3 SSDM: A SIMULATION MODEL FOR INDONESIA

3.1 Introduction

In 1992 I joined a team of regional economic consultants of the Netherlands Economic Institute (NEI) in a project at the Central Planning Bureau of Indonesia BAPPENAS. One of our main tasks was to set up a regional economic model for Indonesia that would be able to simulate various set-ups of the, at the time upcoming 6th 5-year plan REPELITA VI (1994-1999) and the 2nd 25-year plan PJPII (1994-2019). One of the similarities with the ISAM model described in the previous chapter was that we had an integrated interregional i-o table at our disposal at the provincial level, but there were important differences in the institutional research setting that required a different type of model. The first obvious difference was scale and diversity: instead of three tiny Dutch provinces with a total population of 1.5 million, highly industrialized, growing at a rate of 1 to 2%, and with a hardly noticeable below-average GDP per capita, we now had to model an economy of 190 million people with a GDP growth of (at the time) 6% or more, covering 27 regions of which some are larger than a country like France, with dramatic differences in economic structure and stage of industrial development. Secondly, the questions to be answered were much more orientated to long-term policy simulation instead of short-term forecasting. This obviously meant more emphasis on investment, technological change and supply-side factors. Finally, there was the desire to use the model as a consistency check on all kinds of government investment plans that were being developed at many different national and regional levels. Many regional policy scenarios had to be made consistent with macro-economic targets and vice versa, which meant that many simulations were carried out in two directions:

1) national top-down: an evaluation of projected national macro scenarios on their regional distribution performance
2) regional bottom-up: an evaluation of projected regional policy scenarios on their macro performance.

As we have seen, an interregional input-output model can be very valuable in consistently analysing production and employment scenarios at detailed industrial and regional levels. The incorporation of structural change and long-term horizons, however, is of course much more problematic. In the next sections I will present the various model versions used and the way the problems mentioned were tackled.

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13 An earlier version of this chapter was published in Stelder (1995b).
14 This project, coded at BAPPENAS as LTA97, has been active in Jakarta from 1987 until 1993. It was originally financed by Dutch development aid and later by the World Bank. In its last year of existence 1993 it was financed by USA development aid and put under the Development Studies Project (DSPII), also at BAPPENAS. More documentation is given in Van der Windt et.al. (1992).
3.2 Background and model history

There is probably no country in the world where the regional dimension in economic development and planning is as important as it is in Indonesia. The Indonesian archipelago contains 13,677 islands spread over an east-west horizon of 5120 kilometres (see Figure 3.1). Population and economic activity is spread very unevenly with a concentration of 60% of the total population on the island of Jawa, which covers only 6% of the geographical area. The GDP share of Jawa has been rising to 57% during the first 25 year development plan PJP I (1968-1993) and there has been an ongoing political concern about the joint occurrence of rapid GDP growth on the one hand and regional concentration on the other. Indeed, from REPELITA I to REPELITA V the regional policy planning targets have become increasingly specific and ambitious. Large transmigration programs have been set up during the 1970's and 1980's intending to move over a million people from Jawa to other islands but their implementation has hampered due to the lack of sound economic opportunities for the migrants. In the 1990's there has been a shift to a more economic approach aimed at regional investment programs to create local economic growth and job opportunities in order to counter migration flows to Jawa. In particular, REPELITA VI specifically mentioned an increase of the non-Jawa GDP share as a policy target in the longer run.

Figure 3.1 Indonesia by 27 provinces and 5 main regions (1993)
Model history

The Regional Planning Department of BAPPENAS has had a great interest in interregional input-output analysis ever since the start of the 5th five-year plan REPELITA V in 1989. Financed by Dutch development aid, a team of experts had been working in BAPPENAS on a large database of regional economic data and input-output tables since 1987. Interregional input-output tables and models were constructed at various levels of aggregation of the 27 provinces for 1980 and 1985 based on the national input-output table, the system of regional accounts and numerous other data on domestic and foreign trade, inter-island shipping, road and rail transportation, regional income statistics, local government spending etc. For 1985 a full interregional Isard-type table was constructed for 25 industries and 27 regions (Stelder et al., 1992a). This table with over half a million entries is probably one of the largest Isard-type tables in the world. An updated table for 1990 was completed in 1994.

The table has been aggregated into many different formats related to specific implementation needs. In most cases an aggregation was made with one specific province and some of its direct neighbouring provinces as separate regions, and all other provinces aggregated into one region called the Rest of Indonesia. Sometimes such an aggregated table could be released on special request to local agencies such as the Regional Bureaus of Planning and Development (BAPPEDA) or local universities.

Its main applications have been studies of regional structure and interregional interdependence. In 1990 and 1991 several model exercises were carried out in order to assess the regional impact of regional investment programs implemented during the earlier five year plans and some future prospects of regional development (LTA97, 1990; LTA97, 1991a-c). Many results showed the dominant position of the Jawa regions due to substantial import leakages of off-Jawa investment projects back to Jawa. As a follow-up of these quite straightforward impact studies, a Multi Regional Input-Output Forecasting model (MROI) was developed by the team in 1992 (Stelder et al., 1992b) in order to simulate some first preliminary regional development scenario’s for REPELITA VI and the second long term development plan PJP II. In MROI a demand-driven regional input-output approach for 5 main regions and 11 industries was combined with a macro supply block at the national level.

Soon the need was felt to simulate regional investment programs at the more detailed policy implementation level of the 27 provinces using a more bottom-up approach in which specific regional supply constraints could be taken into account. In doing so, the regional scenarios should indicate local bottlenecks for national planning targets giving feedback to the national level and indicating the need for possible readjustments of national priorities. Furthermore, as the deadline of the presentation of the final version of REPELITA VI came closer, a more practical but related issue was the growing need of getting the regional planning scenarios consistent with those that were being prepared by other government agencies on related topics as national macro economics, foreign trade priorities, industrial development, urban planning, labour market policies etc. Indeed, for the upcoming REPELITA VI and PJP II planning periods the goal of
achieving a maximum of consistency between different levels of planning was given a high political priority. Since elaborate consultations between all policy levels is one of the main characteristics of Indonesian economic planning, there is no strong planning coordination centre and each planning level has to "iterate" many times with the other levels in order to fine tune with one another. The separate models used at each planning level therefore needed to share a minimum of common characteristics such as identical coding of export categories, industry aggregating levels, time horizons, using the same basic data on population, GDP etc.

The result was the Simultaneous Supply Demand Model (SSDM) model as a follow-up of MRIOF. Its name stems from the intention to have an interregional model available that takes account of both demand and supply elements and interacts simultaneously with other planning levels. During the preparations for REPELITA VI in 1993, SSDM has been operational in close contact with projections made at the BAPPENAS departments for national macroeconomics, industrial policy, labour market policy and urban planning. As will become clear in the next sections, the structure of SSDM enables inputs from other levels to function as given constraints, but it can also produce non-constrained endogenous output for those levels. In other words, SSDM can be used bottom-up, top-down or as a combination of both.

In section 3.3 the general structure of the model is given. The specific model features are discussed in subsequent sections. The closing of the demand side for household consumption will be discussed in section 3.4. Section 3.5 describes the government block where government spending is endogenized. The role of endogenous regional investment as a supply side constraint is presented in section 3.6, followed by a discussion of the labour market block in section 3.7. In section 3.8 the solving of SSDM, as a constrained growth rate model will be discussed. The final section 3.9 contains some empirical results and concluding remarks.

### 3.3 General model structure

As mentioned above, SSDM is building on the Indonesian interregional input-output table, which contains interregional interindustry relations for intermediate and final demand for 25 industries, 27 provinces and 5 final demand categories. The base table was constructed for the year 1985 but contains in fact more recent information since the interregional trade coefficients were estimated at the time of the table construction in 1989. The table was updated to 1990 with the national input-output table and regional accounts for 1990 but still contained these 1989 trade coefficients.

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15 This priority was mentioned in the Broad Presidential Guidelines GBHN in March 1993. The GBHN is used as a broad framework for REPELITA.

16 A comparable situation occurred in 1999, when new regional tables were constructed for the Netherlands on the basis of regional accounts for 1992, but with survey-based trade coefficients for 1997 (CBS & RuG, 1999).
Figure 3.2 General Structure SSDM

Figure 3.2 show that the general structure of SSDM broadly resembles the ISAM model. The demand side of SSDM follows equation (2.7)-(2.14) of the input-output growth rate approach in the previous chapter, which is the demand-driven calculation of GDP growth rates $\dot{v}$ by sector and region from the matrix of final demand growth rates $\mathbf{F}$ by region, sector and final demand category. The most important difference is the set of feedback mechanisms from GDP back to final demand. As will be described in more detail below, household and government consumption are endogenized on the demand side. Government and private investment are endogenously determined on the supply side, but simultaneously with the demand side as they are also part of final demand.

The projected GDP ($v$) and employment ($e$) partly determine interregional migration. The other two labour supply variables, population and participation, are projected independently and are not connected with the i-o model. The aggregated labour supply and labour demand determine the projected regional unemployment.

We have seen in the previous chapter that an important operational advantage of a full Isard-type accounting framework is the fact that the sectoral results for all the provinces can be added up to their national total generating an implicit national projection by industry. This implicit national projection enables a consistency check with other (exogenous) national macro and sectoral projections so that the interregional i-o model can function as an integrated part of a more general national multisector planning or forecasting model. Indeed, one main purpose of SSDM in this respect was to get the
regional development scenario's consistent with national planning targets at the macro and sectoral level, as well as with macro targets at the regional level. The national constraints block at the top and the regional constraints block at the bottom represent these consistency checks.

Figure 3.3 shows the i-o model in more detail. Because the model is fully interregional each vector is of size \((i \times r)\) where \(i\) is the number of industries and \(r\) is the number of regions. The final demand matrix \(F\) is specified for each sector and region of origin and has four categories for each region of destination: private consumption \((C_p)\), government consumption \((C_g)\), government investment \((I_g)\) and private investment \((I_p)\), added with 1 column with foreign exports for each region of origin \((\text{ex})\). Thus \(F\) has \(i \times r\) rows and \((4 \times r) + 1\) columns. Three operational implementations have been used: a large version for 27 provinces and 11 sectors, its aggregation into 5 main regions and 11 sectors, and a version of 5 main regions and 25 sectors.

**Figure 3.3 Structure of the i-o model in SSDM**

Due to its interregional dimensions the model is able to assume different growth rates for each industry of origin and each region of origin in \(F\). If both column- and row specific growth rates are given the model is 100% bottom-up: growth rates for both sectors and regions are given individually and there is no need to distribute national, regional or sectoral aggregates over some row or column of \(F\). Of course such a situation never occurs. In practice many entries of \(F\) have to be assumed to be equal over rows and/or columns. The most extreme case of a 100% top-down implementation would be a matrix \(F\) 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, for example, all entries of $C^p$ would be 5%, of $C^g$ 4% etc$^{17}$. In most SSDM implementations for REPELITA VI for instance, the entries of $F$ were specified by sector of origin and region of destination but not by region of origin.

As figure 3.3 shows, the model has feedback links from GDP ($\mathbf{v}$) back to $C^g$ through the consumption block, to $C^g$ and $I^g$ through the government block and to $I^p$ through the investment block. These blocks will be discussed in the subsequent sections. This approach leaves foreign exports as the only exogenous variable. This is one column vector $\mathbf{e}_x$ with $i \times r$ entries representing the expected export growth by region and industry. This vector has been constructed for each year based on past performance, the national export strategy by product and regional priorities and bottlenecks, all of these constrained by the national total export growth in each projection year.

### 3.4 Endogenous household consumption

In most input-output implementations household consumption is either considered exogenous or made endogenous by closing the model for household income and expenditure, sometimes combined with endogenous migration and/or unemployment benefits in extended demo-economic models (Batey & Rose, 1990; Oosterhaven & Dewhurst, 1990; West, 2002). The type II, III or IV multipliers$^{18}$ resulting from such models, however, are usually based on constant consumption coefficients. This is not a problem for short-term projections for developed economies, but in the case of long-term projections for a country like Indonesia it is reasonable to assume that consumption patterns will change considerably over time, in particular when large parts of the population are expected to move away from minimum subsistence income levels. These “consumption shifts”, mainly from agricultural to non-agricultural goods, were estimated over the period 1980-1990 in a separate project at BAPPENAS (LTA97, 1991d). In this analysis the growth of consumption in region $r$ of a good produced by industry $i$ was regressed with GDP per capita growth in the region. The results have been entered into SSDM in the following way:

$$
C_r = Q_P \left( V_{r,t} / P_{t,i} \right)
$$

with

- $C = (i \times r)$ matrix of total consumption of goods $i$ in region $r$ aggregated by region of origin
- $P = (r \times r)$ diagonal matrix of total regional population

$^{17}$ In fact the full 100% top-down case is represented by one and the same entry throughout matrix $F$, for example a national GDP growth of 5%. This, however, is a meaningless implementation because it would produce the same 5% growth for each sector in each region.

$^{18}$ The type II model assumes average endogenous consumption effects of the active working force. The type III model uses marginal consumption effects and the type IV model takes income changes of unemployed entering the labour force into account. See West (2002) for further details.
\[ Q = (i \times r) \text{ matrix of regional and sectoral consumption elasticities} \]
\[ V = (r \times r) \text{ diagonal matrix of total regional GDP} \]

The entries \( q(i,r) \) of matrix \( Q \) represent industry specific elasticities for each province indicating the relation between the regional growth of \( C \) and regional growth of GDP per capita:

\[ q(i,r) = \frac{c(i,r)}{C'^r / p'^r} \]  \hspace{1cm} (3.2)

In the total matrix \( C' \) in figure 3.2 the consumption growth rates from (3.1) are applied uniformly over all regions of origin, i.e. it is assumed that changing consumption patterns do not effect regional purchase coefficients.

The time lag in (3.1) enables a recursive 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 the elasticities \( Q \). The advantages of this approach are twofold. First, over a longer period of time changing consumption patterns due to rising incomes can be taken into account. Second, in each year \( t \) population growth \( P_t \) can be adjusted separately with net migration projections from the labour market block without the need to assume constant migration coefficients that are typical for extended interregional i-o models (Oosterhaven & Folmer, 1988).

### 3.5 The government budget

Because the allocation of government investment funds (in Indonesian terminology usually called "development expenditures") was one of the main issues in REPELITA, a separate sub model for the government budget was constructed. Its main purpose is not a sophisticated macro government model but to "iterate" with government budget projections produced by other agencies and planning levels. Its basic principle is the same as elsewhere in the Indonesian context: the available development budget is calculated as a residual from the projected revenues and current routine expenditures.

The government revenues are modelled in the following way:

\[ gr_t = fa_t + mr_t + dt_t + it_t \]  \hspace{1cm} (3.3)
\[ fa_t = fa_{t-1} \cdot f_a \]  \hspace{1cm} (3.4)
\[ mr_t = mr_{t-1} \cdot \hat{V}_{(MIGAS)} \hat{v} \]  \hspace{1cm} (3.5)
\[ dt_t = dt_{t-1} \cdot \hat{V}_t \cdot \hat{v}_t \]  \hspace{1cm} (3.6)
\[ it_t = it_{t-1} \cdot \hat{n}_t \cdot \hat{v}_t \]  \hspace{1cm} (3.7)

with

40
\( gr \) = government revenues  
\( fa \) = foreign aid  
\( mr \) = MIGAS\(^{19} \) revenues  
\( dt \) = direct taxes revenues  
\( it \) = indirect taxes revenues  
\( \sqrt{v} \) = total national GDP  
\( \nu_{(MIGAS)} \) = total national MIGAS GDP  
\( c_{ph} \) = total national household consumption  
\( \tau^d \) = direct tax rate  
\( \tau^i \) = indirect tax rate

The expected growth of the two tax rates \( \tau^d \) and \( \tau^i \) and that of foreign aid \( fa \) are the exogenous variables for (3.3)-(3.7). The non-foreign aid revenues are endogenously determined by the growth of GDP and household consumption.

The government expenditures are modelled as follows:

\[
ge_t = gr_t \tag{3.8}
\]

\[
re_t = dp_t + w_t + o_t \tag{3.9}
\]

\[
dp_t = (\alpha + \beta) d_{t-1} \tag{3.10}
\]

\[
d_t = d_{t-1} - \beta d_{t-1} + \gamma fa_t \tag{3.11}
\]

\[
w_t = w_{t-1} \nu_{t}^{n} \tag{3.12}
\]

\[
o_t = o_{t-1} \nu_{t}^{n} \tag{3.13}
\]

\[
det = ge_t - ret \tag{3.14}
\]

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  
\( \gamma \) = debt rate of foreign aid  
\( w \) = wages and salaries  
\( o \) = other routine expenditures

Equation (3.8) assumes a balanced budget constraint for total government expenditures, i.e. the budget deficit is equal to \( \gamma fa \). The routine expenditures are determined by (3.9)-(3.13), which implies that the development expenditures can be calculated as a residual in equation (3.14). The rates \( \alpha, \beta \) and \( \gamma \) are exogenous and

\(^{19}\)MIGAS is the Indonesian abbreviation for the oil and gas sector.
determine the debt payments in equations (3.10) and (3.11). For government wages \( (w) \) and other routine expenditures \( (o) \), the simple assumption is chosen that they grow proportionally with \( v^T \).

The feedback links from the government block to \( F_n \), as presented in figure 3.3, are implemented as national budget constraints for total national government consumption and government investment:

\[
\begin{align*}
\mathbf{C}^*_g & = \Gamma(\mathbf{C}_g, \mathbf{r}_g) \quad (3.15) \\
\mathbf{I}^*_g & = \Gamma(\mathbf{I}_g, \mathbf{d}_g) \quad (3.16)
\end{align*}
\]

Here, we use superscript * to denote an adjusted value and \( \Gamma(A,B) \) as the short hand notation for a constraint function that re-adjusts an \( (i \times p) \) matrix \( A \) with a \( (j \times q) \) matrix \( B \) that contains new values for \( A \) at some aggregation level \( j < i \) and \( q < p \). In equation (3.15), for example, all initial exogenous \( (ixr)xr \) entries of \( \mathbf{C}^*_g \) are reweighed to match the aggregate macro national government consumption growth \( \mathbf{r}_g \) from in (3.9).

The government block was very useful in analysing the effect of a change in one of the budget variables on regional development. For example, as the preparations for REPELITA VI proceeded, new estimates became available of the projected amount of foreign aid, leading directly to adjustments in the development budget projections and their effect on regional GDP growth. The close link between the size of the budget and regional differences in GDP growth proved to be specifically important in alternative development scenarios that assumed a reallocation of development expenditures in favour of less developed regions.

### 3.6 The supply side: endogenous investment

I-o forecasting models generally assume that there are no supply restrictions to meet growing demand. This assumption clearly does not hold in a long-term regional projection for Indonesia over 25 years in which a “take-off” is assumed from a less developed economy towards an industrialised economy\(^{20}\). Indeed, many government investment programs were precisely aimed at removing existing supply constraints and bottlenecks at the regional level, such as manpower training and infrastructure programs. As already discussed in the first chapter, a CGE approach would have been an alternative to the demand-driven i-o model in this case, but this route was not taken for various reasons.

First, at the time of operation (1993) the size of SSDM was 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 1 digit (10 to 11 sectors) in order to get some policy relevant projections for REPELITA IV and PJP II the

\(^{20}\) The “take-off” target was one of the core elements of the 2nd 25-year plan PJP II.
dimensions of the Leontief matrix already comes close to 300 by 300. Adding another 300 production functions would make the model too big and too complex to handle, given the staffing and computer equipment available. Secondly, the available regional data, cross-sectional or time series, were clearly lacking to estimate regional production functions and/or to find reasonable values for parameters like substitution elasticity’s etc. Another objection to the CGE approach was, as mentioned in chapter 1, the time-consuming process of simulating a sequence of equilibria as a time path when CGE is used for long term forecasting (Partridge & Rickman, 1998).

Instead, the solution chosen in SSDM is a straightforward and simple feedback relation from predicted GDP growth back to capital stock and investment. Of all final demand categories, private investment is the only real endogenous variable for each prediction year \( t \) because, as described above, consumption and government investment are only linked with the predicted GDP for \( t-1 \). Figure 3.4 shows how the outcomes of the demand-driven i-o model for GDP, capital stock and private investment are jointly determined in an iterative process. Private investment plays its role as a final demand category but at the same time it is determined from the supply side: the growth of the capital stock that is needed to match GDP growth determines total investment of which the government part is exogenous and the private part is endogenous.

**Figure 3.4** The modelling of private investment

For each region the aggregate macro investment needed to achieve the GDP growth that results from the demand block, is estimated given the current regional capital stock with the following equations:

\[
\dot{\nu}_t' = \alpha + \beta \dot{k}_t'
\]  

(3.17)

which rearranges to

\[
\dot{k}_t' = \frac{1}{\beta} ((\dot{\nu}_t' - \alpha)
\]  

(3.17a)

\[
k_t' = k_{t-1} + \dot{k}_t'
\]  

(3.18)

\[
k_t = (1-\delta) k_{t-1} + i_{t}^{gr} + i_{t}^{pr}
\]  

(3.19)
which rearranges to

\[ \dot{i}_{t}^{pr} = k_{t}^{r} - (1-\delta) k_{t-1}^{r} - i_{t}^{gr} \]  

(3.19a)

with

\[ v_{t}^{r} = \text{total macro GDP in region } r \]
\[ \alpha_{r} = \text{regional constant term} \]
\[ \beta_{r} = \text{regional GDP/capital stock elasticity; inverse } 1/\beta_{r} = \text{incremental capital output ratio (ICOR)} \]
\[ k_{t}^{r} = \text{total macro capital stock in region } r \]
\[ \delta = \text{depreciation rate capital stock} \]
\[ p_{t}^{gr} = \text{total gross government investment in region } r \]
\[ p_{t}^{ip} = \text{total gross private investment in region } r \]

Equation (3.17) is a simplified Cobb-Douglas function in which the usual variable labour is replaced by a constant term \( \alpha_{r} \). This \( \alpha_{r} \) 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 labour productivity, general level of education, the current state of infrastructure etc. Because of the relative abundance of labour in Indonesia, labour is not taken as a variable as for example in:

\[ \dot{V}_{t}^{r} = \alpha_{r} + \lambda_{t} I_{t}^{r} + \beta_{r} k_{t}^{r} \]

but of course the term \( \lambda_{t} I_{t}^{r} \) should be part of equation (3.17) as soon as labour becomes less abundant, especially when interregional migration is endogenously determined.

Still, additional data on regional capital stock and depreciation rates had to be estimated for equation (3.19). First, a national depreciation rate \( \delta \) was assumed to be the same for all regions. Second, the initial regional capital stock for the first year of the projection period is calculated as a factor \( \kappa \) times regional GDP in t0:

\[ K_{0}^{r} = \kappa y_{0}^{r} \]  

(3.20)

A national average of 2.0 for \( \kappa \) was taken as a starting point being consistent with estimates from other Indonesian sources. SSDM has been calibrated through experimenting with various values of \( \alpha_{r} \), \( \beta_{r} \), and \( \delta \) in order to get a capital stock growth by region that is roughly the same as GDP growth in 1990, given the values of \( v_{r}^{r} \), \( p_{r}^{gr} \) and \( p_{r}^{ip} \) for 1989 and 1990, i.e.:

\[ \dot{k}_{1990}^{r} \approx \dot{V}_{1990}^{r} \]

As expected, the values of \( \kappa \), \( \alpha \) and \( \beta \) turned out to be higher for Jawa then for off-Jawa regions indicating a higher capital stock/GDP ratio, a higher overall labour productivity.
and a lower incremental capital/output ratio (ICOR=1/\beta) for Jawa regions compared with the rest of Indonesia.

For practical reasons an alternative solution was sometimes used that did not need capital stock estimates. A simple direct relation between GDP growth and investment can be given by:

\[ \phi_t^r = \gamma_t i_t^r \]

with

\[ \gamma_t = \text{regional GDP/investment elasticity} \]
\[ i_t^r = f^t + p^t \]

With this type of supply function the parameters \( \gamma_t \) indicate whether the total regional investment/GDP ratio will go up (\( \gamma_t < 1 \)) or down (\( \gamma_t > 1 \)). In a regional development scenario with (3.21) one can make simulations of for example extra infrastructure investment in some less developed region \( s \) by giving not only \( \gamma_s \) a value less than 1 but also with \( \gamma_s < \gamma_r \) for \( r \neq s \).

Both alternatives (3.17) and (3.21) assume a relation between regional GDP growth and total regional investment, but it must be reminded that it is only private regional investment that is the endogenous variable in the supply block. The government investment part is determined on the demand side with a time lag \( t-1 \) and is given for \( t \).

This implicitly means that private investment is following trends in government investment policy: when, other things being equal, government investment goes up, its initial demand effect and the following endogenous increase of the total capital stock have an upward effect on the resulting endogenous private investment. This assumed causality between government and private investment may hold for remote less developed regions in eastern Indonesia, but clearly not for some Jawa regions characterized by rapid economic expansion and urgent bottlenecks in public infrastructure, such as roads, communication, water and energy supply etc. Those regions show high economic growth in the private sector with government investment lagging behind. In the model implementation, this problem was tackled by assuming specific regional (re)distributions of government investment in the exogenous \( g_t^c \) and \( g_t^i \) on the demand side, which are consistent with the parameters \( \gamma_r \) on the supply side.

### 3.7 Labour supply

The projections of population growth and participation ratios will not be discussed in detail here because they have been provided by other agencies like the Indonesian Central Bureau of Statistics (BPS), and are therefore exogenous to SSDM. The BPS regional population growth \( \hat{p}_t \) has been adjusted, however, for its implicitly assumed extrapolation of past migration trends, which was heavily biased in some regions,
especially on the island of Sumatra, due to transmigration programs in the past that were not expected to continue. Instead, the exogenous $\mathbf{p}$ has been recalculated assuming zero interregional migration from the census year 1990 onwards. The BPS projections for labour participation have not been altered which means that the exogenous zero migration projection of regional labour supply is given by:

$$ L_t = \Lambda_t \cdot \mathbf{p}_t $$  \hspace{1cm} \text{(3.22)}

with

$$ L = \text{rx20 matrix of labour supply by sex and 10 age groups} $$

$$ \Lambda = \text{rx20 matrix of labour participation by sex and 10 age groups} $$

$$ \mathbf{p} = \text{rx20 matrix of population by sex and 10 age groups} $$

In the Indonesian situation, regional labour market conditions are expected to play a major role in interregional migration decisions, either measured in GDP or employment opportunities. Indeed, rapid expansion of GDP and employment in some Jawa regions has attracted in migration to Jawa in the past causing additional population growth on this already overcrowded island that could not be countered by the transmigration programs directed to off-Jawa regions\(^{21}\). At the time of SSDM’s implementation in 1993, however, no research resources were available to allocate to the development of an interregional migration model. Later research has indicated that in-migration patterns do relate to regional economic conditions, but out-migration did not and, consequently, net migration as a result could not be modelled satisfactory (Verster, 1994). Recently, Muhidin (2002) has provided a detailed excellent overview of the Indonesian demographic data and empirical studies carried out since 1970. Successful economic migration models are not reported, however, and Maiden’s own migration model is largely demographic without estimated relations with economic variables.

In SSDM the zero migration projection (3.22) was used in combination with the labour demand projection in order to simulate how regional unemployment would develop under the zero migration assumption. Verster (1994) discusses the possible shifts in migration flows that might be induced by the projected economic development.

On the demand side of the labour market the transformation of GDP growth $v$ into labour demand $e$ is given by:

$$ e_t = v_t / \mathbf{e}_t $$  \hspace{1cm} \text{(3.23)}

with

$$ e = (i \times r) \text{ vector of employment} $$

$$ \mathbf{e} = (i \times r) \text{ vector of labour productivity} $$

\(^{21}\) The answer has come from birth control programs that have been the most successful on Jawa. Around 1993 the annual natural population growth on Jawa had dropped to around 1%, which is substantially below the national average of 1.5%.
The labour productivity is derived as an exogenous variable from past employment/GDP elasticity's by sector and region. During the preparations for REPELITA VI, there have been many discussions on the supposed value of these elasticity's in the future. This is not surprising because they have a decisive effect on the (un)employment outcomes of every projection scenario. In particular, the productivity in the manufacturing sector was assumed to rise dramatically, as a result of hidden unemployment in the present labour-intensive manufacturing sectors, which would undo most, if not all of the employment effects of the optimistic - sometimes double digit - production growth rates projected. Indeed, instead of trying to model one consolidated projection, various productivity scenarios have been simulated.

3.8 Solving of the model and exogenous constraints

As is illustrated in Figure 3.2 the model results are subject to constraints for national, sectoral or regional aggregate growth rates within which the projection has to stay. The following constraints can be defined:

\[
\begin{align*}
\mathbf{F}_{t}^{*} &= \Gamma (\mathbf{F}_{t}, \mathbf{f}_{e,t}) \quad (3.24) \\
\mathbf{v}_{i}^{*} &= \Gamma (\mathbf{v}_{i}, \mathbf{v}_{r,i}) \quad (3.25) \\
\mathbf{v}_{i}^{*} &= \Gamma (\mathbf{v}_{i}, \mathbf{v}_{s,i}) \quad (3.26)
\end{align*}
\]

with

- \( \mathbf{f}_{e} = (4 \times r) + 1 \) vector of final expenditure totals
- \( \mathbf{v}_{r} = (r \times 1) \) vector of total regional GDP
- \( \mathbf{v}_{s} = (i \times 1) \) vector of national GDP by sector

and again the asterix * indicating the adjusted value.

All constraints mentioned in the right hand side of (3.24)-(3.26) represent exogenous values. First, the matrix \( \mathbf{F}_{t} \) can be adjusted to exogenous aggregate growth of final expenditure totals, i.e. the growth rates of each column total of \( \mathbf{F} \). The adjustment (3.24) usually only contained a restriction on total national exports in order to keep assumed export strategies by sector and region in \( \mathbf{ex}_{r} \) consistent with some national \( \mathbf{ex}_{n} \) projected by other agencies.

Second, the \( (i \times r) \) vector of GDP growth \( \mathbf{v}_{i} \) can be adjusted at the macro regional level (3.25) and the national sectoral level (3.26). Most regional scenarios that have been projected had to be consistent with a macro target of some national macro GDP growth rate, sometimes specified by a few sectors like national growth of agriculture, manufacturing and services. Projections that use these constraints are not primarily aimed at predicting the regional growth rates themselves but at an adequate forecast of the regional deviations from the national growth path.
If the sectoral restrictions in (3.26) are combined with an only nationally specified (3.24), they represent a national top-down application: a projected national macro and/or sectoral scenario is evaluated on its regional distribution performance. Next, a set of regional restrictions (3.25) combined with an only regionally specified (3.24) 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. Finally, if the model is not constrained in any way by (3.24)-(3.26) then SSDM becomes a full bottom-up model: national projections by sector and regional and national macro totals are all achieved from the unconstrained \((i,r)\) entries of \(F_i\) and \(v_r\). In such an application a projected regional scenario is evaluated on its macro and sectoral performance.

Of course a combination of top-down and bottom-up will be the usual case. As mentioned before in the discussion of Figure 3.2 and 3.3, it is not only the content of (3.24)-(3.26) that determines the bottom-up character but also the extent to which the initial entries of \(F_i\) are specified by sector and/or region of origin. A frequently projected scenario has been for example a bottom-up estimated export scenario by sector and region combined with only national restrictions in (3.24) and (3.26).

Another function of (3.24)-(3.26) is that they work as a check on the consistency of different exogenous constraints produced by different planning agencies. If national and/or sectoral planning targets are to be combined with regional distribution targets, then SSDM works as a check on the consistency of all targets. If for example national investment is fixed, then the model might fail to find a regional distribution of investment that meets the regional targets. Other model simulations indicated that a national priority for growth of some specific industries was not consistent with strategies of regional development.

The model was solved in a three-step iteration procedure in which the constraints, the demand block and the supply block were run subsequently until conversion was reached. The linear structure of the demand and supply block does not lead to conflicts or non-conversion, but of course the various constraints have to be mutually consistent. In only one special case the model produced implausible results. This interesting simulation was in fact created by accident and soon became baptised as the “Krakatau model” (see appendix A).

### 3.9 Some results

Most internal BAPPENAS projections made during the preparations of REPELITA VI and PJP II are confidential and final outcomes have only been published in a qualitative and/or largely aggregated form (Stelder, 1993). Of the few released model projections, two scenarios called R1 and R2 were published in July 1993 (see Table 3.1).
Table 3.1 Two long-term scenarios

<table>
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<tr>
<th>Province</th>
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R1 assumes no reallocation of government and private investment towards provinces that are lagging behind in economic development (mainly off-Jawa provinces). It is a simulation of the regional effects of a national development scenario without any specified regional policy, which shows that a continued concentration of economic activities on Jawa will lead to growing regional divergence either measured in relative differences in GDP per capita or measured in regional share of GDP. The other scenario R2 assumes an active reallocation of government investment towards off-Jawa regions,
accompanied by a similar regional reallocation of private investment, which was calculated by SSDM as a second necessary supply reaction.

Although there have been various versions of both R1 and R2, resulting from reformulations of the national macro and sectoral strategy, all of them show that the regional convergence/divergence pattern changes only in the longer run. Table 3.1 shows that, after simulating a 25-year period of intensified off-Jawa investment, the (non-MIGAS) GDP shares have increased for Sumatra, Kalimantan and the Eastern islands compared with 1993. The Jawa share has decreased by 3.5% (from 64.3% to 60.8%). This result is quite substantial although the Indonesian government had more ambitious targets in mind. What is more important from a policy point of view, however, is that the difference with the R1 scenario is substantial: in R1 the Jawa share would have gone up more than 7% (from 64.3% in 1993 to 71.5% in 2020). Furthermore, when considering the R2 time path of GDP growth by province, it takes some time before regional convergence starts to occur (see Figure 3.4). This was an important issue, because some planning agencies were specifically aiming at off-Jawa growth rates that were higher than the Jawa growth rates right from the start of the planning period. The interregional input-output linkages in SSDM showed that this was an unrealistic assumption, because of the concentration of most production of investment goods on Jawa.

Apart from the severe lagging behind of many provinces in human resource development and production capacity, among the main reasons for this persistence of regional divergence are the sectoral structure by province and the dominant role of export growth in the manufacturing sector in all scenarios, both of which work heavily in favour of the Jawa provinces. The results of R1 and R2 have been used as a starting point for discussions on how to improve the bottom-up content of the planning process. Various parties at the sectoral and regional level were asked to give their comments on the growth potential of their sector or region.

In a later phase, a revised R2 was discussed, in which most of the sectoral and macro constraints were dropped, showing the national macro and sectoral projections as an aggregate result of the regional ones. One result of this bottom-up projection has been that the national macro and sectoral growth rates were adjusted downwards (in particular for agriculture and food processing industries).
3.10 Model evaluation

The experience with SSDM has shown that long-term policy simulation in a developing country with sharp regional differences needs other model features than short-term forecasting with ISAM in an industrialized country with a relatively even regional development. First, the endogenous treatment of consumption patterns is essential when income levels are rising from near-subsistence to higher levels in the long run. Next, in an essentially demand-driven model endogenous private investment is needed when substantial deviations from past regional development in poor regions have to be simulated. Finally, in a complicated planning setting where many agencies are involved, it is important to have optional consistency constraints at various levels of the model.

Despite the numerous number crunching exercises, the main achievements of SSDM have been of a qualitative nature. The numbers presented in Indonesian economic plans merely serve as an indicative framework of priorities for the annual budget decisions, which is when the actual allocations are made. What has become clear in the final version of REPELITA VI and PJP II is that the persistent trend of regional divergence in all scenarios has pushed the importance of regional development policy higher on the political agenda.