the different balances into balances for mobile and non-mobile commodities or components of demand is examined.

3.1. A Non-spatial Regional Accounting Model (Two-by-Two Model)

The point of departure for local commodity balances is, on the one hand, data on local supply (production) and local demand (intermediate consumption, private consumption, governmental consumption, investments) and on the other hand, the national commodity balances as represented in the national Make and Use tables. The difference in relation to the national commodity balance is that interregional imports and exports enter.[2] The core of the regional commodity balance in a SAM is the commodity balance equation for each region and each commodity, or the total balance:

$$\mathbf{q}_i^P + \mathbf{z}_i^{S,O} + \mathbf{z}_i^{S,F} = \mathbf{u}_{i,IC}^S + \mathbf{u}_{i,CP}^S + \mathbf{u}_{i,CO}^S + \mathbf{u}_{i,IN}^S + \mathbf{z}_i^{P,O} + \mathbf{z}_i^{P,F} \tag{1}$$

where $\mathbf{q}_i^P$ is the gross output by commodity i by place of production P; $\mathbf{z}_i^{S,O}$ is the interregional import (O) by commodity by place of commodity market S; $\mathbf{z}_i^{S,F}$ is the import from abroad (F) by commodity by place of commodity market; $\mathbf{u}_{i,IC}^S$ is the intermediate consumption (IC) by commodity by place of commodity market; $\mathbf{u}_{i,CP}^S$ is the private consumption (CP) by commodity by place of commodity market; $\mathbf{u}_{i,CO}^S$ is the governmental consumption (CO) by commodity by place of commodity market; $\mathbf{u}_{i,IN}^S$ is the local investment (IN) by commodity by place of commodity market; $\mathbf{z}_i^{P,O}$ is the interregional export by commodity by place of production; and $\mathbf{z}_i^{P,F}$ is the foreign export by commodity by place of production.

Equation (1) is formulated explicitly in geographical terms (using P and S). In this case there is no difference between the national and the regional perspective except that interregional trade has been introduced. From this commodity balance a progression is made to arrive at a set of institutional balances, corresponding to a process whereby the geographical dimension is transformed from place of production and commodity marketplace, to place of residence for regional institutions. This process starts by transforming the perspective on production so that it is seen from an institutional place of residence point of view, as shown in the following equation.

$$\begin{aligned}\mathbf{x}^P - \mathbf{u}_{IC}^S + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) \\ = \mathbf{u}_{CP}^S + \mathbf{u}_{CO}^S + \mathbf{u}_{IN}^S + (\mathbf{z}^{P,O} - \mathbf{z}^{S,O}) + (\mathbf{z}^{P,F} - \mathbf{z}^{S,F}) \\ + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) \qquad (2)\end{aligned}$$

where $\mathbf{x}^P$ is gross output by place of production (P); $\mathbf{u}_{IC}^{S,F}$, $\mathbf{u}_{IC}^{P,F}$, $\mathbf{u}_{IC}^{S,O}$, $\mathbf{u}_{IC}^{P,O}$ indicate intermediate consumption by foreign (F) or domestic firms (O) in the commodity marketplace (S) or by place of production (P); $\mathbf{h}^{R,F}$, $\mathbf{h}^{P,F}$, $\mathbf{h}^{R,O}$, $\mathbf{h}^{P,O}$ give Gross Value Added (GVA) by foreign production factors (F) or domestic production factors (O) in place of residence (R) or by place of production (P).

In equation (2), supply by place of production is transformed into GVA, by place of residence. This involves a number of steps. First, intermediate consumption is subtracted both on the supply and use sides of equation (1). Second, correction is made for the purchase of intermediate goods obtained from extra-regional suppliers and the purchase of intermediate goods in the region by extra-regional producers. Third, a correction is made for commuting, involving GVA that is generated by institutions resident outside the region and GVA that is brought into the region by institutions resident in the region but who are a factor of production that is employed outside the region. *Outside the region* is further differentiated into a foreign component and a domestic component. The result is that the left-hand side becomes the resident institutions' net earnings. This left-hand side is a first step towards constructing resident institutions' saving balances.

These factor payments from outside the region involve both labour and capital income. In equation (2), impacts on income or savings from net interest payments from outside the region should, in principle, also be included, but here they have been left out for reasons of simplification. Net interest payments could also be subdivided into domestic and foreign payments. On the right-hand side of the equation (2) the first steps in the transformation from a trade balance to a balance of payments are taken. This involves

correction of the trade balance using net purchase of intermediate goods and corrections for commuting.

In the next step, gross savings are derived from gross earnings by subtracting private consumption for households resident in the region. This involves a correction for the private consumption in the region of households resident outside the region, and for private consumption outside the region of resident households. Again, outside the region is further differentiated into a foreign and a domestic component. Consequently, there is a further correction of the trade balance using net purchase for private consumption. This yields

$$\begin{aligned}
&\mathbf{x}^P - \mathbf{u}_{IC}^S + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) \\
&\quad + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) - \mathbf{u}_{CP}^S + (\mathbf{u}_{CP}^{S,F} - \mathbf{u}_{CP}^{R,F}) + (\mathbf{u}_{CP}^{S,O} - \mathbf{u}_{CP}^{R,O}) \\
&= \mathbf{u}_{CO}^S + \mathbf{u}_{IN}^S + (\mathbf{z}^{P,O} - \mathbf{z}^{S,O}) + (\mathbf{z}^{P,F} - \mathbf{z}^{S,F}) + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) \\
&\quad + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) + (\mathbf{u}_{CP}^{S,F} - \mathbf{u}_{CP}^{R,F}) + (\mathbf{u}_{CP}^{S,O} - \mathbf{u}_{CP}^{R,O}) \qquad (3)
\end{aligned}$$

where $\mathbf{u}_{CP}^{S,F}$, $\mathbf{u}_{CP}^{R,F}$, $\mathbf{u}_{CP}^{S,O}$, $\mathbf{u}_{CP}^{R,O}$ indicate private consumption by foreign private households (F) or domestic private households (O) in the commodity marketplace (S) or by place of residence (R).

In the fourth step, regional disposable income is derived by subtracting governmental consumption. In this process, account is taken of the fact that some governmental consumption takes place outside the region and that some governmental consumption inside the region has its origins in demand from institutions that are resident outside the region. Again, there is a correction of the trade balance using net consumption of governmental goods and services. This gives

$$\begin{aligned}
&\mathbf{x}^P - \mathbf{u}_{IC}^S + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) \\
&\quad - \mathbf{u}_{CP}^S + (\mathbf{u}_{CP}^{S,F} - \mathbf{u}_{CP}^{R,F}) + (\mathbf{u}_{CP}^{S,O} - \mathbf{u}_{CP}^{R,O}) - \mathbf{u}_{CO}^S \\
&\quad + (\mathbf{u}_{CO}^{S,F} - \mathbf{u}_{CO}^{R,F}) + (\mathbf{u}_{CO}^{S,O} - \mathbf{u}_{CO}^{R,O}) \\
&= \mathbf{u}_{IN}^S + (\mathbf{z}^{P,O} - \mathbf{z}^{S,O}) + (\mathbf{z}^{P,F} - \mathbf{z}^{S,F}) + (\mathbf{u}_{IC}^{S,F} - \mathbf{u}_{IC}^{P,F}) \\
&\quad + (\mathbf{u}_{IC}^{S,O} - \mathbf{u}_{IC}^{P,O}) + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) \\
&\quad + (\mathbf{u}_{CP}^{S,F} - \mathbf{u}_{CP}^{R,F}) + (\mathbf{u}_{CP}^{S,O} - \mathbf{u}_{CP}^{R,O}) + (\mathbf{u}_{CO}^{S,F} - \mathbf{u}_{CO}^{R,F}) + (\mathbf{u}_{CO}^{S,O} - \mathbf{u}_{CO}^{R,O}) \qquad (4)
\end{aligned}$$

where: $\mathbf{u}_{CO}^{S,F}$, $\mathbf{u}_{CO}^{R,F}$, $\mathbf{u}_{CO}^{S,O}$, $\mathbf{u}_{CO}^{R,O}$ indicate government consumption by foreign governments (F) or domestic governments (O) in the commodity marketplace (S) or by place of residence of the government (R).

Finally, the institutional balance has been subdivided into a private and a governmental savings balance. This is for the sake of illustration only, in order to indicate the possibility of additional subdivisions of the savings balance in relation to different types of institution.

This yields

$$
\begin{aligned}
&[\mathbf{x}^P - \mathbf{u}^P_{IC} + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) - \mathbf{u}^R_{CP} - s^R + t^R] + [s^R - t^R - \mathbf{u}^R_{CO}] \\
&\quad = \mathbf{u}^S_{IN} + (\mathbf{z}^{P,O} - \mathbf{z}^{S,O}) + (\mathbf{z}^{P,F} - \mathbf{z}^{S,F}) + (\mathbf{u}^{S,F}_{IC} - \mathbf{u}^{P,F}_{IC}) + (\mathbf{u}^{S,O}_{IC} - \mathbf{u}^{P,O}_{IC}) \\
&\qquad + (\mathbf{h}^{R,F} - \mathbf{h}^{P,F}) + (\mathbf{h}^{R,O} - \mathbf{h}^{P,O}) + (\mathbf{u}^{S,F}_{CP} - \mathbf{u}^{R,F}_{CP}) + (\mathbf{u}^{S,O}_{CP} - \mathbf{u}^{R,O}_{CP}) \\
&\qquad + (\mathbf{u}^{S,F}_{CO} - \mathbf{u}^{R,F}_{CO}) + (\mathbf{u}^{S,O}_{CO} - \mathbf{u}^{R,O}_{CO})
\end{aligned} \tag{5}
$$

where: $\mathbf{s}^R$ gives the taxes by place of residence (R), and $\mathbf{t}^R$ the income transfers by place of residence.

Whilst at the international level there can be positive or negative residuals in the balances, this is not the case for the interregional components of the balances. As an example, the difference in relation to the national commodity balance is that interregional imports and exports enter, the sum of each being by definition equal. In the construction of the local commodity balance, the national commodity balance is used. The sum of each component over all regions is equal to the component at the national level. For each commodity, the sum of interregional imports equals the sum of interregional exports.

To summarize, the transformation from place of production to place of residence, gives regional net savings. The transformation from place of commodity market to place of residence gives regional net investment plus the balance of payments. This involves the following central corrections. The first correction is a conventional correction for interregional and foreign trade, where in relation to income, supply from domestic producers is isolated.

The second correction involves intermediate consumption: a part of intermediate consumption does not originate from production units producing in the region. For example, business tourism expenditure included in intermediate consumption by place of commodity market stems from production units located outside the region. Therefore, the net surplus on business tourist expenditure is added to both the right and left sides of the equation, as a reduction in business tourist expenditure for the resident production units and as an increase in the balance of payments for the tourist region.

The third correction is to private consumption. If consumption in central regions (with and above average number of retail centres) is included in residential consumption, private consumption is overestimated. Therefore, private residential consumption is reduced by the consumption from non-residents and residential private consumption in other regions is subtracted when calculating private saving. Similarly, expenditure on domestic tourism by non-residents is subtracted, and domestic tourist expenditure from residents outside the region is added. Both corrections on the left-hand side of equation (4) are added to the balance of payments on the right-hand side of the equation in order to maintain the accounting identity.

The fourth correction is for governmental consumption: governmental consumption with the region as place of commodity market for a government residing outside the region is subtracted, and governmental consumption of the region itself in other regions is added. Again a correction to the balance of payments on the right-hand side is added.

The fifth correction is for commuting: income losses from inward commuters are subtracted and income gains from outward commuters are added.

After these corrections, the savings account refers uniquely to the place of residence of the private and governmental institutions. For each of the corrections the identity between demand and supply at the national level holds. That is,

$$\mathbf{i}^P \mathbf{z}^{P,O} = i^S \mathbf{z}^{S,O}; \qquad i^R \mathbf{h}^{R,O} = i^P \mathbf{h}^{P,O}; \qquad i^S \mathbf{u}_{IC}^{S,O} = i^P \mathbf{u}_{IC}^{P,O};$$
$$\mathbf{i}^S \mathbf{u}_{CP}^{S,O} = i^R \mathbf{u}_{CP}^{R,O}; \qquad \mathbf{i}^S \mathbf{u}_{CO}^{S,O} = i^R \mathbf{u}_{CO}^{R,O} \tag{6}$$

where: $\mathbf{i}^P$, $\mathbf{i}^R$, $\mathbf{i}^S$ indicate the unity vectors for place of production (P), place of residence (R) and place of commodity market (S).

Both private and governmental savings can be further subdivided. The private savings account can be divided into a balance for households and one for firms. Governmental savings can be divided by level of government (municipality, county and state).

Finally, if the net trade balance is zero, then investment in the region is equal to regional savings. If it is negative, investment is greater than savings, which means that there will be a net inflow of savings and vice versa. It should be noted that there is no direct link between savings and investment in the region, which is touched upon in the following section. Further, the impacts on savings accounts of net interest payments have not been included.

3.2. A Spatial Regional Accounting Model (Two-by-Two-by-Two)

The non-spatial regional accounting model presented above is based upon the *two-by-two* accounting principle, including only such commodity flows as exports, imports and gross factor income flows (both for labour and capital income). In spatial regional accounting, the gross interaction flows are accounted for by including data on the origins and destinations of the flows.

In the case of commodity flows (see earlier), commodity-based activities can be related to place of production and place of residence, linked by the commodity marketplace. These commodity flows are divided into trade in commodities (from place of production to commodity marketplace) and shopping for commodities (from place of residence to commodity market), and including origins and destinations.

In the case of factor income, as described earlier, in the spatial accounting model, incomes are related to place of production (commodity market) and place of residence (supply) linked by the factor marketplace. On the demand side, factor income is accounted for by place of production and place of factor market as well as by type of factor, whereas on the supply side, factor income is accounted for by place of residence and place of factor market.

The treatment of savings and investments is here not as well developed as is possible, because of data constraints. One way around this problem is to use other methods to link regional savings and investment, for example pool-based methods and supra-regional accounts (Round, 1988). Another way forward, though involving stronger data requirements, is to establish a gross flow origin-destination matrix for saving and investments.

Table 1. Classification of commodities according to mobility in the regional economy

		Shopping/Purchases by type: Intermediate consumption/Private consumption/ Governmental consumption/Gross capital formation/ Changes in inventories	
		Mobile	Non-mobile
Trade in commodities	Mobile	Agricultural products, manufacturing industry products	Heating, electricity, domestic services, construction
	Non-mobile	Retailing and wholesaling, services, hotels, restaurants, hospitals, education	Housing, changes in inventories

3.3. Data Construction in a Spatial Regional Accounting System: Mobile and Immobile Commodities

Even though the spatial regional accounting system represents an extension of Regional Accounts, it also brings simplifications in data collection, because certain types of information already exist, which simplifies the data collection task. When introducing the concept of the marketplace for commodities, it also is useful to distinguish between mobile and immobile commodities or components of demand, in obtain to get the best estimates of regional demand and interaction. Immobility is defined as an identity between the geographical locations of production and the commodity market, whereas mobility is a situation where there may be a difference between the two. Table 1 gives an overview of these concepts and provide some examples.

Commodities are traded and transported from place of production to the marketplace for commodities and from marketplace for commodities to the place of residence of the consumer. If transport does not occur on the vertical axis (transport of commodities), immobility in the commodity trade exists, examples being different types of services or, by definition, changes in inventories. Commodities are in turn transported from the marketplace for commodities to the place of residence of the consumer (institution). This shopping activity can be either mobile (transport is involved) or non-mobile (transport is not involved). Home-based consumption such as housing or domestic services, are examples of immobility.

If there is immobility, data can only be estimated from one side. For an example, production of housing services is an immobile commodity both from a trade and a shopping point of view. Therefore, production data on the production of housing services can also be used for estimating data on the demand for housing at the place of the commodity market and the place of residence.

4. Construction of the Danish Interregional SAM

SAM-K is the interregional SAM constructed for Danish regions (Madsen *et al.*, 2001). Regions can be defined at different spatial levels, including municipalities (275), labour market areas (45) and counties (16). The spatial *two-by-two-by-two* principle described

above has been the guiding principle for the construction of SAM-K. It is, in principle, designed using the structure shown in Figure 1, being based upon the double spatial entry principle or extended regional accounts (*two-by-two-by-two*), rather than the non-spatial regional accounting principles (*two-by-two*).

The structure of SAM-K follows the basic interregional SAM (Figure 1) with: factor markets and commodity markets; demand and supply; origin (supply) and destination (demand); and incorporating some simplifications and extensions. The basic interregional SAM must be adjusted in order to take into account the nature of the statistics, data collection methods and the structure of the regional economy. On one hand, the model must be broken down and in other aspects it must be merged.

First, the concept of the marketplace for factors does not correspond in general to reality, as noted above. In practice, the place of residence of the production factor (such as labour) can be interpreted as both place of residence and marketplace for factors. Only in very few cases does a geographically defined factor market exist. From a data collection point of view, only registration of place of residence and place production is possible. Therefore, the marketplace for factors has been excluded from SAM-K.

Second, only factor income from labour receives a full treatment. In Denmark, regional data on capital income only exist by place of production. Data on interregional transfer of capital income are still lacking, which makes a comparable treatment to commuting flows involving labour income impossible and identification of the marketplace for capital income difficult to develop. Future developments with respect to treatment of savings and investments and identification of marketplaces for these could include the use of pooling methods or identification of gross flows, referred to above.

Third, there is a need to keep track of economic interactions between institutions. Interaction between households and the governmental sector is important in order to describe the economic strength of households, for example measured by disposable income of households including income transfers from government and the subtraction of taxes. From a data collection point of view, this information does not create any special problems as these payments are assigned to individuals.

Fourth, consumption by institutions (households) both from a decision-making and data collection point of view must be divided into two nested steps. First, consumption is determined at a high level of aggregation, for example food, clothing, transport etc. In the next step, the consumption bundles are further divided into specific commodities. From a decision-making point of view, both the first and second steps are a part of the household decision problem, the sellers (the retail sector) reflecting demand from the households. From a data collection point of view the two steps are also related to two data sources: (i) household expenditure surveys, which often include information at a relatively aggregate level, where household consumption is assigned to the place of residence; and (ii) the retail sector and producers (who pay specific commodity taxes) make a substantial contribution to detailed data on demand, usually through information related to the value added tax and commodity taxes. The same is the case for other types of final demand, such as governmental consumption and gross capital formation, where information is available in the marketplace for commodities.

Fifth, different price concepts are included in different accounts, reflecting the fact that different data sources use different price concepts. In the account for goods and services, total expenditures are measured in market prices. Supply of commodities entering the goods and services account is accounted for in basic prices. Basic prices are defined as

the value of production at the factory, not including net commodity taxes paid by the producer. Going from market/buyers prices to basic prices at the place of commodity market involves subtraction of commodity taxes and trade margins, where trade margins also are part of the commodity account.

Sixth, in general, the SAM is constructed using current prices. However, for data concerning production of commodities, values have been deflated to fixed prices at a low level of disaggregation, using national price data. This extension permits analysis of real changes in production over time.

In addition, there are some extensions, such as the transformation from basic prices to market prices and the transformation from institutions to commodities, which in the Danish interregional SAM is divided into two steps: from institutions to components and from components to commodities. Despite this deviation, the Danish system can be represented in a basic four-element system, as shown in Table 2.

4.1. The Basic Interregional SAM and SAM-K

Despite these conceptual deviations, the basic interregional SAM forms a useful framework to describe the data construction procedures and sources used in building SAM-K. Table 2 contains information on the dimensions of SAM-K and the procedures and content of the matrices used to build SAM-K. These cover economic activities related to production and institutions as well as the regional commodity and factor markets. The economic activities associated with production and institutions follow the conventional non-spatial format in the National Accounts. Here the information on production and institutions consists of vectors subdivided by sectors (using axis *J*) and by institutions (using axis *H*). Economic activity associated with the factor and commodity markets builds upon the spatial accounting principle.

The accounts for the factor market have the following structure: (i) the factor market has been divided into supply and demand; (ii) demand for factors of production has been transformed from sectors using axis *J* to factor groups using axis *G* and supply of factors of production has been transformed from Institutions using axis *H* to factor groups using axis *G*; and (iii) demand for factors of production has been transformed from place of production using axis *P* to place of factor markets using axis *Q* and the supply of factors has been transformed from place of residence using axis *R* to place of factor market, using axis *Q*.

Similar transformations take place in the commodity market, where the accounts for the commodity market have the following structure: (i) the commodity market has been divided into supply and demand; (ii) demand for commodities has been transformed from institutions using axis *H* to commodities using axis *I* and supply of commodities has been transformed from sectors using axis *J* to commodities using axis *I*; and (iii) the demand for commodities has been transformed from place of residence using axis *R* to place of commodity market using axis *S* and the supply of commodities has been transformed from place of production using axis *P* to place of commodity market, using axis *S*.

Items (ii) and (iii) in both markets represent collection of data in matrix rather than the vector format, which is used in the non-spatial Regional Accounts. Item (ii) represents a transformation between SAM categories and item (iii) is a geographical specification of the origin and destination of demand and supply in both markets. In the following, construction of the Danish SAM is described with reference to entering data into these

Table 2. The basic interregional SAM set up using the spatial registration system

	Matrix dimension	Bottom Up (BU)/Top Down (TD)	Type of data	Data source
Production	J (NS)	TD	National Accounts	Regional/National Accounts
Factor market				
Demand by factor group (e.g. employment or primary income)	$J \times G$ (NS)	BU	Register-based data	Merged administrative registers: Population, income and tax base registers
Destination of factor demand (e.g. commuting)	$G \times P \times Q$ (S)	BU	Register-based data	Merged administrative registers: Population, income and tax base registers
Supply by factor group (e.g. labour force or income)	$H \times G$ (NS)	BU	Register-based data	Merged administrative registers: Population, income and tax base registers
Origin of factor supply (e.g. commuting)	$G \times R \times Q$ (S)	BU	Register-based data	Merged administrative registers: Population, income and tax base registers
Institutions	H (NS)	TD	National Accounts + survey	Family expenditure survey, tourism expenditure survey
Commodity market				
Demand by commodity (e.g. intermediate consumption, private consumption)	$H \times I$ (NS)	TD	National Accounts + survey	Family Expenditure Survey, tourism expenditure survey, local government account statistics, national Use tables
Destination of commodity demand (e.g. shopping)	$I \times R \times S$ (S)	TD	Survey	National Transport Behaviour survey, tourism expenditure survey, transport cost survey, local government account statistics
Supply by commodity (e.g. production and import from abroad)	$J \times I$ (NS)	TD	National Accounts + survey	Regional/National Accounts, national Make tables
Origin of commodity supply (e.g. interregional trade)	$I \times P \times S$ (S)	TD	Survey	Trade survey, manufacturing firms

(S): spatial, (NS): Non-spatial.

vectors (non-spatial) and matrices (spatial). Full documentation of the principles used to set up the interregional SAM for Denmark is provided in Madsen *et al*. (2001)

4.2. Data on Regional Production, Incomes and Employment by Institution (Regional: Non-spatial)

Data on production by 275 municipalities and 130 sectors is provided by Statistics Denmark, following the principles set out in Eurostat (1996), and is documented in detail in Madsen *et al*. (2001: Chapter 4). Basically, the point of departure is data from the National Accounts by sector, which are used together with different sources to break down the national data to regional data. The methodologies can be divided into use of Top Down (TD) methods where the sum of the regional data is scaled to be consistent with national data and Bottom Up (BU) data where the national sum is by definition equal to the sum of the regional values. Further sources can be divided into statistics for administrative purposes and statistics from surveys (usually undertaken regularly by a government body). Finally there is the issue of whether the statistics are based on population or samples. All in all, ten different methods are used.

Data on institutions (Madsen *et al.*, 2001: Chapter 5) cover at present households and include data on earned income, income transfers, taxes, unemployment and employment, for 275 municipalities and four types of household. The sources of this data include administrative registers, which provide data on income, taxes and employment. The data is Bottom Up, with full population coverage. A central variable is disposable income (related to commodity purchase).

4.3. Data on Factor Markets (Regional: Spatial and Non-spatial)

Madsen *et al.* (2001: Chapter 5) describe these data sources in more detail. Data on production factors include labour force, income and employment. The data are Bottom Up and are obtained from administrative registers, providing data by category on: sectors, factors (distinguishing two gender types, seven age classes, five types of education, and four categories of household composition), place of production and place of factor market (residence). The matrices are filled out with data described above using bottom up principles. Demand goes from place of production to place of residence and supply goes in the reverse direction.

4.4. Data on Commodity Markets (Regional: Non-spatial)

The procedures for estimating commodity balances are described in Madsen *et al.* (2001: Chapters 6–9). First the estimation of supply (in the next section) and demand (in the section after) are described, after which total intra- and interregional trade by commodity is estimated. The geographical patterns of interregional trade flows by commodity are then determined.

For the construction of commodity balances and interregional flows the approach uses regional data on production and demand, which is combined with national assumptions on commodity composition of production and demand. The assumption relating to the national commodity composition is the reason why the approach is termed national. In the construction of the local commodity balances, including the individual components,

which enter into the commodity balance to be found in equation (1), the national commodity balance is used (the Top Down approach).

The commodity balances are determined for a number of Danish regions, typically 16 counties plus one extra artificial county, containing economic activities, which cannot easily be allocated to a geographical location (production of crude oil, maritime transport, etc). The 17 regions have been aggregated from the 275 municipalities, which is the lowest level of disaggregation possible in the Danish interregional SAM. The commodity balances at regional level are estimated for 20–30 commodities, which are aggregated from the available data on 130 commodities.

4.5. Regional Supply by Commodity (Regional: Non-spatial)

Supply of commodities consists of local production of commodities, imports of commodities from abroad and interregional commodity import. Local production of commodities is estimated using local sectoral values for gross output combined with sector-specific information on the composition of gross output by commodity (Make matrix).

$$\mathbf{q}_i^P = \mathbf{i}_j \, \mathbf{D}^{NAT} \circ \mathbf{x}^P \tag{7}$$

where $\mathbf{i}_j$ is an aggregation vector by sector j; $\mathbf{D}^{NAT}$ is gross output by commodity i as a share of gross output by sector j at the national level; and $\mathbf{x}^P$ is gross output by sector by place of production P.

The data on gross output by sector and by municipality are obtained from Statistics Denmark (described earlier). Gross output is in basic prices (by definition) and in both fixed and current prices. Data on the composition of gross output by commodity originate from the national Make matrices. The basic approach to estimation of international imports by commodity at the local level is to multiply local demand for a commodity by a (national) import share (of the aggregated local demand). Local demand is calculated as the sum of local intermediate and local final demand in basic prices. It is assumed that there is no major deviation between national and local import shares.

$$\mathbf{z}_i^{S,F} = \mathbf{z}_i^S \circ D_i^{F,NAT} \tag{8}$$

where $\mathbf{z}_i^{S,F}$ are international imports by commodity i by municipality S; $\mathbf{z}_i^S$ is local demand by commodity and by municipality; and $\mathbf{D}_i^{F,NAT}$ gives the import share by commodity at the national level.

Technically, imports are divided into imports for the domestic market and imports for re-export, the latter being smaller than the former. Estimation of interregional imports by commodity is described in the section after next.

4.6. Regional Demand by Commodity (Regional: Non-spatial)

Demand for commodities in any locality consists of local demand, foreign exports and interregional exports. Local demand, by region, by commodity and in total, is, by definition:

$$\mathbf{z}_i^S = \mathbf{u}_{i,IC}^S + \mathbf{u}_{i,CP}^S + \mathbf{u}_{i,CPR}^S + \mathbf{u}_{i,COR}^S + \mathbf{u}_{i,CO}^S + \mathbf{u}_{i,IR}^S + \mathbf{u}_{i,IL}^S \tag{9}$$

where: $\mathbf{z}_i^S$ is local demand by place of commodity market S and by commodity i; $\mathbf{u}_{i,IC}^S$ is intermediate consumption by place of commodity market and by commodity; $\mathbf{u}_{i,CP}^S$ gives private individual consumption expenditure by place of commodity market and by commodity; $\mathbf{u}_{i,CPR}^S$ is private consumption in membership organisations by place of commodity market and by commodity; $\mathbf{u}_{i,COR}^S$ is governmental individual consumption expenditure by place of commodity market and by commodity; $\mathbf{u}_{i,CO}^S$ is governmental collective consumption expenditure by place of commodity market and by commodity; $\mathbf{u}_{i,IR}^S$ is gross fixed capital formation by place of commodity market and by commodity; and $\mathbf{u}_{i,IL}^S$ gives the changes in inventories by place of commodity market and by commodity.

Intermediate consumption by commodity is calculated using information on intermediate consumption by sector and by place of production and the national Use matrix. Each element is calculated as local demand (intermediate consumption by sector and final demand by component) multiplied by a national commodity share (Use matrix).

For intermediate consumption, transformation from sector to commodity takes place in three steps. First, the demand of a sector for a commodity by place of production is given by:

$$\mathbf{U}_{IC}^P = \mathbf{B}_{IC}^{NAT} \circ \mathbf{u}_{j,IC}^P \tag{10a}$$

$$\mathbf{u}_{i,IC}^P = \mathbf{i}_j \mathbf{U}_{IC}^P \tag{10b}$$

where $\mathbf{U}_{IC}^P$ is local demand for intermediate consumption by commodity i, by sector j and by place of production P in buyers' prices; $\mathbf{B}_{IC}^{NAT}$ is intermediate consumption by commodity as share of intermediate consumption, by sector, all at national level; and $\mathbf{u}_{j,IC}^P$ is intermediate consumption by sector by place of production.

Second, intermediate consumption by place of production is transformed from place of production to place of commodity market. Third, intermediate consumption is transformed from market prices to basic prices by subtracting taxes and subsidies on products and trade margins paid by the producer:

$$\mathbf{u}_{i,IC}^{S,BP} = \mathbf{u}_{i,IC}^S - \mathbf{sipu}_{i,IC}^S - \mathbf{sigu}_{i,IC}^S - \mathbf{rmu}_{i,IC}^S - \mathbf{wmu}_{i,IC}^S \tag{11a}$$

$$\mathbf{sipu}_{i,IC}^S = \mathbf{SIPUQ}_{i,IC}^S \circ \mathbf{u}_{i,IC}^S \tag{11b}$$

where $\mathbf{u}_{i,IC}^{S,BP}$ is local demand for intermediate consumption by commodity i by place of commodity market S in basic prices (BP); $\mathbf{u}_{i,IC}^S$ is local demand for intermediate consumption by commodity by place of commodity market S in market prices; $\mathbf{sipu}_{i,IC}^S$ are commodity taxes by place of commodity market and commodity; $\mathbf{sigu}_{i,IC}^S$ are value added taxes by place of commodity market and commodity; $\mathbf{rmu}_{i,IC}^S$ are retail margins by place of commodity market and commodity; $\mathbf{wmu}_{i,IC}^S$ are wholesale margins by place of commodity market and commodity; and $\mathbf{SIPUQ}_{i,IC}^S$ are commodity taxes by place of commodity market and commodity as share of intermediate consumption.

Intermediate consumption by municipality by 130 sectors ($\mathbf{u}_{j,IC}^P$) is estimated by Statistics Denmark using their own local production data. In the estimation of regional commodity balances, the 130 sectors are aggregated, normally into 12–20 sectors. The data on aggregate commodity composition by sector, in equations (10a) and (10b), are taken from national Use tables. The number of commodities used is normally 20–30.

Shopping for intermediate consumption is estimated using transport survey data. Estimation of commodity taxes and trade margins is based upon national commodity tax rates and national shares in the case of wholesaling margins and regional shares in the case of retail margins. The corresponding calculations are made for the components of final demand.

Exports to the Rest of World are distributed as exports from localities in proportion to gross output by commodity, by place of production. The basic approach to estimation of international exports is to multiply gross output with a national export share:

$$\mathbf{z}_i^{P,F} = \mathbf{q}_i^P \circ \mathbf{B}_i^{F,NAT} \tag{12}$$

where $\mathbf{z}_i^{P,F}$ are international exports by commodity i by place of production P; and $\mathbf{B}_i^{F,NAT}$ is the share of exports in production by commodity at the national level.

The national approach in this field also relies on the assumption that location close to a border does not affect export shares. Modification of this assumption would have to be based upon survey data. Technically, exports are divided into exports produced domestically and re-exports, the latter imported from abroad. Interregional export by commodity is dealt with in the following section.

4.7. Estimation of the Regional Commodity Balances (Regional: Non-spatial)

The geographical transformation from place of production to place of commodity market follows, although the framework remains, strictly speaking, non-spatial. In Table 3 the procedures used to construct intraregional and interregional trade are presented. The numbers 1–5 in the table indicate the sequence of steps, used and the arrows show how variables are calculated from others. From the previous section, the value (1) in Table 3 shows which information has been obtained from the calculations of commodity balances using the national approach. On the basis of this information, the following procedure has been used to estimate the full trade matrix. In step 2, total supply and total demand have been calculated:

$$\mathbf{z}_i^{P,excl.O} = \mathbf{q}_i^P + \mathbf{z}_i^{S,F} \tag{13a}$$

$$\mathbf{z}_i^{S,excl.O} = \mathbf{u}_i^S + \mathbf{z}_i^{P,F} \tag{13b}$$

Table 3. Intra regional, interregional and international trade

	The region itself	Other regions	Rest of the World	Total	From other regions: Preliminary estimate
The region itself	$\mathbf{z}_i^P$ (4)	$\mathbf{z}_i^{P,O}$ (5)	$\mathbf{z}_i^{P,F}$ (1)	$\mathbf{q}_i^P$ (1)	
Other regions	$\mathbf{z}_i^{S,O}$ (5)			$\mathbf{z}_i^{P,excl.O}$ (2)	$\mathbf{Z}_i^{S,O,preliminary}$ (3)
Rest of the World	$\mathbf{z}_i^{S,F}$ (1)			$\mathbf{z}_i^{S,F}$ (1)	
Total	$\mathbf{u}_i^S$ (1)	$\mathbf{z}_i^{S,excl.O}$ (2) →	← $\mathbf{z}_i^{P,F}$ (1)		
To other regions: Preliminary estimate		$\mathbf{z}_i^{P,O,preliminary}$ (3)			

where $\mathbf{z}_i^{P,excl.O}$ is total supply, excluding interregional imports, by commodity i; and $\mathbf{z}_i^{S,excl.O}$ is total demand, excluding interregional exports, by commodity.

In step 3 total supply, excluding interregional imports, has been compared to total demand, excluding interregional exports, in order to calculate a preliminary value for interregional imports and exports by commodity:

$$\text{if } \mathbf{z}_i^{P,excl.O} > \mathbf{z}_i^{S,excl.O} \text{ then } \mathbf{z}_i^{P,O,preliminary} = \mathbf{z}_i^{P,excl.O} - \mathbf{z}_i^{S,excl.O} \tag{14a}$$

$$\text{if } \mathbf{z}_i^{P,excl.O} \leq \mathbf{z}_i^{S,excl.O} \text{ then } \mathbf{z}_i^{S,O,preliminary} = \mathbf{z}_i^{S,excl.O} - \mathbf{z}_i^{P,excl.O} \tag{14b}$$

where $\mathbf{z}_i^{P,O,preliminary}$ are interregional exports by commodity i – preliminary values; and $\mathbf{z}_i^{S,O,preliminary}$ are interregional imports by commodity – preliminary values.

In the fourth step, intra regional supply and demand have been calculated on the basis of the preliminary values of interregional import and export by commodity:

$$\mathbf{z}_i^{P,preliminary} = \mathbf{q}_i - \mathbf{z}_i^{P,F} - \mathbf{z}_i^{P,O,preliminary} \tag{15}$$

where $\mathbf{z}_i^{P,preliminary}$ is intra regional supply by commodity i – preliminary value.

In the last step, two-way trade (cross hauling) has been included in the estimation of interregional trade flows:

$$\text{if } \mathbf{z}_i^{P,O,preliminary} = 0 \text{ then } \mathbf{z}_i^{P,O} = \mathbf{z}_i^{P,O,preliminary} + \gamma \cdot \mathbf{q}_i^P \text{ and}$$
$$\mathbf{z}_i^{S,O} = \mathbf{z}_i^{S,O,preliminary} + \gamma \cdot \mathbf{q}_i^P \tag{16a}$$

$$\text{if } \mathbf{z}_i^{S,O,preliminary} = 0 \text{ then } \mathbf{z}_i^{S,O} = \mathbf{z}_i^{S,O,preliminary} + \gamma \cdot \mathbf{u}_i^S \text{ and}$$
$$\mathbf{z}_i^{P,O} = \mathbf{z}_i^{P,O,preliminary} + \gamma \cdot \mathbf{u}_i^S \tag{16b}$$

where $\mathbf{z}_i^{P,O}$ is interregional export by commodity i; γ is the cross-hauling parameter (see below); and $\mathbf{z}_i^{S,O}$ is interregional import by commodity.

The exogenous variable γ is a cross-hauling parameter that varies between groups of commodities and determines the additional interregional trade that is due to cross-hauling. Note that γ is not equal to the share of the region's production that meets its own demand, as the level of cross-hauling depends on local production and local demand, respectively. The proportion of the region's production that meets its own demand is the result of the estimation procedure. If the region is a net supplier, the additional interregional trade (cross-hauling) is calculated by multiplying local production by γ. If the region is a net demander, the local demand is multiplied by γ. In Jensen-Butler *et al.* (2004), a trade survey is used to estimate γ for seven industrial commodities.

Even though the equations for calculation of the different balances are the same for all commodities, there is also an implicit difference in the treatment of mobile and immobile commodities. Immobile commodities are characterised by the fact that local demand and local production are equal, being located in the same geographical unit. This is a definition that can be compared with tradable and non-tradable commodities. Tradable commodities are those that compete with the same or similar products from the Rest of the World. Non-tradable commodities are those that are protected from this competition, either

because of their characteristics or because of their fundamental immobility. Commodities that are non-tradable at the international level may well be tradable at lower levels of spatial aggregation. Thus, the concept of immobile commodities is narrower than non-tradable commodities. For immobile commodities, intraregional trade is equal to supply, which in turn is equal to demand. For mobile commodities, intraregional trade is calculated as follows:

$$\mathbf{z}_i^P = \mathbf{q}_i^P - \mathbf{z}_i^{P,F} - \mathbf{z}_i^{P,O} \tag{17}$$

where $\mathbf{z}_i^P$ is intra regional supply by commodity i.

Now a system has been established to estimate intraregional-, interregional and international trade flows. The distribution between intra- and inter-regional trade is determined by the share of cross-hauling in domestic trade.

4.8. Interregional Trade Flows by Commodity (Regional: Spatial)

From the procedure described in the previous section, two sets of information are obtained. First, supply for local market ($\mathbf{z}_i^P$) by commodity is calculated. In an intra- and interregional trade matrix, this information is located at the diagonal and shows the region's sales to the region itself or the region's demand for commodity produced in the region itself. Second, exports to other regions ($\mathbf{z}_i^{P,O}$) and imports from other regions ($\mathbf{z}_i^{S,O}$) have been determined. These data are the margin sum of the off-diagonal cells in the trade matrix.

On the basis of these margin sums the final step is the determination of the detailed off-diagonal data in the intra- and interregional trade matrix, in other words calculation of interregional trade flows, using the calculated totals for interregional export ($\mathbf{z}_i^{P,O}$) and imports ($\mathbf{z}_i^{S,O}$) by region and by commodity. These values are given by the procedure described in the previous section. There are different approaches to estimation of interregional trade flows. The approach used here is to employ entropy maximising procedures, including, as a special case, the linear programming solution:

$$\mathbf{z}_i^{P,S} = \mathbf{A}_i^P \cdot \mathbf{B}_i^S \cdot \mathbf{z}_i^{P,O} \cdot \mathbf{z}_i^{S,O} \cdot \mathbf{e}^{-\beta_i \mathbf{c}_i^{P,S}} \tag{18}$$

with $A_i^P = 1/\sum_S \mathbf{B}_i^S \cdot \mathbf{z}_i^{S,O} \cdot e^{-\beta_i \mathbf{c}_i^{P,S}}$ and $B_i^S = 1/\sum_P A_i^P \cdot \mathbf{z}_i^{P,O} \cdot e^{-\beta_i \mathbf{c}_i^{P,S}}$, and where: $\mathbf{z}_i^{P,S}$ is interregional trade by place of production P and place of commodity market S, by commodity i; $\mathbf{A}_i^P$, $\mathbf{B}_i^S$ are balancing factors, by commodity; $\mathbf{c}_i^{P,S}$ is transport cost for the transport of the interregional traded commodities from place of production to place of residence, by commodity; and β_i the deterrence parameter in the entropy maximising model by commodity.

The entropy maximising procedures were also used in the construction of data on interregional trade flows by sector in Denmark used in the AIDA-model (Jensen-Butler and Madsen, 1996). These entropy maximising procedures have been used in the estimation of the interregional trade flows in the present version of SAM-K. Data on interregional transport cost[3] from the Danish Department of National Roads have been used in the estimation of interregional trade. The distance deterrence parameter β varies between groups of commodities and has been estimated for a range of industrial products manufactured by Danish firms (Jensen-Butler *et al.*, 2004). The use of entropy maximising principles

involving a distance deterrence function implies that distance related transportation costs play a central role in determining the pattern of trade flows.

5. Data Quality Considerations

Regional accounting as described here uses four primary sources of data, as shown in Table 2. First, there are data obtained from register-based data sets, usually maintained and updated continuously by public authorities. Second, there are survey data of firms and households based on total enumeration. Third, there are survey data based upon sampling. Fourth, there are data, which are calculated, designed to provide data for areas not covered by the three other sources. These are often calculated using best practice modelling, where the data construction model estimates the data on the basis of limited information using National Accounts and a set of constraints, as for example for the interaction data described in the third section.

In the case of Denmark, the first source of data provides information of very high quality for a substantial part of the interregional SAM, including most of the labour market (see Table 2). Even for countries where census data (which corresponds to the second type of data) must be used in data construction, this information, often in extended form, is usually available for specific years.

Sample-based surveys, such as Family Expenditure Surveys can be regarded as reasonably reliable. If these are combined with register-based data (for example disposable income and earned income) and national totals to be found in the National Accounts, then data quality (for example for private consumption) can be further improved. This has been undertaken in the Danish case, and a similar approach is possible in countries that do not have such register-based data, using census data and the National Accounts.

The fourth type of data is constructed using models and National Accounts constraints. One example in the Danish case where this approach has been used is in establishing commodity and trade balances at the regional level. Discussion of data quality in relation to this type of data can be found in Madsen and Jensen-Butler (1999), where we conclude that in relation to the estimated values of most variables at regional and interregional levels, relative and absolute degrees of uncertainty are in general low. However, one important conclusion of this paper has since been modified empirically, namely that, in all circumstances, the highest level of disaggregation possible should be used to ensure accuracy. Normally it is assumed that this type of data modelling should be undertaken at the most disaggregated level possible (for example in terms of spatial unit, industry or commodity) and hereafter aggregated into a higher-level data set, which meets the data needs for the modelling exercise in question. However, recent research (Jensen-Butler *et al.*, 2004) indicates that this is not necessarily a general requirement. For certain types of interaction data, for example interregional rather than intraregional trade flow data, there seems to be little advantage gained from the use of a high level of disaggregation.

There are costs involved in following a disaggregated approach to data modelling, including costs of accessing the data to be used in the modelling exercise, programming, consistency checks and data processing. These costs have to be compared with the benefits that are assumed to exist, principally the assumption that better data are obtained by proceeding in this way. In the Danish case, a high level of disaggregation is used to estimate intraregional interaction, whilst a lower level of disaggregation can be used for

interregional interaction. There is no reason to assume that this finding cannot be generalised to other countries.

6. Conclusion

The paper shows that construction of interregional SAMs involves two steps to improve the Regional Accounts, as recommended by Eurostat (1996). First, the balancing procedures of the National Accounts for commodities and factors have to be transferred to the Regional Accounts. Second, procedures to construct spatial data on interaction in the regional economy should also be included in the data-building process. Both improvements build on the novel geographical concepts – place of production, place of residence, place of commodity market and place of factor market – identified in the paper. The concrete procedures used to set up a Regional Account with a spatial dimension for Denmark have been presented.

The Danish interregional SAM has used the spatial *two-by-two-by-two* accounting methods described above. Even though the construction of the spatial interregional SAM appears to be an major undertaking, the Danish example shows that introducing an extension of the conventional non-spatial to spatial accounting methods is not unrealistic, if suitable and reasonable limitations are accepted, such as is the case with the treatment of capital income. Even for countries with limited data, it is possible to set up a spatial SAM based on an explicit spatial dimension.

Notes

1. 'Spatial' includes both regional and local levels, corresponding to the *inter* and *intra* regional levels. The regional level typically involves trade and tourism, but when incorporating shopping and commuting, it is necessary to construct accounts at the local (sub-regional) level.
2. The commodity balance system is set up in basic prices, where supply equals demand in basic prices. However, the commodity balance also contains information on components of demand and demand in both basic prices and market prices, including data on trade margins and commodity taxes. Therefore, the demand side is estimated in two steps. First, demand is converted from components to commodities, and in the second step, market prices are transformed to basic prices. The commodity balance is estimated in both fixed and current prices, as both supply and demand are in both fixed and current prices.
3. In order to avoid values in the diagonal, the intraregional transport cost is set at a very high level (in principle infinite).

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Queries

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No queries