STRUCTURE OF THE PARA MODEL

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1. Introduction

PARA is a conventional, real, micro-theoretic general equilibrium model of the Thai economy. Its features are designed primarily to enable it to address micro-economic policy issues relevant for Thailand. PARA belongs to the class of general equilibrium models which are linear in proportional changes, sometimes referred to as Johansen models after the seminal work of Johansen (1964), which also used this approach. PARA shares many structural features with the highly influential ORANI general equilibrium model of the Australian economy (Dixon, et.al., 1982), which also belongs to this Johansen category, but these features have been adapted in light of the realities of the Thai economy. The principal distinguishing feature of PARA is its solid empirical basis. The structure of the model itself is relatively conventional.

This paper describes the structure of the PARA model. It is meant to be read in conjunction with the equation set contained in the Appendix. The text of this paper is meant to be as non-technical as possible to enable non-specialist readers to grasp the essential features of the model.

2. Overview of the Model

There are two principal versions of the PARA model: a *national* version and a *regional* version. The regional version is larger and somewhat more complex. For expository purposes, it will be convenient to describe the national version first and then turn to the features that make the regional version different.

2.1 General Features of the National Model

Industries

The national model contains 60 producer goods and services produced by 60 corresponding industries - 20 agricultural industries and 40 non-agricultural. Each industry produces a single output, so the set of commodities coincides with the set of industries. The various industries of the model are classified as either export-oriented or import-competing. In the normal closure used for experiments with PARA the level of exports of an export-oriented industry are treated as being endogenous, while the exports of an import-competing industry are treated as being exogenous.[1] The criterion used to classify these industries is the ratio of an industry's imports to its exports. If this ratio exceeds 1.5, then the industry is regarded as producing an importable. If the import/export ratio is less than 0.5, then the industry is deemed to be export-oriented. For ratios between 0.5 and 1.5, additional relevant information is used in classifying the industry.

Commodities

PARA contains two types of commodities - producer goods and consumer goods. Producer goods come from two sources - domestically-produced and imported. All 60 producer goods are in principle capable of being imported, although in fact some (10 commodities) have zero levels of imports in the data base, services and utilities representing most of the examples. The 20 consumer goods identified in the model are each transformed from the producer goods, where the proportions of domestically produced and imported producer goods of each kind used in this transformation is sensitive to their (Armington) elasticities of substitution and to changes in their relative prices.

Factors of production

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[1] Given that the exported and domestically sold good are treated as being identical, this assumption is necessary to make it possible to separate the domestic price of the import competing good from the price of the exported good. Otherwise, the Armington structure we have described above would be redundant.

The mobility of factors of production is a critical feature of any general equilibrium system. 'Mobility' should be interpreted to mean mobility across economic activities (industries), rather than geographical mobility. The greater the factor mobility that is built into the model, the greater is the economy's simulated capacity to respond to changes in the economic environment. It is clearly essential that assumptions about the mobility of factors of production be consistent with the length of run that the model is intended to represent.

Within PARA, one factor of production, unskilled labour, is mobile across the entire economy. Other factors are less mobile. Agricultural variable capital is mobile among the various agricultural industries. It consists of machinery such as tractors of various kinds, which can be used in a variety of agricultural activities. Two primary factors are mobile among the various non-agricultural industries of the model: non-agricultural variable capital and skilled labour. Non-agricultural variable capital includes non-agricultural land and structures which are not necessarily devoted to any particular production activity, such as buildings and related fixed structures. When relative prices change, it is possible for owners of such assets to rent them out to producers facing more profitable circumstances, but these assets are not capable of being used for agricultural production.

Skilled labour is mobile across all non-agricultural industries but is not used in agriculture. It is defined as those in the work force who are capable of performing tasks requiring more than a specified level of formal training and who are paid on a monthly, rather than a daily, basis. In the Thai context, being paid on a monthly basis is a good indicator of skill and Thai employment data are collected in such a way as to reflect this labour market characteristic While skilled labour can presumably perform unskilled tasks, the model treats these two kinds of labour as distinct.

Besides these variable factors, there are two sets of fixed primary factors, agricultural land and sector-specific capital. Changes in relative prices do not cause any reallocation of such capital inputs across industries in the short run, as a movement to other sectors is assumed to require sufficient re-tooling costs as to render such reallocations economically infeasible. In a long run setting, the amounts available of each of these region and sector-specific capital resources would adjust as a result of the investments made in each time period of the model. PARA does not allocate its level of fixed capital formation in a given time period into specific industries, because it is essentially a short-run model. The length of run implicit in the model's comparative static adjustment processes should be thought of as being between two and four years.

Households

The model contains ten households - five urban and five rural, differentiated by income quintile in each case. That is, the set of all rural households is classified into five income classes of equal population size, arranged by per capita income level (ie. quintile groups). Each of these income classes is then treated, for simplicity, as a single household. The sources of income of each of these five rural households are different, depending on their ownership of factors of production, as derived from the *Socio-Economic Survey* data, and their demand behaviour also differs from one another in ways which reflect empirical demand estimation based on the *Socio-Economic Survey* expenditure data. The five urban households are treated in an exactly parallel manner.

Market behaviour

The microeconomic behaviour assumed within PARA is competitive profit maximisation on the part of all firms and utility maximisation on the part of consumers. Markets for final outputs, intermediate goods and factors of production all clear at prices which are determined endogenously within the model.

2.2 General Features of the Regional Model

The regional version of PARA disaggregates the agricultural sector into four regions: North, Northeast, Central and South, which correspond to the four principal agricultural regions of Thailand. Non-agricultural production is not disaggregated regionally, and the treatment of these industries in the 'regional' version remains the same as in the national version. Regional issues are more important for agriculture than for any other sector and this is why priority was given to agriculture in the regional disaggregation. The regional version of PARA contains 120 industries. The 20 agricultural industries of the national model are each disaggregated to four regional agricultural industries, making a total of 80 agricultural industries plus the 40 non-agricultural industries, which are unchanged from the national version. The market clearing conditions for these comodities are defined at the national level, implying that commodities, once produced, are mobile across regions and that their prices are equated across production regions.

In the regional version of the model variable capital in agriculture remains mobile within regions but not between them. It is important to re-emphasise that 'mobility', in the sense that is relevant here, means mobility across agricultural activities, rather than geographical mobility. Land remains industry-specific. The mobility of all other factors is the same as in the national version. It should be noted that at this stage of PARA's development, rural households are not disaggregated regionally. This is a priority matter for future work.

3. The Microeconomic Structure of PARA

3.1 Primary Factor Demands

The demands for primary factors and intermediate goods are treated differently in PARA and it is best to discuss these two types of input demands separately. Primary factors have three features that distinguish them from intermediate goods.[2] First, unlike intermediate goods, they are not 'produced' within the system and their supply must be specified exogenously. Second, although this feature is not particularly important for our discussion, primary factors have a life longer than the (annual) production process, whereas intermediate goods are used up fully during the production process. Third, primary factors are owned by households and the payments to these factors are the principal sources of household incomes. Insofar as the

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[2] Fertiliser used in agriculture will be an exception to this discussion in that although it is a produced good its demand within agriculture will be treated in the same manner as primary factors. See the discussion under 'intermediate goods, below.

households in different income categories own different combinations of factors of production, changes in relative factor prices will have important income distributional implications.

Now consider the production of *value added* - the difference between the gross value of the output of an industry and the cost of its inputs of intermediate goods. We imagine a production function with value added in a particular industry as the dependent variable and input levels of primary factors as the independent variables. The function exhibits constant returns to scale and is concave in primary factor inputs. Firms maximise profits subject to these production functions, treating prices of outputs and inputs as given. That is, they behave as profit maximising perfect competitors. As is well known, the assumption of constant returns to scale means that at the level of the individual industry, output is indeterminate. The aggregate levels of employment of primary factors and their allocation across industries will determine those outputs, and these issues will be taken up below.

At the industry level, it is most convenient to consider a necessary condition for profit maximisation - minimisation of the costs of producing a given level of output. Cost minimisation implies demand functions for primary factors that are functions of the level of output being produced and the prices of the primary factors. Constant returns to scale implies that these demand functions are homogeneous of degree one in output. Moreover, given the output being produced, the demand for individual factors depends only on *relative* factor prices, and so the demand functions are homogeneous of degree zero in factor prices.[3]

The resulting factor demand functions are given by equations (1.1.2) and (1.2.2). These are flexible functional form demand equations, meaning that no particular functional form has been imposed upon them except for the regularity conditions discussed above. Constant returns to scale is imposed through the unitary implicit coefficient on the level of industry output appearing in the first right hand side term of equations (1.1.2) and (1.2.2). Homogeneity of degree zero in factor prices is imposed through the sum of the elasticity parameters β_{vmj} adding to zero across the subscript m.

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[3] There will also be symmetry across demand functions. See Varian (1990)

The remaining items in the factor demand equations are terms for technical change, denoted z. These terms play no role except in experiments involving technical change and discussion of them is best left to the description of experiments which do involve technical change. Except in such cases, these variables are exogenously set at zero and they may safely be ignored.

The treatment of primary factor demands in PARA is considerably more flexible than that found in most applied general equilibrium models. Previous models have typically assumed that factor demands are consistent with production functions which are, in increasing order of sophistication, Cobb-Douglas, Constant Elasticity of Substitution (CES), or Constant Ratio of Elasticity of Substitution-Homothetic (CRESH). But the treatment of factor demand employed here makes *none* of these restrictive assumptions. It imposes only the minimal neo-classical regularity assumptions of constant returns to scale, homogeneity of degree zero in prices and symmetry which are required for the functioning of a general equilibrium system. Obviously this degree of generality can be implemented satisfactorily only with a large empirical effort. The results of that effort are described elsewhere in this study.

3.2 Five Types of Demands for Producer Goods

Intermediate input demand from industries

The system of demand for intermediate inputs - commodity inputs which are exhausted during the production process - is best understood at two levels. First, we imagine the demand for a *composite* intermediate input of each commodity into each industry, where that composite consists of a mix of imported and domestically produced versions of the intermediate good, and then we consider the composition of that composite between domestically produced and imported versions of the good. Composite intermediate goods of each kind are demanded by each industry in fixed proportion to the industry's output. This is the well-known Leontief input demand assumption. The proportions in which composite intermediate inputs of different commodities are demanded by an industry are thus determined by the industry's technology and are independent of the relative prices of those inputs.

Next, this composite intermediate input demand is divided between domestically produced and imported versions of the good in proportions which depend on the relative prices of the two goods and their elasticities of substitution - known as Armington elasticities. This accounts for equations (1.1.1) and 1.2.1), which combine these two aspects of intermediate good demand - Leontief demand for composite inputs and Armington substitution between imported and domestic sources. The demand for composite input rises in proportion to the output of the industry. But the proportion of this composite demand that is satisfied by domestically produced rather than imported versions of the good depends on their relative prices and the elasticity of substitution between them. The proportion of composite demand for intermediate good i in industry j that is satisfied by the domestic rather than the imported version of good i increases as the price of the imported version of good i rises relative to the domestic version, at a rate that depends on the Armington elasticity of substitution.

The crucial feature of our treatment of intermediate demand is that even if the price of both the imported *and* domestic versions of good i fell relative to those of good k, there would be no substitution on good i for good k in intermediate demand. The technology determines the proportions in which composite forms of the various intermediate goods must be used, but relative prices can play a role in determining the proportions of these composite demands that are made up by domestically produced intermediate goods, on the one hand, and imports on the other.

An exception to this treatment of intermediate input demand arises in the case of fertiliser used in agriculture. Fertiliser meets the definition of an intermediate good in that it is a produced good that is fully used up during the production process. Nevertheless, there is ample evidence from studies of agricultural crop production that fertiliser can be substituted for primary factors of production, notably land, depending on the relative prices of the two. This, together with the importance of fertiliser demand in agricultural production, mean that the standard treatment of intermediate goods (the Leontief assumption) would not be satisfactory in the case of fertiliser.

The treatment of fertiliser is set out in equations (1.2.2) and (1.2.3). Like other intermediate inputs, fertiliser is a composite of imported and domestically produced versions and the proportions in which the two are used depends upon their relative prices and the elasticity of substitution between them (equation (1.2.3)). But the demand for inputs of composite fertiliser is not simply proportional to output, as with other intermediate inputs. Fertiliser is substitutable for primary factors in a way that depends on their relative prices and elasticities of substitution between them (equation 1.2.2), as discussed under 'primary factors', below.

Demand for capital creation

PARA is a short run model. The allocation of investment by industry is not an important feature of the model because, in common with virtually all such short run models, PARA assumes that the investment in a particular industry does not affect the level of the capital stock of that industry within the current period and so does not affect the industry's current output. The level of total investment in the economy has macroeconomic implications, but the allocation of this investment across industries plays essentially no role in the operation of the model. Within PARA, each industry is assumed to invest in composite investment goods of type *i* in proportion to the level of economy-wide aggregate investment. This is the role of the variable $f_v^{(0)}$ in equation (1.4.1). This total level of composite investment is then allocated to imported and domestic versions of good *i* in proportions which depend upon the relative prices of the two goods and their elasticities of substitution, analogously to the manner described above for intermediate demand.

Household consumption demand for producer goods

Within PARA, consumer goods are demanded by households in the manner described below. The demand for consumer goods gives rise to household demands for the producer goods from which they are formed. It may be helpful to imagine that an industry exists which converts producer goods into consumer goods, using no primary factors, incurring no wastage and in the process earning no profits. Leontief fixed proportions applies to the technology of this industry but imported and domestic versions of each producer good are used in the production of the various consumer goods in proportions which reflect their relative prices and their (Armington) elasticities of substitution. This accounts for equations (1.4.2). It should be emphasised that the household consumption demand for producer goods is entirely a derived demand, from the demand for consumer goods, c_j, which is predetermined in these equations. The determination of these demands is discussed in a later section below.

Government demand

The government's demand for producer goods is given by equations (1.4.8). Government demand for each composite commodity are exogenously determined within PARA. The economic theory underlying the model includes theories of firm behaviour (competitive profit maximisation), and household behaviour (competitive utility maximisation), but it does not include a theory of the government's economic behaviour. Consequently, the economic behaviour of the government must be specified from outside the model structure. The variables $x_i^{(5)}$ appearing in equation (1.4.8) must therefore be specified exogenously. The exception to this characterisation of government behaviour, however, is that the government's demand for the imported and domestically produced versions of each producer good reflect the Armington structure described above for intermediate and capital creation demands.

Export demand

Export demand is given by equations (1.4.4). As the volume of exports of commodity i, $x_{is}^{(4)}$ rises, the international price p_{is}^{*} falls at a rate given by the inverse demand elasticity γ_i. It should be emphasised that in this formulation, γ_i is the inverse of the price elasticity of export demand for commodity i. Thus the more elastic the export demand for commodity i, the lower the value of γ_i.

For most of Thailand's commodity exports, it may be safely assumed that the price received by Thailand is relatively independent of the volume of exports. This clearly applies to essentially all of Thailand's manufactured good exports, for which Thailand's exports comprise a very small proportion of world exports. This corresponds to low values of γ_i and the value of this parameter is set at around 0.001 for all export commodities except two. These are the two commodities for which Thailand might reasonably be expected to possess some degree of market power - rice and cassava (animal feeds, within PARA). Empirical estimation of the export demand functions applying to these two commodities (Warr and Wollmer, 1994) led to values of 0.4 and 0.25, respectively for these two commodity categories.

3.3 Zero Profit Conditions

The assumption of constant returns to scale implies that no above normal profits are received by industries which are characterised by this form of production function. This fact plays a major role in price determination within models like PARA, because it constrains the relationship between the output price of any industry and its input prices. For example equations (4.1) and (4.2) require that the output price of each industry be equal to a weighted sum of the input prices - those of intermediate goods and primary factors - faced by that industry. The terms involving the variable z relate to the implications of technical change and can be disregarded for the purposes of this discussion.

Equation (4.3) imposes a similar restriction on the relationship between the prices of consumer goods, q_j, and the prices of the producer goods from which they are formed, $p_{is}^{(3)}$. Equations (4.5.1) and (4.5.2) require that the domestic prices of exports be determined by their international prices, p_{is}^{*}, the exchange rate, r, and any taxes that may be imposed, while equation (4.6) imposes a similar condition on the domestic prices of imported commodities.

3.4 Market Clearing Conditions

Equation set (7) imposes market clearing conditions of the various goods and factor markets appearing within PARA.

Goods markets

Equation (7.1) aggregates the demands for domestically produced goods across the various users - intermediate demand, consumption demand, government demand, capital formation and export demand - and equates this to the aggregate domestic supplies of these goods appearing in equation sets (1.1) and (1.2). Equation (7.2) does the same for imported producer goods, equating aggregate demand from various domestic users, as above, to aggregate domestic supply of imports appearing in equation (9.1.1).

Factor markets

Equation sets (7.3) to (7.4) equate the demand and supply of mobile factors skilled labour, unskilled labour, agricultural variable capital and non-agricultural variable capital to their respective aggregate supplies, specified elsewhere in the model. The market clearing conditions for industry-specific factors of production in equation sets (7.5) and (7.6) should be interpreted as analytical devices for determining the returns to these factors. We ask the hypothetical question: what price for this factor would induce the industry to demand exactly the quantity of that factor that is available. The answer is: the marginal value product of the factor in question, given the prices of other factors and of the industry's output, together with the zero profit condition for the industry. This is the competitive return to the factor we wish to determine.

3.5 Income determination

Equation set (5) determines household gross and disposable incomes. Gross incomes are divided into two categories: incomes derived from factor ownership, determined by household ownership of factors of production and the market returns to those factors; and non-factor incomes. The latter consist of transfers from abroad in the form of remittances, transfers from other domestic households and transfers from the government. Household disposable income is then gross income minus income tax obligations and transfers to other households. In equation (5.5), the third left hand side term, $\tau_h^P u^P$ is intended to facilitate uniform adjustments to the tax rate for all households. Such adjustments may be employed, under some closure assumptions, to achieve fiscal balance on the part of the government.

3.6 Demand for Consumer Goods

Before turning to the demand for individual consumer goods we must describe the determination of aggregate consumption expenditure. Equation (5.7.1) should be viewed in conjunction with equation (5.8).

The demand for consumer goods c_j is determined by equations (5.1) and the aggregating equation (5.2). In equation (5.1) the demand by household *i* for consumer good *j* is determined by a demand function which reflects the outcome of a utility maximisation process on the part of household *i*, subject to the prices of the consumer goods, q_k, and the aggregate expenditure of household h, c_h. These demand functions satisfy the usual neo-classical properties of homogeneity of degree zero in prices (implying that the price elasticities of demand add to zero across the subscript *k*), that expenditure elasticities add to unity across commodities (ie. across the subscript *i*), and that symmetry properties are satisfied across demand functions. The price elasticity and expenditure elasticity parameters used within PARA were estimated econometrically, using Thai data, with all of the above properties imposed during the estimation process (Sarntisart and Warr, 1994).

3.7 Factor Supplies

Factors of production are supplied by households, and the household endowments of primary factors, along with their market returns, is the most important determinant of income distribution in the model. However, it should be noted that these household factor supplies are independent of factor prices. This must be regarded as a simplifying assumption, but it is particularly important in the case of labour supply.

A more satisfactory treatment of household labour supply would have households' supply of labour determined simultaneously with their demand for consumer goods. The trade-off between leisure and consumption would then be analysed along with the trade-off among the various forms of consumption and would lead to a supply of labour function that would depend on its wage, along with other prices. Unfortunately, the data set available for the empirical study of consumption demand did not permit this treatment because household labour supplies are not recorded in these data, the *Socio-Economic Survey* conducted by the National Statistical Office (Sarntisart and Warr, 1994). It seems likely that the supply of labour is indeed price inelastic, and our assumption may be regarded as the limiting case of that, the case of *zero* price elasticity.

4. Macroeconomic Relations Within PARA

4.1 Foreign Trade Sector

The (annual) income and expenditure of foreign exchange are brought together in the balance of payments account that contains two separate accounts - current and capital. Under the current account, the foreign exchange is spent on the imports of commodities and are earned from the exports of domestic commodities to the rest of the world and from the net transfer income to the households and to the government from the rest of the world. Net inflow of capital from the rest of the world into Thailand summarises the movements in the capital account. The sum of the two accounts yields the balance of payments of Thailand.

Equations (9.1.1) to (9.4.2) state these relationships in percentage change form. Equations (9.1.1) and (9.1.2) describe the percentage change in the cost of imports in foreign and domestic currencies respectively, and equations (9.2.1) and (9.2.2) describe the changes in the fob value of exports in domestic and foreign currencies respectively. In equation (9.3), changes in the foreign currency price of imports and exports are determined by the extent of changes in the foreign currency prices and quantities of imports and exports of the commodities.

Equation (9.2.3) brings the net transfer incomes to the Thai households and the Thai government from the rest of the world together with the current income of foreign exchange of Thailand from exports of goods and services to obtain the changes in the current account of

Thailand. In this equation the terms M^*, E^*, G^{f*} and H_h^{f*} are respectively the base year values of total. value of imports, total f.o.b. value of exports, net transfer income revived by the government from the ROW, and net transfer incomes received by the households from the ROW in units of foreign currency. Equation (9.2.3) therefore states that change in the current account deficit is given by the difference between the changes in the current expenditure of foreign exchange, which is given by the change in the cost of imports and changes in the current income of foreign exchange, which is given by the sum of changes in the value of exports and the net transfer incomes form the ROW to the government and to the households.

Balance of Payments

To arrive at the balance of payments we introduce the capital account in conjunction with the current account. A summary of the movements of the capital account is given by I^{F*}, the net inflow of foreign capital (FDI) in Thailand in the base year. Percent change in the net inflow of foreign capital into Thailand in units of baht is given by

(9.3.1) $$s^f = s^{f*} + r.$$

The condition for balance of payment is that

(9.3.2) $$100 * \Delta D^* = I^{F*} s^{f*};$$

that is, the balance of payments the balance of payments accounting system requires that the change in the current account deficits is exactly offset by the change in the net inflow of foreign capital into Thailand.

It should be noted that the model does not have a theory of changes in net transfer incomes and the net inflow of foreign capital into Thailand. They are the subjects of model closure.

4.2 Government Revenue

Equations (10.1) to (10.11) describe the income and the expenditure of the government in detail. The Thai Government's income from various taxes is explained by equations (10.1) to (10.3), and incomes form non-tax sources are described by equations (10.4.1) to (10.4.4). Equations (10.5) to (10.10) describe the government's total outlay. Finally, equation (10.11) describes the government's budget constraint.

Equation (10.1.1) calculates the collection of tariff revenue from the imports of each of the commodities, and equation (10.1.2) aggregates them. Equation (10.2.1) describes the collection of personal income tax from each of the 10 households and equation (10.2.2) aggregates the collection of these personal income taxes. Equation (10.2.3) describes the collection of corporate income tax from the domestic production sectors in non-agriculture. This equation states that the collection of corporate income tax from each of the non-agricultural sector changes as the rental rate on sector specific capital change, and/or the quantity of the specific factor employed changes or the corporate income taxes change.

Collection of other indirect tax revenues are described by the equations (10.3.1) to (10.3.11). Equation (10.3.1) and equation (10.3.2) respectively calculate the collections of excise taxes on the sale of domestic and imported commodities. The bases of these taxes are the basic values for the domestic goods and the c.i.f. price in domestic currency for the imported goods. Equation (10.3.3) aggregates the collection of excise tax revenue.

Thailand also levies business taxes, sales taxes and other taxes on the sale of commodities from both domestic and imported sources. The collection of revenues from these taxes is described by equations (10.3.4) to (10.3.9). Equation (10.3.10) calculates the VAT revenue from each of the non-agricultural sectors and (10.2.11) aggregates them. The base of the VAT is the value added in each of the non-agricultural sectors.

The government of Thailand also receives income from non tax sources - particularly, from the net transfer incomes from the households as well as from the rest of the world. Net transfer income received from the government from the households is described by the equation

(10.4.1) and equation (10.4.2) calculates the real burden of these transfers to the respective households in units of consumer goods. The government's net income from foreign transfers is given by equation (10.4.3). The aggregate income of the government from all sources is calculated in equation (10.5), which shows how the government's income changes as any of the tax revenue components changes or the net transfer income from any source changes.

4.3 Government Expenditure

The total current outlay of the government constitutes its expenditure on commodities for consumption and savings. Equation (10.6) describes this relationship. Equations (10.7) and (10.8) evaluate the government's consumption expenditure at constant prices, as paid by the government, and government saving at constant consumer prices. Equation (10.9) evaluates government's savings at constant prices of the capital goods. Equation (10.10) details the composition of government's consumption expenditure on commodities form both domestic and imported sources.

Equation (10.11) describes the change in government's budget deficit, which equals the difference between the change in government's total outlay and change in the government's total income. Equations (10.11.1) and (10.11.2) describe the changes in government's total outlay and the government's total income respectively.

4.4 National savings

Equation (11.1) collects households savings, government's savings and foreign saving to obtain the total investible resource at the national level and equation (11.2) calculates its value at constant price of the capital good.

4.5 Price Indices

Equation (12.1.1) and (12.1.2) calculate the aggregate consumer price index from two sides. Equation (12.1.1) calculates it using the prices of producer goods whereas equation (12.1.2) calculates it on the basis of prices of consumer goods. Note that the price of consumer goods are fully explained by the prices of the producer goods by the zero profit condition imposed on the production of consumer goods and the process of producing consumer goods that does not use any primary factors. Equation (12.1.3) calculates household specific consumer price index.

Equation (12.2) describes the price index for government's consumption of producer goods. The percentage change of the government's price index is the share weighted average of the percentage change in the prices of the producer goods from both domestic and imported sources, where the weights reflect the government's expenditure shares. Equation (12.3) describes the f.o.b. price index for Thai exports and equation (12.4) describes the c.i.f. price index for Thai imports of the producer goods. Finally, equation (12.5) combines all these price indices to obtain the GDP deflator for the whole Kingdom. Where, the H's are the respective ratios of the component to the GDP at base year prices.

4.6 GDP Accounting

Equation (13.1.1) aggregates the consumption expenditures of the households, and equation (13.1.2) measures it at constant prices. Equation (13.1.3) calculates the consumption expenditure of each household at constant prices, reflecting of the household-specific bundle of consumer goods. The government's consumption expenditure at current prices is given by equation (10.10), equation (13.2) calculates it at constant prices of the bundle of commodities consumed by the government. Equation (13.3) calculates the aggregate expenditure in capital creation (gross investment and net inventory accumulation) at current prices. Using equations (9.1.2) and (9.2.1) equation (13.4.1) obtains the equation for changes in GDP at current prices, and equation (13.4.2) obtains the equation for GDP at constant prices.

4.7 Walras' Law, and the Choice of Numeraire

PARA contains 120 producer goods and 20 consumer goods on the commodity space and 2 types of labour, 20 types of agricultural land, 2 types of mobile capital, and 40 types of sector specific capital in the factor space. Market clearing condition for each of these commodities and factors have been specified in the structure of PARA, in addition to this the condition for the balance of payment insures that the market for the foreign exchange also clears. Furthermore, the total investible resources available in the economy has to be spent in the capital creating activity in order to clear the "real financial" market. Note that the market clearing condition for the real financial market has not been specified explicitly in the structure of PARA because it will hold by Walras' law. It is well known that in a model like PARA, the level of the nominal exchange rate does not affect the real magnitudes of the model. Recognising this role played by the nominal exchange rate in PARA, foreign exchange has been chosen as the numeraire of the model.

TABLE 1 *APEX Model Equation Set*

BLOCK 1:	**Input Demands** Non-agricultural sector input demands Agricultural input demands in each region Aggregate intermediate input demands
BLOCK 2:	**Supply Relations: Agriculture** Regional supplies of agricultural commodities Aggregate supplies of agricultural commodities
BLOCK 3:	**Price Definitions: Agriculture** Price indices for agricultural regions and composite industries
BLOCK 4:	**Zero Profit Conditions** Non-agricultural production Agricultural production in each region Capital goods production Consumer goods production Exporting activities Importing activities
BLOCK 5:	**Household Demand for Consumer Goods** Individual household demands Aggregate demand for consumer goods Household non-factor incomes Household gross and disposable incomes
BLOCK 6:	**Price Relations** User and producer prices for commodities User and supplier rental rates for specific factors
BLOCK 7:	**Market Clearing Conditions** Domestic and imported producer goods markets Factor markets
BLOCK 8:	**Equalization of Mobile Factor Prices** Skilled and unskilled labor Variable capital Fertilizer
BLOCK 9:	**Trade Account** Import bill Export revenue Trade balance
BLOCK 10:	**Government Budget** Tax revenue Expenditure Budget deficit
BLOCK 11:	**Other Macroeconomic Accounting Identities** Consumer price index Real consumption expenditure Real government expenditure Nominal and real GDP GDP deflator

FIGURE 1 Structure of Produc ı: regional agriculture

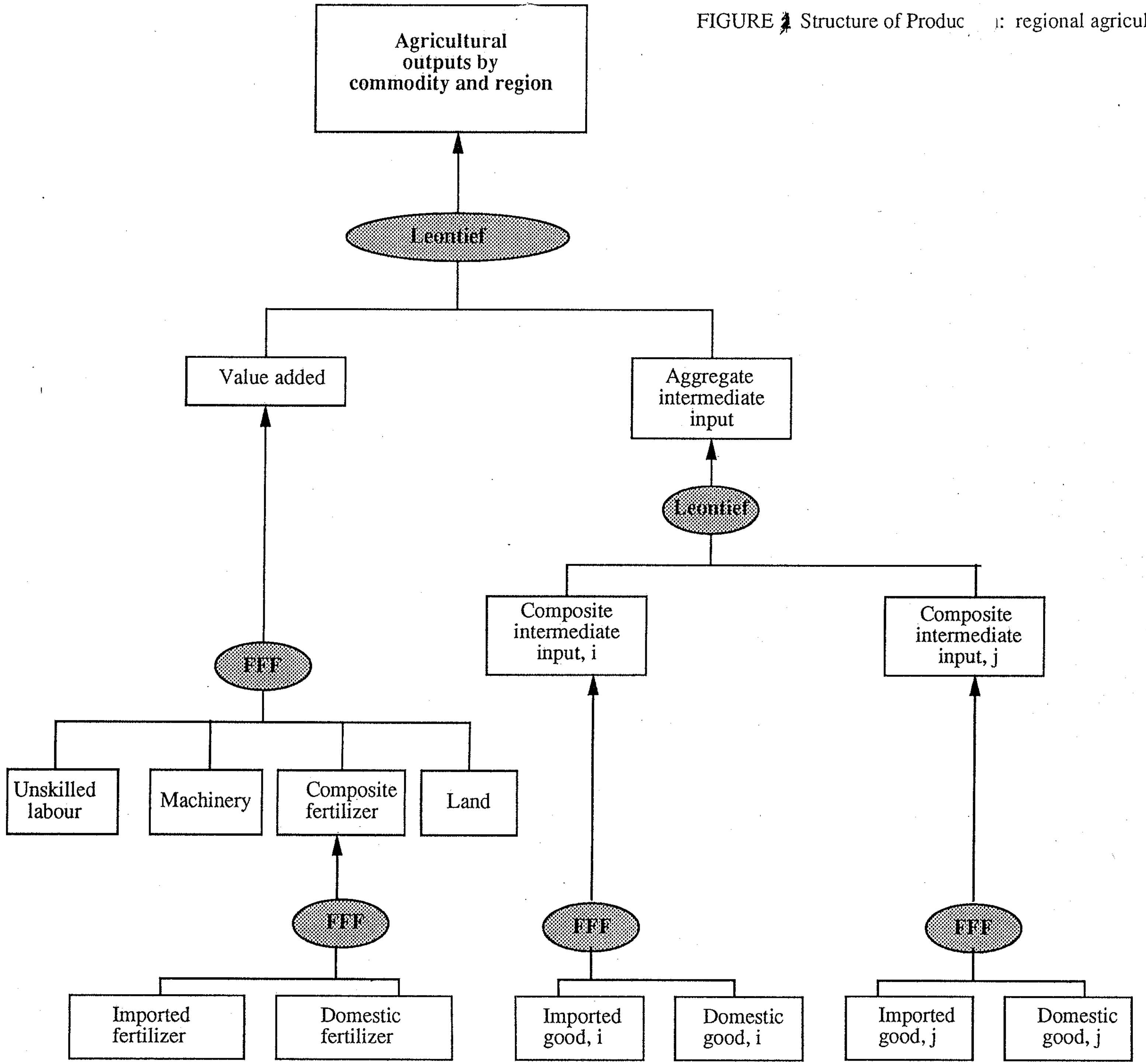
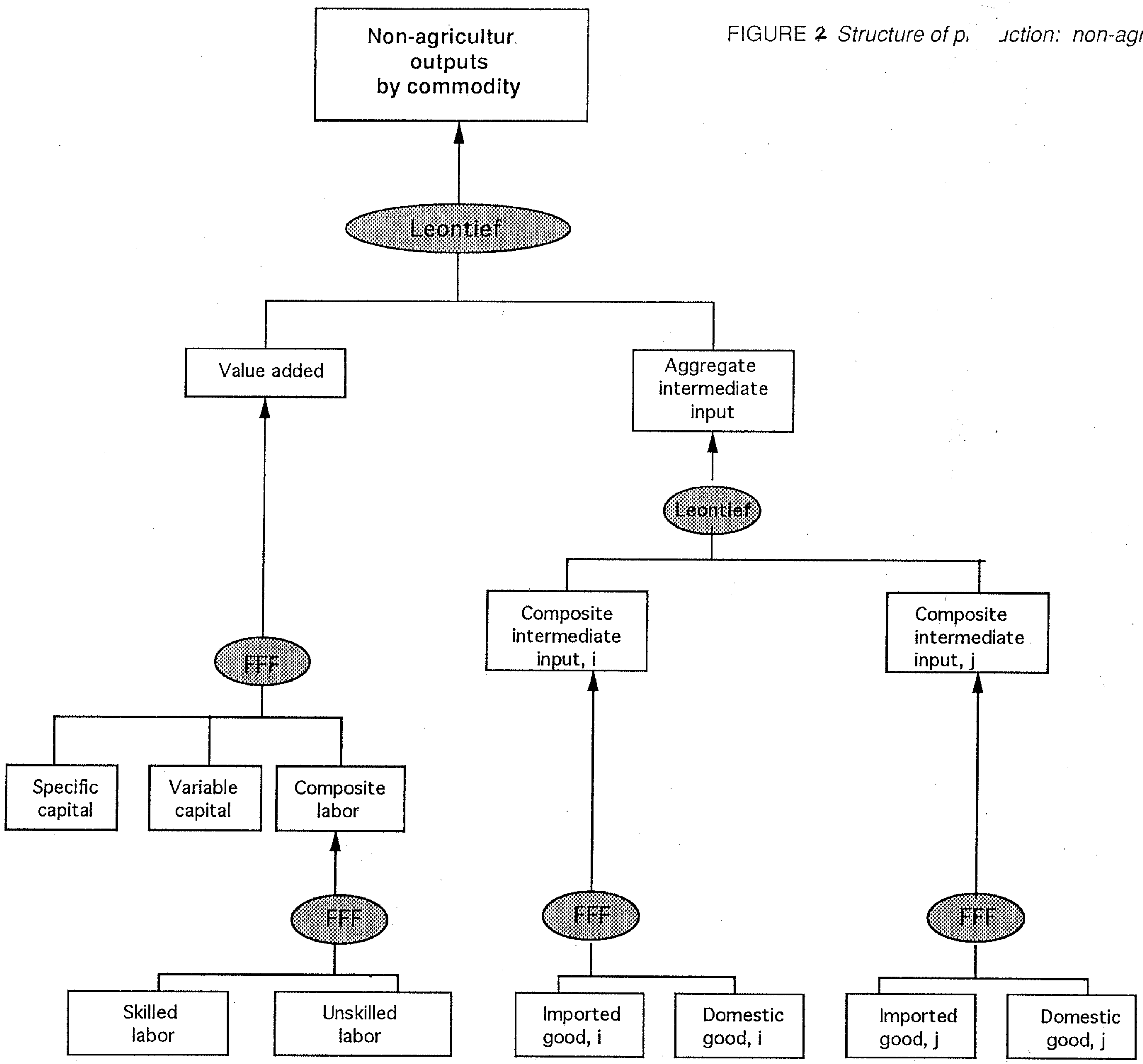


FIGURE 2 *Structure of p. ɹction: non-agriculture*



APPENDIX:

Structural Equations of the PARA Model

REGIONAL VERSION (June 1994)

1 Input Demand System

1.1 Non-agriculture Sector

1.1.1 Intermediate Input Demand

$$x_{isj}^{(1)} = x_{jt}^{(0)} - \sigma_{ij}^{(1)}\left(p_{is}^{(1)} - \sum_{u \in SG} H_{i(u)j} p_{iu}^{(1)} \right) - z_j^{(1)} - z_{ij}^{(1)}; \qquad i \in PG, s \in SG, j \in NAI, t \in LOC.$$

1.1.2 Factor Demand

$$f_{vj}^{(1)} = x_{jt}^{(0)} + \sum_{m \in RNA} \beta_{vmj} w_{mj}^{(1)} - z_j^{(1)} - z_{vj}^{(1)} - \sum_{m \in RNA} \beta_{vmj} z_{mj}^{(1)}; \qquad v \in RNA, j \in NAI, t \in LOC.$$

1.1.3 Demand for Labour by Type

$$f_{vj}^{(1)} = f_{mj}^{(1)} - \sigma_{mj}^{(1)}\left(w_{vj}^{(1)} - \sum_{n \in LAB} H_{m(n)j} w_{nj}^{(1)} \right) - z_{vj}^{(1)} + \sigma_{mj}^{(1)}\left(z_{vj}^{(1)} - \sum_{n \in LAB} H_{m(n)j} z_{nj}^{(1)} \right);$$

$$v \in LAB, j \in NAI, m \in LCOM.$$

1.2 Agricultural Sectors

1.2.1 Intermediate Input Demands

$$x_{isjr}^{(1)} = x_{jr}^{(0)} - \sigma_{ijr}^{(1)}\left(p_{is}^{(1)} - \sum_{t \in SG} H_{i(t)jr} p_{it}^{(1)} \right) - z_{jr}^{(1)} - z_{ir}^{(1)} - z_{ijr}^{(1)};$$

$$i \in (PG \setminus FERT), s \in SG, j \in AI, r \in REG.$$

1.2.2 Factor Demands, Including Composite Fertilizer, in Agriculture

$$f_{vjr}^{(1)} = x_{jr}^{(0)} + \sum_{m \in RA} \beta_{vmjr} w_{mjr}^{(1)} - z_{r}^{(1)} - z_{jr}^{(1)} - z_{vjr}^{(1)} - \sum_{m \in RA} \beta_{vmjr} z_{mjr}^{(1)};$$

$$v \in RA, j \in AI, r \in REG.$$

1.2.3 Fertilizer Demand as a Factor Input by Source

$$x_{vsjr}^{(1)} = f_{vjr}^{(1)} - \sigma_{vjr}^{(1)} \left(p_{vs}^{(1)} - \sum_{t \in SG} H_{v(t)jr} p_{vt}^{(1)} \right); \qquad v \in FERT, s \in SG, j \in AI, r \in REG.$$

1.2.4 Aggregate Intermediate Input Demand of Each Agricultural Industry

$$x_{isj}^{(1)} = \sum_{r \in REG} J_{isjr} x_{isjr}^{(1)}; \qquad i \in PG \setminus FERT, s \in SG, j \in AI$$

1.2.5 Aggregate Fertilizer Demand of Each Agricultural Industry

$$x_{vsj}^{(1)} = \sum_{r \in REG} J_{vsj(r)} x_{vsjr}^{(1)}; \qquad v \in FERT, s \in SG, j \in AI.$$

1.3 Aggregate Intermediate Input Demand for Commodity Productions of all Industries

$$x_{is}^{(1)} = \sum_{j \in IND} J_{isj} x_{isj}^{(1)} \qquad i \in PG, s \in SG$$

1.4 Components of Final Demand (as Inputs)

1.4.1 Demand for Capital Creation

$$x_{is}^{(2)} = f_{v}^{(0)} - \sigma_{i}^{(2)} \left(p_{is}^{(2)} - \sum_{t \in SG} H_{i(t)} p_{it}^{(2)} \right); \qquad i \in PG, s \in SG, v \in CAP.$$

1.4.2 Intermediate Input Demand by source for Household Production of Each Consumer Good

$$x_{isj}^{(3)} = c_j - \sigma_{ij}^{(3)}\left(p_{is}^{(3)} - \sum_{t \in SG} H_{i(t)j} p_{it}^{(3)} \right); \qquad i \in PG, s \in SG, j \in CG.$$

1.4.3 Aggregate Intermediate Input Demand for Consumer Goods Production

$$x_{is}^{(3)} = \sum_{j \in CG} J_{is(j)} x_{isj}^{(3)}; \qquad i \in PG, s \in SG.$$

1.4.4. Foreign Demand for Home-exportables

$$p_{is}^{*} = -\gamma_i x_{is}^{(4)} + u_{is}^{(4)}; \qquad i \in PG, s \in LOC.$$

1.4.5 Exports from Import Competing sectors

$$x_{is}^{(4)} = u_{is}^{(4)*}; \qquad i \in IMP, s \in LOC.$$

1.4.8 Government Demand

$$x_{is}^{(5)} = x_i^{(5)} - \sigma_i^{(5)}\left(p_{is}^{(5)} - \sum_{t \in SG} H_{i(t)} p_{it}^{(5)} \right); \qquad i \in PG, s \in SG.$$

2 Supply Aggregates

2.1 National Supplies of Agricultural Commodities

$$x_{is}^{(0)} = \sum_{r \in REG} J_{i(r)} x_{ir}^{(0)}; \qquad i \in APG, s \in LOC.$$

2.2 Aggregate Regional Agricultural Output

$$x_r^{(0)} = \sum_{i \in APG} J_{(i)r} x_{ir}^{(0)}; \qquad r \in REG$$

3 Price Definitions

3.1 Regional Price Index for Composite Agricultural Product

$$p_r^{(0)} = \sum_{i \in APG} I_{(i)r} p_{ir}^{(0)} \qquad r \in REG, s \in LOC.$$

4 Zero Profit Conditions

4.1 Zero Profit in Non-Agricultural Production

$$p_{js}^{(0)} = \sum_{i\in PG}\sum_{t\in SG} H_{itj(k)} p_{it}^{(1)} + \sum_{v\in RNA} H_{vj(k)} w_{vj}^{(1)} - z_j^{(1)} - \sum_{i\in PG} H_{ij(k)} z_{ij}^{(1)} - \sum_{v\in RNA} H_{vj(k)} z_{vj}^{(1)};$$

$$j \in NAI, s \in LOC, k \in ((PG \otimes SG) \cup RNA).$$

4.2 Zero Profit in Agricultural Production in Each Region for Each Crop

$$p_{jr}^{(0)} = \sum_{i\in(PG\setminus FERT)}\sum_{t\in SG} H_{itjr(k)} p_{it}^{(1)} + \sum_{v\in RA} H_{vjr(k)} w_{vjr}^{(1)} - z_r^{(1)} - z_{jr}^{(1)} - \sum_{i\in(PG\setminus FERT)} H_{ijr(k)} z_{ijr}^{(1)} - \sum_{v\in RA} H_{vjr(k)} z_{vjr}^{(1)};$$

$$j \in AI, r \in REG, k \in (((PG \setminus FERT) \otimes SG) \cup RA).$$

4.3 Zero Profit in the Production of Capital Goods

$$w_v^{(0)} = \sum_{i\in PG}\sum_{s\in SG} H_{(is)} p_{is}^{(2)}; \qquad v \in CAP.$$

4.4 Zero Profit in the Production of Consumer Goods

$$q_j = \sum_{i\in PG}\sum_{s\in SG} H_{(is)j} p_{is}^{(3)}; \qquad j \in CG$$

4.5 Zero Profit in Exporting - Export Industries

$$p_{is}^{(4)} = p_{is}^{*} + r; \qquad i \in EXP, s \in LOC.$$

4.6 Zero Profit in Importing

$$p_{is}^{(0)} = p_{is}^{*} + r + \tau_i^M t_i^M; \qquad i \in PG, s \in FOR.$$

4.8 Equalization of Prices of Agricultural Commodities across Regions

$$p_{jr}^{(0)} = p_{js}^{(0)} \qquad j \in AI, r \in REG, s \in LOC$$

5 Household Demand for Consumer Goods

5.1 Individual Household Demands for Each Consumer Good

$$c_{ih} = \sum_{k \in CG} \varepsilon_{ikh} q_k + \eta_{ih} c_h; \qquad i \in CG, h \in HH.$$

5.2 Market Demand for Each Consumer Good

$$c_i = \sum_{h \in HH} J_{i(h)} c_{ih}; \qquad i \in CG.$$

5.3 Households' Total Factor Incomes

$$y_h^F = I_h^{FL} y_h^{FL} + I_h^{FV} y_h^{FV} + I_h^{FA} y_h^{FA} + I_h^{FN} y_h^{FN} + I_h^{FZ} y_h^{FZ}; \qquad h \in HH.$$

5.3.1 Labour Income

$$y_h^{FL} = \sum_{v \in LAB} I_{(v)h}^{FL} \left(w_v^{(1)} + f_{vh}^{(0)} \right); \qquad h \in HH.$$

5.3.2 Factor Income from Mobile Capital Employed within NAI's

$$y_h^{FV} = w_v^{(1)} + f_{vh}^{(0)}; \qquad h \in HH, v \in NAIMCAP.$$

5.3.3 Factor Income from Regionally Mobile Capital Employed in Agriculture

$$y_h^{FA} = \sum_{r \in REG} I_{v(r)h}^{FA} \left(w_{vr}^{(1)} + f_{vrh}^{(0)} \right); \qquad h \in HH, v \in AMCAP.$$

5.3.4 Factor Income from Sector-specific Capital in Non-agriculture

$$y_h^{FN} = \sum_{j \in NAI} I_{v(j)h}^{FN} \left(w_{vj}^{(0)} + f_{vjh}^{(0)} \right); \qquad h \in HH, v \in SCAP.$$

5.3.5 Income from Land

$$y_h^{FZ} = \sum_{r \in REG} \sum_{j \in AI} I_{v(j)rh}^{FZ} \left(w_{vjr}^{(1)} + f_{vjrh}^{(0)} \right); \qquad h \in HH, v \in LAND.$$

5.4 Households' Non-factor Incomes

5.4.1 Households' Nominal Non-factor Incomes

$$y_h^N = y_h^{NF*} + r; \qquad h \in HH.$$

5.5 Households' Gross Incomes

$$y_h^T = I_h^F y_h^F + I_h^N y_h^N; \qquad h \in HH.$$

5.6 Households' Disposable Incomes

$$y_h^T = S_h^D y_h^D + \tau_h^P t_h^P + \tau_h^P u^P + S_h^G l_h^g; \qquad h \in HH.$$

5.7.1 Allocation of Household Disposable Income

$$y_h^D = I_h^c c_h + (1 - I_h^c) s_h; \qquad h \in HH.$$

5.7.2 Change in the Aggregate Savings of all Households

$$\Delta S = \frac{\sum_{h \in HH} s_h S_h}{100}; \qquad h \in HH.$$

5.7.3 Real Savings of Households

$$\tilde{s}_h = s_h - p_h^{Hq} \qquad h \in HH.$$

5.8 Consumption Expenditure of Household h

$$c_h = y_h^D + u_h; \qquad h \in HH.$$

6 Price Relations

6.1.1 Relation between User Price and Producer Price of Domestic Goods

$$p_{is}^{(k)} = p_{is}^{(0)} + \tau_{is}^{Vk} t_{is}^{Vk} + \tau_{is}^{Ek} t_{is}^{Ek} + \tau_{is}^{Bk} t_{is}^{Bk} + \tau_{is}^{Ok} t_{is}^{Ok}; \qquad i \in PG, s \in LOC, k \in USER$$

where superscript V denotes VAT, E denotes excise tax, B denotes Business sales tax, and O denotes Other taxes.

where, $\tau_{is}^{jk} = \dfrac{S_{Vis}T_{is}^{jk}}{1+S_{Vis}T_{is}^{Vk}+T_{is}^{Ek}+T_{is}^{Bk}+T_{is}^{Ok}}$ for $j=V$, and

$\tau_{is}^{jk} = \dfrac{T_{is}^{jk}}{1+S_{Vis}T_{is}^{Vk}+T_{is}^{Ek}+T_{is}^{Bk}+T_{is}^{Ok}}$ for $j=E, B, O$. Where, T_{is}^{jk} is the appropriate tax rate to user $k \in \{1,2,3,4,5\}$, and S_{Vis} is the share of value-added in the basic price of commodity i from source s.

6.1.2 Relation between User Price and Importer Price of Imported Goods

$$p_{is}^{(k)} = p_{is}^{(0)} + \tau_{is}^{Ek}t_{is}^{Ek} + \tau_{is}^{Bk}t_{is}^{Bk} + \tau_{is}^{Ok}t_{is}^{Ok}; \qquad i \in PG, s \in FOR, k \in USER.$$

6.2 Relation between User and Supplier Rental Rates of the Sector-specific Factors

$$w_{vj}^{(0)} = w_{vj}^{(1)} - \tau_{vj}^{C}t_{vj}^{C}; \qquad v \in SCAP, j \in NAI.$$

where $\tau_{vj}^{C} = \dfrac{T_{vj}^{C}}{1-T_{vj}^{C}}$, and T_{vj}^{C} is the corporate income tax levied on the rents of the sector j.

7 Market Clearing Conditions

7.1 Domestic Producer Goods Market

$$x_{is}^{(0)} = \sum_{k \in USER} J_{is(k)}x_{is}^{(k)}; \qquad i \in PG, s \in LOC.$$

7.2 Imported Producer Goods Market

$$H_{is}^{ms}x_{is}^{ms} + H_{is}^{m}x_{is}^{*} = \sum_{k \in USER} J_{is(k)}x_{is}^{(k)}; \qquad i \in PG, s \in FOR.$$

where, x_{is}^{ms}, percentage change in special imports will be determined exogenously.

7.3 Labour Markets

7.3.1 Equilibrium in Unskilled Labour (Mobile Across All Sectors) Market

$$f_v^{(0)} = \sum_{j \in AI} \sum_{r \in REG} J_{vjr(k)} f_{vjr}^{(1)} + \sum_{i \in NAI} J_{vi(k)} f_{vi}^{(1)};$$

$$v \in LU, k \in IND \equiv ((AI \otimes REG) \cup NAI).$$

7.3.2 Equilibrium in Skilled Labour (Mobile within NAIs) Market

$$f_v^{(0)} = \sum_{j \in NAI} J_{v(j)} f_{vj}^{(1)}; \qquad v \in LS.$$

7.3.3 Supply of Labour by Types (Skilled and Unskilled)

$$f_v^{(0)} = \sum_{h \in HH} J_{v(h)} f_{vh}^{(0)}; \qquad v \in LAB.$$

7.4 Variable Capital Market

7.4.1 Equilibrium in Mobile Non-agricultural Capital Market

$$f_v^{(0)} = \sum_{j \in NAI} J_{v(j)} f_{vj}^{(1)}; \qquad v \in NAIMCAP.$$

7.4.2 Supply of Moble Non-agricultural Capital

$$f_v^{(0)} = \sum_{h \in HH} J_{v(h)} f_{vh}^{(0)}; \qquad v \in NAIMCAP.$$

7.5 Land Markets

Land is assumed to be crop/region specific.

7.5.1 Crop-Region specific Land

7.5.1.1 Equilibrium in the Land Markets

$$f_{vjr}^{(0)} = f_{vjr}^{(1)}; \qquad v \in LAND, j \in AI, r \in REG.$$

7.5.1.2 Supply of Land

$$f_{vjr}^{(0)} = \sum_{h \in HH} J_{vjr(h)} f_{vjrh}^{(0)}; \qquad v \in LAND, j \in AI, r \in REG.$$

7.6 Sector-specific Capital Market

7.6.1 Equilibrium in Non-agricultural Sector-specific Capital Markets

$$f_{vj}^{(0)} = f_{vj}^{(1)}; \qquad v \in SCAP, j \in NAI.$$

7.6.2 Supply of Sector-specific Capital (NAI's)

$$f_{vj}^{(0)} = \sum_{h \in HH} J_{vj(h)} f_{vjh}^{(0)}; \qquad v \in SCAP, j \in NAI.$$

7.6.3 Equilibrium in Agricultural Mobile Capital Market

$$f_{vr}^{(0)} = \sum_{j \in AI} J_{vjr} f_{vjr}^{(1)}; \qquad v \in AMCAP, r \in REG.$$

7.6.4 Supply of Mobile Capital in Regional AI's

$$f_{vr}^{(0)} = \sum_{h \in HH} J_{vr(h)} f_{vrh}^{(0)}; \qquad v \in AMCAP, r \in REG.$$

8 Equalization of Mobile Factor Prices Across Indistries

8.1 Price of Unskilled Labour (mobile across the entire economy) in NAI's

$$w_{vj}^{(1)} = w_{v}^{(1)}; \qquad v \in LU, j \in NAI$$

8.2 Price of Unskilled Labour in Regional Agriculture

$$w_{vjr}^{(1)} = w_v^{(1)}; \qquad v \in LU, j \in AI, r \in REG$$

8.3 Price of Skilled Labour and Mobile Non-agricultural Capital (mobile across NAI's)

$$w_{vj}^{(1)} = w_v^{(1)}; \qquad v \in (LS \cup NAIMCAP), j \in NAI.$$

8.4 Price of Composite Labour in NAI's

$$w_{vj}^{(1)} = \sum_{m \in LAB} H_{v(m)j} w_{mj}^{(1)}; \qquad v \in LCOM, j \in NAI.$$

8.5 Price of Factor Fertilizer by Regional Crop

$$w_{vjr}^{(1)} = \sum_{s \in SG} H_{v(s)jr} p_{vs}^{(1)}; \qquad v \in FERT, r \in REG, j \in AI.$$

8.6 Equalization of Price of Mobile Agricultural Capital within a Region

$$w_{vjr}^{(1)} = w_{vr}^{(1)}; \qquad v \in AMCAP, r \in REG, j \in AI.$$

9 Trade Account

9.1 Import Bill

9.1.1 Import Bill in Foreign Currency (cif value)

$$m^* = \sum_{i \in PG} H_{(i)s} \left(p_{is}^* + x_{is}^*\right); \qquad s \in FOR.$$

9.1.2 Import Bill in Local Currency (cif)

$$m = m^* + r;$$

9.2 Export Revenue

9.2.1 Export Revenue in Foreign Currency

$$e = \sum_{i \in PG} I_{(i)s} \left(p_{is}^{(4)} + x_{is}^{(4)}\right); \qquad s \in LOC.$$

9.2.2 Export Revenue in Local Currency

$$e^* = e - r;$$

9.3 Trade Balance

9.3.1 Condition for Overall Balance of Payments

$$\Delta D^* = \Delta K^*;$$

where balance of payments always balances through counter movements in capital and current accounts.

9.3.2 Change in Current Account Deficit

$$\Delta D^* = \frac{1}{100}\left(M^* m^* - E^* e^* - G^{f^*} g^{f^*} - \sum_{h \in HH} H_h^{f^*} y_h^{NF^*} \right);$$

Where, G^{f*} is the income of the government from the ROW in units of foreign currency.

9.3.3 Change in Net Capital Inflow

$$\Delta K^* = \Delta K^{x^*} + \Delta K^{e^*};$$

where, ΔK^{x^*} is the net autonomous capital inflow, which is exogenous, and ΔK^{e^*} is the endogenously determined capital inflow which is required to maintain the balance of payments if a shock displaces the balance.

10 Government Budget

10.1 Tariff Revenue

10.1.1 Tariff Revenue by Commodities

$$n_i^M = p_{is}^* + r + t_i^M + x_{is}^*; \qquad i \in PG, s \in FOR.$$

10.1.2 Aggregate Tariff Revenue

$$n^M = \sum_{i \in PG} A_{(i)}^M n_i^M;$$

10.2 Income Tax Revenue

10.2.1 Income Tax Collection from Individual Households

$$n_h^P = y_h^T + t_h^P + u^P; \qquad h \in HH.$$

10.2.2 Aggregate Personal Income Tax Collection

$$n^P = \sum_{h \in HH} A_{(h)}^P n_h^P; \qquad h \in HH.$$

10.2.3 Corporate Income Tax Collection

$$n^C = \sum_{j \in NAI} A_{(j)}^C \left(w_{vj}^{(1)} + f_{vj}^{(0)} + t_{vj}^C\right); \qquad v \in SCAP.$$

10.3 Indirect Tax Revenue

10.3.1 Excise Tax Collection from Domestic Goods

$$n_{is}^E = t_{is}^E + p_{is}^{(0)} + x_{is}^{(0)}; \qquad i \in PG, s \in LOC.$$

10.3.2 Excise Tax Collection from Imports

$$n_{is}^E = t_{is}^E + p_{is}^* + r + x_{is}^*; \qquad i \in PG, s \in FOR.$$

10.3.3 Aggregate Excise Tax

$$n^E = \sum_{s \in SG} \sum_{i \in PG} A_{(i)s}^E n_{is}^E;$$

10.3.4 Business Sales Tax Collection from Domestic Goods

$$n_{is}^B = t_{is}^B + p_{is}^{(0)} + x_{is}^{(0)}; \qquad i \in PG, s \in LOC.$$

10.3.5 Business Sales Tax Collection from Imports

$$n_{is}^B = t_{is}^B + p_{is}^* + r + x_{is}^*; \qquad i \in PG, s \in FOR.$$

10.3.6 Aggregate Business Sales Tax

$$n^B = \sum_{s \in SG} \sum_{i \in PG} A_{(i)s}^B n_{is}^B;$$

10.3.7 Other Tax Collection from Domestic Goods

$$n_{is}^{O} = t_{is}^{O} + p_{is}^{(0)} + x_{is}^{(0)}; \qquad i \in PG, s \in LOC.$$

10.3.8 Other Tax Collection from Imports

$$n_{is}^{O} = t_{is}^{O} + p_{is}^{*} + r + x_{is}^{*}; \qquad i \in PG, s \in FOR.$$

10.3.9 Aggregate of Other Taxes

$$n^{O} = \sum_{s \in SG} \sum_{i \in PG} A_{(i)s}^{O} n_{is}^{O};$$

10.3.10 VAT collection by Commodities

$$n_{j}^{V} = \sum_{m \in RA} S_{mj}^{V} (w_{mj}^{(1)} + f_{mj}^{(1)} + t_{j}^{V}); \qquad j \in NZVAT$$

10.3.11 Aggregate VAT Collection

$$n^{V} = \sum_{j \in NAI} A_{(j)}^{V} n_{j}^{V};$$

10.4 Other Revenues (including foreign transfer incomes)

$$n^{OR} = S^{H} (\sum_{h \in HH} I_{h} l_{h}^{g}) + S^{G} g^{f};$$

10.4.1 Government income from Household Transfers

$$\tilde{l}_{h}^{g} = l_{h}^{g} - p_{h}^{Hq}; \qquad h \in HH$$

10.4.2 Government Income from Foreign Transfers

$$g^{f} = g^{f*} + r;$$

10.4.3 Government Income from Factors

$$n^{F} = A^{M\_NAI} (f_{v_1 G}^{(0)} + w_{v_1}^{(1)}) + \sum_{i \in NAI} A_{i}^{F} (f_{v_2 G}^{(0)} + w_{v_2 j}^{(0)}) + A^{M\_AI} (f_{v_3 G}^{(0)} + w_{v_3}^{(1)}) + \sum_{j \in AI} A_{j}^{L} (f_{v_4 jG}^{(0)} + w_{v_4 j}^{(1)});$$

$$v_1 \in NAIMCAP; v_2 \in SCAP; v_3 \in AMCAP; v_4 \in LAND$$

10.5 Aggegate Revenue

$$n = A^{M}n^{M} + A^{C}n^{C} + A^{P}n^{P} + A^{E}n^{E} + A^{V}n^{V} + A^{B}n^{B} + A^{O}n^{O} + A^{OR}n^{OR} + A^{F}n^{F};$$

10.6. Nominal Government Expenditure

$$g = B^{d}g^{d} + B^{s}g^{s};$$

10.7 Real Government Expenditure

$$\tilde{g} = g - p^{H};$$

10.8 Government Savings;

$$\tilde{g}^{s} = g^{s} - p^{H};$$

10.10 Government Expenditure on commodities

$$g^{d} = \sum_{i \in PG} \sum_{s \in SG} B^{d}_{(is)} \left(p^{(5)}_{is} + x^{(5)}_{is} \right);$$

10.11 Change in Budget Deficit in Government's Current Account

$$\Delta D = \Delta G - \Delta N;$$

10.11.1 Change in the Government Expenditure

$$\Delta G = \frac{1}{100} Gg;$$

10.11.2. Change in the Government Revenue

$$\Delta N = \frac{1}{100} Nn;$$

10.11.3 Total National Savings

$$s^{N} = \sum_{h \in HH} S^{H}_{h} s_{h} + S^{G} g^{s} + S^{F} (f^{s} + r);$$

10.11.4 Real National Savings

$$\tilde{s}^{N} = s^{N} - w^{(0)}_{v}; \qquad v \in CAP$$

11 Other Macroeconomic Accounting Identities

11.1 Price Indices

11.1.1 Overall Consumer Price Index

$$p^{H} = \sum_{i \in PG} \sum_{s \in SG} H_{(is)} p_{is}^{(3)};$$

11.1.2 Consumer Price Index Computed from Prices of Consumer Goods

$$p^{Hq} = \sum_{k \in CG} H_{(k)} q_k;$$

11.1.3 Consumer Price Index by Household

$$p_h^{Hq} = \sum_{k \in CG} H_{(k)h} q_k;$$

11.2 Private Consumption Expenditures

11.2.1 Aggregate Nominal Private Consumption Expenditure

$$c = \sum_{h \in HH} H_{(h)} c_h;$$

11.2.2 Real Private Aggregate Consumption Expenditure

$$\tilde{c} = c - p^{H};$$

11.2.3 Real Consumption Expenditure of Household

$$\tilde{c}_h = c_h - p_h^{Hq};$$

11.3 Real Government Expenditure on commodities

$$\tilde{g}^{d} = g^{d} - p^{H};$$

11.4 GDP Accounting

11.4.1 Nominal GDP:

$$y = H^{CY}c + \sum_{i \in PG}\sum_{s \in SG} H^{IY}_{is}(x^{(2)}_{is} + p^{(2)}_{is}) + H^{GY}g^{d} + H^{EY}e - H^{MY}m;$$

11.4.2 Real GDP

$$\tilde{y} = y - p^{Y};$$

11.5 GDP Deflator

$$p^{Y} = \sum_{j \in NAI} V_{j(k)}p^{(0)}_{js} + \sum_{j \in AI}\sum_{r \in REG} V_{jr(k)}p^{(0)}_{jr};$$

$$s \in LOC, k \in (NAI \cup (AI \otimes REG)).$$

11.6 Social Welfare

$$w = \sum_{k \in CG} H_{k}c_{k};$$

SET DEFINITIONS

PG = {xlx is a vector of 60 producer goods}

APG = {xlx is a vector of 21 agricultural producer goods}

PERNCROP = {coconut, Palm_oil, Coffee, Rubber, Tobacco}

= {xlx is a vector of perennial/contractual crops that do not compete with other crops for land in the short-run}.

ANCROP ={set of 16 annual crops}

IND = {yl y ia a vector of 60 industries}

NAI = {yly is a vector of 39 non-agricultural industries}

AI = {yly is an agricultural industry producing one of the 21 agricultural commodities}

CAP = {capital good}

CG = {xlx is a consumer good}

FERT = {fertilizer}

SG = {sls is a source of producer goods}
= {dom, imp}

FOR = {imp}

LOC = {dom}

HH = {hlh is a household type}

EXP = {xlx is an exportable good}

IMP = {xlx is an import competing good}

LAB = {vlv is a vector of 2 labour types - LS, & LU}

LAND = {land resource}

LCOM = {composite labour}

LS = {skilled labour}

LU = {unskilled labour}

RA = {v|v is an agricultural resource}

= {Fertilizer, unskilled labour, land, animal and machinery}.

REG = {y|y is a region which produces agricultural goods}

= {actual names of the four regions}.

RNA = {v|v is a resource in non-agricultural sectors}

= {composite labour, Mobile capital, and Immobile capital}

SCAP = {sector-specific (or immobile) capital}

USER = {u|u is a vector of users of commodities}

AMCAP = {mobile capital in AI's}

NAIMCAP ={mobile capital employed in NAI's}

SOME IMPORTANT RELATIONSHIPS:

$AI \subset IND$

$ANCROP \subset AI$

$PERNCROP \subset AI$

$NAI \subset IND$

$SG = LOC \subset SG$

$FOR \subset SG$

$LAB = LS \cup LU$

$RNA = LCOM \cup VCAP \cup SCAP$

$RA = LU \cup SCAP \cup LAND \cup FERT$

$FERT \subset PG$

FERT $\subset$ RA

PERNCROP $\subset$ APG.

ANCROP $\subset$ APG.