Simultaneous Supply - Demand Model - An Update of the Model

Description

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No. 5

SIMULTANEOUS SUPPLY - DEMAND MODEL
an update of the model description

Restricted

Jakarta, June 1995

Regional Economic Analysis for Regional Investment Planning Project (TAP4I/NEI)
Badan Perencanaan Pembangunan Nasional (BAPPENAS)
PREFACE

The Regional Economic Analysis for Regional Investment Planning Project (TAP4I/NEI) is attached to Deputy V of BAPPENAS. It is funded by the PMU-TAP 41 Loan Number 3385 IND for Public and Private Provision of Infrastructure and executed by the Netherlands Economic Institute. The project is aimed at strengthening the regional planning capabilities of BAPPENAS in general and Deputy V in particular. During this Addendum period the project activities focuses on the transfer and training of the members of the Research Development Planning Unit (RDPU) within Deputy V of BAPPENAS.

This training and transfer consist of training on the job and classroom sessions. The contents of these classroom sessions are regularly presented in the Transfer Memorandum Series.

This fifth memorandum of this series issues a model description of the Regional Simultaneous Supply Demand Model (SSD-Model). We hope it may give a useful insight in the way regional economic projections can be build and how regional economic planning in Indonesia can be integrated into a larger national and sectoral planning context. This memorandum provides an update and extension of the model description written by Mr. Dirk Stelder in an earlier phase of the project. Mr. Albert W. de Groot prepared this memorandum, but received valuable comments and suggestions from the staff of the RDPU in BAPPENAS.
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1. Introduction

The present Simultaneous Supply Demand Model (SSD-Model) model was developed by the project team in 1992. Its name stems from the intention to have an interregional model developed that takes account of both demand and supply elements. This model is an extension of its predecessor the MRIOF-Model which was fully demand oriented.

The main reason for building a new model version was the need for a more advanced regional forecasting system that is consistent with national macro and sectoral projections produced by other departments in BAPPENAS. For the Repelita VI and PJPII planning periods the goal of achieving a maximum of consistency between different levels of planning has been given a high political priority. Since there is no central integrated economic planning/forecasting model available yet, each planning level has to "iterate" with the other levels in order to fine tune with each other. The structure of the SSD-Model enables inputs from other levels as given constraints, but it can also produce non-constrained endogenous output for those levels. In other words, the SSD-Model can be used "bottom-up," "top-down" or as a combination of both.

This model description has the following structure. First, in section 2 the basic structure of an interregional input output model is given. Next, in section 3 the basic equations for the demand side will be discussed. The supply side is presented in section 4, followed by a description in section 5 of the way in which labor market variables are incorporated. Finally, in section 6 the solving of the model and the integration of constraints from the macro, regional and sectoral level will be discussed. A technical manual that describes how to run the SSD-Model on the computer has been published earlier as a separate document1.

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1 Regional Economic Development Planning in Indonesia; An integrated Modeling Approach for REP ELITA VI and PJP II, Part III, SSD-Model Manual, DSP II, 1993
2. Global structure of the SSD-Model

The SSD-Model is built on the Multi-Regional Input-Output Table (MRIOT) for Indonesia. Such a table has been constructed for 1990 by the project team and for 1980 and 1985 by the predecessor of this project. These tables show interregional interindustry relations for intermediate and final demand for 25 industries, 27 provinces, and 5 final demand categories (see figure 1a and 1b).

with

\[ r = \text{region of origin (27)} \]
\[ s = \text{region of destination (27)} \]
\[ i = \text{sector of origin (25)} \]
\[ j = \text{sector of destination (25)} \]
\[ k = \text{final demand category (5)} \]

Figure 1a: Structure of Intermediate Demand in MRIOT-Table
Although the base table has been constructed for the year 1990 more recent information is incorporated in the SSD-Model. The SSD-Model has some updating mechanisms that can reduce forecasting errors caused by outdated i-o data. This will be discussed in more detail in section 3.

The main advantage of a full interregional model is that interregional trade and interindustry linkages can be calculated throughout the economy. If, for example, construction in Aceh will grow due to an investment impulse in that region the model can show its effect on the construction materials industry in Sumatera Utara. Earlier studies with this model have shown the dominant position of Java regions in the capital goods sectors leading to a substantial import "leakage" of off-Java investment projects back to Java.

A second distinctive feature of a full interregional model is that the sectoral results for all provinces can be added to their national total because the model covers the whole national economy. This enables consistency checks with national macro and sectoral projections that might be available from other sources. In this way an interregional i-o model can be useful as an integrated part of a more general national economic planning or forecasting model.

As is mentioned before there is not a fully developed BAPPENAS model available yet that covers the macro, sectoral, regional and urban level in one integrated economic planning framework. Therefore, for the time being the current version of the SSD-Model is
constructed in such a way that interaction and/or iteration with other planning departments is as flexible as possible. The main purpose of the SSD-Model is to get adequate regional economic projections of GDP and employment which are consistent with economic planning targets at all relevant levels (see figure 2).

Figure 2: Structure of the SSD-Model

Going from left to right in figure 2, the first basic step of a demand driven i-o model is given with the calculation of GRDP growth rates by sector and region from final demand growth rates by regions, sectors and final demand categories. Next, these GRDP growth leads to employment growth by using employment elasticities. Feedback mechanisms are shown in the lower part of this figure. The GRDP feeds back to final demand, as some parts of final demand are endogenously determined. Finally, at the top and at the bottom of this figure constraints from the national and regional level are applied on model input and outcomes.

The feedback mechanisms from GDP directly to consumption and government finance are
extensions of the demand side and will be discussed together with the basic demand driven i-o growth rate model in section 3. The feedback link between GDP and investment is the core of the supply model and will be presented separately in section 4. Section 5 is devoted to role of the labor market and related topics as population and participation, while section 6 focuses on the solving of the model with a supply and a demand block.
3. The demand side: an i-o growth rate model

Because of its constant coefficients basic IO models are less suitable for forecasting applications when final demand developments of the total economy need to be estimated over longer periods of time. From 1960 onwards these kinds of input output applications were experimented with at the national level by Gosh (1964), Theil (1966), Polenske (1970), Ehret (1970) and others, but they have been gradually replaced by econometrics time-series techniques.

At the regional level the possibilities of building econometrics models based on time series remain most of the time very limited because of the unavailability of the necessary data. When the time-series data are scarce it can still be better to use input-output models that give a detailed picture of the regional economy at one moment of time rather than to rely on poorly estimated econometrics models that do not use the input-output information. This might be one of the reasons why input-output analysis continues to be a standard tools of regional analysis (Hewings & Jensen, 1988). Furthermore, especially in regional analysis a substantial amount of research has recently emerged that is aimed at an integration of input-output, econometrics and general equilibrium techniques in order to achieve a satisfying modeling of both demand and supply variables and changing technology (see Madden & Anselin, 1990).

3.1. The input-output growth rate approach

Because input-output forecasts of absolute productions levels made with absolute levels of exogenous final demand become unreliable when the forecasting is done over 5 years or more, a more fruitful approach is to look only at the change of production resulting from a change of final demand without worrying about the errors of the absolute levels themselves. This seminal analysis of input-output forecasting errors carried out by Theil (1966) found the interesting result that under certain conditions input output forecasting errors can be subtracted from one another.

If for instance:

\[ \bar{x}_t = (I - A_0)^{-1} f_t \]  

(1)

with:

- \( \bar{x}_t \) = predicted output in year \( t \)
- \( f_t \) = exogenous final demand in year \( t \)
- \( A_0 \) = matrix of input coefficients in year \( t_0 < t \)

In the equations in this memorandum capital letters represent matrices, while small letters show vectors.
Forecasting errors $e(x_t)$ can be approximated by the sum of all year-to-year forecasts over the period $t_0 \rightarrow t$. This means that the errors of two forecasts $e(x_{t_0})$ and $e(x_t)$ can be subtracted from each other so that the errors over the period $t_0 \rightarrow t$ are eliminated. A forecast of production growth over for example the period 1993-1994 then only has an error level of a one-year-ahead input-output forecast, even when an input-output table of 1990 is used.

Using "*" and "/" for cell-to-cell multiplication and division we will define any growth rate like $x_t / x_{t-1}$ as $x_t$. A basic i-o growth model for any projection period $t=1,...,n$ is given by:

\[
\begin{align*}
F_t &= F_{t-1} \ast F_t, \\
f_t &= F_t \ast i, \\
x_t &= (I-A)^{-1} \ast f_t, \\
x_t &= x_t / x_{t-1}, \\
y_t &= v \ast x_t
\end{align*}
\]

with

- $F$ = matrix of final demand (one column for each final demand category)
- $f$ = vector of final demand (row sum of matrix $F$)
- $x$ = output
- $y$ = GDP
- $v$ = GDP/output ratio
- $i$ = vector with ones ("1") of the appropriate size

Figure 3a gives an illustration of this basic i-o growth rate approach. Figure 3b shows the structure of the interregional final demand matrix with the growth rates of the five final

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See Stelit (1991) for more details.

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demand categories:

- $c_p$ = private consumption
- $c_g$ = government consumption
- $i_g$ = government investment
- $i_p$ = private investment
- $x$ = foreign exports (goods and services)

Figure 3a: Basic structure of an Interregional Input-Output Growth Model

Each row of $F_i$ in Figure 3b has a width of $(S*r)$ columns which means that consumption, etc. can be specified for each region of destination. Each of its columns has a length of $(i*r)$ giving the opportunity to the user to assume different growth rates for each industry of origin and each region of origin.

If all these growth rates can be specified the model is 100% bottom-up: sectors and regions are given individually and there is no need to distribute national, regional or sectoral aggregates over some row or column of $F_i$. 
Figure 3b: Final Demand Growth Rates

Of course such a situation never occurs. In practice many entries of the $F_i$ matrix need to be assumed equal over rows and/or columns. The most extreme case of a 100% top-down implementation would be an $F_i$ matrix with only five specific national macro growth rates for each final demand category equally applied to all sectors and regions of origin and destination. In such a case all entries of the block $c_p$ in figure 3b would be for example 5%, in $c_p$ 4% etc. In most SSD-Model implementations for Repelita VI for instance, the entries of $F_i$ are specified by sector of origin and region of destination but not by region of origin.

The i-o growth rate specification given in (2)-(6) has two important advantages. First, more recent GDP data than the table construction year $t_0$ can be used (GDP data are usually available for more recent years than i-o tables). This enables us to calculate aggregate growth rates $\gamma_{agg}$ by weighing $\gamma_i$ not with the forecasted $\gamma_i$ itself (which as mentioned can suffer from substantial forecasting errors) but with some exogenous weighing vector.

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4 In fact the full 100% top-down case is represented by one and the same entry throughout matrix $F$, for example a national growth of 5% for all final demand categories. This, however, is a meaningless implementation because it would produce the same growth for each sector in each region.


Second, since the absolute levels of $y_t$ do not need to predict the actual level of GDP in year $t$, there is no need to restrict final demand structure $F_0$ to the year $t=0$. $F_0$ can be updated with all recent information that is available as long as the updated $F_0'$ gives a better description of the final demand structure at the beginning of the forecasting period. For example, the $F_0$ from 1990 can be updated with national final demand totals for 1994, regional final demand totals for 1993, and a regional/sectoral specific export structure of 1992. In doing so, the growth rates of final demand in $F_0'$ will get a more appropriate weight than they would have had with the old original $F_0$ from 1990.

Using such an updated $F_0'$ will of course produce endogenous levels of $y_t$ that have no empirical meaning anymore because they no longer refer to any specific year (1990, 1991 or 1992). Again, that does not matter because it is $y_t$ that counts.

Because model (2)-(6) is based on the MRIO-Table for Indonesia 1990 each matrix is of the size $(i \times r)$ where $i$ is the number of industries and $r$ is the number of regions.

The matrix $F_0$ can be used fully exogenous but in the implementation of the SSD-Model for Indonesia its major part is endogenously determined. As is shown in figure 2 the SSD-Model has feedback links between GDP growth $y_t$ and household consumption, government expenditures and private investment. The first two links are basically an extension of the demand block and will be discussed in section 3.2 and 3.3. The investment link serves as a supply constraint on the demand block and will be presented in section 4.
3.2. Endogenous household consumption

In most input-output implementations household consumption is either considered exogenous as a component of final demand or made endogenous by closing the \((I-A)^{-1}\) matrix for household income and expenditure. The latter solution can be straightforward with proportional consumption coefficients or with income elasticities (see LTA97, 1991). Such extensions of the \(A\) matrix, however, assume additional constant coefficients and are therefore more suitable for short-term applications. In our case, a different approach is chosen which is more suitable for long-term projections. The following extension of (2)-(6) is made:

\[
\begin{align*}
\mathbf{C}_p &= (r^*i) \text{ matrix of household consumption, transformation of vector } c_p \\
p &= (r^*1) \text{ vector of regional population} \\
Q &= (r^*i) \text{ matrix of regional and sectoral consumption elasticities} \\
y^r &= (r^*1) \text{ vector of total regional GDP}
\end{align*}
\]

The entries \(q_{ir}\) represent industry-specific elasticities for each province, indicating the relation between regional consumption growth of good \(i\) and regional growth of GDP per capita.

The time lag in (7) enables a dynamic solution of the model: total consumption growth is determined by population growth and the growth of GDP per capita in the previous period multiplied by consumption elasticities \(Q\). The advantages of this method are twofold. First, over a longer period of time changing consumption patterns due to rising incomes can be taken into account. During the projection period a substantial shift from demand for food crops to manufactured goods is expected, due to the gradual transition of the large subsistence income groups to a middle class. Second, over longer periods the impact of population growth can be noticed.

These estimation of these elasticities, based on Susenas data, is described in Research Memorandum Series, No 7, "The Multi-Region Input-Output Table of Indonesia. Construction, Description and Analysis," BAPPENAS, TAP-NMEL.
3.3. Endogenous government expenditures

While in standard input-output applications the government expenditures are usually treated exogenously, the SSD-Model has a separate sub model for the government budget and government expenditures. Government development expenditures result as the government revenues are larger than the routine expenditures. The government revenues are modeled in the following way:

\[ g_i = f_a + m_i + d_i + i_i \]  \hspace{1cm} (8)

\[ f_a = f_{a,1} \times f_{a, i} \]  \hspace{1cm} (9)

\[ m_i = m_{i,1} \times y_{migas} \]  \hspace{1cm} (10)

\[ d_i = d_{i,1} \times y_i \times t_i \]  \hspace{1cm} (11)

\[ i_i = i_{i,1} \times c_i \times t_i \]  \hspace{1cm} (12)

with

- \( g_i \) = government revenues
- \( f_a \) = foreign aid
- \( m_i \) = migas revenues
- \( d_i \) = direct taxes revenues
- \( i_i \) = indirect taxes revenues
- \( y_i \) = total national GDP
- \( y_{migas} \) = total national migas GDP
- \( c_i \) = total national household consumption
- \( t_i^d \) = direct tax rate
- \( t_i^f \) = indirect tax rate

The expected growth of the two tax rates \( t_i^d \) and \( t_i^f \), and of foreign aid, \( f_{a,i} \), are the exogenous variables for (8)-(12). The non-foreign aid revenues are endogenously determined by the growth of (migas)-GDP and household consumption (see equation (10)-(12)).
The government expenditures are modeled as follows:

\[ g_{et} = g_{e1} \]  

(13)

\[ re_{t} = dp_{t} + w_{t} + o_{t} \]  

(14)

\[ dp_{t} = (\alpha + \beta) d_{t-1} \]  

(15)

\[ d_{t} = d_{t-1} - \beta d_{t-1} + \delta f_{a} \]  

(16)

\[ w_{t} = w_{t-1} + \gamma_{n}^{w} \]  

(17)

\[ o_{t} = o_{t-1} + \gamma_{n}^{o} \]  

(18)

\[ de_{t} = ge_{t} - re_{t} \]  

(19)

with:

- \( ge \) = total government expenditures
- \( re \) = routine expenditures
- \( de \) = development expenditures
- \( dp \) = debt payments
- \( d \) = total government debt
- \( \alpha \) = interest rate on government debt
- \( \beta \) = amortization rate of government debt
- \( \delta \) = debt rate of foreign aid
- \( w \) = wages and salaries
- \( o \) = other routine expenditures

Equation (19) assumes a balanced budget constraint for total government expenditures. The routine expenditures are determined by (14)-(18) which implies that the development expenditures can be calculated as a residual. The rates \( \alpha, \beta, \delta \) are exogenous and determine the debt payments in (15) and (16). For government wages (w) and other routine expenditures (o) the simple assumption is chosen that they grow proportionally with \( y_{n}^{n} \).

The feedback links from the government block to the final demand growth as presented in Figure 2 are implemented as a national budget constraint for total national government consumption and government investment. Based on this government block the initial exogenous values of the vectors \( \xi_{p} \) and \( \zeta_{p} \) are readjusted in order to match with the aggregate national consumption and investment growth from this block, respectively.
Note that this is different from the endogenous treatment of household consumption. In (7) each entry of $c_p$ is determined, while for government consumption and investment the column structure of the initial $c_s$ and $i_s$ is not changed. In various implementations these initial values have been used of $i_s$ have been used to simulate regional redistribution scenarios of government investments.

The government block also proved to be useful in analyzing the effect of a change in one of the budget variables on regional development. For example, new estimates of the expected amount of foreign aid resulted in adjustments in the development budget projections and their effect on GDP growth.
4. The supply side: endogenous investment

In principle the i-o demand side can be extended with a supply equation for each individual regional industry. As is common practice in CGE models one could specify regional/sectoral production functions with capital and labor as the obvious variables. The CGE approach, however, has not been adopted here due to various practical and theoretical reasons.

First, the size of the SSD-Model is much too big to even think of anything like production functions for each individual regional sector. Because of the need to produce results for 27 provinces at a sectoral level of at least 10 sectors in order to get some policy relevant projections for Repelita VI and PJP II the dimensions of the Leontief matrix come close to 300 by 300. Adding another 300 production functions would make the model too big and too complex to handle given the present staffing and equipment. Second, regional time series data are not available to estimate these production functions. Finally, the CGE approach needs to match supply and demand with regional prices for which again the data are not available. The solution chosen in the SSD-Model is much more straightforward and simple. For each region the aggregate macro investment needed to achieve GDP growth as it results from the demand block is estimated given the current capital stock with the following equations:

\[
y_r' = \alpha_r + \beta_r k_r' \\
k_r' = k_r' / k_{r-1} \\
k_r' = (1-\delta) k_{r-1} + i_{r-1} + i_r'
\]

with

- \( y_r' \) = total macro GDP in region \( r \)
- \( \alpha_r \) = regional constant term
- \( \beta_r \) = regional capital stock parameter
- \( k_r' \) = total macro capital stock in region \( r \)
- \( \delta \) = depreciation rate capital stock

---

6 See Behrman et al. (1989) for national experiments in Indonesia. Other examples are Robinson & Roland-Holst (1988) and Higgs et al. (1988). Dervis et al. (1982) still may serve as a good handbook on CGE models.
\[ i_r^p = \text{total private investment in region } r \]
\[ i_r^g = \text{total government investment in region } r \]

Equation (19) is a simplified Cobb-Douglas function in which the usual variable labor is replaced by a constant term \( \alpha \). This \( \alpha \) is used as a general indicator of technical progress or relative productivity in each region which of course is determined by many interacting factors such as labor productivity, general level of education, the current state of infrastructure, etc. Due to the relative abundance of labor in Indonesia, labor \( (\lambda) \) as a production factor is not taken as a quantitative variable as for example:

\[ y_r' = \alpha_r + \lambda_r f_r + \beta_r k_r' \]  \hspace{1cm} (19a)

but of course the term \( \lambda_r f_r \) should be part of (19) as soon as labor becomes less abundant.

Unfortunately, there are no data available yet on regional capital stock or on regional depreciation rates in (21). Therefore, for the SSD-Model some own estimates had to be made. First, a depreciation rate \( \delta \) is assumed to be the same for all regions. Second, the initial capital stock for the first year of the projection period is calculated as a factor \( \kappa \), times GDP in \( t_0 \):

\[ k_{10} = (\kappa) y_{10}' \]  \hspace{1cm} (22)

A national average of 2.0 for \( \kappa \) was taken as a starting point being consistent with estimates from other Indonesian sources. The SSD-Model has been calibrated through experimenting with various values of \( \alpha \), \( \delta \), \( \kappa \), and \( \delta \) in order to get a realistic growth rate for the capital stock by region. We assume that this growth rate is roughly the same as GDP growth rate in the latest available year, given the values of \( y_r \), \( i_r^p \) and \( i_r^g \) for this year:

\[ k_{10} = y_{10}' \]  \hspace{1cm} (23)

As expected, the values of \( \kappa \), \( \alpha \) and \( \delta \) turned out to be higher for Jawa than for the off-Jawa regions indicating a higher capital stock/GDP ratio, a higher overall labor

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productivity and a low ICOR for Jawa compared with the rest of Indonesia.

Due to the lack of data it was only possible to fully calibrate the model in the small version of the SSD-Model with only 5 regions. For the larger version with all 27 provinces the supply side had to be simplified into a simple direct relation between GDP growth and investment growth similar to the ICOR approach:

\[
\gamma_r = \gamma_r \left( \frac{I_r}{Y_r} \right),
\]

(19b)

with

\[
\gamma_r = \text{regional GDP/investment elasticity}
\]

\[
i_r = I_r + I_{gov, \text{in region } r}
\]

private investment in region \( r \).

With this type of supply function the \( \gamma_r \) parameters indicate whether the total regional investment/GDP ratio will go up (\( \gamma_r < 1 \)) or down (\( \gamma_r > 1 \) ). In a regional development scenario with (19b) one can make simulations of for instance an extra infrastructure investment in a less developed region \( s \), giving not only \( \gamma_s \) a value less than 1 but also with \( \gamma_r < \gamma_r \) for \( r \neq s \).

Note that both alternatives (19) and (19b) assume a relation between regional GDP growth and total regional investment, but it need to be reminded that it is only the private regional investment that the endogenous variable in the supply block. The government investment is determined on the demand side. Since a time lag of one period is taken into account, government investment is given for period \( t - 1 \).

\[\text{Of course the role of the Migas sector has been explicitly taken into account in the calibration process. The estimates of total capital stock with } K_n \text{ has been done using total GDP, but in (19) non-migas GDP is used.}\]
5. **The labor market**

On the labor market matching takes place of the labor supply on one side and the labor demand or employment on the other side. On the demand side, labor productivity growth rates can be specified straightforward by sector and region of origin. However, many recent productivity studies for Indonesia have shown difficulties of getting reliable estimates of labor productivity growth even at the national level. The SSD-Model is using own estimation results of labor elasticities as a starting point at the provincial level for 11 sectors. These elasticities are based on past employment/GDP relations by sector and by region.

Equation (27) gives the basic relation between production and employment.

\[ m_t = a_t \cdot y_t \]  

(24)

with

\[ m = (i*r)^m \]  

vector of employment

\[ a = (i*r)^a \]  

vector of employment elasticities

During the preparations for Repelita VI there have been many discussions on the supposed adjustments in the values of the employment elasticities in the future, since these elasticities have a decisive impact on the (un)employment outcomes of every projection. Dramatic increases in productivity are assumed for the coming 25 years, to cope with the high and rising GDP growth rates and the reducing labor supply growth. Such hikes in productivity does not seem to be unreasonable given the high level of underemployment and hidden unemployment at present.

Projections for the population growth and the participation rates are not calculated within the SSD-Model but have been provided by other agencies and are therefore exogenous to the model. Labor supply growth results from regional population growth and participation rates.

\[ s_t = r_t \cdot s_t \]  

(25)

with

\[ s = \text{labor supply} \]

\[ r = \text{rate of labor participation} \]

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8 See "Regional Economic Projections from the SSD-Model, the regional scenario R2", Research Memorandum Series, No. 3, BAPPENAS, TANUNEL, 1994.
p = population

Participation rates may change first due to changes in age structure of the population. Within specific age groups also changes may occur in anticipation of shifts in income and employment opportunities. The most recent estimates include some adjustment in regional participation rates per age cohort for labor supply after Repelita VI. Provincial differences between labor supply and demand give some indication of the direction of future interregional migration flows.

In short, at the moment labor demand results from GDP growth and labor productivity growth by sector and region, while labor supply is fully exogenous in the SSD-Model. Only the feedback link from population to household consumption is implemented through equation (7) (see also figure 2).

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9 See "Employment Based Population Projections for Provinces in Indonesia" by Peter Cardiner in support of the Operationalization of SNPTM, with assistance from UNDP/UNCHS, February 1995.
6. Solving of the model and exogenous constraints

The technique used to solve the SSD-Model is a system of non-linear equations consisting of a demand block (section 3) and a supply block (section 4). The technical details are described in a manual on the SSD-Model10. For each projection year the model tries to find a combination of regional GDP and regional investment growth rates that matches both the demand and the supply block. As the household sector and the government are endogenized with a time lag, GDP growth in the demand block can be solved for year t if the export growth and the private investment growth are given. Since the export growth is exogenous, the two vectors in the demand block that remain to be solved simultaneously are the GDP growth and the private investment growth. The supply side also provides a relation between GDP growth and the private investment growth.

As a result, a non-linear system of $2r$ equations need to be solved in order to find the $(1*r)$ vectors of private investment and GDP growth. Non-linearity stems from the fact that the direct relation between private investment and GDP growth in the demand block is constrained at various levels.

All constraints are represented by exogenous values. First, the matrix $F_i$ can be adjusted to exogenous aggregate growth of final expenditure totals, either at the regional level, at the national level or both. Most of the time, these constraints have only partly been used. If all constraints are fully specified the supply block would become redundant, as the investment growth of the government and the private sector would be given. The chief constraint on the final demand is a restriction on national exports, in order to keep exports consistent with some national growth rate estimated by other agencies.

Second, the $(i*r)$ vector of GDP growth rates can be adjusted at the macro-regional and macro-national level. These constraints may give an overall macro GDP growth target or some macro GDP growth rates for specific economic sectors. The regional and sectoral GDP results are reweighed to some national macro or sectoral total growth rate within which the regional projection has to stay. Projections that use these constraints are primarily aimed at providing an adequate forecast of the regional deviations from the national growth path, instead of predicting the regional growth itself.

National restrictions on final demand and GDP, without any regional restrictions imply a complete "top-down" application: a national macro or sectoral scenario can be evaluated on its regional distribution effects.

If the model is not constrained in any way it becomes a full "bottom-up" model: national projections by sector and regional and macro totals are all achieved from unconstrained entries of final demand and GDP growth rates. Due to its complete interregional structure

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all regional sectors add to the national sectors and all regions add to the national economy. In such an application a possible regional scenario may be evaluated on its macro and sectoral performance.

A set of regional restrictions on GDP growth and final demand represent the intermediate case: national results are achieved bottom-up from regional totals, but the regional projections by sector are restricted top-down from the regional totals.

A combination of "top-down" and "bottom-up" will likely be the usual case. Some national and/or sectoral targets can be combined with some region distribution targets. The SSD-Model may then work as a check on the consistency of all targets. If for example national investment is fixed the SSD-Model might fail to find a regional distribution of investment that meets the regional targets. An SSD-Model simulation might also indicate that a national priority for growth of some specific industries will not be consistent with regional distribution targets.

Restrictions may also work as a check on the consistency of different exogenous constraints produced by different planning agencies. If national and/or regional planning targets are combined with regional distribution targets the model works as a check on the consistency of all targets. If, for example the national investment growth is fixed, the model might fail to find a regional distribution of investment that meets the regional targets. Other model simulations may indicate that a national priority for growth of some specific industries is not consistent with strategies of regional development.
References


