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HOUSEHOLD SURVEY DATA APPLICATIONS AND ANALYSIS

C O N T E N T S

* The appendix is based on examples developed by the International Center for Public Enterprises in Developing Countries (ICPE), Lujubljana, Yugoslavia, for a course on development planning. The authors of the original material are Dr. A. Vahcic and Dr. T. Petrin.

INTRODUCTION

1. It has been recognised over the years by both producers and users of household survey data that the absence of a comprehensive document on household data applications is one of the main reasons why demand for such data has not been very high in a number of African countries. True a number of UN publications have highlighted some uses of survey data in special fields but these have not embodied the concept of continuing survey programmes generating integrated demographic, social and economic data. In the absence of such guidance, data analysis has also tended to be concentrated in individual subject-fields without showing the inter-relationships between data collected during different survey rounds. Also the question of policy relevance of data analysis has received but scant attention in the region to the extent that planning has tended to be non-technical. These issues have been examined by a number of working groups and also previous sessions of the Joint Conference of African Planners, Statisticians and Demographers. In April 1983, the problem was again discussed by the ECA Conference of Ministers when examining the problems of African Statistical Services. A resolution 469 (XVIII) was passed which inter alia recommended to the United Nations and its specialised agencies that they should "extend international statistical recommendations to include guidelines on data analysis and applications".

THE RELEVANT ISSUES

2. As already mentioned, the analysis of survey data has been discussed extensively in the region. The various issues arising from the discussions relate to the need to elaborate the various techniques for exploring data structures and also the preparation of a document for the training of both statisticians and users on the presentation, interpretation and analysis of data. The 1981 seminar on household surveys had recommended that training workshops on survey data analysis should be organised. Before such workshops can be organised, however, the relevant background document had to be produced. It may be recalled that other papers on analysis of survey data had been presented to the 1979 and 1981 working groups on Organization, Content and Methodology of Household Surveys. It was, however, felt that these documents were incomplete for the purposes of summarising the state of the art and inadequate as guidelines for national statistical offices, statistical training centres and users of household survey data. It was proposed therefore that a comprehensive document which would provide sufficient guidelines to statisticians and analysts on the uses and analysis of the data generated from household surveys planned to be undertaken within the framework of the African Household Survey Capability Programme should be prepared.

3. The manual or working document to be produced was expected not only to be used for the analsis of survey data but also for the training of statisticians so that they would acquire the necessary expertise during their initial training at STPA Centres.

4. In order to produce such a document it was proposed that an approach should be made to the Government of the Federal Republic of Germany for the use of the unspent balance of the funds provided for the 1981 seminar to engage a consultant who will carry out this assignment. It was envisaged that the consultant would initially look at the data requirements already identified under the AHSCP and examine more closely the core items listed. It may be noted that the present list of subject-fields identified by ECA in consultation with the UN Statistical Office, UN specialised agencies and some African countries is as follows

(a) Demographic characteristics

(b) Household income, consumption and expenditure

(c) Labour force (employment, unemployment and under-employment)

(d) Conditions of health, nutrition, housing, water supply, education, literacy and access to related services

(e) Food consumption

(f) Household enterprises (agriculture, handicrafts, trade, transport, etc.)

5. This classification was contained in Household Data Requirements (E/CN.14/SM/22) presented to the Working Group on Organization. Content and Methodology of Household Surveys (Addis Ababa, 15-19 October 1979). This identification of main subject-fields is for illustrative purposes only and does not necessarily indicate how countries will develop their survey programmes nor the subjects to be covered nor the priorities to be given. In addition ECA attempted to identify core items which would be covered in each survey round. These items were divided into three categories: community level, the household as a unit and for each household member and visitor. In the core items two criteria were taken into account:

(i) Items which change significantly from year to year and which therefore need constant monitoring, and

(ii) Items which will serve as explanatory or intermediate variables either for the survey in which they are collected or for the integration of results from several surveys.

6. It was expected that the consultant would not devote too much time to the problem of statistical inter-linking of data from the different rounds (i.e., the use of the same sampling units at the ultimate stage) because

(i) The question has already been examined by a UN consultant, Mr. E.K. Foreman, and his paper is available for use.

(ii) At this stage of the development of the survey programme in Africa, any attempt to introduce sophisticated techniques for inter-linking different sets of survey data may inhibit survey data analysis rather than promote it. This, however, does not rule out the possibility of considering other means of inter-linking data at stages prior to the ultimate stage.

7. It was also considered that analysis cannot be done in isolation. It should be related to the uses to which the survey results are likely to be put. Therefore, the consultant should cover both the policy uses and analysis of survey data.

8. It should be stressed that the document produced by the consultant will not duplicate any efforts of the United Nations Statistical Office (UNSO) with which the ECA Statistics Division maintains close contacts. Analysis and applications are not generally covered in publications of the UNSO such as the Handbook of Household Surveys or in its statistical recommendations and the ECA document on survey data analysis and applications will be a first step in remedying this defect. It should also be mentioned that the document will have great value in planning national household surveys, since it will help countries to focus on the type of data with major and priority applications.

9. It was decided in determining the terms of reference of the consultant that the type of person required is not a satsitician with analytical skills but a user, preferably an economist, with a knowledge of surveys and with analytical skills. Prof. Irma Adelman, a distinguished economist of the University of California at Berkeley, was identified.

OUTLINE OF STUDY

10. At the request of the ECA Statistics Division, Prof. Adelman prepared a rough and preliminary outline of the document which is reproduced below.

- Current uses of household surveys are limited especiallycompared to their potential.
- Mainly used in:
  (a) the construction of national statistics;
  (b) diagnostics for policy formulation.

Report will be limited to potential applications, some of which are starting in African countries and elsewhere.

Project level

11. (a) Project evaluation:

Partial equilibrium, retrospective - requires pre and post household surveys, both in project area and in matched non-project area.

(b) Project design or general equilibrium project evaluation:

Requires the construction of project area model, using household surveys and econometric analysis.

Example

(i) Construction of a project area SAM from household surveys data and use of the SAM project design. (Ex., from Mexico and Philippines.)

(ii) Econometric analysis of household surveys data to derive production and consumption functions and their embedding in a project area model for use in project design. (Ex., from Egypt.)

Sectoral Policy analysis

12. Construction of micro-based household behavioral models from household surveys data for use in sectoral policy formulation.

(a) Agricultural policy analysis:

(technological change; price policy; land reform)

(b) Manpower policy analysis:

(education, employment, migration)

(c) Social development policy analysis

(BACHUE and basic needs models)

Economy-wide planning

13. Issues to be addressed by economy-wide planning major constraints - foreign exchange, human resources, and institutional development.

(a) Major objectives:

Industrialization and poverty alleviation (or social development)

(b) Major instruments:

Investment allocation including human capital, and public/private mix.

- Foreign exchange allocation
- Price policy, including commercial/trade policy and subsidies and value added taxes.

Requires the building of economy wide models which incorporate the policy instruments and constraints, are subject to the behavioural, technological, accounting and institutional constraints of the economy, and give as outputs indicators of the planning objectives.

14. These models require a melding of micro and macro data sources. That is, they require melding of census and national account data with household survey data. They require the building of an integrated accounting base, such as the economy-wide SAM, using input/output, household surveys, manpower under-employment (census or survey) data, and national account statistics. Ex. 1 national level SAM, Cameroon. The SAM can either be used directly for policy analysis by applying the "proportionate behaviour" assumption. (Ex. Zimbabwe.) Or, preferably, it can be expanded into a computable general equilibrium (CGE) model by embedding into the SAM accounting framework behavioral relationships derived from econometric modelling of the behaviour of institutional factors based on household surveys. The CGE model can then be used to trace how the various methods of policy intervention enumerated above are likely to affect the welfare of the various socio-economic, religious/ethnic, urban/rural members of society. Ex. Cameroon (currently in progress) semi-industrial countries (S.Korea, Turkey, Brazil).

15. It should be noted that before embarking on the assignment, Prof. Adelman visited Ethiopia (28 November - 2 December 1983), Kenya (2 - 9 December 1983) and Cameroon (9 - 15 December 1983) and held discussions with both producers and users (actual and potential) of household survey data.

16. The first draft of the document under the title "Policy Uses of Household Budget Surveys Data" is reproduced for discussion as an annex to this report. The paper is an interesting and useful one and shows the types of models which can be constructed from household transactions and other data. The change of title is not important since it discusses household data applications and analysis, though the analysis is limited to household budgets.

17. The workshop has to consider the document in detail, focus on how it can be applied and highlight any short-comings which have to be corrected.

POLICY USES OF HOUSEHOLD BUDGET SURVEYS

I. INTRODUCTION

1. In December of 1983, I was commissioned by the Statistical Division of the Economic Commission for Africa to look into the uses of household budgets in policy formulation in African countries. Visits were set up for me in three African countries: Ethiopia, Kenya, and Cameroon. In each country, my hosts were the respective statistical offices. They arranged for discussions with the central planning offices, several sectoral offices (the ministries of agriculture and of labor), and the ministries concerned with social services (education, population, and health). The issues discussed were the uses, current and contemplated, of data generated by household budget surveys.

2. The general conclusion was that the uses of household budget surveys in policy formulation were much below their potential. In Ethiopia the potential was generally understood; and the planning, agriculture, and labor ministries were anxious for the results of the current and past rounds of surveys. There are, however, serious processing bottlenecks partly because of overly ambitious sample sizes and partly because of inadequate availability of computer facilities and systems analysts for the processing. The ministries also seem to wait for data to be published rather than obtain the prerelease of the data before it is fully processed.

3. In Kenya the data processing and tabulations do not appear to be a problem. However, the only uses which the Planning Ministry has for household budget data are to generate a few macroeconomic parameters: the savings rate and weights for the consumer price index. There also appears to be some duplication between the statistical efforts of the Ministry of Agriculture and those of the statistical office. The economic data collected from budget surveys is used for policy purposes mostly by international agencies and donors (the World Bank and the United States Agency for International Development) for project formulation and project evaluation.

4. In Cameroon the use of budget survey data seems to be the most sophisticated. A well designed and executed budget survey is currently in process. Policy uses of the data are being planned. Indeed, a general equilibrium model of the type discussed below which is based on the use of household budget surveys is in process of implementation by the Planning Commission of Cameroon. In addition, the statistical office is interested in implementing household models of the type discussed below with the data once it comes on line.

5. There is clearly a gap between the potential and the actual uses of household budget surveys in planning and policy analysis in most African countries. Part of the gap arises from a lack of appreciation for the potential which this kind of data holds. The present report is designed to bridge this gap by describing the kinds of econometric analyses which can be performed with household budget data and the policy uses to which these analyses can be put.

II. THE USE OF HOUSEHOLD BUDGET SURVEYS FOR RURAL DEVELOPMENT POLICY

II.1 Policies for the Rural Sector

6. In formulating policies for the economic development of African economies, the planner is often hampered by a lack of adequate information. Nowhere is this more apparent than in designing policies for the agrarian sector where the absence of econometric estimates of critical parameters does not permit one to predict even the direction of the impact of crucial policy interventions. This is so because the subsistence nature of the African family farm results in production and consumption decisions being combined in the same unit. This fact, in turn, makes the signs of some response elasticities to certain critical price changes ambiguous without numerical estimates of the magnitudes of price and income effects which go in opposite directions.

7. More specifically, the household-firm nature of quasi-subsistence farming adds a third effect to the usual substitution and income effects of consumption theory, i.e., the profit effect coming from the production side. The addition of this effect may alter the sign of the initial response. As a result, theory alone does not suffice to predict even the direction, let alone the magnitude, of so critical a policy parameter as the output elasticity of the marketable surplus with respect to changes in price.

8. Even with total rationality on the part of the farmer, the answers to such important policy questions as whether the marketable surplus of a given crop responds positively to a price increase in that crop and how that price increase affects total farm output and total marketable surplus become empirical issues which cannot be answered without household budget surveys. With the aid of household surveys and some theoretically rigorous empirical work to compute the relevant functions, we can answer these and other policy questions. The answers to these questions, for which household surveys are essential, may help avoid the formulation of misguided policies with respect to both rural and national economic development.

II.2 Empirical Models of the Subsistence Sector

II.2.1. Background

9. The family farm is essentially a household-firm. There are two important characteristics of family farming which cannot be ignored in applied work. These are that part of the output of the agricultural household is consumed by the household and that part of the input of the farm is provided by the household. This contrasts with the pure firm which purchases all of its inputs and sells all of its outputs and with the pure consumer who buys all the products he consumes. The household-firm makes transfers in kind internally; part of its output is transferred from the household-firm as producer to the household-firm acting as consumer and part of its labor power is transferred in the opposite direction; neither is completely traded in markets. The result of this institutionally hybrid behavior is that consumption and production decisions cannot be decoupled but have to be modeled simultaneously. It is this feature which introduces the theoretical indeterminancy of some reactions to changes in output prices and in wages.

10. Economic models of the household-firm are not new (see, for example, Nakajima, 1969; Jorgensen and Lau, 1969; Yotopoulos and Lau, 1974; Barnum and

Squire, 1979; Singh and Squire, 1978; and Ahn, Singh, and Squire, 1981). Application to Africa is, however, quite recent; Strauss (1984) used a model of the household-firm to estimate the joint determination of food consumption and production in rural Sierra Leone.

II.2.2. Theoretical Specification

11. The theoretical specification of models appropriate to the analysis of quasi-subsistence farming involves the optimization of a utility function whose arguments are consumption and leisure subject to three or more constraints: (1) a full income constraint which includes the net income from the operation of the family farm as well as earnings from wage labor outside the farm and non-wage, noncrop income; (2) a labor time constraint which allocates total available labor time between farm labor, nonfarm labor, wage labor, and leisure; and (3) one or more production functions for all crops.

12. The optimization of the utility function yields equilibrium conditions which, on the production side, determine the labor input on the farm, the cropping pattern and outputs of the farm, and the amounts of labor purchased and those supplied by the farm household. On the consumption side, the optimization determines the amount of farm output retained for own consumption, the consumption of marketed goods, and the amount of leisure. As soon as any part of the farm output is marketed, the labor input on the farm is set by the condition that the value of the marginal product be equated to the wage rate in each crop. As soon as any labor is sold, the own-labor input of the farm household is determined by the requirement that the subjective marginal valuation of family labor equal the wage rate. Finally, as soon as any part of the farm output is sold on the market, the retained output for family consumption is determined by the condition that the subjective valuation of retained output at the margin be equated with the market price. The amount of hired labor used in production is determined by the difference between labor demand and the own-labor input. The production function sets total output, and the difference between farm production and household autoconsumption determines marketable surplus.

13. The production side of the model can be solved independently of the consumption side as long as there exists a labor market, and family and hired labor are perfect substitutes. The solution of the consumption side of the model, however, is conditional on the production decisions of the household-firm since the definition of income used to determine consumption includes the net income from farming and, therefore, requires one to know the total profits from farming. Therefore, when prices or wages change, one effect on consumption is through the effect of those changes on profits. The introduction of the profit effect can change the sign of the overall response elasticities; in other words, the price elasticity holding profits constant can be negative while the total price elasticity allowing for the effects due to variations in profits is positive. That such a change in sign can occur is not merely a theoretical possibility. The study for Sierra Leone cited above (Strauss, 1984) found that, for low-income households, the own-total price elasticity of demand for root crops and cereals changed from negative to positive when profit effects were added. Furthermore, in his study, the cross-price elasticities were mostly reversed in sign, from negative to positive when profit effects were included. Strauss also found that the profit effects were larger for low-income households, implying that their economic behavior is less predictable a priori.

II.2.3. Econometric Estimation

14. The estimation of the household-firm model reguires the estimation of production functions and the estimation of systems of demand equations. The different models estimated so far differ in their choices of functional forms and in their degrees of disaggregation. Lau, Lin, and Yotopoulos (1978) estimated a three-goods linear logarithmic expenditure system which required a unit elasticity of aggregate expenditures with respect fo full income. The production side of their model used a Cobb-Douglas production function on a single aggregate output and estimated it by estimating the associated profit function and input demand functions. Their data were regional averages derived from household budget studies and grouped by region, bu farm size, and by year. Prices varied by region and over time.

15. Barnum and Squire (1979) and Singh and Squire (1978) specified a three-commodity linear expenditure system for the demand side of their household-firm and estimated a one-good, Cobb-Douglas production function on the supply side. Their data were based on a cross section of household budget studies in which the only price that varied was the wage rate. (The use of a linear expenditure system allows one to estimate all price elasticities from the variation with respect to a single price.)

16. Ahn, Singh, and Squire (1981) disaggregated production and consumption into six commodities (four foods, leisure, and nonfood). The production side of their model was specified by using linear programming, and their consumption system was of the linear expenditure variety. Their data were from household-budget studies at a single point in time and included only variations in wage rates.

17. The Strauss (1984) model for Sierra Leone used the most sophisticated statistical specification and greatest commodity disaggregation. The consumption system of the model was a quadratic expenditure system which allows Engel curves to vary nonlinearly with income and incorporated demographic effects in a manner which allows one to use the results for estimating household-composition equivalence scales. The production system used a Cobb-Douglas aggregation of inputs and a constant elasticity of transformation among outputs and assumed separability between all inputs and all outputs.

II.2.4 Data Requirements

18. Since Strauss's (1984) study is for an African country and is based on household budget surveys, his data will be discussed in some detail to give some indication of data requirements for the estimation of household-firm models. Strauss's data are from a survey of rural households in Sierra Leone during the 1974-75 cropping year. Sierra Leone was divided into eight agro-climatic zones, and in each of these zones, stratified random samples of households were selected. The households were visited twice a week to obtain information on production, sales, and labor. Half of the households were visited twice during one week per month to gather information on market purchases.

19. Estimates of quantities of home production consumed were derived residually by subtracting sales, wages in kind, and seed, and adding wages in kind received. The result was adjusted for processing and for storage losses. The quantities of home-produced product consumed were multiplied by farm-gate prices, to derive the values of autoconsumption, and added to the purchases of commodities in the respective categories to get total consumption.

20. Household labor supply was estimated by summing hours worked by all family members on the family farm on nonagricultural enterprise and labor sold to the market. It excluded labor for household maintenance such as food preparation, child care, and ceremonies. Labor equivalence units were used to convert labor by children and women into male equivalent hours by using the ratio of wages as weights.

21. Prices were estimated from transactions prices by dividing regional sales by sales quantities for each of 195 commodities. Commodity prices for each region were formed by suitable aggregation. These were used to derive farm sale prices, wages, and purchase prices.

22. Land was measured as total area cropped with no adjustment for land quality. Capital was measured in flow terms; and the stock of fixed capital was converted into flow terms to enable adding its value to the expenditures on seed, fertilizer, and hired machinery. Fixed capital included livestock, tree crops, farm tools, animal equipment, and nonfarm equipment.

II.3. Policy Questions which can be Adressed by Means of the Farm Household Model

23. The estimated household-firm model can be used to analyze a multitude of policy issues relating to the economic efficiency and social equity impact of many types of potential price and nonprice interventions in the rural sector. The elasticities computed from the household model indicate the impact of a change in an exogenous variable on household behavior when all other variables are held constant. They exclude the effects of interactions among the exogenous variables and assume that the relevant macro relationships for the rural economy can be derived by multiplying the micro relationships by the number of households. Interdependence at the macrolevel among variables that are taken as exogenous at the microlevel is thus excluded at this point. The general equilibrium models discussed later are needed to estimate these effects.

II.3.1. Output Price Policies

24. Among the most important policy issues with respect to the rural sector is how to set the agricultural terms of trade. This is an issue with significant efficiency and equity consequences which involves trading off rural and urban interests as well as the interest of landowners, tenant farmers, and landless labor. While the farm household model cannot fully answer the questions raised by this issue (to do so requires a price responsive general equilibrium model), it does provide important pieces of the answer.

25. The model can be used to evaluate the elasticity of the marketable surplus of a crop with respect to the contemplated price change, the elasticity of total agricultural output with respect to the change when cross effects on other crops are included, the elasticity of demand for hired labor, and the elasticity of supply of family labor.

26. It is by no means obvious, a priori, that an increase in the price of a given crop will necessarily increase the marketable surplus of that crop. The increase in price raises the income of the household and, hence, may increase its own consumption of that crop. The effect on household labor supply, too,

may be either positive or negative. This is because the increase in price operates both to augment the value of the marginal product of labor allocated to that crop and to increase the marginal utility of leisure.

27. The empirical estimates obtained from household-firm models so far tend to indicate that the elasticity of supply of family labor with respect to the price of a crop is negative while the elasticity of demand for labor is positive. They, therefore, suggest that an increase in the market wage for hired labor is likely to occur. When the anticipated increase in the market wage rate is allowed for (see Barnum and Squire, 1979, pp.89-91), the increase in wages is sufficient to lead to counterintuitive conclusions: despite an increase in the price of a crop, farm labor demanded for that crop decreased, and total crop output fell; and the marketable surplus declined. It is, therefore, by no means clear that an increase in the price of, say, rice will increase its supply to urban groups; it may mean that farmers eat more of it and work less.

II.3.2. Nutrition Policy

28. How will a shift from food crop production to market production affect nutrition? The household production model can be used to answer this question by translating food consumption, by commodity, into calories and nutrients (see Strauss, 1984). The answers obtained are by no means obvious, a priori, and appear to depend upon precisely what exogenous variables are changed to effect the shift. To quote Strauss: "Looking at our results, if we examine oils and fats, ... an increase in own-price results in decreased calorie availability for high and middle expenditure groups but increased availability for the low expenditure group .... Hence increased reliance on the market for oils and fats as a consequence of a rise in oils and fats price results in higher calorie availability for a typical low expenditure household, but lower caloric availability for typical middle and high expenditure households.... Alternatively, ... an increase in rice price will lead to increased calorie availability for the low expenditure group and decreased availability for the middle expenditure group. Hence for an increase in rice price, lower reliance on the market for oils and fats is accompanied by lower calorie availability for the middle expenditure household "(p.97).

II.3.3. Income Distribution Policy

29. What are the income distribution implications of changes in farm output price? The impact on the income of producers of a crop of price increases in that crop can be evaluated directly from the definition of income and of profits in the model. The spread of those effects to new households occurs through changes in consumption and changes in the demand for hired labor. The consumption effects can be evaluated by noting that the elasticity of farm profits with respect to a change in output price has generally been found to be positive and high. This leads to income-induced changes in consumption patterns which can have major effects on the incomes of other households. It is evident from estimates of the compensated cross-price elasticites that an increase in the price of farm output generally leads to a large increase in the consumption of nonfarm commodities. This in turn can be expected to give rise to increases in the incomes of urban and rural suppliers of nonfarm goods.

30. Landless labor is negatively affected by the increase in price as consumers and positively affected as suppliers of labor. The functions of the model which provide estimates of the elasticities of response of wages to output price and the elasticities of hired-labor use with respect to price can be used to estimate the income effect upon the wage laborer of a rise in output price. When the income effects are combined with estimates of the elasticities of farm laborer consumption with respect to an increase in price, the overall effect upon real farm worker income of the output price increase can be evaluated from the model.

II.3.4. Rural-Urban Migration

31. The household decision model can be used to estimate the costs of rural urban migration. If the model includes demographic variables in the system of demand equations, then quasi general equilibrium estimates of the costs of migration can be obtained. These estimates include not only the direct estimates of the marginal product of labor but, also, the effects of withdrawing the labor of a family member on the labor of other family members and the effects of the induced change in family composition upon the consumption pattern of the household. Barnum and Squire (1979) have estimated that the true shadow price of a rural-urban migrant is approximately half of the marginal product of rural labor when allowances are made for the supply response of family labor to the reduction in household size and for the labor market response to the removal of labor.

II.3.5 Family Planning

32. The model presented above can also be used to estimate the potential benefits of family planning. By evaluating the short-run effects on consumption and household labor supply of having one less family member, the model can be used to suggest the potential benefits of delaying the expansion of the family for one period. One result of a successful family planning program is to reduce both family and market-labor supply and labor demand. The estimates of these labor market effects obtained by Strauss (1984) and by Barnum and Squire (1979) suggest that they are small. The impact of family planning on farm output is, therefore, likely to be small. However, their estimates also suggest that the impact of family reduction on own consumption of grain and, therefore, on marketed surplus is likely to be substantial. The model of the household-firm, thus, provides the elasticities required to gauge the impact of family planning on the marketed surplus. The social benefits from this source must be added to other benefits of family planning.

II.3.6 Technical Efficiency and Innovation

33. The model of the household-firm can be used to evaluate the degree to which a farm is efficient from both the technical and the economic points of view. For any grouping of farms (by size, by tenurial conditions, or by commercialization), the production side of the model can be used to test the hypothesis that all groups of farms face the same production technology. The results will indicate whether or not all groups of farms are equally efficient technologically. If some farms are less efficient than others, the policy options include reallocation of resources away from the less efficient farm or efforts to identify and remedy the sources of inefficiency.

34. The model can also be used to test the allocative efficiency of each kind of farm by comparing the ratio of its marginal productivities to the ratio of its factor costs. If the ratios differ, there is allocative inefficiency. If allocative inefficiency is significant, additional research into which factors lead to under- or overinvestment in certain inputs may be needed. The list of potential candidates includes risk, imperfect credit markets, insufficient information, etc. Knowledge of which kinds of allocative or technical inefficiency exist is a necessary prelude to policy intervention for their removal.

35. The model can also be used to estimate the impact of technological change taking account of a broader range of effects than are evident from the analysis of production alone. Technical innovation shifts the production function outward. This affects not only the demand curve for labor but also the household supply curve of labor in as much as the income effects due to increased profits change the allocation of household time between production and leisure. The diffusion of benefits to other households and sectors can also be estimated: the elasticity of expenditures with respect to technological change will generate increased expenditures on nonfarm goods, thus, benefiting households and enterprises that supply nonfarm goods and services. Since agricultural innovations increase the demand for labor (both own and hired) and decrease the supply of family labor, neutral technical change will increase the wage bill. The income of households dependent on wage labor will, therefore, rise. The household-firm model permits estimating all the appropriate elasticities required to evaluate all of these direct and indirect impacts of technical change.

III. THE USE OF URBAN HOUSEHOLD BUDGET DATA FOR DEVELOPMENT POLICY

III. 1 The Urban Household Model

36. Urban households differ from rural households in that they buy all their consumption goods and services on the market and sell all their labor. The amounts of autoconsumption and autoproduction are small. The household budget data can, therefore, be used only to estimate consumption demand, labor supply, and savings; these estimates can be derived without conditioning them on the solution of the production side of the urban economy.

37. Formally, the household model appropriate to the urban household is a special case of the household-firm model described in some detail above. It can be derived from that model by setting the profit term in the definition of household income to zero, by omitting the amount of labor devoted to home production from the labor time constraint, and by deleting the production function (s) from the constraint set for the optimization of household utility. This makes the derivation of the system of consumption demand, labor supply, and savings functions the result of optimizing a utility function, whose arguments are present and future consumption and leisure, subject to a set of budget constraints which include savings and a set of time constraints for each period. The solution of this optimization problem can be used to rewrite the household utility function in terms of prices (including wage rates) present and future, and a sequence of incomes. The system of consumption functions can then be estimated from either the original system (the direct utility function approach) or the system derived by substitution (the indirect utility function approach).

III.2. Econometric Estimation

38. The general model, as described above, involves the estimation of too many parameters. It is usually simplified by embodying restrictions on the shape of the utility function. One restriction common to all empirical work is that the utility function is additively separable in its arguments both at a given point in time and across time periods. When the latter constraint is imposed, the problem of estimating the savings rate can be solved separately from the problem of estimating the composition of consumption (Lluch, Powell, and Williams, 1977). The problem can then be decomposed into (1) the estimation of an aggregate consumption function out of income which is used to derive total expenditure and (2) the estimation of a system of consumption allocations among commodity groups out of total expenditure.

39. The most common specification of consumption systems used in empirical work derives from an additively separable utility function linear in the logarithms of the amounts consumed in excess of required minima which are purchased regardless of their price (Geary, 1950). The demand functions obtained by maximizing this utility function subject to the constraint that total purchases equal total expenditures yield linear expenditure systems with constant marginal budget shares (Stone,1954). These can be used to estimate income and price elasticities, subsistence minima, and marginal and average budget shares.

40. Recent refinements in the estimation of consumption systems include more flexible forms for the utility function aimed at overcoming the major theoretical deficiencies of the linear expenditure system. The linear expenditure system implies that the Engel curves, or the relationship between purchases and income when prices are held constant, are linear and that the wants satisfied by broad categories of goods are independent. Quadratic expenditure systems (Pollak and Wales, 1978 and 1980) generate nonlinear Engel curves. Transcendental logarithmic utility functions (Christensen, Jorgenson, and Lau, 1975) permit one to test the validity of several restrictive assumptions embodied in the linear expenditure system since the latter is a special case of the former.

41. Recent work on the estimation of consumption systems has also focused on the appropriate incorporation of demographic effects (i.e., family size, age of head of household, and ethnicity) into the system of demand equations. Pollak and Wales (1978) assume that the intercept and the subsistence minima in the quadratic expenditure system are linear functions of demographic variables. An alternative specification of the effects of demographic variables ascribed to Barten (1964) is to scale the amounts of commodities which enter the utility function by indices which are functions of the demographic variables. This specification leads to commodity-specific equivalence scales for household members with different demographic characteristics. While the scaling specification is superior, it is difficult to estimate when a nonlinear system is used.

42. Other recent developments have dealt with how to incorporate dynamic effects, such as habit formation or shifts in subsistence minima over time, and how appropriately to formulate models capable of explaining the consumption of durable goods. (Pollak, 1970, Phlips, 1970; and Lluch, Powell, and Williams, 1977).

III.3. Policy Uses of Urban Household Budget Surveys

43. Consumer expenditures constitute from 60 to 80 percent of the GNP in African countries. Their variation with prices and income changes is a major determinant of structural changes in the composition of production, imports, employment, and income distribution in the course of economic development. Since the commodity composition of demand varies systematically with income and price changes, an economy with growing per capita GNP will require a different structure of production to satisfy the changing demand patterns. The alteration in the patterns of production induced by the changes in consumption will, in turn, affect the country's external trade since the import and export content of different industries differs. For these reasons, the demand systems discussed above constitute invaluable inputs into national planning.

44. The policy uses of urban household budgets are a subset of the policy uses of the rural budgets. They can be used to address all the consumption, income distribution, and demographic issues listed in the discussion of policy uses of rural budgets. Since urban household budgets do not include a productive sector, they cannot be used to analyze the production aspects of price policy, except as an input into a general equilibrium model, or the issues of efficiency and technical change in production. Some other uses of urban household budgets are discussed below. These should be considered as expansions of uses of rural household budgets as well. They are discussed here rather than earlier because the modeling and estimation problems involved in the econometrics of demand systems relevant to these applications are explicated more fully above.

III.3.1. Estimating Savings Rates

45. The savings rate is an important parameter in national planning. The econometric analysis outlined above provides a basis for estimating that rate (Lluch, Powell, and Williams, 1977) under base period conditions. The model described allows for the joint treatment of savings with the allocation of consumption expenditures. It, therefore, permits one to estimate how prices, income, family size, and income distribution are likely to affect the national savings rate. Lluch, Powell, and Williams (1977) found that the savings rate is sensitive to the price of food and that this sensitivity is more important at low income levels. They also found that age and location are important determinants of savings.

III.3.2. Subsistence and Levels of Living

46. Can the subsistence expenditures be measured, and what are the implications of these measurements for policies aimed at ensuring adequate nutrition and adequate levels of living? The systems of demand equations whose estimation has been discussed above can be used to provide estimates of subsistence expenditures and how these vary with changes in price, income, family composition, ethnicity, and other demographic variables. The estimates of subsistence levels can be obtained directly by summing the minimum bundles appearing in the linear or quadratic expenditure systems across all commodities. The relevant price and income elasticities are the weighted sums of the elasticities computed by comparative statics analyses of how the minimum bundles vary when income or prices change. The demographic equivalence scales can be computed by averaging the results of making the commodity-specific subsistence minima functions of demographic variables. Examples of applications of this kind are provided in Strauss (1984), Lluch, Powell, and Williams (1977), and Deaton (1981).

47. Armed with estimates of this kind, one can then proceed to ask the difficult policy questions. What kind of income growth will it take to reduce the percentage of households falling below subsistence to, say, 10 percent? Is such a rate of growth feasible? If yes, what kind of policies must be taken to achieve this rate of growth; if not, what kind of redistribution policies should be employed? What kind of price policies could achieve the desired objective? What kind of food subsidies do they imply? Can the government budget support the subsidies required? How would a reduction in family size affect the answers to the above questions?

48. Partial equilibrium answers to questions such as these can be provided by direct analysis of urban and rural household budgets. The answers, especially at the urban level which ignores the production side of the urban economy, assume that there are no secondary repercussions through interactions in labor and commodity markets to the policy interventions undertaken. To take these into account requires incorporating the analysis of the consumer sector into a general equilibrium framework for national planning. We now turn to a description of how this can be carried out.

IV. THE USE OF HOUSEHOLD BUDGET SURVEYS IN SYSTEM WIDE PLANNING

49. Policy issues which arise out of the allocation of resources (i.e., the distribution of inputs among various commodities and the distribution of outputs among various consumers) are best analyzed within a general equilibrium framework. This is so because the overall quantity of at least some resources is limited. An increase in one commodity can, therefore, only be obtained at the expense of a reduction in other commodities. At least in principle, resource allocation is, therefore, necessarily a matter for general equilibrium analysis.

50. Resource allocation issues are also at the heart of economic planning. Development policy is concerned with the attainment of the optimal allocation of resources at any point in time and with the optimal trajectory of the economy over time. Economywide approaches to development planning, therefore, play a large role in the formulation of development policy.

51. Household budget surveys, in turn, constitute an important element in the data inputs required for the statistical implementation of such models. This is so because general equilibrium models are concerned with the interactions among institutions (consumers, household-firms, producers, government, and the foreign sector) in factor and commodity markets. The consumer and household-firm models described above, therefore, provide important building blocks of general equilibrium based planning models.

52. The overall data base for these models consists of censuses of production, household budget surveys, and national income and product accounts. To implement the general equilibrium planning models requires harmonizing these disparate data inputs within an internally consistent accounting framework. This is accomplished by means of a social accounting matrix (SAM) described in the next section.

IV.1. The Social Accounting Matrix

53. The derivation of the SAM is described in detail in Appendix A of this report. We start there with a description of the circular flow of the transactions which characterize an economy and explain how these transactions are captured in the rows and columns of the SAM.

54. The SAM is a system of socioeconomic accounts which captures in a consistent manner all aspects of economic activity: the allocation of factors of production to production, their transformation into final products, the disposition of these products between domestic and foreign markets, the distribution of commodities among consuming households, the distribution of income, and the allocation of income between current consumption and accumulation.

55. The SAM offers a static image of the circular flow of economic activity. Its basic formal characteristics are: it is a square matrix in which the columns represent expenditures and the rows represent receipts. Each row and corresponding column is called an account. Accounts represent a partition of the economy into entities such as factors of production, institutions (households, household-firms, and firms), activities (production and accumulation), government, and the rest of the world. Column sums always equal the corresponding row sums.

IV.2. Policy Uses of Social Accounting Matrices

56. There are two principal uses of a SAM: it can be used directly, and it can be used as a statistical base for the building of structural planning models. The direct use of the SAM involves using the rows and columns of the matrix in much the same way as one can use the economic accounts of firms to study what they do, how they do it, and how they interact with other institutions and economic entities in the system. The SAM can, therefore, be used to gain insights into the economic and social structure of the economy.

57. The use of the SAM as the statistical base for a model can also take two major forms. The SAM can be converted into an expanded input-output system, and various multipliers can be calculated in much the same way as in input-output analysis (Pyatt and Round, 1979a, b and Pyatt and Torbecke, 1976). The conversion of the SAM into an expanded input-output system entails the assumption of "proportionate behavior" with constant coefficients for all the entities in the system. It is implemented by dividing all the cells in a column by the corresponding column totals to obtain a coefficient matrix whose columns sum to unity. Matrix algebra can then be used to compute how changes in a exogenous variable (such as exports, foreign investment, government projects, or government taxes) work their way through the system. In particular, the model can be used to distinguish first from subsequent round effects and effects which occur through the firm side of the economy from those which occur through the consumption side and from those that occur through interactions among firms and households. This analysis can yield a clearer understanding of the manner in which shocks, whether induced by policy or by random effects, percolate through the economy.

58. Alternatively, the SAM can be used as an accounting framework for a computable general equilibrium (CGE) model based on microeconomic models of the individual entities in the SAM (Adelman and Robinson, 1978; Dervis, de Melo, and Robinson, 1982; and Dixon, Parmenter, Ryland, and Sutton, 1977); Typical micro models would take the form of the household or household-firm models described in the previous sections. The economic interactions which take place among the individual entities of the model in the goods and factor markets must then obey the accounting constraints specified in the rows and columns of the SAM. The decisions underlying the qualification of the entities in a row of the SAM are undertaken by entities different from the decisions underlying the quantification of the entities in the corresponding columns. The model must, therefore, indicate what adjusts (prices, quantities produced or consumed, or imports or exports) to ensure that the accounting constraints of the SAM are obeyed.

IV.3. The Computable General Equilibrium Model

59. The detailed specification of a CGE model is given in Appendix A. The Appendix presents the equations of a simplified CGE model and illustrates its derivation from the transactions represented in the circular flow of the SAM. The CGE model is based on microeconomic theory. The equations of a typical computable general equilibrium model can be classified into five groups: (1) equations describing household and other final demands for products, (2) equations describing industry and other demands for primary factors and intermediate inputs, (3) equations describing the supplies of factors, (4) market-clearing equations for primary factors and commodities, and (5) miscellaneous definitional equations of an accounting nature derived from the SAM and from the theory of national accounts.

60. The equations are supplemented by an institutional characterization of the economy which indicates which kinds of variables adjust to achieve the market clearing called for by the system of equations (4) above. The market clearing could be accomplished by varying prices until equilibrium is attained, by rationing inputs or outputs if there is excess demand, by government purchases or sales, or by using foreign trade.

61. The CGE model consists of an economywide, simultaneous, multisectoral model that solves endogenously not only for quantities but, also, for prices (for detailed description of the model, see Adelman and Robinson, 1978 and Dervis, de Melo, and Robinson, 1983). The core of the model consists of the reconciliation of potential demand and supply imbalances in the factor and commodity markets by price adjustments which simulate the workings of the markets of labor, commodities, and foreign exchange. The technological and behavioral functions are nonlinear and incorporate substitution possibilities among factors in production and among commodities in final demand. Imports and domestic production in a given sector are neither perfect substitutes nor complete complements; rather, there is an elasticity of substitution among them which lies between zero and unity, The model solves for wages, profits, product prices, and the exchange rate; sectoral production, import, export, employment, consumption, and investment; the flow of funds, GNP, and the balance-of-payments accounts; and the functional and personal distributions of income.

62. Production technology for intermediate goods is represented by fixed input-output coefficients and by constant elasticity of substitution functions for labor and capital. In the factor markets, labor demand arises from the profit-maximizing behavior of producers. The supply of labor is disaggregated by skill type. Farmers and service workers are immobile within each period although mobile between periods. The model determines market-clearing wages for skilled workers and their sectoral allocation; unskilled wages may be fixed, and unemployment may be allowed to develop.

63. The demand for commodities is responsive to relative price and income variations. The price responsiveness arises both because of the use of linear expenditure consumption functions and because of the trade specification which induces price-sensitive substitution among imports and domestic production. The incomes of consumers are determined in the factor markets after taxes are subtracted. The demand for commodities by sector is determined from these incomes (given the exogenously specified savings rates) and from the government consumption function. Relative prices that clear commodity markets are then solved so as to equate demand and supply. The wholesale price level is fixed as numeraire and sets absolute prices. The balance of trade determines the net demand for foreign exchange. The exchange rate adjusts so as to maintain a predetermined level of foreign capital inflow.

64. Several macro closure rules are possible for the model. The models are generally either savings or investment driven. Either investment absorbs the full brunt of the adjustment since it is forced to adjust directly to the enlarged or diminished supply of domestic plus foreign savings, or the distribution of income is forced to adjust so as to generate a supply of domestic savings equal to an exogenously specified level of investment.

IV.4. Policy Uses of Computable General Equilibrium Models

65. Once the CGE model has been formulated, it can be used to perform policy experiments. The uses to which CGE models have been put in planning in developing countries have fallen into three general categories: the design of income distribution policy, the design of development strategy, and the design of trade and structural adjustment policy. In developed countries CGE models have been used to analyze tax policy and energy investment policy. African applications are currently in progress (Dethier, 1984 and Devarajan and Benjamin, 1985). Dethier is applying a CGE model to the choice of a price policy for agricultural staples in Egypt under a joint University of California-Egypt project financed by the U.S. Agency for International Development. Devarajan and Benjamin are collaborating with the Planning Agency in Cameroon on the implementation of a CGE model designed for the formulation of development strategies. This effort is financed by the World Bank.

IV.4.1 Income Distribution and Basic Needs

66. The CGE models were initially developed in order to analyze income distribution issues and what policies and programs the government might employ in order to ameliorate the lot of the poorest segments of the country's population. The CGE model is particularly well adapted to the analysis of this class of issues.

It includes all the policy instruments which a government could use to effect changes in the distribution of income and has an income distribution subsector which permits the identification of who gains and who loses from a particular intervention when indirect interactions through markets have run their course.

IV.4.2 The Design of Development Strategies

67. The choice among development strategies is a basic issue in development planning. It involves selecting a strategy posture-industrialization through import substitution or through export expansion as well as the sequencing of leading sectors for investment (industry versus agriculture and light versus heavy industry). It also requires a specification of the means by which the desired strategy is to be accomplished-direct government investment or particular price and nonprice incentives.

68. The CGE models are extremely well suited to the analysis of development strategy issues in mixed economies in which the effects of government interventions impinge on private actors, in part, by modifying the prices which they face. In such economies CGE models give better answers to the question of strategy selection than do other kinds of planning models in which interactions through prices and markets are not modeled. In addition, unlike other planning models, CGE models can help not only in the choice of strategy but, also, in the selection of the incentive schemes (subsidies, taxes, or tariffs) necessary to implement the desired strategy.

IV.4.3. The Design of Structural Adjustment Strategies

69. Today's world is one of severe pressure on foreign exchange availability in virtually all developing nations. One class of answers, the International Monetary Fund package, operates at the purely macroeconomic level. It seeks to find the level of income compatible with an import surplus. This requires severe deflation.

70. The alternative approach combines changes in microeconomic trade policy incentives in order to effect structural adjustments in patterns of production, import, and export so as to achieve the desired surplus in the balance of payments. The CGE model can be used to analyze how trade policy affects resource allocation and the composition of imports and exports in both manufacturing and in the primary sector. It can be used to examine, sector by sector, the impact of sectoral tariff and subsidy rates by providing a detailed quantitative examination of the price and quantity linkages in the economy (Dervis, de Melo, and Robinson, 1983). It can, therefore, be employed in the design of a package of structural adjustment policies to balance-of-payments constraints.

V. CONCLUSIONS

71. In this report we examined how household budget surveys can be used in policy analysis. We divided the discussion into rural, urban, and economy-wide policy applications. With respect to each, we described the appropriate model specification, the issues that arise in model estimation, and the policy uses of the models once estimated. The review provided in this report should have convinced the reader that household budget surveys provide a rich and indispensable data source for policy analysis, economic planning, and informed policy formulation and evaluation.

THE CONSTRUCTION OF SOCIAL ACCOUNTING MATRICES AND COMPUTABLE GENERAL EQUILIBRIUM MODELS*

by

John Praveen and Sherman Robinson

A.1. The Circular Flow of Economic Activity

1. The simplest representation of the interdependence of economic activities is a flow chart showing the circular flow of economic activity. Examples are Charts 1, 2, and 2, and 3 which have two basic elements: (1) institutions such as households, producers, and the rest of the world, and (2) markets such as factor markets and product markets.

2. The basic fact of economic activity is that factors and products flow between institutions. These are called real flows. In monetary economies, they flow through the markets. In exchange for factors and products, there are flows of money payments in the reverse direction. These are called money flows.

3. Let us now briefly summarize the three charts and spell out the similarities and differences between them.

Chart 1

4. There are three institutions: households, producers, and the rest of the world. Note that these institutions are extremely aggregated: households include all households in the economy, producers include all all producers in the economy, and the rest of the world includes all foreign institutions.

5. There are two markets involved here: factor markets and product markets. Note, again, that these markets are also extremely aggregated; factor markets include markets for all factors of production, and product markets include markets for all products.

6. The products produced have three uses: (1) intermediates demand in the production process by producers, (2) final consumption by households, and (3) exports. The factors are all lumped together into one category. Chart 1 represents only real flows:

1. Households, which are the owners of factors of production, supply factors of production to the factor markets.

2. Factor markets supply factors of production to the producers.

3. Producers combine factors of production in the production process to produce products.

4. Producers supply the product markets with products.

5. From the product markets, some of the products are exported to the rest of the world.

6. From the rest of the world, some products are imported and placed on the domestic market.

7. From the product market, some domestically produced and some imported products are sent to the producers for intermediate consumption, and some are sent to households for final consumption.

*The appendix is based on examples developed by the International Center for Public Enterprises in Developing Countries (ICPE) Ljubljana, Yugoslavia, for a course on development planning. The authors of the original material are Dr.A.Vahcic and Dr. J.Petrin.

CHART 1

Circular Flow of Economic Activity

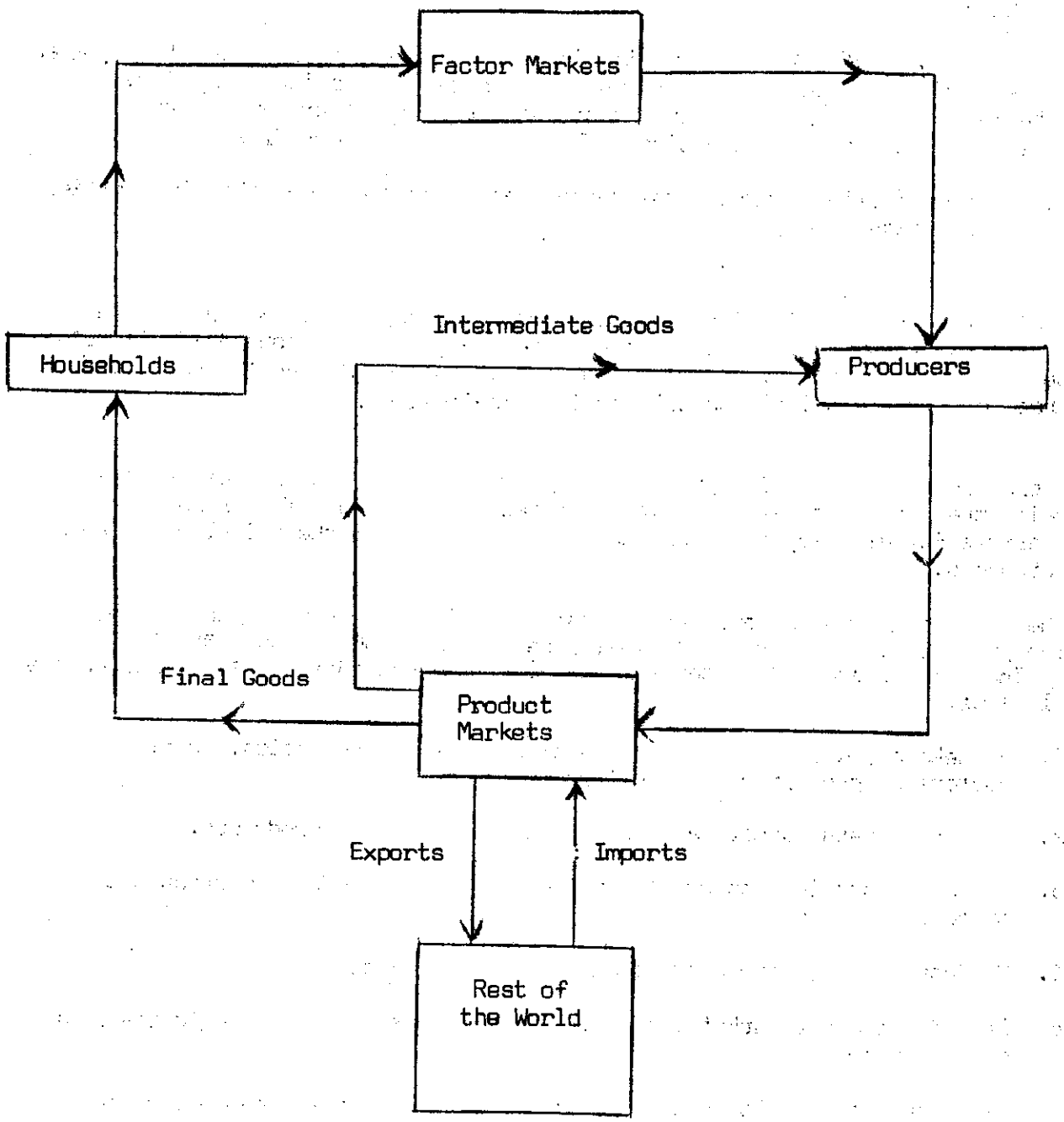


CHART 2

Circular Flow of Economic Activity

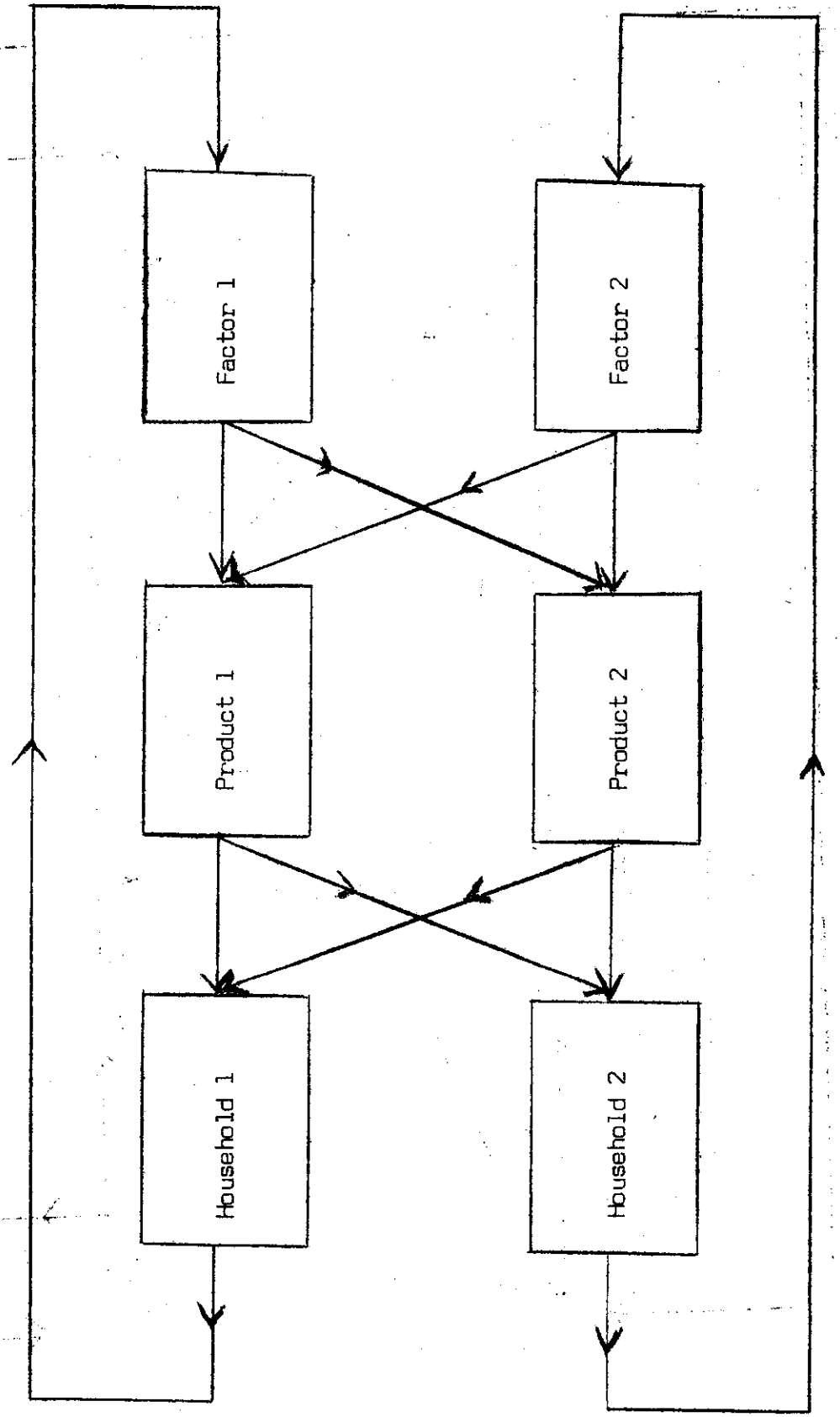


CHART 3

Circular Flow of Economic Activity

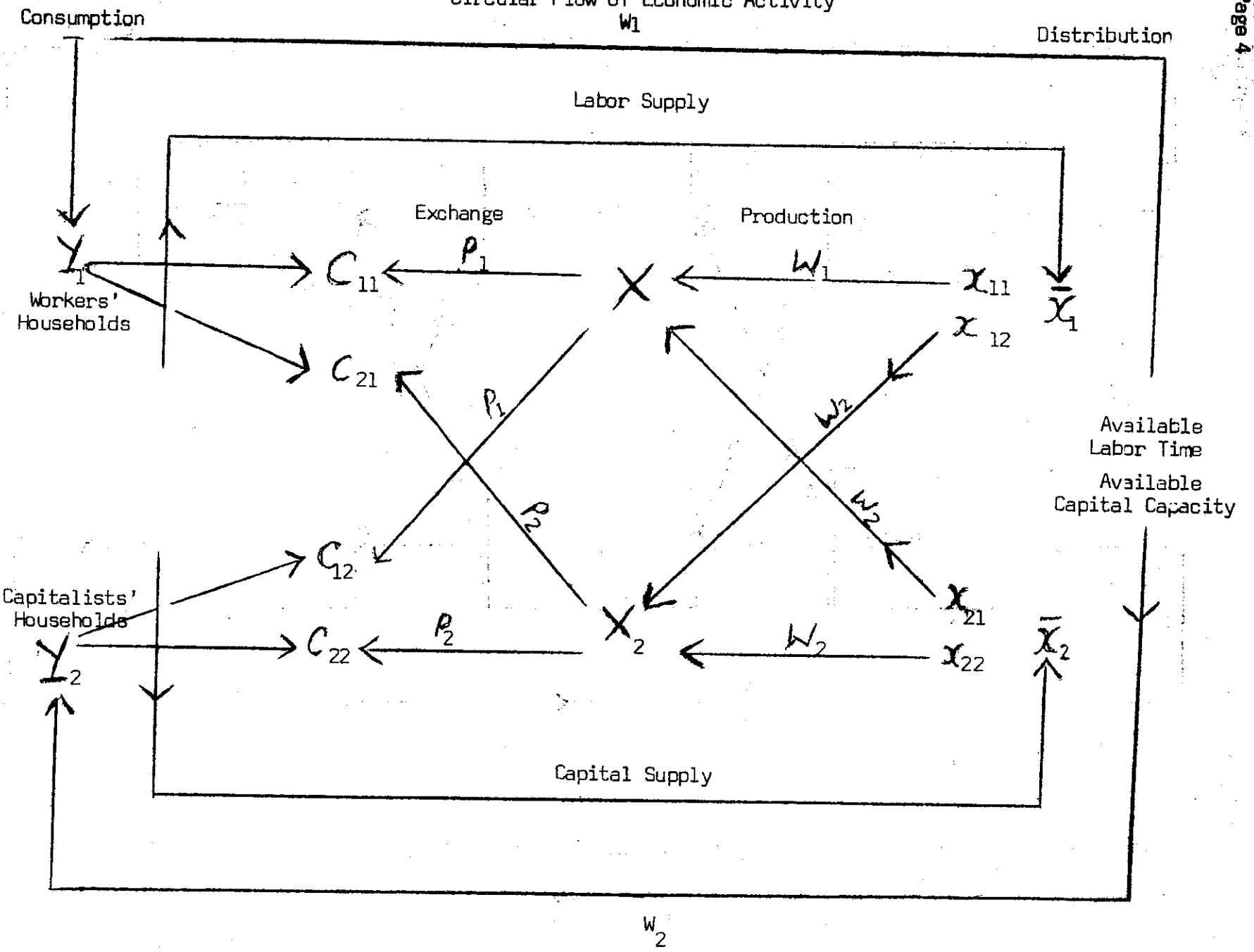


Chart 2

7. The institutions represented in Chart 2 are household 1, household 2, producers of product 1, and producers of product 2. By contrast with Chart 1, the res of the world is left out in Chart 2. Furthermore, the institutions are disaggregated. Households are now disaggregated into two types: workers' households and capitalists' households. Producers are also disaggregated into two types: producers of food and producers of clothing.

8. The markets--factor and product-- are similarly disaggregated. Factor markets; market for factor 1 and market for factor 2, and product markets: market for product 1 and market for product 2. There are now two factors of production: factor 1 (labor) and factor 2 (capital). Similarly, two different kinds of products are produced: product 1 (food) and product 2 (clothing). By contrast to Chart 1, both of the products in Chart 2 have one use only, that is, for final consumption by the households. Intermediate consumption and exports are left out in Chart 2. As in Chart 1, Chart 2 also represents only real flows:

1. Household 1 owns factor 1 and supplies it to the market for factor 1.

2. Household 2 owns factor 2 and supplies it to the market for factor 2.

3. A part of factor 1 goes to producer 1, and the remaining part goes to producer 2. Similarly, part of factor 2 goes to producer 1, and the rest, to producer 2.

4. Producer 1 uses his share of both factors to produce product 1, and producer 2 uses the remaining factors to produce product 2.

5. A part of product 1 is sent to household 1 for final consumption, and the remaining part is sent to household 2. Similarly, a part of product 2 is sent to household 1, and the remaining part is sent to household 2.

Chart 3

9. Chart 3 depicts the same economic activity as Chart 2. The same institutions, markets, products, and factors are portrayed. However, there are some notable differences from Chart 2.

10. First, in Chart 3, money flows are represented by arrows flowing in the reverse direction from the arrows showing real flows. Therefore, in addition to the physical quantities of factors and products, prices at which physical quantities are exchanged are also shown.

11. Second, symbols representing quantities and prices are stated explicitly. The symbols have the following meaning:

$\bar{x}_1$ = quantity of factor 1 (labor) fixed

$\bar{x}_2$ = quantity of factor 2 (capital) fixed

$\bar{x}_{11}$ = quantity of factor 1 used in the production of product 1

$\bar{x}_{12}$ = quantity of factor 1 used in the production pf product 2

$\bar{x}_{21}$ = quantity of factor 2 used in the production of product 1

$\bar{x}_{22}$ = quantity of factor 2 used in the production of product 2

X_1 = quantity of product 1 produced by producer 1

X_2 = quantity of product 2 produced by producer 2

C_{11} = quantity of product 1 consumed by household 1

C_{12} = quantity of product 1 consumed by household 2

C_{21} = quantity of product 2 consumed by household 1

C_{22} = quantity of product 2 consumed by household 2

W_1 = price of factor 1

W_2 = price of factor 2

P_1 = price of product 1

P_2 = price of product 2

Y_1 = income of household 1

Y_2 = income of household 2

12. The flow of economic activity depicted in Chart 3 can be described verbally as (1) households 1 (workers' households) supply $\bar{x}_1$ units of factor 1 (labor) to factor market 1 (labor market), and (2) households 2 (capitalist households) supply $\bar{x}_2$ units of factor 2 (capital) to factor market 2 (capital market).

13. In exchange, workers' households receive labor income (Y_1) which is obtained by multiplying the quantity of labor (factor 1), $\bar{X}_1$, by the price of labor, W_1. Similarly, capitalist households receive capital income (Y_2), obtained by multiplying the quantity of capital (factor 2), $\bar{x}_2$, by the price of capital, W_2.

14. Producers of product 1 buy $\bar{x}_{11}$ units of labor from the labor market (market 1) and x_{21} units of capital from the capital market (market 2). In exchange, they pay $W_1\bar{x}_{11}$ units of money to the labor market and $W_2\bar{x}_{21}$ units of money to the capital market.

15. Producers of product 2 buy $\bar{x}_{12}$ units of labor from the labor market and $\bar{x}_{22}$ units of capital from the capital market. In exchange, they pay $W_1\bar{x}_{12}$ units of money to the labor market and $W_2\bar{x}_{22}$ units of money to the capital market.

16. With the purchased quantities of labor and capital ($\bar{x}_{11}$ and $\bar{x}_{21}$)) the producers of product 1 produce X_1 units of product 1. Similarly, with the purchased quantities of labor and capital ($\bar{x}_{12}$ and $\bar{x}_{22}$), the producers of product 2 produce X_2 units of product 2. Product 1 is then sold to the households for P_1X_1 units of money and product 2, for P_2X_2 units of money.

17. Workers' households buy C_{11} units of product 1 and C_{21} units of product 2. In return, they pay P_1C_{11} units of money to producers of product 1 and P_2C_{21} units of money to producers of product 2.

18. Similarly, capitalists' households purchase C_{12} units of product 1 and C_{22} units of product 2. In exchange, they pay P_1C_{12} units of money to the producers pr product 1 and P_2C_{22} units of money to the producers of product 2. From this, we can see that the following equalities will hold:

a. The total amount of money that producers are paying to factors is equal to total income of households.

$$Y_1 = W_1\bar{x}_{11} + W_1\bar{x}_{12}$$

$$Y_1 = W_1\bar{x}_1$$

$$Y_2 = W_2\bar{x}_{21} + W_2\bar{x}_{22}$$

$$Y_2 = W_2\bar{x}_2$$

$$Y_1 + Y_2 = W_1(\bar{x}_{11} + \bar{x}_{12}) + W_2(\bar{x}_{21} + \bar{x}_{22})$$

Total income of households = total factor costs of the producers.

b. The total income of households is equal to the total value of purchases of both products by both households.

$$Y_1 = P_1C_{11} + P_2C_{21}$$

$$Y_2 = P_1C_{12} + P_2C_{22}$$

$$Y_1 + Y_2 = P_1(C_{11} + C_{12}) + P_2(C_{21} + C_{22})$$

Total income (households) = total value of purchases of products by households

c. The value of purchase of both products is equal to the total revenue of the producers.

Total revenue of producer 1 = P_1X_1

Total revenue of producer 2 = P_2X_2

$$P_1X_1 + P_2X_2 = P_1(C_{11} + C_{12}) + P_2(C_{21} + C_{22})$$

Total revenue to producers = total value of purchases by households.

d. It follows that the total revenue of producers is equal to the total factor cost of producers.

$$P_1X_1 + P_2X_2 = W_1(\bar{x}_{11} + \bar{x}_{12}) + W_2(\bar{x}_{21} + \bar{x}_{22})$$

Total revenue to producers = total factor costs of producers.

This follows since

$$P_1X_1 + P_2X_2 = P_1(C_{11} + C_{12}) + P_2(C_{21} + C_{22})$$

but

$$P_1(C_{11} + C_{12}) + P_2(C_{21} + C_{22}) = Y_1 + Y_2$$

so

$$P_1X_1 + P_2X_2 = Y_1 + Y_2,$$

but

$$Y_1 + Y_2 = W_1(\bar{x}_{11} + \bar{x}_{12}) + W_2(\bar{x}_{21} + \bar{x}_{22})$$

so

$$P_1X_1 + P_2X_2 = W_1(\bar{x}_{11} + \bar{x}_{12}) + W_2(\bar{x}_{21} + \bar{x}_{22}),$$

where $W_1(\bar{x}_{11}\bar{x}_{12}) + W_2(\bar{x}_{21} + \bar{x}_{22})$ is the total factor cost to the producers. So the circular flow of money expenditure is in equilibrium. We can see that the circular flow of economic activity gives a description of the working of the economy. In particular, it shows (1) the quantity and structure of output, (2) the employment of factors, and (3) the distribution of income among households.

A.2. Social Accounting Matrices

19. In order to be able to analyse the working of a real economy, it is necessary to collect the data measuring the events in an economy. No empirical model of an economy can be constructed without the appropriate data base. For the orderly collection of socioeconomic data, it is necessary to have an appropriate system of socioeconomic accounts.

20. There are various systems of socioeconomic accounting in existence. The SAM is a system of socioeconomic accounting which captures in a consistent manner all aspects of economic activity: output quantity, output structure, factor employment, and income distribution. In fact, we will show that a SAM can be used to represent exactly the same type of money flows as represented by Chart 3 in Section 1.

21. The SAM has the following characteristics: a SAM is an accounting framework for organizing information on the economic and social structure of an economy over a period of time, say, one year. It represents a static image of the circular flow of economic activity.

22. There are two principal uses of a SAM. First, a SAM can be used for the analysis of economic and social structure directly. Second, a SAM can serve as a statistical basis for the building of structural planning models. These models enable a consistent analysis of output, employment, and income distribution.

23. There are certain important differences between a SAM and other national accounting frameworks such as national income accounts (NIA) and input-output (I-O) tables. A SAM incorporates both NIA data and I-O tables in a consistent manner. In addition, it gives information on income distribution.

The basic formal characteristics of a SAM are:

(a) A SAM is a square matrix containing the same number of rows and columns,

(b) Each row and the corresponding column is called an account.

(c) Accounts represent entities such as factors of production, institutions (households, firms), activities (production), government, and the rest of the world.

(d) A column represents expenditures of an account.

(e) A row represents receipts of an account.

(f) Column sums and the corresponding row sums are always equal.

24. Let us now represent the circular flows of economic activity by the use of a SAM.

Consider a simplified economy with the following characteristics:

(1) There are only two factors of production, F_1 and F_2.

(2) There are only two households, H_1 and H_2.

(3) There are only two products (and the corresponding two producers), X_1 and X_2.

(4) The total quantity of F_1 is 100, and it is owned by H_1. The total quantity of F_2 is 200, and it is owned by H_2.

(5) The total payment of producer 1 to factor 1 is \$50, and the total payment of producer 2 to factor 2 is \$75.

(6) The total payment of household 1 to producer 1 is \$50.

25. We can construct the SAM for a highly simplified economy as given in Table 1. In order to read a SAM correctly, the following should be noted. Each entry in the matrix represents a transaction between two accounts. A transaction usually implies two flows: a money flow and a real flow. There are always two ends to each flow: the giving end and the receiving end. Therefore, a full description of a transaction between two accounts can be schematically represented as in Table 1. Note that, in this simplified economy, we have excluded the government and the rest of the world.

26. Chart 4 represents a transaction between factor 1 (F) and household 1 (H). Recall that we have assumed that factor 1 is owned by household 1.

27. Factor 1 is giving \$100 to household 1. (Alternately, we may say factor 1 is earning \$100 for household 1 which owns factor 1.)

28. Household 1 is receiving \$100 from factor 1. (Alternately, we may say household 1 is receiving \$100 by supplying factor 1.) These are the two sides of the money flow.

29. In exchange, household 1 is giving (or supplying) \$100 worth of factor 1. Factor 1 is receiving \$100 worth of factor 1 from household 1. These are the two sides of the real flow of the transaction.

The SAM in table 1 can be interpreted as follows:

Transaction 1: X_1 is paying \$50 to F_1. In exchange, F_1 is supplying factor 1 to X_1. (Alternately, we may say that X_1 is spending \$50 on factor 1.)

Transaction 2: X_1 is paying \$125 to F_2. In exchange, F_2 is supplying factor 2 to X_1. (Alternately, X_1 is spending \$125 on factor 2.)

Transaction 3: X_2 is paying \$50 to F_1. In exchange, F_2 is supplying factor 1 to X_2. (Alternately, X_2 is spending \$50 on factor 1.)

Transaction 4: X_2 is paying \$75 to F_2. In exchange, F_2 is supplying factor 2 to X_2. (Alternately, X_2 is spending \$75 on factor 2.)

30. Transactions 1, 2, 3, and 4 involve the producers and the factors of production. The producers acquire the factors of production in the factor markets and incur factor costs. After acquiring the factors of production in the factor markets, the producers combine the purchased factors in the production process and produce commodities which are then placed for sale on the product markets.

Transaction 5: H_1 is paying \$25 to X_1. In exchange, X_1 is giving product 1 to H_1. (Alternately, H_1 is spending \$25 on the purchase of product 1 from X_1.)

Transaction 6: H_1 is paying \$75 to X_2. In exchange, X_2 is giving product 2 to H_1. (Alternately, H_1 is spending \$75 on the purchase of product 2 from X_2.)

Transaction 7: H_2 is paying \$150 to X_1. In exchange, X_1 is giving product 1 to H_2. (Alternately, H_2 is spending \$150 on the purchase of product 1 from X_1.)

Transaction 8: H_2 is paying \$50 to X_2. In exchange, X_2 is giving product 2 to H_2. (Alternately, H_2 is spending \$50 on the purchase of product 2 from X_2.)

31. Transactions 5, 6, 7 and 8 involve the households (as consumers of products) and producers (as sellers of products) in the product markets. The commodities that producers produce and place on the product market are purchased by the households for final consumption. To purchase these commodities, households need income which they earn by selling in the factor markets--the factors of production which households own.

TABLE 1

SAM Corresponding to the Economy Represented in Chart 3 of Appendix A.1

Expenditures →

Receipts ↓

	X_1	X_2	F_1	F_2	H_1	H_2	Total
X_1					25	150	175
X_2					75	50	125
F_1	50	50					100
F_2	125	75					200
H_1			100				100
H_2				200			200
Total	175	125	100	200	100	200	

F_1 = factor 1 (labor)

F_2 = factor 2 (capital)

H_1 = household 1 (workers' household)

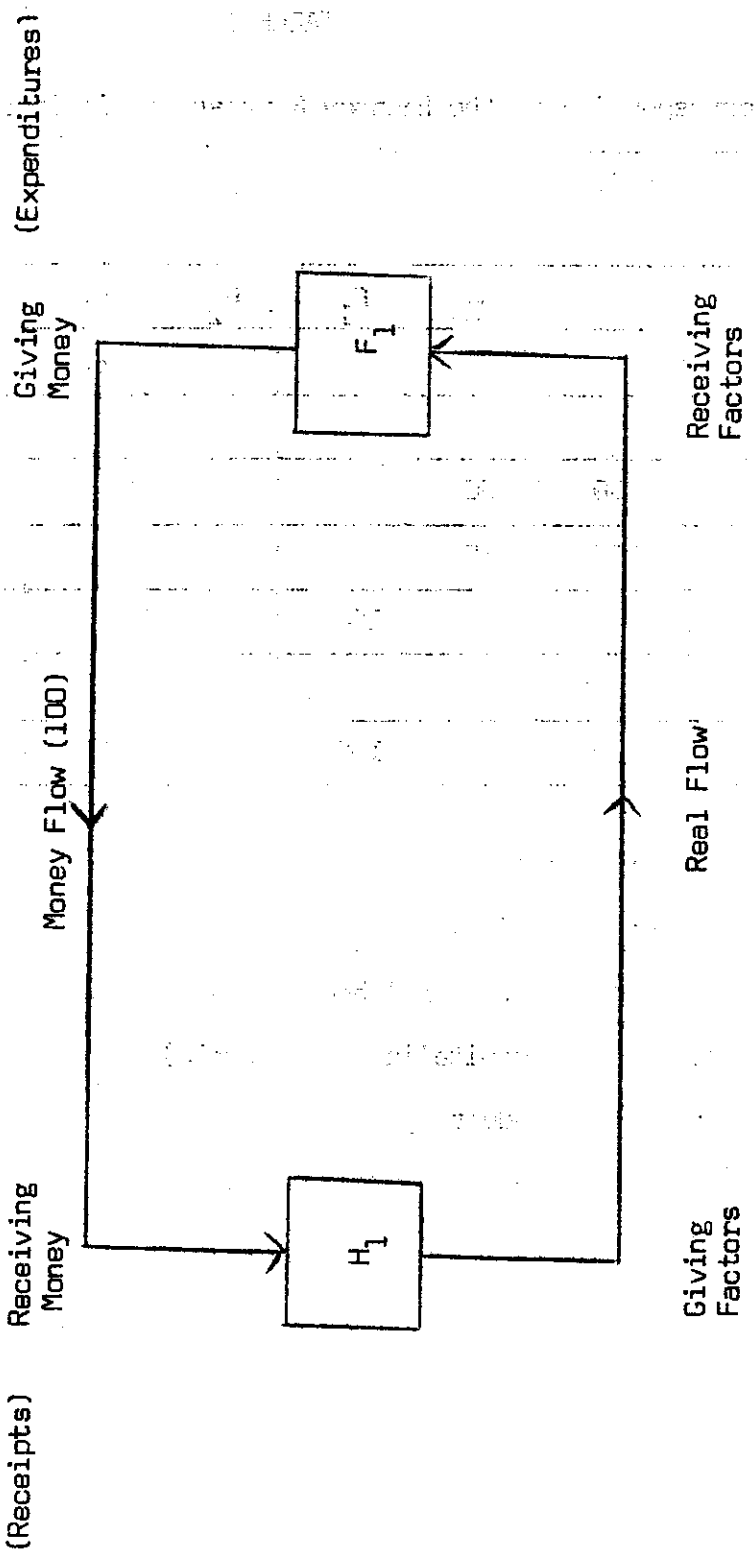
H_2 = household 2 (capitalists' household)

X_1 = producer (product) 1 (food)

X_2 = producer (product) 2 (clothing)

CHART 4

A Transaction Between Factor 1 (F_1) and Household (H_1)



Transaction 9: F_1 is paying \$100 to H_1. In exchange, H_1 is supplying factor 1 to F_1. (Alternately, H_1 earns \$100 by selling factor 1 which it owns.)

Transaction 10: F_2 is paying \$200 to H_2. In exchange, H_2 is supplying factor 2 to F_2. (Alternately, H_2 earns \$200 by selling factor 2 which it owns.)

32. Transactions 9 and 10 involve households (the owners of factors of production) and the factors of production. The households sell in the factor market the factors of production that households own and earn factor income which they spend on the purchase of commodities (in the product market) for final consumption. The factors of production sold by the households are purchased by the producers for use in the production process.

A.3. The Data Requirements

33. The data requirements for the construction of a SAM consist of a census of manufacturing, rural and urban household budget surveys, and national income and product accounts. Rows 5 and 6 and columns 3, 4, 5, and 6 of Table 1 are filled in from household budget surveys. Rows 1 through 4 and columns 1 and 2 come from the census of manufacturing. Columns and rows G and W in Table 2 come from national income and product accounts.

34. Just as we can base a general equilibrium model on a SAM, we can base an input-output model on an input-output table. This will be done in Appendix A.5.

A.4. Social Accounting Matrices and Input-Output Representation

35. In this section we will examine the relationship between a SAM representation of an economy and the well-known I-O representation of the economy. The basic characteristic of an I-O representation of economic activity is that it shows intersectoral flows of intermediate products. It shows how much of the total production of one sector is used as material input in other sectors over a period of time. Recall that intermediate production was shown in Chart I in Appendix A.1.

36. In order to show intersectoral flows, we will again expand the SAM. Consider the SAM of Appendix A.3. which included government and foreign trade relationships. Instead of having only one aggregate production account, X, we will expand the matrix to include two producers, X_1 and X_2. We also now add the assumption that not only households, government, and the rest of the world are demanding products 1 and 2 but, also, the producers themselves demand their products as intermediate inputs. These intermediate flows are presented in the dotted square within the dark bordered section in Table 2. For example, box(X_1, X_1) shows payments of \$70 by X_1 to X_1. In exchange, X_1 receives \$70 worth of product 1 for intermediate use. The interpretation is that producer 1 is buying \$70 worth of product 1 for intermediate use in the production of product 1. Similarly, box (X_2, X_1) shows payment of \$20 by X_1 to X_2. In exchange, X_2 is giving \$20 worth of product 2 to X_1 for intermediate use in the production of product 1.

37. Consider the dark bordered section of the SAM matrix in Table 2. By eliminating the H row and the F column from this section, we obtain a submatrix as in Table 3, which is the I-O table. It is, thus, obvious that an I-O table can be regarded as a truncated SAM.

TABLE 2

SAM Including Intermediate Products

Expenditures →

Receipts ↓

	X_1	X_2	F	H	G	W	Total
X_1	70	20		40	30	10	170
X_2	20	50		40	30	10	150
F	50	50					100
H			100		10		110
G	20	20		20		30	90
W	10	10		10	20		50
Total	170	150	100	110	90	50	

↑ Input-output table

A.5. Computable General Equilibrium Models

38. In Appendix A.1., we represented an overview of the working of an economy, with the help of charts, depicting the circular flow of economic activity. Chart 3 described the working of a very simple market economy with only two households, two factors of production, and two products. We saw that it was possible to a SAM to portray a consistent accounting picture of the money flows between different institutions in such an economy.

39. A detailed study of the decision-making process of the households and producers is the subject matter of microeconomic theory. In microeconomic theory, we study that, in a market economy, there are a large number of households and producers who make their choices subject to market signals: factor prices and product prices. In consumer theory, households are assumed to maximize utility subject to their preferences and budget constraints. In the theory of the firm, producers are assumed to maximize profits subject to their production function.

40. It is worthwhile here to recollect some of the important conclusions of the theories of the consumer and the firm:

1. The household demand for a consumer good is negatively related to the price of the good, positively related to the price of a substitute, negatively related to the price of a complementary good, and positively related to income. Furthermore, household incomes are positively related to factor prices, which implies that household demand will also be positively related to factor prices.

2. The producer's supply of a good is positively related to the price of the good and negatively related to factor prices.

3. Any inconsistency between demand and supply on the product or factor markets will be eliminated by changes in price. For example, if there is an excess demand for a good, an increase in the price of this good will reduce the quantity demanded and increase the quantity supplied leading to market equilibrium.

41. The question then is whether there exist product and factor prices which lead to equilibrium in all product and factor markets, implying that all households can obtain all the goods they want to buy and that all producers can sell all of the goods they produce. An additional question is whether, in this state of the economy, the producers receive enough revenues to cover all their costs and thereby survive in the long run, and also, whether households receive enough income to buy enough goods to survive. The answer is that, under certain conditions, there exist prices which ensure this. The analysis dealing with the determination of equilibrium in interdependent markets is called the General Equilibrium Analysis.

42. A rigorous mathematical treatment of the general equilibrium analysis is beyond the scope of this appendix. Nevertheless, we can examine the essentials of such an analysis with a simple model.

43. Consider a simple general equilibrium model of a two-household, two-factor, two-product economy in which all of the relationships are given by simple functions and all of the parameters are given numerically. The model with 16 equations in 16 unknowns is given in Table 4. Note that this model describes the same type of simple economy as in Chart 3 of Appendix A.1.

TABLE 3

Input-Output Table Derived from the SAM Including Intermediate Products

Outputs →

Inputs ↓

	X_1	X_2	Final demand H	Final demand G	Final demand W	Total
X_1	70	20	40	30	10	170
X_2	20	50	40	30	10	150
F	50	50				
G	20	20				
W	10	10				
Total	170	150				

The equations of the model may be interpreted as follows.

Equations 1 and 2:	two production functions determining the quantity of product 1 and product 2.
Equations 3,4,5 and 6:	four factor demand functions determining the quantities of the two factors demanded by the two producers.
Equations 7,8,9 and 10:	four product demand functions determining the demand by the two households for the two products.
Equations 11 and 12:	two income equations determining the incomes of the two households.
Equations 13,14,15 and 16:	four equilibrium conditions specifying equilibria for two factor and two product markets.

44. Note that, apart from the parameters of the functions which are numerically given, the only variables determined from outside the model (exogeneous variables) are the Initial Quantities of factor 1 (x_1) and factor 2 (x_2). Also given initially is the DISTRIBUTION of factors among households. Recollect that, in Chart 3, we assumed that the total quantity of factor 1 (labor) was owned by household 1 (workers) and the total quantity of factor 2 (capital) was owned by household 2 (capitalists).

The Solution of the Model

45. Although it is not very difficult to construct the initial equations of a general equilibrium model, we run into difficulties in finding a solution of such a model. Two separate problems present themselves: first, does there exist a solution of such a model; and, second, if a solution exists, can we find it? These models are nonlinear, and no general procedures for solving nonlinear models exist.

46. Regarding the first question, we state without elaboration that, in such models, if the solution exists, it will not be unique. In our model, only 15 of the 16 equations are independent. We thus need to fix one of the variables from outside. In our model, we have fixed the price of factor 1 (labor) as 1.

47. Regarding the second question concerning the solution procedure, we note that, in our model, the values of the parameters are numerically given, which enables us to solve the system numerically for given values of x_1 and x_2 with the help of a computer. Note, however, that, in our model, we have used very simple functional forms so that the solution can also be obtained analytically. The actual process of solving the model is not presented here because it is quite tedious and, for our purposes, not very important. Only the final solution of the model is presented in Table 5.

TABLE 4

A Simple General Equilibrium Model of an Economy

(As Represented by Chart 3)

	Equations:		
(1)	X_1	$= x_{11}^{0.2}\, x_{21}^{0.8}$	Production function for product 1 (food)
(2)	X_2	$= x_{12}^{0.5}\, x_{22}^{0.5}$	Production function for product 2 (clothing)
(3)	x_{11}	$= 0.2\frac{P_1}{W_1} X_1$	Demand for factor 1 by product 1 (labor demand for food production)
(4)	x_{21}	$= 0.8\frac{P_1}{W_2} X_2$	Demand for factor 2 by product 2 (capital demand for food production)
(5)	x_{12}	$= 0.5\frac{P_2}{W_1} X_2$	Demand for factor 1 by product 2 (labor demand for cloth production)
(6)	x_{22}	$= 0.5\frac{P_2}{W_2} X_2$	Demand for factor 2 by product 2 (capital demand for cloth production)
(7)	C_{11}	$= 0.2\ Y_1/P_1$	Demand for product 1 by household 1 (workers' demand for food)
(8)	C_{21}	$= 0.8\ Y_1/P_1$	Demand for product 2 by household 1 (workers' demand for clothing)
(9)	C_{12}	$= 0.2\ Y_2/P_1$	Demand for product 1 by household 2 (capitalists' demand for food)
(10)	C_{22}	$= 0.8\ Y_2/P_2$	Demand for product 2 by household 2 (capitalists' demand for clothing)
(11)	Y_1	$= W_1\bar{x}_1$	Income of household 1 (workers' income from sale of labor)
(12)	Y_2	$= W_2\bar{x}_2$	Income of household 2 (capitalists' income from capital)

(Continued...)

TABLE 4 (Continued)

Equations:

(13)	$\bar{x}_1 = x_{11} + x_{12}$	Equilibrium in market for factor 1 (labor market)
(14)	$\bar{x}_2 = x_{21} + x_{22}$	Equilibrium in market for factor 2 (capital market)
(15)	$X_1 = C_{11} + C_{12}$	Equilibrium in market for product 1 (food market)
(16)	$X_2 = C_{21} + C_{22}$	Equilibrium in market for product 2 (clothing market)

Unknowns: X_1, X_2

$x_{11}, x_{21}, x_{12}, x_{22}$

$C_{11}, C_{21}, C_{12}, C_{22}$

Y_1, Y_2

P_1, P_2

W_1, W_2

Number of equations = 16
Number of unknowns = 16
⟹ the system can be solved for the unknowns

48. The solution for all 15 variables of the model (recollect that the 16th variable, W_1, is fixed to 1) with unspecified values for x_1 and x_2 is presented in the left-hand half of Table 5. We also present numerical solutions of the model if we assume that $x_1 = 22$ and $x_2 = 14$. Therefore, if we change the values of x_1 and x_2, i.e., the initial quantities of the two factors of production, the solution values of all 15 variables will change. The solution will also change if we change the initial distribution of factors between households.

SAM Representation of the Simple General Equilibrium Model Solution

49. The economy described by the simple general equilibrium model can be represented by the SAM. This SAM can be constructed using the following steps.

Step 1: Enter all numerical values for equilibrium quantities (obtained from Table 5) in the appropriate boxes of the SAM. This is done in Table 6. Note, however, that these are real flows; and, hence, we should read the entries in the reverse direction as in the SAM representing money flows--for example, the entry H_1-F_1 of 22.000 H_1 is giving 22 units of factor 1 to F_1.

Note also that, in the "real flow" matrix, the rule that column sums necessarily equal the corresponding row sums does not hold any longer. Only the following flows are equal:

a. Factor supplies by households (22, 14) are equal to factor demands by producers (2.002 + 19.998; 4.004 + 9.996).

b. Product supplies by producers (3.478, 14.128) are equal to household demands for products (1.532 + 1.946; 6.213 + 7.915).

We cannot add numerically the demands for X_1 and X_2 by household 1 and the demands for X_1 and X_2 by household 2 because we cannot add physical units of food (X_1) and clothing (X_2). Similarly, we cannot add demands for F_1 and F_2 by X_1 and demands for F_1 and F_2 by X_2 since we cannot add physical units of labor (F_1) and capital (F_2).

Step 2: Enter all numerical values for equilibrium prices in the appropriate boxes in the SAM. This is done in Table 7. For example, the price of 1.000 is entered in the(H_1, F_1) box meaning that the equilibrium price of factor 1, $W_1 = 1$.

Step 3: Multiply all quantities from Table 6 with the corresponding prices from Table 7 and enter the resulting money flows in a new SAM. The resulting SAM (Table 8) should balance (except for rounding errors in the computation of the solution).

TABLE 5

The Solution of the Simple General Equilibrium Model

Solution for unspecified $\bar{x}_1$, $\bar{x}_2$	Numerical solution for $\bar{x}_1 = 22/\bar{x}_2 = 14$
(1) $X_1 = 0.227(\bar{x}_1)^{0.2} (\bar{x}_2)^{0.8}$	$X_1 = 3.479$
(2) $X_2 = 0.806(\bar{x}_1)^{0.5} (\bar{x}_2)^{0.5}$	$X_2 = 14.145$
(3) $x_{11} = 0.091(\bar{x}_1)$	$x_{11} = 2.002$
(4) $x_{21} = 0.286(\bar{x}_2)$	$x_{21} = 4.004$
(5) $x_{12} = 0.909(\bar{x}_1)$	$x_{12} = 19.998$
(6) $x_{22} = 0.714(\bar{x}_2)$	$x_{22} = 9.996$
(7) $C_{11} = 0.100(\bar{x}_1)^{0.2} (\bar{x}_2)^{0.8}$	$C_{11} = 1.532$
(8) $C_{21} = 0.354(\bar{x}_1)^{0.5} (\bar{x}_2)^{0.5}$	$C_{21} = 6.213$
(9) $C_{12} = 0.127(\bar{x}_1)^{0.2} (\bar{x}_2)^{0.8}$	$C_{12} = 1.946$
(10) $C_{22} = 0.451(\bar{x}_1)^{0.5} (\bar{x}_2)^{0.5}$	$C_{22} = 7.915$
(11) $Y_1 = \bar{x}_1$	$Y_1 = 22$
(12) $Y_2 = 1.273(\bar{x}_1)$	$Y_2 = 28.006$
(13) $P_1 = 2.000(\bar{x}_1/\bar{x}_2)^{0.8}$	$P_1 = 2.871$
(14) $P_2 = 2.256(\bar{x}_1/\bar{x}_2)^{0.5}$	$P_2 = 2.828$
(15) $\bar{W}_1 = 1$	$\bar{W}_1 = 1$
(16) $W_2 = 1.273(\bar{x}_1/\bar{x}_2)$	$W_2 = 2$

TABLE 6

SAM Representation of the Simple General Equilibrium Model Solution

Real Flows

	X_1	X_2	F_1	F_2	H_1	H_2	Total
X_1					1.532	1.946	3.478
X_2					6.213	7.915	14.128
F_1	2.002	19.998					22.000
F_2	4.004	9.996					14.000
H_1			22.000				22.000
H_2				14.000			14.000
Total			22.000	14.000			

X_1 = Producer (product) 1 (food)

X_2 = Producer (product) 2 (clothes)

F_1 = Factor 1 (labor)

F_2 = Factor 2 (capital)

H_1 = Household 1 (workers)

H_2 = Household 2 (capitalists)

TABLE 7

SAM Representation of the Simple General Equilibrium Model Solution

Prices

	X_1	X_2	F_1	F_2	H_1	H_2
X_1					2.871	2.871
X_2					2.828	2.828
F_1	1.000	1.000				
F_2	2.000	2.000				
H_1			1.000			
H_2				2.000		

TABLE 8

SAM Representation of the Simple General Equilibrium Model Solution

Monetary Flows

	X_1	X_2	F_1	F_2	H_1	H_2	Total
X_1					4,398	5.587	9.985
X_2					17.570	22.383	39.953
F_1	2.002	19.998					22.000
F_2	8.008	19.992					28.000
H_1			22.000				22.000
H_2				28.028			28.028
Total	10.010	39.990	22.000	28.028	21.970	27.970	

APPENDIX B

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