MODELING URBANIZATION AND ECONOMIC GROWTH

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FOREWORD

Roughly 1.6 billion people, 40 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates, about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policy makers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth in many parts of the globe. Some see this trend as fostering national processes of socioeconomic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

As part of a search for convincing evidence for or against rapid rates of urban growth in developing countries, the Human Settlements and Services Area initiated in 1977 a research project to study the process of structural transformation in nations evolving from primarily rural-agrarian to urban-industrial societies. Data from several countries selected as case studies are being collected, and the research is focusing on spatial population growth and economic development, and on their resource and service demands.

This report describes a prototype model of the urbanization and development process. It sets out a general equilibrium perspective that illuminates several fundamental aspects of the process of demoeconomic structural change and synthesizes the growing recent literature on general equilibrium modeling of dualistic development. When subjected to empirical analysis it should be capable of describing the past and of assessing alternative future consequences of rapid urbanization and growth.

A list of papers in the Population, Resources, and Growth Series appears at the end of this report.

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1 THE PROBLEM

1.1 Introduction

The past quarter of a century has witnessed unprecedented economic progress in the Third World as gauged by the standards of history since the Industrial Revolution. Yet major problems have arisen, some of which are the consequence of the progress itself and may become serious constraints on future development. City growth is one such problem. By the end of this century the United Nations (UN) forecasts (1976: 22–44, 77–83):

1. Urban population growth rates three times those of rural areas;
2. Two billion people, exceeding 40 percent of the Third World population, living in cities;
3. Some cities reaching extremely large sizes: Mexico City (31.6 million); São Paulo (26.0 million); and Cairo, Jakarta, Seoul, and Karachi each exceeding 15 million.

Analysts and policy makers are sharply divided on the validity and consequences of these forecasts. Pessimists stress the developing countries' inability to cope with the resource and social systems requirements of rapid urban growth and high urban densities, thus prompting the term "overurbanization." Optimists view urban growth as the key device for raising average living standards and labor productivity. The optimists also view urbanization as a natural outcome of economic development, and a necessary requirement for the more rational use of economic resources. Debate over public policy options regarding Third World urban growth remains intense.

A second and related problem which is often cited as constraining economic progress is the "population explosion." From 1950 to 1979 Third World populations (excluding China) increased from 1.8 billion to 3.3 billion;

by the end of the twentieth century the tally is estimated to read 5.1 billion. This exceptional pace of population growth has resulted in enormous resource demands, especially given the low labor productivities and high dependency rates found in these countries. Economists and demographers cannot agree on the quantitative effects of these trends on economic development, although the general assessment ranges from extreme pessimism to mild concern. (Compare, for example, Coale and Hoover, 1958 and Enke, 1971 with Kuznets, 1960, 1967 and Adelman and Robinson, 1978.)

To assess the nature of urban growth and demographic change, and their significance for economic development, it is necessary to specify a theoretical framework which, when subjected to empirical analysis, is capable of describing the past, assessing the future, and displaying relevant policy options. This report presents the elements of one such economic model. Four criteria have guided our selection of specifications.

First, we have attemped to develop a framework that is as analytically rich as possible. At the same time we have suppressed regional, sectoral, and household detail. While such detail might appear to add "realism," in our judgment it would add little analytical insight.*

Second, we have specified the model so as to be empirically implementable. At every stage in model formulation, extensive use has been made of information assembled by the World Bank, the United Nations, national governments, and of the results of numerous econometric studies of developing countries.

Third, the model has been designed to analyze a low-income growing economy which falls within the small-country category. The latter refers less to size of land area, population or economic market, and more to the assumption that the country is a price taker in world markets. The country must not be so important in export markets that it can materially influence world prices. Given this assumption, countries with primary product exports which are important in their domestic economy, and which constitute a notable share of world consumption (e.g., oil, copper, tin), may not be well explained by our model.

Finally, the model has been developed to offer additional insight into the standard questions in development economics: the sources of growth and structural change, the determinants of physical and human capital accumulation, the impact of growth on the distribution of income, the role of technological progress, and so forth. The model has also been developed to offer insight into questions which are less conventional: the role of energy imports, the determinants of land use, the explanation for the rise in urban land prices, the impact of housing market behavior, the role of spatially

* For a framework possessing considerable detail, the most ambitious effort in a general equilibrium modeling is by Irma Adelman and Sherman Robinson. Their Korean model contains over 3,000 endogenous variables; the requirements for parameterization were extensive (Adelman and Robinson, 1978).

nontradeable services on migration, and others. Moreover, the framework has been specified with an eye toward performing policy "counterfactuals" and, as a result, numerous government policy parameters have been included in the model.

1.2 An Overview of the Model

The model possesses a high degree of closure in its general equilibrium properties. Most input and output prices are determined endogenously, and thus interactions of supply and demand are critical to resource allocation. Neoclassical production functions are assumed, and price-responsive demand relationships within an integrated household demand system are highlighted. A period-by-period equilibrium is sought where factors move between and within sectors minimizing the rate of return and earnings differentials, subject to various constraints. Optimization at the micro-economic level is imposed on firms and households who, within a Walrasian tâtonnement process, independently maximize their returns and utilities, thereby implying an efficient allocation of economic resources.

It should already be apparent that the model descends from a robust family tree: small scale general equilibrium models of dualistic development, large scale computable general equilibrium models, multisectoral models stressing interindustry linkages in the Leontief tradition, and even macro-economic–demographic models of limited closure which highlight population and government policy options.* Given this large and expanding literature, it might prove useful to stress the novelties in our own approach.

We distinguish between *tradeables* and *nontradeables*, the latter including various location-specific services. This is hardly the first multisectoral model to recognize nontradeables but it is the first spatial dualistic model which simultaneously stresses the importance of nontradeables as an influence on migration behavior. The presence of nontradeables results in urban–rural cost-of-living differentials. Since migrants are assumed to move in response to improvements in expected earnings adjusted for cost-of-living differentials, the latter may exert an important impact on the rate of urban growth. For example, rapid urban growth will increase the relative scarcity of housing (and support services) – both due to the short-run rise in structure rents and to the long-run rise in land rents. As a result, the city will be somewhat less appealing to potential migrants. Furthermore, new house building (and social

* Early dualistic models include those of W. A. Lewis (1954), J. C. Fei and G. Ranis (1961, 1964), D. W. Jorgenson (1961, 1967), and P. Zarembka (1972). A review and extension of these and other models can be found in A. C. Kelley, J. G. Williamson, and R. J. Cheetham (1972:7–17, 53–57), and C. Lluch (1974). The earliest general equilibrium multisectoral framework revealing interindustry linkages is by L. Johansen (1959). Recent applications include I. Adelman and S. Robinson (1978) and L. Bergman (1978). Macro-economic–demographic models of limited closure originated with the work of A. Coale and E. Hoover (1958). Later contributions include R. Barlow (1967), R. Barlow and G. Davis (1974), F. Denton and B. Spencer (1976), S. Enke (1971), Bachue–Phillipines by G. Rodgers, M. Hopkins, and R. Wéry (1978), and J. Simon (1976).

overhead) serves to diminish the rate of "productive" capital accumulation in the city and thus diminishes the rate of growth of job vacancies in the modern urban sector, reducing the attraction of the city still further. Urban growth, therefore, has embedded in it countervailing forces which may produce retardation over time, a characterization consistent with the stylized facts of history.

Development economists have long emphasized the importance of *human capital accumulation* during the process of growth (Schultz 1961, 1972), but it has appeared infrequently in formal models; the emphasis almost always has been on conventional physical capital. A somewhat broader view of accumulation is taken in the present model. The modern urban sectors are specified to utilize skilled labor and these skills are assumed to be complementary with physical capital. Imperfect capital markets exclude individual investment in human capital, but firms invest in skills accumulation through training programs. This investment decision is made by comparing the discounted flow of augmented profits to the current training cost, namely the average return to investment in physical plant and equipment. The accumulation of human capital is thus determined by its return to the using firms as well as by the demographic trends influencing the stock of "potential trainables," and this stock is determined jointly by demography *and* government policy toward formal education. In contrast to the Coale and Hoover (1958) tradition, demographically-induced expenditures on education are *not* considered unproductive consumption financed at the expense of productive investment. Our treatment may well alter assessments of the effect of population growth on the pace of economic growth.

While growth and development theory has made significant strides in introducing labor heterogeneity into its paradigms, a symmetric treatment of capital is less common. Of course capital has multisector uses, and frequently capital is treated as "putty-clay" so that once in place there are in effect many types of physical capital stocks. But this mainly represents a migration specification. Our model explicitly confronts *a portfolio of heterogeneous capital stocks* consisting of "productive" conventional capital (plant and equipment), "unproductive" capital in residential structures (housing), and human capital (training and skills accumulation). All are financed out of a common savings pool and, *subject to the constraints of capital market fragmentation*, new investment is allocated according to its greatest return. Elements of a portfolio choice are, therefore, confronted even in a simple model without financial assets. Moreover, the economy's critical allocation of saving between "productive" and "unproductive" uses obeys traditional neoclassical rules, except that the institutional realities of the undeveloped Third World capital market constrain that allocation. These constraints include:

- the absence of a mortgage market so that all housing must be self-financed

- the absence of a household loan market so that individual investment in human capital is suppressed
- demographic restrictions on the stock of "potential trainables" thus inhibiting firms' investment in human capital and making it possible for the rate of return to human capital to remain at high levels
- the immobility of physical capital once in place, making it possible for rate of return differentials across sectors to persist over long periods of time

These "capital-market imperfections" provide abundant options for government policy to eliminate inefficient resource allocations and "market failures" induced primarily by the disequilibrating impact of successful growth. Our model allows us to decompose the sources of those market failures as well as to evaluate the benefits from government intervention.

Typically, development models incorporate very simple specifications for land use, constraining it to agricultural production and specifying its growth as exogenous. This treatment is appropriate for many purposes, but it is unacceptable in a model where a focus is urban growth and urban problems. In our model *optimal land use* is explicitly confronted. Although we do not employ the urban economist's land-gradient function, we are still able to formulate an explanation of the rate of urban encroachment on farmland at the city's margin. This urban land-use specification has potentially important implications. Urban growth will bid up the price of urban land largely due to the requirements for residential structures and social overhead. Because land is immobile, it partakes of the same characteristics as nontradeables. Thus, endogenously determined land use and rents can notably influence sectoral cost-of-living differences with a resulting impact on rural–urban migration and city growth. In addition, the model is equipped to deal with two additional urban problems: first, the tension between rising urban population densities, on the one hand, and "suburbanization," on the other; and second, the dramatic rise in urban land values widely observed in the Third World.

Government activities are typically specified as exogenous in formal models of development. However, given the accumulating evidence that government spending exhibits broadly systematic patterns, which are related to growth and structural change, it seems appropriate to move toward a specification of *endogenous government fiscal behavior* (Heller, 1975). In our model, government spending is constrained by the availability of public income, stemming from endogenous tax revenues and exogenously determined international capital flows. The latter is specified in a manner which places us in the "revisionist" foreign-aid camp since foreign capital does not augment the domestic savings pool dollar for dollar. Furthermore, the government allocates its capital budget to maximize returns while the current account is determined in response to social preferences. In addition, spending has an "urban bias." The government's domestic revenue sources are numerous, thus providing an opportunity to assess the effects of alternative government taxation policies on structural change, the commodity price structure, growth, and distribution.

While the above specifications can be considered the most novel features of our economic model, it should also be emphasized that our framework attempts a synthesis from the growing literature on general equilibrium systems.* Many of our model specifications can be found elsewhere. To our knowledge, however, these specifications have yet to be combined in a single model capable of confronting many of the key macro-development issues of the 1980s. For example, *nested constant elasticity of substitution production functions* have been employed by Bergman (1978) and Edmonston, Sanderson, and Sapoznikow (1976), but the former incorporates only a limited role for demand, while the latter is not designed to confront urbanization or policy issues. *Labor market fragmentation* and *wage gaps* have been highlighted by Yap (1972, 1976a), but endogenous demand forces are suppressed in her model. Similar observations may be made for the treatment of *imported energy requirements*, the use of the *extended linear expenditure system*, and the specification of a *migrants' remittances function*. The time is ripe to exploit the theoretical advances in general equilibrium modeling.

All of these remarks are directed toward the economic model discussed in Chapter 2. We have said nothing about the demography with which the economic model interacts. The demographic model, yet to be specified,† will be detailed, involving urban and rural age-sex-specific schedules of mortality, fertility, and migration. The demographic model determines urban and rural labor force supplies; the economic framework determines labor force needs as well as the equilibrating mechanism for matching needs with supplies from period to period. Demography enters directly by its influence on the level of demand and its composition (especially through housing requirements), by determining labor force growth (fixed age–sex–location labor force participation rates are assumed), by its impact on regional settlement patterns and land use, and by modifying the distribution and availability of new investment or capital formation through the urban–rural remittance mechanism. Population growth rates are determined exogenously given the constancy of the various demographic schedules, although aggregate population growth can change due to intersectoral migration.

A final distinguishing feature of our model relates to the forces motivating its development and choice of specifications. Our model is not designed to

* Studies using this approach include: I. Adelman and S. Robinson (1978), F. Ahmed (1974), L. de Bever (1976), J. G. Williamson and L. de Bever (1977), J. Edmonston, W. C. Sanderson, and J. Sapoznikow (1976), A. C. Kelley and J. G. Williamson (1974), A. C. Kelley, J. G. Williamson, and R. J. Cheetham (1972), K. Mera (1975), R. Mohan (1977), J. G. Williamson (1974), M. Yamaguchi (1973), L. Yap (1972, 1976a), J. de Melo (1978), J. de Melo and S. Robinson (1978), and F. Lysy and L. Taylor (1977).

† The demographic model is being developed by R. M. Schmidt, and will be presented in *The Demographic Dimensions of Economic Population Modeling*, forthcoming. The broad elements of Mr. Schmidt's model are outlined above.

explain the behavior of a specific low-income country. A case study approach is more appropriate to this task. Rather, our goal has been to capture the key features of a *group* of Third World, growing countries which are price-takers in international markets (around 50 countries fulfill this specification). Ours is a model of "representative" Third World countries. In developing our theoretical specifications, we have benefited notably from the results of extensive empirical analysis undertaken on a sample of 22 such countries. For this purpose data from the World Bank, the United Nations, the International Labour Office, country studies, and the general economics literature have all been systematically exploited. It is our view that theorizing is most likely to succeed where there is sensitivity to empirical reality. Moreover, a model of theoretical elegance that cannot be empirically implemented is of little use. In many instances our theoretical specifications have been conditioned by this constraint. While the present paper focuses on modeling urbanization, demographic change, and economic growth, it is to be emphasized that the model has drawn upon an extensive data base.

1.3 Issues and Analysis: The Counterfactual

While the model we have developed is parsimonious in its specification, it is still sufficiently large to require numerical techniques to analyze the results. For this purpose we will estimate the parameters and initial conditions using data for our "representative" countries, and employing the methodology now common to this type of general-equilibrium modeling (see Kelley, Williamson, and Cheetham, 1972, chp. 4). With estimation complete, the model will then be simulated over a quarter of a century. Does the model replicate historical Third World experience since the 1950s? The answer will be supplied by the comparison of the model's dynamic forecasts with time series of relevant endogenous variables documented in *World Tables 1976*.

The second stage of analysis will involve an examination of comparative static results. Considerable insight into the workings of the model can be obtained by using the relatively simple tools of short-run comparative statics, where the labor force, the stock of skills, technology, and capital assets are all exogenous. Moreover, comparative static analysis is especially suited to sensitivity analysis: critical parameters for which empirical information is more tenuous can be identified with greater clarity. In addition, since the profession is far less confident about economic dynamics, it might be especially fruitful to explore that portion of the model about which we are more certain, before pressing on to the comparative dynamics.

After completing the comparative static analysis, we shall then turn to the more speculative comparative dynamics. Our first goal will be to confront conventional "growth" issues by exploring the impact of the rate and bias of technical progress, the saving parameters, and public and private demand parameters. The historical counterfactual will also be employed at this stage, where one or more parameters representing historically relevant situations will be varied and the resulting consequences examined. We also expect to dwell at length on policy counterfactuals. A sample of these counterfactuals follows.

1. *Government policy toward "squatters' settlements."* Some countries have acted to limit the size of urban squatters' settlements, even by the violent means of razing poor residential areas. The impact of such policies can be captured in our model in various ways.
2. *Government education policy.* The demographic model will be equipped to handle changes in government educational policy through its impact either on the drop-out rate and/or on the rate of entry into the formal educational system. With a lag, such policy will have an impact on the stock of "urban trainables" and thus the rate of expansion in the stock of unskilled labor. It should also influence immigration rates and urbanization.
3. *Government and/or union policy toward the "wage gap" between modern and informal service sectors.* The economic model postulates a nominal wage gap between modern sector unskilled labor employment and the informal urban service sector. Variations in this gap can be explored in the model and its impact on the distribution of income, migration, and urbanization evaluated.
4. *Energy scarcity and the Organization for Petroleum Exporting Countries (OPEC).* Imported raw materials include fuel, and the price of these imports are exogenously determined in world markets. Counterfactual changes in the price of such imports can be investigated in the model, and in particular, their influence on the internal price structure, the rate of urbanization, growth, and distribution.
5. *Urban property taxes.* Very few Third World economies have urban property taxes, but debate over their use should increase especially in the face of rising land scarcity, notable capital gains in land, and the presence of "empty lots" in otherwise dense urban centers. The model allows us to examine the impact of such policies on urbanization, rents, and income distribution.
6. *Population policy.* The demographic model will treat mortality and fertility as exogenous variables (subject to variation over regions and thus subject to aggregate variations as urbanization proceeds). The present model is well equipped to trace through many of the likely economic impacts of government population policy. Indeed, this exercise will be especially helpful in identifying the impact of "population explosions" on Third World urbanization experience.
7. *Government policy toward financial institutions and its impact on migrants' remittances.* Urban migrant remittances (as a share of income) to rural households are given exogenously in our model. The remittance rate will be influenced by the availability of financial

institutions to facilitate the transfer. The model is equipped to explore the impact of such changes on the structure of demand and other key endogenous variables in the system, especially migration and urbanization itself.

8. *Foreign aid and government attitude toward saving "self-sufficiency."* Many countries are taking a more jaundiced view of foreign assistance and multinationals' investment. Since private and public foreign capital is given exogenously in the model, we can readily examine the impact of reductions in these "aid" levels. In particular, we shall be able to examine the extent to which domestic investment responds to changes in foreign aid.
9. *The role of the export tax and import tariff.* The general equilibrium impact of export tax and import tariff policies can easily be evaluated in the model. Endogenous variables of interest include distribution and the rural out-migration rate from agriculture.

This is only a sample of policy counterfactuals, but it should give a flavor of the scope of the model.

Central to the analysis are the questions: What are the sources of urbanization? What can we expect the urbanization experience in the remainder of the twentieth century to be like? What role have policy and demographic forces played in influencing Third World urbanization experience?

2 MODELING URBANIZATION AND ECONOMIC GROWTH

2.1 Sectoral Activities: An Overview

Our economy consists of eight sectors, each of which produces a single homogenous commodity or service. These sectors have a specific spatial location, urban or rural, and produce tradeables and nontradeables. As we shall see, the distinction between tradeables and nontradeables is central to cost-of-living differentials between regions and thus potentially important to the migration process and to urbanization. The tradeable and nontradeable distinction is also relevant to the international exchange and specialization choices open to the economy. While the inclusion of nontradeable service activities has become familiar in the literature on computable general equilibrium models, we feel they are especially important in understanding the growth-inequality-urbanization process and have yet to receive the emphasis they deserve.

There are two commodity producing sectors in the model: manufactures and primary products, both of which are tradeable internationally and interregionally. Their empirical counterparts are the following: the manufactures sector M includes both mining and manufacturing, since these sectors have broadly comparable technological characteristics. The primary product sector A includes agriculture, forestry, and fishing. Clearly, the M-sector is an urban activity while the A-sector is rural. No effort has been made in this report to distinguish between the subsistence and commercialized farm sectors, although we hope to do so in case-study applications of the model.

Service-sector activities are highlighted in the model, especially those that are not tradeable between locations. There are six service-sector activities. The modern capital-cum-skill intensive service sector KS has, as its empirical counterpart, the combination of electricity, gas, water, transportation, communications, defense, education, other government services, and construction of what we call urban high-cost housing stocks. While the output of the KS sector cannot be traded internationally, it *can* be traded interregionally within the economy. It is urban location-specific and is the central activity supplying the final demand needs generated by the government sector. Given demand conditions to be discussed below, the KS sector can be expected to be one of the "leading" growth sectors in our developing economy, a feature commonly ignored in development models.

Recent qualitative models of migration (Todaro, 1969; Corden and Findley, 1975; Yap, 1972, 1976a) have focused at length on the urban "traditional" service sector as a source of low-productivity urban employment, and it has figured importantly in current conventional wisdom regarding the determinants of rural–urban migration and the rate of urbanization in the Third World. The literature has made no effort, however, to introduce similar activities for the rural sector, ignoring Hymer and Resnick's (1969) useful emphasis on rural "Z goods" activities. We have chosen to follow Hymer and Resnick by introducing symmetry into the model. The rural labor-intensive service sector RS and the urban labor-intensive service sector US both produce services with empirical counterparts including domestics, personal services, and the construction of lower-quality housing stocks for relatively low-income wage earners. These two "traditional" labor-intensive service sectors do not produce outputs tradeable between regions and here lies one potential source of cost-of-living differences between urban and rural areas.

The model is completed by the addition of three remaining service sectors, all of which produce housing services from location-specific housing stocks. There is only one such housing activity in the rural sector, H, RS, since housing stocks there appear to be predominately low-cost, labor-intensive structures. The model will be developed to permit housing rents to be lower in rural areas, thereby providing the farm sector with a cost-of-living advantage. Relatively cheap rural labor might yield that result by itself, but high site rents attached to scarce urban land should reinforce the rental differential. There are two housing activities in the urban sector: a higher-cost housing sector H, KS constructed by "modern" relatively capital-intensive methods and consumed by higher income groups; and a lower-cost housing sector H, US constructed by "traditional" labor-intensive methods thus generating lower-quality housing for the urban poor at low rents. Accessibility of this low-cost housing, the government's attitude toward squatter settlements, and thus the level of urban rents will figure importantly in migration decisions in our model.

In reality, there is a continuum of housing units by quality. The dichotomy embedded in our model reflects an important aspect of that continuum – the differing nature of construction technology as well as the different costs implied. Since housing represents the most important asset in the household's portfolio, and accounts for most of the household's investment activity, we felt it important to elaborate on its nature, especially in the urban area where issues of migration and asset accumulation, related to housing, may be particularly important to the process of development and structural change.

2.2 Technological Conditions and Factor Inputs

Like all models of economic dualism, ours stresses production dualism. (A complete mathematical statement of the model can be found in the appendix. Equation numbers in the text are consistent with those in the appendix.) Thus, the eight sectoral activities exhibit quite different rates of technical progress, factor-intensity, distributional attributes, and substitution elasticities.

It is assumed that the production process in all sectors (except rural housing) can be described by a continuous, twice-differentiable, single-valued function. Conventional physical capital, K_i, is used in agriculture, manufacturing, and the modern service sector, although it is specific to a given sector once in place. Unskilled labor, L_i, is used in all sectors except housing, and is mobile between them, subject to migration rules to be discussed later. Skilled labor, S_i, is utilized in the M and KS sectors only while land, R, is used as an input in both agriculture and urban housing. Each of these four factors of production is homogeneous. Production is subject to constant returns to scale and diminishing marginal rates of substitution are assumed to prevail. Joint products are excluded and external economies (and diseconomies) do not exist. It is assumed that factor-augmenting technical change applies to capital, skills, and labor but not to land. Thus each sector is analogous to a large firm or industry having a production function and exhibiting optimal behavior. Such behavior implies cost minimization with respect to inputs and revenue maximization with respect to outputs.

The production processes in the two modern urban sectors are viewed to be more capital-cum-skill intensive than in agriculture. The importance of factor-intensity differentials has been appreciated since Eckaus (1955) brought it to our attention. He argued that in underdeveloped economies agriculture was far less capital intensive, which, together with differences in elasticities of factor substitution, gave rise to the phenomenon of "technological dualism." We shall impose alternate restrictions consistent with his view: namely that the current elasticity of substitution in urban modern sectors is less than one, while it is equal to one in agriculture (i.e., Cobb–Douglas). There is abundant empirical evidence supporting this view (Chenery and Raduchel, 1971; Fallon and Layard, 1975; Yotopolous and Nugent, 1976).

The modern urban-sector production functions must capture these overall attributes, but the presence of three factors of production makes the conventional constant elasticity of substitution (CES) production function inappropriate. Since it is not possible to confront the issue of earnings distribution without paying explicit attention to labor heterogeneity, we have insisted that the working population be distinguished, at the very minimum, by skilled and unskilled labor. Furthermore, we are convinced by several empirical studies that the elasticity of substitution between each of the three pairs of inputs in these modern sectors is *not* the same. Rather, we are persuaded that conventional capital and skills are relative complements (Griliches, 1969; Fallon and Layard, 1975; Kesselman, Williamson, and Berndt, 1977) and that this fact goes a long way in accounting for the phenomena of rising skilled-wage premia, "wage stretching" (Morley and Williamson, 1977), and increased earnings inequality in much of the Third World where capital accumulation is so rapid.

Given the need to specify modern-sector production functions that allow for relative complementarity between skilled labor and capital, the usual CES production function cannot be employed. The most useful specification for our purposes is the "two-level" or "nested" CES first proposed by Sato (1967) and since applied to developing economies in a number of case studies (Bowles, 1970; Fallon and Layard, 1975; Edmonston, Sanderson, and Sapoznikow, 1976; Lysy and Taylor, 1977; Adelman and Robinson, 1978). This function separates factors into groups and generates an index for one group using the CES function in its usual form. This index is then combined in another CES function to generate value-added output. In our case, ϕ_i is a composite index of conventional and human capital (skills) inputs, ξ_i' and ξ_i are distribution parameters, and σ_i' and σ_i are elasticities of substitution. Following Eckaus and the "structuralists" (Chenery and Raduchel, 1971), we anticipate that these substitution elasticities will generally fall below unity.

Furthermore, we anticipate that the elasticity of substitution between capital and skilled labor will be significantly less than that between unskilled labor and composite capital, thus conforming to the capital–skill complementarity hypothesis. The implication of this hypothesis is that rapid physical capital accumulation in the modern sector tends to raise the demand for skilled relative to unskilled labor. Accumulation tends to breed earnings inequality in our model as a result.

Moving from a value-added to a gross-output production function where intermediate inputs are specified explicitly, we shall consider separately those inputs supplied domestically and those obtained from abroad. Imported intermediate inputs Z_i, including fuel, have been incorporated in both modern sectors. Intermediate input demands are almost always captured by fixed coefficients in development and planning models. Such Leontief-like specifications might be appropriate in short-run applications, but they are unacceptable in a model covering a 20- to 30-year span, especially given the OPEC shocks of the 1970s (Hoffman and Jorgenson, 1977; Berndt and Wood, 1979).

Since it is mandatory to admit the possibility of economizing on imported raw material inputs if the longer-run implications of OPEC pricing policies are to be sensibly investigated, substitution between imported inputs, domestically supplied intermediate inputs, and the conventional primary inputs must be allowed.

Imported non-competitive inputs are combined with other domestic and primary factor inputs following a Cobb–Douglas specification. While this specification introduces greater flexibility into our economy's structure, aspects of "import dependency" associated with modern-sector expansion can still be investigated with our model. In particular, our specification permits analysis of unbalanced sectoral growth on aggregate imported intermediate inputs, especially fuels, given different import intensities by sector. Chenery and Raduchel (1971) have demonstrated that the latter can be a relatively important aspect of import dependency in a typical developing country. This specification also makes it possible to explore the impact of changes in the price of such imports on the industrialization and urbanization process. Since Z_i is imported at exogenous world market prices, the impact of changes in such prices, attributable, for example, to OPEC policy, can be readily explored.

The model also allows for domestic intermediate inputs, although we take a somewhat restricted view of their importance. The output of both traditional service sectors is treated as satisfying final demand only, a reasonable assumption since they are dominated by domestics, personal services, and highly labor-intensive low-cost housing construction. Neither of these two sectors enters into the intersectoral production flows. The same is true of housing services, or the rental stream generated by housing stocks. The motivation for the addition of the remaining intersectoral production flows is to recognize the direct *and* indirect output mix changes induced by demand or supply changes in a given sector. One of our key interests is to account for trends in the distribution of income and earnings. By focusing on direct factor requirements only, and given factor-intensity differences across sectors, we would surely exaggerate induced changes in factor demand were we to ignore these direct factor requirements induced by the input–output relationships.

The two modern-sector production functions take the following form:*

$$\left.\begin{aligned}
Q_i &= A_i Q_{i,F}^{\alpha_{i,F}} Z_i^{\alpha_{i,Z}} \prod_{j=A,M,KS} Q_{i,j}^{\alpha_{i,j}} && i = M, KS \neq j \\
Q_{i,F} &= \{\xi_i \phi_i^{(\sigma_i - 1)/\sigma_i} + (1 - \xi_i)[zL_i]^{(\sigma_i - 1)/\sigma_i}\}^{\sigma_i/(\sigma_i - 1)} \\
& && i = M, KS \\
\phi_i &= \{\xi_i' [xK_i]^{(\sigma_i' - 1)/\sigma_i'} + (1 - \xi_i')[yS_i]^{(\sigma_i' - 1)/\sigma_i'}\}^{\sigma_i'/(\sigma_i' - 1)} \\
& && i = M, KS \\
\sum \alpha_{i,j} &= 1, \qquad i = M, KS \neq j = F, Z, A, M, KS
\end{aligned}\right\} \quad (1), (2)$$

* Equation numbers correspond with the mathematical statement in the appendix.

where Q_i is gross output in sector i, Z_i is imported raw materials, $Q_{i,j}$ are intersectoral inputs (excluding intrasectoral inputs), $\alpha_{i,j}$ are the cost shares of each factor in gross sales, ϕ_i is a composite input index of conventional and human capital (skills), ξ_i and ξ_i' are distribution parameters, and σ_i and σ_i' are substitution elasticities. Factor-augmenting technical progress determines the level of $x(t)$, $y(t)$, and $z(t)$; xK_i, yS_i, and zL_i will be referred to as "efficiency capital," "efficiency skilled labor," and "efficiency labor" in what follows.

Agriculture's production function is specified as Cobb–Douglas:

$$\left.\begin{aligned} Q_A &= A_A [xK_A]^{\alpha_{A,K}} [zL_A]^{\alpha_{A,L}} R_A^{\alpha_{A,R}} Z_A^{\alpha_{A,Z}} \prod_{j=M,KS} Q_{A,j}^{\alpha_{A,j}} \\ \sum \alpha_{A,j} &= 1, \qquad j = K, L, R, M, KS, Z \end{aligned}\right\} \quad (3)$$

where Q_A denotes *gross* agricultural output, and R_A the endogenously determined stock of land, unaugmented by technical progress.*

Following the now standard conventions in the formal literature (Mazumdar, 1975), the traditional service sectors utilize unskilled labor inputs only. In the absence of sector-specific technological change, the average physical product of efficiency labor diminishes with the continued application of labor, and the law of diminishing returns is held to prevail ($\alpha_i < 1$). Thus,

$$Q_i = A_i [zL_i]^{\alpha_i}, \qquad 0 < \alpha_i < 1, \qquad i = US, RS \qquad (4), (5)$$

Below we shall assume that labor in the traditional service sectors is paid its *average* product, thus satisfying product exhaustion. Since much of the traditional service labor is self-employed (barbers, vendors), the difference between average and marginal product may be considered as a reward for entrepreneurship.

Housing services are produced by the combined inputs of existing residential structures and land. Housing is obviously quite different than the other five commodity and service activities since it utilizes neither labor nor "productive" capital. Housing is, therefore, discussed more conveniently as a separate topic, in conjunction with land-market and optimal land-use issues (see Section 2.8).

2.3 Commodity Prices, Service Prices, and Aspects of Tax Policy

Prices of manufactured and agricultural goods are determined exogenously by the combined influences of world market prices and the country's commercial policy. Thus, import substitution and tariff policy is captured by an equivalent *ad valorem* tariff rate, $\tau_{T,M}$, so that

* See Binswanger (1974) on the factor-augmenting attributes of agriculture in the American twentieth century case.

$$\bar{P}_M = \bar{P}^W_M(1 + \tau_{T,M}) \tag{9}$$

$$\bar{P}'_M = \bar{P}_M - \bar{P}_Z\frac{Z_M}{Q_M} - \bar{P}_A\frac{Q_{M,A}}{Q_M} - P_{KS}\frac{Q_{M,KS}}{Q_M} \equiv \alpha_{M,F}\bar{P}_M \tag{10}$$

where $\bar{P}'_M$ refers to value-added price, $\bar{P}_M$ refers to domestic selling price, and the country is assumed to be a price taker in world markets at $\bar{P}^W_M$.* This describes the bulk of developing countries but excludes, most notably, those which are endowed with exceptional deposits of exportable raw materials, where these exports loom large not only in the country's exports, but in world trade as well.

Agriculture is much more difficult to capture with a simple model since in reality the Third World is beset with a bewildering variety of export taxes, marketing boards, and subsidies and taxes on purchased inputs (Hayami and Ruttan, 1971; Johnston and Kilby, 1975; Schultz, 1978). Our "representative" economy is assumed to have the following attributes regarding agricultural markets: the country is a price taker, subsidies and taxes are applied to purchased inputs from manufacturing (e.g., fertilizer), and export taxes are common. Thus, domestic agricultural prices are exogenous and "distorted" by policy in the following way:

$$\bar{P}_A = \bar{P}^W_A(1 + \tau_{T,X})^{-1} \tag{11}$$

$$\bar{P}'_A = \bar{P}_A - \bar{P}_Z\frac{Z_A}{Q_A} - \bar{P}_M(1 + \tau_{A,M})\frac{Q_{A,M}}{Q_A} - P_{KS}\frac{Q_{A,KS}}{Q_A} \tag{12}$$

$$\equiv (\alpha_{A,K} + \alpha_{A,L} + \alpha_{A,R})\bar{P}_A$$

where $\bar{P}_A$ refers to the domestic selling price, $\bar{P}'_A$ refers to the value added price (received by farmers), $\tau_{T,X}$ is an average *ad valorem* equivalent export tax, and $\tau_{A,M}$ refers to the domestic tax or subsidy on purchased inputs in the agricultural sector. The relative magnitudes of these two taxes will determine the extent to which agriculture is "squeezed."

The treatment of the export tax may be made more transparent. The value of exports expressed in domestic prices ($\bar{P}_A X_A$) is taxed at the rate $\tau_{T,X}$ so that

$$\bar{P}_A X_A(1 + \tau_{T,X}) = \bar{P}^W_A X_A$$

which with some simple manipulation yields equation (11). An increase in this tax serves to diminish domestic output, increase domestic demand at the lower domestic prices (a source of subsidy to the urban workforce at the

* It should also be noted that per unit value-added prices should exhaust total factor payments per unit of output. Thus,

$$\bar{P}'_M = w_{M,S}a_{M,S} + w_{M,L}a_{M,L} + r_M a_{M,K} \equiv \alpha_{M,F}\bar{P}_M$$

where $w_{M,j}$ are wage rates, r_M is the return to capital, and $a_{M,j}$ is the endogenous input–output ratio of factor j to value added. Similar conditions hold for all other sectors.

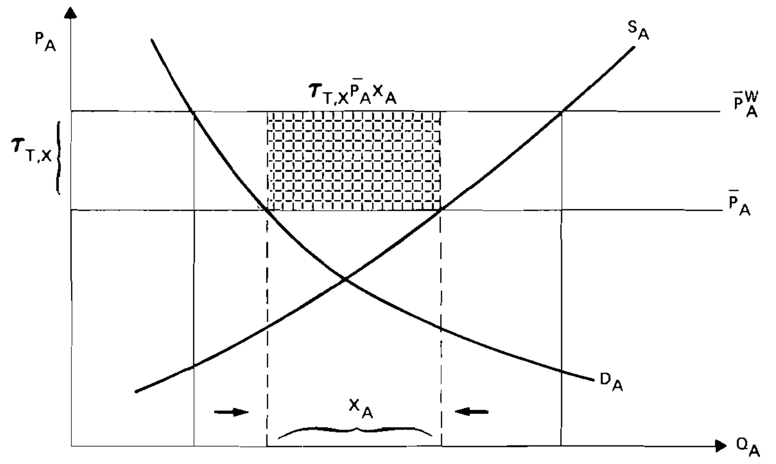

FIGURE 1 Partial equilibrium analysis of the export tax.

farmer's expense), diminish exports, but may or may not change government tax revenues, depending on domestic demand and supply elasticities. This can be seen in Figure 1.

The remaining prices in our model (rural services, P_{RS}; urban traditional services, P_{US}; urban modern services, P_{KS}) are all determined endogenously where, in addition,

$$P'_{KS} = P_{KS} - \bar{P}_Z \frac{Z_{KS}}{Q_{KS}} - \bar{P}_M \frac{Q_{KS,M}}{Q_{KS}} - \bar{P}_A \frac{Q_{KS,A}}{Q_{KS}} \tag{13}$$

following the same notation as above. (Rents are discussed in Section 2.8.) There are other commodity taxes present in the model, but since they appear as expenditure or sales taxes, we need not discuss them until we confront the government sector (Section 2.10) and the private sector demand system (Section 2.11).

A possible extension of the model would be to include transport costs, thereby providing an added regional dimension. There is accumulating evidence, however, that simple modeling of transportation yields little insight or impact in general equilibrium systems of this type. In a study of Indian economic development, for example, Rakesh Mohan (1977) highlighted transport costs in an attempt to gain an insight into intersectoral commodity flows, factor migration, and urbanization. Mohan regarded transport as an intermediate good produced by the industrial sector. Transport demand originated from movements of final and intermediate goods between urban and rural areas, and regional commodity prices differed by a factor of proportionality to reflect transport margins. Simulation experiments revealed a negligible impact even when transport margins were increased fivefold. Williamson and de Bever (1977) have also experimented with transport margins in a general equilibrium model of Japanese historical development. Their formulation focused on the cost of moving agricultural goods to urban markets. As with the Indian case, Williamson and de Bever find trade margins had little quantitative impact on the course of Japanese growth and structural change.

Based on these and other findings, we are reluctant to include interregional transportation in the present model. To do so properly would involve data requirements on transportation production activities, as well as product-specific trade margins, that are extremely scarce for most developing countries. And the studies cited above have already shown that simple formulations of transport costs yield little added insight and negligible quantitative impact.

2.4 Labor Demand, Labor Supply, and Wage Determination

Economy-wide supplies of skilled and unskilled labor are exogenously given at any point in time in the static model. This is not true over time, of course, since skills are augmented endogenously (Section 2.7) and unskilled labor grows in response to long-run demographic forces (Section 2.14). Although total labor supplies are given by previous history in the static model, the distribution of the labor force over space and across sectors is not. The next section will analyze the migration behavior embedded in the model which determines labor allocation. The present section will focus on labor demand and wage determination in the absence of migration forces.

There are five sectors that employ unskilled labor:

$$L_U = L_M + L_{KS} + L_{US} \tag{50}$$

$$L_R = L_A + L_{RS} \tag{51}$$

$$L = L_U + L_R \tag{52}$$

where L_R is the total rural unskilled labor force and L_U is the total urban unskilled labor force. Overt unemployment is *not* an attribute of our model since very few unskilled laborers in the Third World can afford the luxury, having few or no assets to finance significant periods of overt unemployment. Apparently this characteristic holds true even for rural immigrants to some Third World cities, since the evidence suggests that they secure employment relatively soon after arrival (Yotopoulos, 1977, chp. 6; Yap, 1976, 1977). Low-productivity *under*employment in the traditional service sectors appears to offer a better measure of the extent of labor surplus (Mazumdar, 1975).

With the exception of the two labor-intensive service sectors, efficiency factors are assumed to be paid their marginal value products, provided that, at each point in time, the marginal value product of efficiency labor in each sector is sufficient to allow every member of the unskilled labor force to consume at levels that satisfy subsistence. We interpret "subsistence" to be the level of *per capita* consumption considered by households to be essential for their welfare. This minimum level of consumption will be defined explicitly when we turn to the household demand system, but for the moment we shall assume that it is above the caloric level at which starvation occurs, and that it also exceeds levels at which marginal increases in consumption significantly influence productivity, efficiency, and thus earnings. (See Fei and Chiang, 1966; Mirrlees, 1975.)

Defining $\tilde{w}_{i,L}$ to be the wage per efficiency unskilled laborer in the ith sector, *annual earnings* can be denoted by $w_{i,L} = z\tilde{w}_{i,L}$ where, we will recall, z is a factor of augmentation through technical change (or utilization). Thus, wage equations for these five sectors can be written as

$$\tilde{w}_{i,L} = P_i' \frac{Q_i}{Q_{i,F}} (1 - \xi_i) \left[\frac{Q_{i,F}}{zL_i}\right]^{1/\sigma_i} = \frac{w_{i,L}}{z}, \qquad (19), (20)$$

$$i = M, KS \text{ and where } P_M' = \bar{P}_M'$$

$$\tilde{w}_{A,L} = \bar{P}_A \alpha_{A,L} \left[\frac{Q_A}{zL_A}\right] = \frac{w_{A,L}}{z} \qquad (21)$$

$$\tilde{w}_{i,L} = \frac{P_i Q_i}{zL_i} = \frac{w_{i,L}}{z}, \qquad i = RS, US \qquad (22), (23)$$

Note that marginal product pricing does not hold in the informal service sectors, but rather average value product determines wages there. It may be appealing to view wage determination in traditional services as the result of income sharing. Alternatively, the output produced above the laborer's marginal product may be considered a premium of entrepreneurship distributed back to the laborers – a view consistent with the fact that self-employment and family enterprise dominate this sector.

It might be helpful to emphasize two issues at this point: the distinction between wage *rates* and annual *earnings*, on the one hand, and the *structure of earnings* by occupation-sector, on the other. Both of these issues are important to income distribution patterns generated by the model. First, we have shown elsewhere that wage rates and earnings can behave quite differently over time in the developing economy, depending, to a large part, on the character of technical progress. (See Kelley, Williamson, and Cheetham, 1972, chps. 4, 5, and 8.) As we shall see in Section 2.13, labor-saving technological change implies rapid increases in z, an influence that serves to suppress the rise in the real wage *rate*, confirming the historical evidence of wage stability. Yet that influence also seems to drive a wedge between wage *rates* and annual *earnings*, the latter rising even in the face of wage-rate stability. Thus, stability in the wage-rate of efficiency unskilled labor does not necessarily imply stability in wage earnings or, for that matter, stability in the unskilled labor's share. Second, our choice of migration rules will be crucial in determining the *structure* of earnings among the unskilled in our model. If we were to assume complete factor mobility between sectors, and thus wage equalization, there would be no room for anything other than a fully egalitarian distribution of unskilled earnings: all earnings inequality would take the form of wage differentials between skilled and unskilled labor. Migration specifications become important, therefore, to the distribution patterns generated in any model of Third World economies.

Equations (19)–(23) can be readily converted into sectoral (unskilled) labor requirements, demand conditions that are central to issues of employment, labor migration, income distribution, and urbanization. Sectoral unskilled labor demands are, therefore, written as the combined influence of technology, output levels, and, of course, real wages themselves:

$$L_i = \left[\frac{w_{i,L}}{P'_i}\right]^{-\sigma_i} [Q_i(1-\xi_i)Z^{(\sigma_i-1)/\sigma_i} Q_{i,F}^{(1-\sigma_i)/\sigma_i}]^{\sigma_i} \qquad i = M, KS$$

$$L_A = \left[\frac{w_{A,L}}{\bar{P}_A}\right]^{-1} \alpha_{A,L} Q_A$$

$$L_i = \left[\frac{w_{i,L}}{P_i}\right]^{-1} Q_i, \qquad i = US, RS$$

It should be clear from these labor demand functions that wage elasticities vary across sectors, being higher in agriculture (unity) than in the modern sectors where σ_i is usually less than unity.

Consider next the skilled labor market. Skilled labor supplies, S, are given at some exogenous level in the static model, depending on previous experience with skill accumulation. Since skilled labor is utilized only in the two modern urban sectors it follows that

$$S = S_M + S_{KS} \tag{53}$$

Defining $\tilde{w}_{i,S}$ to be the wage per efficiency skilled laborer in the ith sector, his annual earnings can be denoted by $w_{i,S} = y\tilde{w}_{i,S}$ where y is a factor of augmentation comparable to that for unskilled labor. Once again marginal productivity conditions are invoked so that

$$\tilde{w}_{i,S} = P'_i \frac{Q_i}{Q_{i,F}} \xi_i (1-\xi'_i) \left[\frac{Q_{i,F}}{\phi_i}\right]^{1/\sigma_i} \left[\frac{\phi_i}{yS_i}\right]^{1/\sigma'_i} = \frac{w_{i,S}}{y} \qquad (24), (25)$$

$$i = M, KS \text{ and where } P'_M = \bar{P}'_M$$

As with unskilled labor, these two wage equations can be converted into skilled-labor demand functions:

$$S_i = \left[\frac{w_{i,S}}{P'_i}\right]^{-\sigma'_i} [Q_i \xi_i (1-\xi'_i) Q_{i,F}^{(1-\sigma_i)/\sigma_i} \phi_i^{(1-\sigma'_i)/\sigma'_i} y^{(\sigma'_i-1)/\sigma'_i}]^{\sigma'_i} \qquad i = M, KS$$

2.5 *Labor Migration and Wage "Gaps"*

Research on the determinants of labor migration in developing economies has proceeded along two lines. The first has its source in formal dualistic labor transfer models where the treatment of migration has typically been quite simplistic. The Lewis (1954), Fei–Ranis (1961), Jorgenson (1961, 1967), and Kelley–Williamson–Cheetham (1972) models all exploit the hypothesis that current wage differentials induce labor migration between sectors. Since the significance of wage differentials as a determinant of migration is well documented (Beals et al. 1967; Sahota, 1968; Yap, 1976b), the hypothesis would hardly seem contestable. Yet, this evidence hardly justifies the extreme but common assumption in the general equilibrium literature that wages are in fact equalized by the process of migration. In fact, nominal wage equalization is not observed in the Third World (Reynolds, 1965; Johnston and Nielsen, 1966; Johnson and Whitelaw, 1974), although the lion's share of the observed nominal wage "gaps" appears to be due to skill and cost-of-living differences (on the alleged Brazilian "low-wage" northeast, see Fishlow, 1972; on the alleged American "low-wage" south, see Bellante, 1979). Since it is widely recognized that wage differentials are not the sole determinant of migration, and that all determinants are not necessarily economic, we cannot adopt wholesale the simple wage equalization assumptions of the simpler general equilibrium models in a more policy-oriented framework, especially one like ours which focuses on the urbanization process.

A second line of thought extends the classical treatment of the migration decision. Either it includes an urban unemployment (or underemployment) variable, and thus focuses on expected annual earnings differentials (Todaro, 1969; Harris and Todaro, 1970; Zarembka, 1972; Corden and Findlay, 1975), or it utilizes a capital theoretic framework that explicitly introduces present value calculations, migration costs, job search, and distributed lags (Sjaastad, 1962; Kelley, Williamson, and Cheetham, 1972; Williamson and de Bever, 1977). In particular, the Todaro framework has enjoyed considerable popularity over the past decade and there have been many attempts to introduce this hypothesis into static and dynamic intersectoral development models.

The Todaro hypothesis is simple and elegant. While similar statements can be found elsewhere (Harris and Todaro, 1970; Stiglitz, 1974), the most effective illustration can be found in Corden and Findlay (1975), reproduced in Figure 2 assuming perfect capital mobility. There are only two sectors analyzed, but they are sufficient to illustrate the point. Under the extreme assumption of wage equalization through migration, and in the absence of wage rigidities, equilibrium is achieved at E (the point of intersection of the two labor demand curves, AA′ and MM′). Here $w_A^* = w_M^*$ and the urbanization rate is $O_M L_M^* / L$, where M denotes the manufacturing sector and A denotes agriculture. In addition, the Corden–Findlay model incorporates the widely-held belief that the wage rate of Third World manufacturing sectors is "pegged" at artificially high levels, say at $\bar{w}_M$. If overt unemployment is assumed away, then

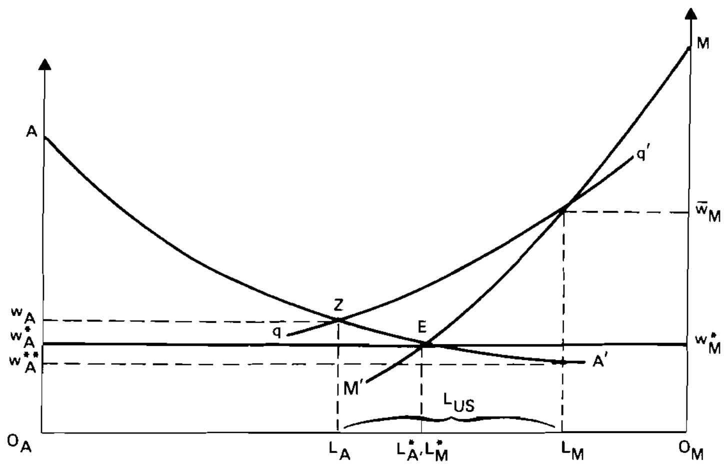

FIGURE 2 The Harris–Todaro–Corden–Findlay Model.

all who fail to secure the favored jobs in the M sector would accept lower-paying jobs in the A-sector at w_A^{**}.

Clearly, the level of employment in the urban sector has been choked off by the high wage in the manufacturing sector and both migration and urbanization have been forestalled. As Todaro initially pointed out, however, urbanization rates have been dramatic in the Third World and furthermore there has been an expansion in traditional urban service underemployment (see also Sabot, 1975; Mazumdar, 1975; Rogers, 1977; Merrick, 1978). Todaro explains this apparent conflict (e.g., migration in the face of urban underemployment) by developing an expectations hypothesis which, in its simplest form, states that the favored jobs are allocated by "lottery," that the potential migrant calculates the expected value of that lottery ticket, and compares it with the certain employment in the rural sector. Migration then takes place until the urban expected wage is equated to the rural wage. Given the "pegged" $\bar{w}_M$, at what rural wage would the migrant be indifferent between "underemployment" in the traditional urban service sector and employment in the agricultural sector? If his probability of getting the favored job is simply the ratio of L_M to the total urban labor pool, L_U, then the expression

$$w_A = \frac{L_M}{L_U} \bar{w}_M$$

indicates the agricultural wage at which he is indifferent between employment locations. This is in fact the qq′ curve in Figure 2. The equilibrium agricultural wage, w_A, and urban underemployment (e.g., the size of the traditional, unorganized sector) is thus given at Z.*

* The Harris–Todaro curve, qq′, is a rectangular hyperbola with unitary elasticity. The elasticity of the labor demand curve in the urban "modern" sectors is assumed to be less than unity in Figure 2 according to our expectations revealed in Section 2.4.

While this conventional wisdom is elegant, we adopt it here only with qualifications. These qualifications are motivated by the following observations. First, we are not convinced that $\bar{w}_M$ can be viewed as "pegged" in the Third World and independent of market forces. (See Mazumdar, 1975; House and Rempel, 1978; Henley and House, 1978.) Put differently, the apparent wage rigidity attributed to institutional factors (unions, government regulations) may in fact be explained by market forces, with institutions merely responding to those forces (Taylor, 1979, chp. 5). In any case, we have no way of projecting such a fixed wage into the future, and without that information dynamic analysis is sorely limited.

Second, we agree with Willis (1979) that the lottery view of who gets favored jobs is naive and ignores property rights. It seems to us that the allocation of new job vacancies in the favored sectors is hardly random, but rather very much a function of bribes, nepotism, employment search costs, union dues, and the like. That is, these favored jobs have property rights earning rents that command an implicit or explicit price. Third, the Todaro formulation ignores the obvious fact that the majority of the favored jobs are more skill-intensive than either farm labor or traditional urban service activity. Finally, and we think most important, the formulation ignores cost-of-living differentials between regions.

Our own approach is a hybrid which attempts to meet at least some of these criticisms. On the one hand, we assume perfect mobility of unskilled labor *within* the rural sector since everyone seems to agree that free entry and costless mobility are reasonable approximations there. We make the same assumption for both skilled and unskilled labor between the two modern urban sectors, certainly an acceptable premise to the Todaro adherents given their willingness to aggregate all modern-sector activities. Thus,

$$w_{A,L} = w_{RS,L} \tag{26}$$

$$w_{M,S} = w_{KS,S} \tag{27}$$

$$w_{M,L} = w_{KS,L}$$

On the other hand, we model the unskilled wage gap between traditional urban services and the modern sectors by inserting an exogenous differential κ that reflects the costs of the property right as discussed above. Thus,

$$w_{M,L} = w_{KS,L} = \kappa w_{US,L} \tag{28}$$

Finally, and most important, the rural–urban migration process must be specified. Here we adopt a position which is closer in spirit to the Todaro hypothesis, but, we feel, with more to defend it. The potential rural–urban migrant is assumed to behave as if he calculates an expected urban nominal wage, w_U. This wage is simply the weighted average of potential urban unskilled earnings and skilled earnings (net of taxes), where the weights are *marginal* probabilities rather than average probabilities, as in the simple Corden–Findlay version. Thus,

$$
\left.
\begin{aligned}
w_U = {} & [(1-\tau_Y)w_{M,S}]\left[\frac{\dot{S}(-1)}{L_U(-1)}\right] + \left[1 - \frac{\dot{S}(-1)}{L_U(-1)}\right] \\
& \left[w_{M,L}\frac{L_M(-1)}{L_U(-1)} + w_{KS,L}\frac{L_{KS}(-1)}{L_U(-1)} + w_{US,L}\frac{L_{US}(-1)}{L_U(-1)}\right]
\end{aligned}
\right\} \quad (30)
$$

where τ_Y is the income tax rate on high-wage skilled labor. The migrant has accessible current information on city wages, but not on his employment probabilities. Thus employment weights are lagged one year in the migrant's calculation of expected urban income.* In summary, the migrant is induced into the cities with the anticipation of having the chance of gaining one of two favored modern-sector jobs: either unskilled employment at a higher wage rate, or training and perhaps subsequent skilled employment at an even higher wage. Training and skills creation will be discussed in Section 2.7 when we confront the dynamic specifications in the model.

Finally, we assume that the migrant is not motivated solely by nominal (expected) wage gaps, but rather by *real* income differentials. Thus,

$$
\frac{w_{A,L}}{COL_R(-1)} = \frac{w_U}{COL_{US}(-1)} \quad (29)
$$

where the location-specific cost-of-living indices, COL_i, are influenced by price differentials for nontradeables as well as budget weights. This specification will be discussed at greater length when the household demand system is elaborated in Section 2.11.

In summary, our model is capable of generating an endogenous earnings structure in four dimensions: rural unskilled earnings, urban traditional-sector unskilled earnings, modern-sector unskilled earnings, and skilled earnings. The wage spread over these employment categories will be determined by the endogenous forces of market demand, supply, and the migration process itself. The speed of urbanization will be determined by the same set of forces. While expectations of favored sector employment may well generate the Todaro result of "over-urbanization," it is also possible that cost-of-living influences may choke off that tendency without the overt introduction of government policy. The issue is an empirical one.

2.6 "Productive" Capital Markets

Our assumption that efficiency factors are paid their marginal value products applies not only to labor, but to physical capital as well. Thus, the sectoral rates of return to capital r_i are written as

* In our specification of skill augmentation and training (Section 2.7, equation (90)), we introduce a longer lag for migrants in obtaining skilled employment. For simplicity, this feature has been suppressed in the migration equation, since it would introduce unnecessary complexity of little empirical consequence.

$$\left.\begin{aligned}\tilde{r}_i &= P_i' \frac{Q_i}{Q_{i,F}} \xi_i' \xi_i \left[\frac{Q_{i,F}}{\phi_i}\right]^{1/\sigma_i} \left[\frac{\phi_i}{xK_i}\right]^{1/\sigma_i'} = \frac{r_i}{x} \\ & \qquad\qquad\qquad\qquad i = M, KS\end{aligned}\right\} \qquad (31), (32)$$

$$\tilde{r}_A = \bar{P}_A \alpha_{A,K} \left[\frac{Q_A}{xK_A}\right] = \frac{r_A}{x} \qquad (33)$$

We assume capital immobility, so after-tax rates of return need not be equalized between sectors. That is, once investment is allocated to a given sector and used to augment the capital stock there, the new stock of capital becomes specific to that production activity. Thus, any economic event that serves to raise the rate of return in one sector, relative to another, will tend to generate rate of return differentials, a disequilibrium attribute typical of most developing economies, and often labelled as "market failure."

On the other hand, we assume that the current pool of productive investment goods can be allocated freely between sectors. Indeed both private investors and government authorities are assumed to allocate current saving (excluding, of course, that earmarked for housing investment) so as to minimize rate of return differentials. The rate of return differentials minimized, however, are not simply the net returns on existing capital, since these are determined primarily by the sectoral capital stocks that are fixed in the current time period. Rather, private and public agents form expectations of projected rates of return based on investment plans that will serve to augment sectoral capital stocks in the next time period. Thus, the differentials minimized by current investment allocation decisions might be called *ex ante* net (after tax) rates of return or quasi-rents. Formally, where the $\tau_{\Pi,i}$ are "corporate" tax rates ($\tau_{\Pi,M} > \tau_{\Pi,KS}$) we wish to

$$\underset{I_{i,M}}{\text{MINIMIZE}} \left[\begin{aligned}\text{RETURN DIFFERENTIALS} = \; & |[\tilde{r}_A^* - \tilde{r}_M^*(1-\tau_{\Pi,M})]| + \\ & |[\tilde{r}_A^* - \tilde{r}_{KS}^*(1-\tau_{\Pi,KS})]| + \\ & |[\tilde{r}_M^*(1-\tau_{\Pi,M}) - \tilde{r}_{KS}^*(1-\tau_{\Pi,KS})]|\end{aligned}\right]$$

such that

$$I_M = \sum_i I_{i,M} \qquad i = A, M, KS \qquad (34)$$

where

$$\tilde{r}_i^* = \{\tilde{r}_i + \frac{\partial r_i}{\partial K_i}\bigg|_{K_i} [I_{i,M} - \delta_i K_i]\} - \delta_i \bar{P}_M \qquad i = A, M, KS$$

The *ex ante* (after tax) rates of return are thus the result of the combined impact of the current *net* rate of return in sector i, $[\tilde{r}_i - \delta_i \bar{P}_M]$, plus the expected impact of current *net* investment allocations, $[I_{i,M} - \delta_i K_i]$, on that rate of return.

It is quite possible, indeed likely, that the current net investment pool is insufficient to equalize these quasi-rents, and differentials between *ex post* rates of return may persist or increase over periods of time. Even so, some readers might wish to see more evidence of capital market fragmentation and ineffective financial intermediation introduced into the model.

Indeed, there is a growing empirical literature which emphasizes capital market fragmentation (Gurley and Shaw, 1955, 1956, 1967; Patrick, 1966; Shaw, 1973), although development economists have found it difficult to model the process (McKinnon, 1973; de Melo, 1976, 1977). We certainly agree with this emphasis. As a result, critical elements of capital market imperfection and fragmentation are introduced explicitly into the model when we consider investment in human skills in Section 2.7 (individuals cannot borrow to finance skill acquisition), as well as investment in housing in Section 2.8 (households are restricted to "self-finance" and mortgage markets are nonexistent).

Given these several elements of capital market fragmentation, we consider it relatively unproductive to add more capital market "realism" to our model at this point. In an earlier work (Kelley, Williamson, and Cheetham, 1972, chp. 7), we did make an effort to formulate a disequilibrium dualistic model which incorporated capital market imperfections in the allocation of conventional physical capital. That exercise pointed out the heavy empirical requirements which this "move toward realism" implies. It also underscored the *ad hoc* devices used in the literature to circumvent the explicit estimation of key parameters.

The most popular device has its origin with Rosa Luxemberg (1969), who assumed that all rental income was reinvested in the sector of origin. Many have followed in her footsteps; a recent example offered by Yap (1972), who assumed that 80 percent of a given sector's savings was reinvested while the remaining 20 percent was allocated in response to rates of return.

We do not find these *ad hoc* approaches to capital market fragmentation appealing, and believe that the assumptions embedded in our basic model supply the best starting place for an analysis of Third World urbanization and distribution. For example, capital market imperfections in the skill acquisition process are already in our model; the absence of a mortgage market is also there; and the immobility of current stocks of physical (productive) capital adds another market-clearing constraint. All of these capital-market attributes are likely to produce the relevant stylized facts of Third World development: persistent rate of return differentials, sectors "starved" for funds, heavy reliance on self-generated funds, high reinvestment rates, "thin" intersectoral savings flows, and an urban investment bias. The latter is assured since increasing government expenditures can be satisfied in our model only by the expansion of the *KS* sector (e.g., education, health, defense, communications), and increases in the *KS*-sector's output implies a rise in investment requirements there (e.g., the construction of school buildings, medical facilities, harbors, airports, roads). By definition, such investment is urban based. There are also other forces in our model which are likely to make the rural sector appear "starved" for funds.

Finally, in the remainder of this exposition we shall find it useful to make reference to an "economy-wide discount rate." In what follows, this percentage rate will be defined as the average net (after taxes, excluding depreciation requirements) rate of return to "productive" physical capital. Equation (35) supplies the calculation where sectoral capital stocks are used as weights in computing the average:

$$i = \left[\sum_i (1 - \tau_{\Pi,i}) x K_i (\bar{r}_i^*) \right] \left[\bar{P}_M \sum_i K_i \right]^{-1}, \qquad i = A,M,KS \qquad (35)$$

2.7 *Education, Training, and Skills Accumulation*

The availability of skilled labor can have a potent impact on growth and distribution. Slow rates of growth in the stock of skills can constrain expansion in the two modern sectors where skilled labor is utilized in production. Demand shifts favoring these skill-intensive sectors will serve to raise the skill premium, and produce "wage stretching" and earnings inequality (Chiswick, 1974; Phelps-Brown, 1977). The importance of a possible skills "bottleneck" depends critically on the degree to which unskilled labor and capital can be used as substitutes for skills.

Debate on this issue has been extensive and until recently divided into two camps: the manpower "structuralists" who see little opportunity for substitution between labor of different skills, and their opponents who argue that, on the contrary, substitution elasticities are very high between labor of different skills (Bowles, 1970). The issue has apparently been resolved by recent empirical research (Griliches, 1969; Fallon and Layard, 1975; Kesselman, Williamson, and Berndt, 1977) which finds elasticities with intermediate values. These results have been incorporated in the production function specifications discussed in Section 2.2.

The importance of a skilled labor bottleneck also depends on the response of skill accumulation to demand conditions. Skill formation rates are a function of three forces in the specification which follows: the stock of "trainable" urban labor, the relative scarcity of skills (measured most commonly by the skill premium) which offers incentives to engage in training, and the level of government expenditures on formal education which influences the ease with which "trainables" can, in fact, be converted to skilled labor. We are aware that many Third World economies appear to exhibit a glut of formal school graduates. The specification which follows is designed to account for a variety of Third World experience, since the model may generate abundance or scarcity of those formally schooled. In any case, the stock of trainables will be limited to *urban* workers only. This seems reasonable: rural workers, regardless of educational training, must first migrate to urban areas before being considered for training. This in itself supplies an incentive to migrate. Furthermore, to the extent that such education is more accessible in the city, a household head may well migrate to insure the education of his children (a motive perhaps mislabeled as "bright lights").

How, then, is the skills-acquisition process modeled in our economy? We shall assume the training to be financed by the industries which utilize skilled labor. Either due to insufficient funds implied by capital-market imperfections, or due to the absence of an effective "private schooling industry" or both, we shall assume that individuals cannot gain access to training unless selected for such training by firms who find it profitable to make such investments. The full cost of the training is, therefore, borne by the industries rather than the individual. (Trainees do bear the time cost of training, but only in foregone leisure.) Furthermore, we shall treat the two industries as if in collusion on their training investments, and that neither industry tries to obtain a "free ride" simply by hiring newly skilled workers after the other industry has made the necessary investments. Both industries invest in training, if profitable, and they jointly share the fruits of that investment.

The procedure involves first determining the returns to investment in training (and thus the demand function for skills), second determining the costs of training (and thus the supply function for skills), and third determining the supply of workers actually trained. Given the latter, the training activity can be priced and thus the total investment requirements computed. These investment requirements become one component of the current saving pool. The economy therefore accumulates three types of long-lived assets – physical capital, housing, and skills.

We are conscious of the fact that the *KS* sector relies heavily on skilled workers drawn directly from the formal education sector (clerks, bureaucrats, teachers, and doctors), while the *M* sector normally relies on blue collar workers who acquire skill by on-the-job training. Yet, our simplification does not appear to be totally inappropriate. Public education *is* determined in part by government investment decisions, and thus the formal-education-using *KS* sector can also be viewed in the same light as the *M* sector. Moreover, considerable training may even be required in government activity to convert the formally educated student into a worker of more immediate use.

After taxes, total profits in industry $j(j = M, KS)$ are simply $r_j(1 - \tau_{\Pi,j})K_j$. Total profits are augmented by the marginal addition of one more trained skilled worker as follows:

$$\frac{\partial(r_j[1-\tau_{\Pi,j}]K_j)}{\partial S_j} = K_j\frac{\partial r_j[1-\tau_{\Pi,j}]}{\partial S_j} + r_j[1-\tau_{\Pi,j}]\frac{\partial K_j}{\partial S_j}$$

With physical capital stocks fixed in the short run,

$$\frac{\partial(r_j[1-\tau_{\Pi,j}]K_j)}{\partial S_j} = K_j[1-\tau_{\Pi,j}]\left.\frac{\partial r_i}{\partial S_j}\right|_{S_j+\dot{S}_j} = \phi_{S,j} \qquad j = M, KS \qquad (86), (87)$$

where $\phi_{S,j}$ is the marginal after-tax revenue from the addition of one skilled worker.

For purposes of simplification, assume for the moment that the per unit cost of training a worker is constant at c, a parameter over which the government has some control. These are marginal (and average) costs common to both industries. While these training costs are all incurred in the current time period, the revenue stream will continue throughout the working life of the skilled worker. We shall assume that firms find it profitable to train only young workers with a long working life ahead of them. For computational simplicity, we shall also assume that firms compute the present value of these anticipated returns supposing (1) naive expectations that $\phi_{S,j}$ shall prevail indefinitely and (2) that the young skilled laborer can be viewed, at least approximately, as an asset with infinite life. The resulting present value of the benefit stream generated by current investment in training is simply

$$\hat{r}_{S,j} = \frac{\phi_{S,j}}{i}, \qquad j = M, KS \qquad (88), (89)$$

where i is the economy-wide discount rate, taken here as the weighted average of returns to physical capital in the various sectors. Thus, we have explicitly introduced the notion that training must compete with alternative investments in economy-wide physical accumulation. Presumably, the firm is indifferent between investment in training and alternative modes of accumulation such that current costs and capitalized benefits are equated:

$$\hat{r}_{S,j} = c \qquad j = M, KS \qquad (91), (92)$$

What determines the stock of potential trainables? Generally, this includes all of last year's unskilled workers (excluding deaths and retirements) plus all new entrants who are children of urban households, but excludes any of this year's rural in-migrants. The exclusion of recent in-migrants is based on a "two-staged" view of in-migration: only those of the unskilled who have already had some exposure to urban work are considered trainable by modern-sector firms. The urban unskilled are also distinguished by their level of *formal* education (Ed), the latter dictated by previous government educational policy and the demographic structure of the urban population. Thus, the stock of urban trainables by formal educational achievement is, in the current period, determined exogenously. Furthermore, we shall assume that the trainability of the urban unskilled worker is a function of formal education: those with high formal-educational attainment tend to be relatively cheap to train. A "step" cost function of the following kind is postulated:

$$c = \begin{cases} c_0,\ 0 \leq \dot{S} \leq L_{U,0}, & k = 0, \quad Ed > n \text{ years} \\ c_1,\ L_{U,0} < \dot{S} \leq L_{U,1}, & k = 1, \quad n - 1 < Ed \leq n \\ \vdots & \qquad\qquad \vdots \\ c_n,\ L_{U,n-1} < \dot{S} \leq L_{U,n}, & k = n, \qquad Ed = 0 \end{cases} \qquad (90)$$

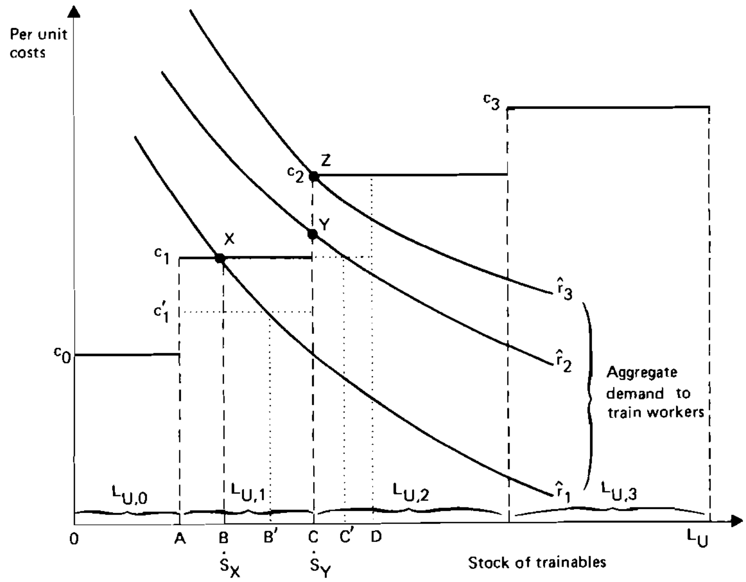

FIGURE 3 The skills investment market.

where k represents the formal-education class ($k = 0$ denoting highest attainment), and the total trainables constraint is

$$\dot{S} = \sum_j \dot{S}_j \leqslant L_U, \qquad j = M, KS \tag{93}$$

where $\dot{S}$ are total workers trained.

Figure 3 portrays the training market. Anticipated returns and the discount rate dictate the aggregate demand function for training. High anticipated returns generate buoyant demands in the two industries combined; such high anticipated returns may manifest themselves by skill "bottlenecks" with sizeable skill premia. Low rates of return to physical capital investment in A, KS, and M would yield the same result: investment in training would appear relatively profitable. Figure 3 illustrates two possibilities. At point X, demand ($\hat{r}_i$) is slack and a substantial share of those in the $k = 1$ educational class would find themselves glutting the market and thus employed at unskilled tasks. (In the $k = 1$ class $\overline{AB}$ workers will be trained and $\overline{BC}$ workers will remain untrained.) In contrast, at point Y, a much larger share of those with formal education are trained as skilled workers, leaving perhaps only elementary school graduates ($k = 2$) and dropouts, plus illiterates ($k = 3$), in unskilled jobs. Note too that an expansion in demand for skilled workers may in some circumstances be met with a rise in skilled wages and *no* additional training (Y to Z), while in other circumstances the training rate may rise (X to Y). The stock of trainables by k class as well as the height of the "step" in the cost function both matter to this result.

Total training costs, or total investment in training, can be written in either of two ways:

$$\text{TRAINING COSTS} = \sum_k c_k L_{U,k} + c_l \left[\dot{S} - \sum_k L_{U,k} \right], \quad k = 0, \ldots, l-1 \qquad (94)$$

$$\text{TRAINING COSTS} = P_{KS} I_{S,KS} \qquad (95)$$

where l is the optimal class trained satisfying (91) and (92). These training costs must lay claim on some real resources in the economy; that is, some "capital goods" sector must allocate resources to that investment activity and the investing firm's training cost ("tuition") must accrue as income to some sector. As is apparent in equation (95), it seems sensible to us to assign this capital goods activity to the *KS* sector since, after all, *KS* includes formal education. We are aware that this specification may have important implications for wage structure dynamics: high skill premia and earnings inequality imply profitability of investment in skills acquisition. The training investment response places demands on the *KS* sector. These added demands for *KS* output imply the augmentation of demand of skills (since they are used especially intensively there), and thus the wage premium may remain high in spite of rapid skills accumulation.

Finally, it should be noted that the training activity has another cost to the firm since the unskilled urban labor force is diminished by the training activity. Unskilled "labor scarcity" may cause a short-run rise in costs as a result. To the extent that rural labor supplies are elastic, urban unskilled labor scarcity is unlikely to persist for the longer run.

The model of skills accumulation presented to this point is one of firms investing in vocationally-oriented training according to their profit-maximizing calculus, given an exogenously determined cost-of-training function. While our model does not explain the cost function, changes in it can notably influence the rate of skills accumulation. These changes will derive primarily from government education policies which, while implicit in our exposition, can now be elaborated.

The formal education system is not explicitly modeled in our economy. Education is produced within the *KS* sector, together with many other government and private services. However, such an aggregation does not preclude an examination of the impact of government education policies which can be represented in our model by altering the cost-of-training function. Two such policies are illustrated in Figure 3.

For simplicity, consider the case where the share of education in the government's budget is constant, and two alternative policies are evaluated. The first policy represents a reorientation of the curriculum for the $k = 1$ education class toward more vocational training. This will reduce the training costs facing the firm from c_1 to c_1' and, for a given demand (say $\hat{r}_1$), result in an expansion in skills investment by $\overline{BB'}$. The second policy represents a reallocation of the education budget toward producing more $k = 1$ students at the expense of $k = 2$ students. This will expand the numbers in the $k = 1$ education class to $\overline{AD}$. If the firms' aggregate demand for skills were represented by $\hat{r}_2$, the new education policy would increase the number of skilled laborers by $\overline{CC}'$. These two examples illustrate the analytical as well as the policy-related features of our skills-generation framework. We do not, as is common in development modeling, view education solely as a consumer durable. Rather, educational outputs can play a productive role in the economy; human capital accumulation is important in explaining the process of growth and development. The specific way education enters is complex, and in our model determined by the interplay of production possibilities, demographic forces, and government education policies.

2.8 Housing, Land Markets, and Equilibrium Land Use

There are two competing uses to which land stocks can be put in our model – farming and urban residential land sites. We shall assume that urban residential sites implicitly include, in fixed proportion, factor-site requirements as well as public land (parks, roads, schools). The fixed proportion assumption will simplify the analysis considerably, since we can focus exclusively on the residential site demand component of urban land use. Furthermore, we shall assume that "wasteland" exists in the rural area. This wasteland has no competing use, has no inherent site value, but it can be used for rural housing construction. In the real world, of course, wasteland can be and is exploited for both urban and farmland expansion through drainage, clearing, and filling. These activities involve investment, and to confront land accumulation endogenously would require the explicit introduction of urban and rural land-supply functions, presumably inelastic to capture investment costs, and competitive with other investments in housing, training, and physical accumulation. We ignore such complications and take the expansion of productive land R as exogenously given, although not necessarily constant. To do otherwise would take us far afield and empirical implementation would be much too demanding.

The stock of productive land in our model is, therefore, defined as

$$R = R_{U,US} + R_{U,KS} + R_A \tag{54}$$

where urban land sites are utilized for two types of housing – low-cost "squatter settlements" ($R_{U,US}$) and high-cost "luxury housing" ($R_{U,KS}$).

The urban housing-market is central to migration behavior and thus to our analysis of the urbanization process. One of the limits on urban growth rates in the Third World is the availability (and cost) of urban housing facing new urban households, whether the housing is of the informal, labor-intensive, owner-occupier type in "squatter settlements" – so typical of rapidly expanding Third World cities – or more substantial dwelling units constructed by capital-intensive techniques and rented in a formal housing market. Any serious model of urbanization must admit this possible source of "limits to urban growth." The "limits" may take various forms, but we shall focus on two constraints in particular.

First, urban rents may rise in the long run due to the inflation of urban site rents as in classical urban location theory (Mills, 1972; Henderson, 1977). In addition, urban rents may also rise in the short run if investment in new structures lags behind demands generated by rapid urban population growth (Song and Struyk, 1976; Mills and Song, 1977). Second, to the extent that investment in housing responds to those demands generated by the in-migration, aggregate saving available for "productive" accumulation or training will contract and thus the rate of output expansion will suffer economy-wide (Coale and Hoover, 1958). Since physical capital and skills are used most intensively in the modern sectors (*M* and *KS*), the rate of urban labor absorption is diminished. In-migration to the cities and urbanization rates may slack off as a result. Our model incorporates these forces so that "over-urbanization" (Hoselitz, 1955, 1957; Sovani, 1962; Kamerschen, 1969; Preston, 1979; Ledent and Rogers, 1979) in our economy may be forestalled.

As pointed out above, there are two housing types in our model: low-cost "squatter settlements" and high-cost "luxury housing." In this we follow the United Nations' *Habitat* (1976, p. 70) where they state:

> In many less developed countries building is characterized by the existence of two sectors: a) a multitude of very small enterprises . . . which operate in the rural and peri-urban areas, belonging almost entirely to the informal sector of the economy; b) a small number of large firms using modern techniques and organization,

and their *Global Review of Human Settlements* (UN, 1976, p. 11) where "squatter settlements":

> . . . generally refer to areas where groups of housing units have been constructed on land to which the occupants have no legal claim. In many instances housing units located in squatter settlements are shelters or structures built of waste materials without a predetermined plan. Squatter settlements are usually found . . . at the peripheries of the principal cities.

According to the same source, these squatter settlements are by no means a small share of total urban dwellings, but account for the bulk of the growth in cities throughout the Third World (see also Mohan, 1979, chp. 1). It seems to us important to distinguish between two types of urban dwellings, to indicate the different sectors that produce them as well as the different socio-economic classes that consume the rental services that flow from these residential structures. Thus, the quality of housing is denoted by a jth subscript in the production functions which follow.

Urban housing services are produced under constant returns to scale with housing structures, H_j, and land, $R_{U,j}$, as inputs. While estimates of the elasticity of substitution between land and structures in residential-housing production functions vary considerably (Muth, 1969, 1971; Arnott and Lewis, 1977; Ingram, 1977; Henderson, 1977), the estimates are almost always quite high. We shall adopt a Cobb–Douglas specification for urban housing in what follows:

$$Q_{H,j} = A_{H,j} H_j^{\alpha_{H,j}} R_{U,j}^{\alpha_{R,j}}, \qquad j = US, KS \qquad (6), (7)$$

where $\alpha_{H,j} + \alpha_{R,j} = 1$, US denotes "squatter settlements," and KS "luxury housing." In contrast, rural housing services do not require the input of land of significant site value, so that a fixed coefficient production function is assumed to apply:

$$Q_{H,RS} = \frac{H_{RS}}{a_{H,RS}} \qquad (8)$$

This rural–urban asymmetric treatment of housing insures that rising land prices and increased site rents will have a disproportionate effect on the cost-of-living in urban areas as urbanization proceeds. Perhaps this can be seen more clearly when the total rental price for urban housing is written explicitly as

$$P_{H,j} = \frac{r_{H,j}^{\alpha_{H,j}} d_U^{\alpha_{R,j}}}{A_{H,j} \alpha_{H,j}^{\alpha_{H,j}} \alpha_{R,j}^{\alpha_{R,j}}}, \qquad j = US, KS$$

where d_U is the site rent and $r_{H,j}$ is the structure rent. Of course, the real-estate market never decomposes total rental price into these two component parts, and in our model all dwellings are owner-occupied. (In Korea, for example, 94 percent of rural and 83 percent of urban households were owner-occupiers in 1975 (Suh, 1979, table 11, p. 47).) Nevertheless, it will still prove analytically useful to decompose total rental prices in this fashion. In percentage rates of change (denoted by an $*$), these rental prices are related by

$$\overset{*}{P}_{H,j} = \alpha_{R,j} \overset{*}{d}_U + \alpha_{H,j} \overset{*}{r}_{H,j}, \qquad j = US, KS$$

Land's share, $\alpha_{R,j}$, has been estimated to be about 0.10 (Muth, 1971; see also Muth, 1969; Henderson, 1977; and Ingram, 1977). It follows that modest increases in urban rental prices may be consistent with dramatic increases in urban site rents (called the "magnification effect" in the urban literature). Dramatic increases in urban site rents imply equally dramatic increases in urban land prices and the latter have become a notable feature of twentieth century development even in the Third World. For example, urban land prices in Korea have been rising in real terms at 16 percent per annum since the early 1960s. (Mills and Song, 1977. For information on the boom of urban land values in the Third World, see Woodruff and Brown, 1971, pp. 16–25, chps. 5, 6, and 9. The same phenomenon can be found in postwar Japan. See Mills and Ohta, 1976.)

What, then, determines land rents, land prices, and land use in our model?

The agricultural production function is Cobb–Douglas. Under competitive assumptions, land rents per hectare can be written as

$$d_A = \bar{P}_A \alpha_{A,R} \frac{Q_A}{R_A} \tag{45}$$

Alternatively, expression (45) can be written as a derived demand function for farmland:

$$R_A = \bar{P}_A \alpha_{A,R} Q_A d_A^{-1}$$

where the derived demand function has an elasticity of -1. Similarly, the urban-housing, Cobb–Douglas production functions imply derived urban land demands for residential purposes (recalling that "residential" requirements embody commercial, factory, and public site needs). Thus,

$$d_{U,j} = P_{H,j}^S \alpha_{R,j} Q_{H,j} R_{U,j}^{-1}, \qquad j = US, KS \tag{46), (47}$$

where $P_{H,j}^S$ is the net rent received by the owner (imputed, not cash) after paying an urban property tax. Since it is not our purpose here to determine the distribution of urban populations across urban space – as in classic urban location theory – nor to confront the Third World reality that "squatter settlements" tend to be located at the fringe of the city while "luxury housing" tends to be located nearer the central business district (Mohan, 1977; Ingram and Carroll, 1978; Mills and Song, 1977), we shall assume that urban site rents are the same for all urban households. Thus,

$$d_U = P_{H,j}^S \alpha_{R,j} Q_{H,j} R_{U,j}^{-1}, \qquad j = US, KS$$

or

$$R_{U,j} = P_{H,j}^S \alpha_{R,j} Q_{H,j} d_U^{-1}, \qquad j = US, KS$$

Like farmland, these derived demand functions for urban land also have an elasticity of -1. The *aggregate* derived demand function for urban land is simply

$$R_U = d_U^{-1} \{P_{H,US}^S \alpha_{R,US} Q_{H,US} + P_{H,KS}^S \alpha_{R,KS} Q_{H,KS}\}$$

Our model is in no way a true spatial framework since distance plays no role in either of the two sectors. Thus, farmgate prices do not rise with greater proximity to urban markets and therefore farmland does not exhibit a "rental gradient" reflecting such heterogeneity. Similarly, proximity to the central business district does not offer any of the advantages typically postulated in conventional urban location theory (savings in transport costs and commuter time). There is, therefore, no urban "rental gradient" implied. Since urban land is homogenous in this sense, only the "extramarginal" rent on the fringe of the city matters in determining land use.

Figure 4 supplies the optimal land-use solution under such conditions. The equilibrium rent is denoted by $d^* = d_U = d_A$, and the optimal land-use mix is derived accordingly. What seems interesting to us is how many central

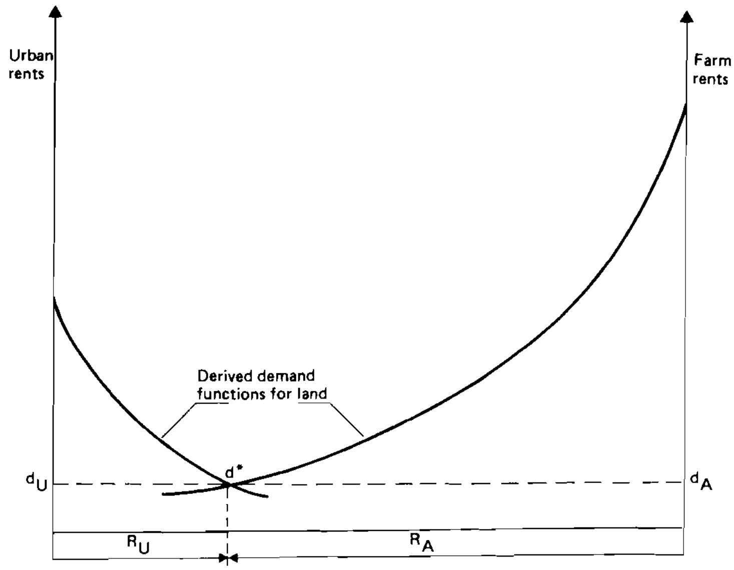

FIGURE 4 The determinants of land rents and optimal land use.

land-use issues are captured by this simple framework. Three such issues are contronted in what follows:

- Does the model predict rising urban densities over time?
- Can it account for the dramatic rise in urban land values?
- Will it produce an encroachment on farmland over time?

It is a common theorem of growth theory that factors in relative inelastic supply will increase in relative rent (and thus price or value) unless technology tends to be very factor-saving of the inelastically-supplied input (e.g., Nichols, 1970). In our model, capital accumulates, skills are augmented through training, population growth swells the labor force (and thus residential housing stocks), but the stock of land grows exogenously, and presumably at relatively low rates. The presumption is that relative rents will rise, over time, unless technological change serves to save on land. If one focuses only on land for agricultural use, "technological change" surely *does* tend to save on land, since the agricultural sector declines in relative size with successful economic growth.

On the other hand, our model explicitly introduces an additional land use – urban residential-site needs – and since successful economic growth implies rapid urbanization, the "land-saving" attributes of the simpler growth model are no longer so relevant. Indeed, while our urban housing production function specifications include the possibility of extensive substitution of structures for land (guaranteeing that urban densities will increase in the face of rising land rents), rapid urbanization implies a relatively voracious demand for land and the encroachment of farmland at the cities' margins. Additionally, there are forces at work in agriculture which will shift outward the derived demand for farmland: e.g., the rising price of foodstuffs and the accumulation of agricultural capital. In short, we expect the model to produce, over time, an outward shift in the derived demand for land in both uses, but we also expect that the derived demand for urban land will shift outward at a more rapid rate.

The long-run implications of such derived demand growth can be seen in Figure 5, where the following trends should be observed:

1. Urban and rural rents rise at a rapid rate;
2. Land use shifts in favor of urban residential use, but the rate of shift is choked-off by two forces – the downward sloping character of the derived demand for farmland and the tendency for urban housing to consume less space as land gets scarcer;
3. Urban land densities rise.

All of these attributes are "stylized facts" of urbanization in the Third World.*

Consider next the determinants of urban land values. In the simplest formulation, urban land values can be calculated assuming naive expectations regarding the behavior of future rents (i.e., d_U is expected to prevail at the current rate forever) and assuming infinite life. Thus,

$$V_U = d_U/i$$

where i is the economy-wide "discount rate." In the absence of inflation, it seems unlikely that i will drift upward over time. This is because since

* This analysis ignores both property and capital-gains taxes. Very few Third World economies utilize such taxes, but they may well be introduced in the near future. As a result, we thought it useful to introduce such tax parameters into the model to allow exploration of their potential impact. The value of urban property is

$$V_{H,j} = \frac{P_{H,j} - \tau_{H,j} V_{H,j}}{i} = \frac{P_{H,j}}{(i + \tau_{H,j})}, \qquad j = US, KS \qquad (15), (16)$$

or, alternatively,

$$V_{H,j} = \frac{P^S_{H,j}}{i}$$

where $P_{H,j}$ is the (imputed) rent on the jth type of housing – a "demand price," $P^S_{H,j}$ is the (imputed) net rent after property taxes on site and structure – a "supply price," and $\tau_{H,j}$ is the urban property tax rate (most likely zero rated on "squatter settlements"). Therefore,

$$V_{H,j} = \frac{P^S_{H,j}}{i} = \frac{P_{H,j}}{(i + \tau_{H,j})}$$

so

$$P^S_{H,j} = \left[\frac{i}{(i + \tau_{H,j})}\right] P_{H,j}, \qquad j = US, KS \qquad (17), (18)$$

the "demand price" for housing exceeding the "supply price" by

$$\frac{i + \tau_{H,j}}{i} \geqslant 1.$$

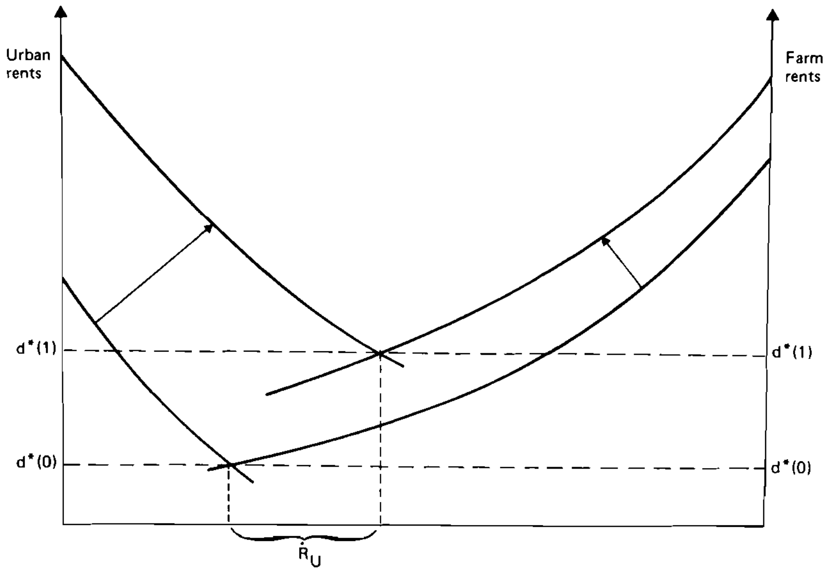

FIGURE 5 Shifts in land's derived demand over time.

conventional capital will accumulate rapidly over time in the successful Less Developed Country (LDC), thus lowering the returns to "machines" unless technology is very capital-using (a distinct possibility with the capital-intensive sectors, *KS* and *M*, growing relatively rapidly). But the percentage rate of return i is related to the returns to machines r by $i = r/P_M$. Thus, while increases in the relative price of urban land should be a characteristic of our model, the sources of this increase are more complex than just the expected increases in land rents.

2.9 Balance of Payments and the Foreign Trade Sector

Since there are no monetary variables in our model, the balance of payments must always be in equilibrium. We assume, therefore, that the foreign-exchange rate is consistent with the balance of payments equilibrium such that the external clearing equation is satisfied by

$$[\bar{P}_M^W M_M + \bar{P}_Z(Z_{KS} + Z_M + Z_A)] - [\bar{P}_A^W X_A + \bar{F}] = 0 \quad (55)$$

where $\bar{P}_A^W X_A$ are export earnings, $[\bar{P}_M^W M_M + \bar{P}_Z(Z_{KS} + Z_M + Z_A)]$ are foreign-exchange requirements for imports, and $\bar{F}$ denotes exogenous levels of net foreign aid and private capital imports. Equation (55) hides more than it reveals and what follows is an elaboration of our implicit assumptions regarding trade relationships.

Our model is a conventional "vent for surplus" paradigm. That is, our

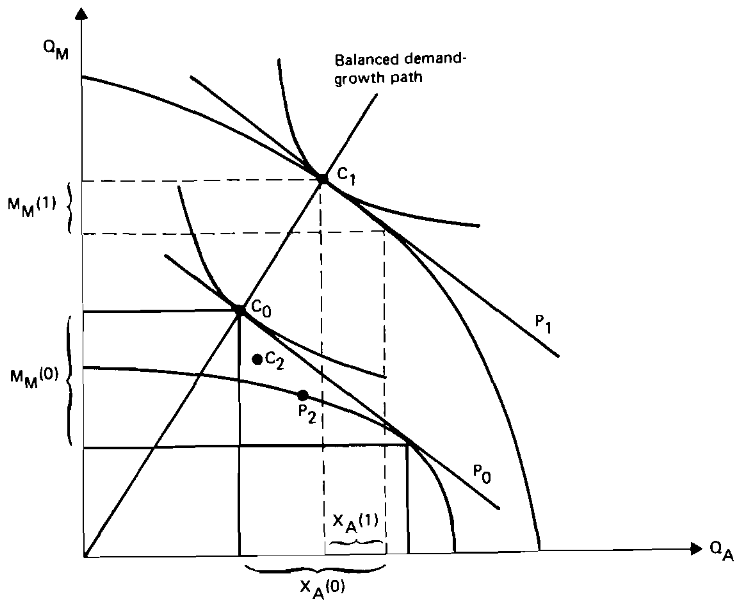

FIGURE 6 Dynamic comparative advantage and "vent-for-surplus."

economy is viewed as a price taker with $\bar{P}_A^W$, $\bar{P}_M^W$, and $\bar{P}_Z$ all determined in world markets.* Given domestic demand and supply conditions, excess supplies of the primary product can be "vented" on world markets and excess demands for manufactured goods can be satisfied in the same fashion. It should be noted that this approach focuses attention exclusively on the *net* trade of both commodity types. The model does not confront gross trade relationships, including dynamic changes in the mix of commodity trade within these export and import categories. Thus, while the model is fully capable of explaining the net impact of dynamic comparative advantage, it cannot deal with any tendency toward specialization in the export of labor-intensive consumer goods in exchange for more capital-cum-skill intensive producer durables.

It does seem likely, however, that the observed tendency of comparative advantage to shift specialization from primary products to manufactured goods will be captured by the model. This process of dynamic comparative advantage can be seen in the conventional trade diagram in Figure 6, where P_0 represents an initial production mix (i.e., Q_A and Q_M) and C_0 an initial domestic consumption mix (i.e., D_A and D_M). Relatively rapid capital and skill accumulation, compared to unskilled labor and land, as well as unbalanced total-factor productivity growth favoring manufacturing, is likely to shift the production possibility frontier in such a fashion that (at C_1 and P_1) *net* dependence on

* We invoke the "law of one price" here. See, however, Isard, 1976; Kravis and Lipsey, 1977; and Dervis and Robinson, 1978.

exports of primary products will diminish unless domestic demand conditions are highly biased toward manufactured goods. Indeed, the model may well yield a shift in comparative advantage to a net *export* of manufactured goods, although Figure 6 does not elaborate on this case.

These trade conditions can be influenced by tariffs, $\tau_{T,M}$, and export taxes, $\tau_{T,X}$. They can also be influenced by the many tax parameters which comprise domestic tax policy, including all of those governmental influences that affect the mix of demand. Commercial policy would normally take the form of raising the price of manufactured goods relative to agricultural goods in *domestic markets*; that is, the price line in Figure 6 would be rotated counterclockwise. A relative expansion in the production of manufactured goods would take place, say at P_2. The now cheaper relative price of agricultural goods would foster a relative increase in the domestic consumption of agricultural goods, say at C_2. Of course world market prices would still prevail. Tariffs and export taxes serve, therefore, to distort the price between domestic and international markets as well as to generate government revenues.

Net foreign capital inflows $\bar{F}$ are given exogenously. This treatment of "foreign aid" may, at first sight, appear to be in the tradition of the "two gap" literature (Chenery and Strout, 1966), but it actually conforms more readily with the revisionist literature which has developed in recent years (Griffen and Enos, 1970; Weisskopf, 1972; Papanek, 1973; Heller, 1975; Bhagwati and Grinols, 1975; Grinols and Bhagwati, 1976). That literature has pointed out that domestic saving appears to bear a negative correlation with foreign aid levels, implying that the domestic-savings effort is relaxed with the addition of foreign aid. Presumably, the "relaxation" of the domestic-savings effort lies primarily with the government sector where, it is thought, the tax effort is diminished and current expenditures are expanded at the expense of government saving. As we shall see in the next section, our model does indeed capture such behavioral responses. On the other hand, since the rate of return plays no direct role as an influence on domestic savings in our model, the possibility that $\bar{F}$ may "crowd out" private savings (McKinnon, 1973) is ignored. Our own view is not that "crowding out" forces are irrelevant, but rather that development economists have not yet successfully accounted for their quantitative influence (see, however, Heller, 1975; Ortmeyer, 1979).

2.10 The Government Sector

The government has two sources of revenue in our model: endogenously determined taxes and exogenous levels of net foreign "aid" and private foreign capital, the latter assumed to flow through government channels. These revenues form the total government budget constraint which is allocated between saving (largely construction in irrigation projects, roads, schools, and public buildings), but also including current expenditures in education and consumption (largely expenditures on defense and social services). With the exception of current education expenditures the empirical counterpart of these two spending categories are the government's capital and current budgets, respectively.

The inclusion of education expenditure in government "saving" represents a break with the conventional treatment of government in most growth and development models. Typically, the government is modeled so that its consumption does not directly contribute to household income or utility, nor does it contribute to future output expansion. While this is a useful abstraction for some purposes, especially given the difficulty of valuing and allocating public goods to consuming units, it will not suffice in our model. In particular, education expenditures may well yield consumption utility to its recipients, but in our model they have an impact on future income as well. This reality is explicitly incorporated in our model since skills are produced by training investment and these compete with alternative modes of accumulation. It seems appropriate, therefore, to include this category of government expenditure as saving. While other categories of government expenditure might also qualify (e.g., health expenditures), our approach can be considered as, at least, a partial rectification of an anti-growth bias attributed to government in most development models.

All government final demands are produced by the capital-cum-skill intensive *KS* service sector, and government demand dominates this sector's total output. We make no distinction between governmental and privately owned and operated enterprises, focusing instead on the demand characteristics of government activities.

Taxes come from a wide range of sources. These include:

1. taxes on households' consumption of *M* sector goods,

$$\tau_M[\bar{P}_M D_M]$$

2. taxes (or subsidies) on agricultural intermediate inputs purchased from manufacturing,

$$\tau_{A,M}[\bar{P}_M Q_{A,M}]$$

3. taxes on urban property (including housing),

$$\tau_{H,US}[V_{H,US}Q_{H,US}] + \tau_{H,KS}[V_{H,KS}Q_{H,KS}]$$

4. taxes on enterprise income (net of depreciation allowances) in the *M* and *KS* sectors,

$$\tau_{\Pi,M}[r_M - \delta_M \bar{P}_M]K_M + \tau_{\Pi,KS}[r_{KS} - \delta_{KS}\bar{P}_M]K_{KS}$$

5. taxes on distributed profits,

$$\tau_Y\{\psi_M[(1-\tau_{\Pi,M})(r_M - \delta_M \bar{P}_M)]K_M + \psi_{KS}[(1-\tau_{\Pi,KS})(r_{KS} - \delta_{KS}\bar{P}_M)]K_{KS} + r_A K_A\}$$

6. taxes on rental income in agriculture,

$$\tau_Y [d_A R_A]$$

7. taxes on skilled labor's income,

$$\tau_Y [w_{M,S} S_M + w_{KS,S} S_{KS}]$$

8. taxes on foreign trade,

$$\tau_{T,M} [\bar{P}_M^W M_M] + \tau_{T,X} [\bar{P}_A X_A].$$

For the most part the tax specification is straightforward, but tariffs and export taxes could pose some technical difficulties. Treating import tariffs and export subsidies as *ad valorem* rates, the tax revenue is $\tau_{T,M} [\bar{P}_M^W M_M] + \tau_{T,X} [\bar{P}_A X_A]$. As we pointed out in the previous section, however, our model examines *net* imports of manufactured goods M_M and *net* exports of primary products X_A, a feature common to this type of model where the composition of imports and exports is suppressed. Since the composition of imports and exports shifts systematically as economic development takes place, and since *net* imports of manufactured goods decline through import substitution (with perhaps the country even becoming a net exporter of this commodity), a tax function based on *net* trade flows could yield inappropriate estimates of revenues derived from international trade. However, this is unlikely to be a problem with our "representative country" which, over a period of 20 to 40 years, remains, on average, a net importer of manufactured goods and a net exporter of agricultural commodities.

The government tax-revenue function can now be summarized in equation (56):

$$\left.\begin{aligned} T = {} & \tau_M [\bar{P}_M D_M] + \tau_{H,US} V_{H,US} Q_{H,US} + \tau_{H,KS} V_{H,KS} Q_{H,KS} \\ & + \tau_{A,M} [\bar{P}_M Q_{A,M}] + \tau_Y [\psi_M (1 - \tau_{\Pi,M})(r_M - \delta_M \bar{P}_M) K_M \\ & + \psi_{KS} (1 - \tau_{\Pi,KS})(r_{KS} - \delta_{KS} \bar{P}_M) K_{KS} + r_A K_A + d_A R_A \\ & + (w_{M,S} S_M + w_{KS,S} S_{KS})] + \tau_{\Pi,M} (r_M - \delta_M \bar{P}_M) K_M \\ & + \tau_{\Pi,KS} (r_{KS} - \delta_{KS} \bar{P}_M) K_{KS} + \tau_{T,M} [\bar{P}_M^W M_M] + \tau_{T,X} [\bar{P}_A X_A] \end{aligned}\right\} \quad (56)$$

This tax function exhibits an urban bias, a feature documented in surveys of fiscal finance in low-income countries. Only labor income of the relatively high-paid urban skilled worker is taxed; in addition, the income of capitalists and landlords, who are assumed to be largely located in cities, is also subject to income taxes. While in some countries lower income workers have been taxed, the yield has typically been small, due to low tax rates, tax evasion, and high costs of administration. This form of taxation is, therefore, omitted from our specification. The urban bias is also evident given our treatment of commodity taxation of manufactured goods, as well as the tax on urban residential property.

Another characteristic of the tax function is its apparent high elasticity with respect to the Gross National Product (GNP) and the attributes of structural change that accompany economic growth: an increase in the share of manufactured goods in total household expenditures, a rising share of modern-sector output, a shift of the labor force into higher-skilled occupations, and an increasing inequality in the distribution of income in the early to intermediate stages of economic development. A rising share of taxes and government spending in GNP is a likely outcome from our model, and such patterns would conform to empirical results obtained in several studies (Bird, 1976; Bolnick, 1978; Chelliah, 1971; Chelliah, Bass, and Kelly, 1975).

One qualification of the tax function is in order. While the profits of the *KS* sector are taxed, a major portion of this sector produces government goods and services. This is a mixed public–private sector, a reality captured in the model by specifying lower "corporate" tax and payout rates in the *KS* than in the *M* sector, i.e., $\tau_{\Pi,KS} < \tau_{\Pi,M}$ and $\psi_{KS} < \psi_M$.

Unlike most general equilibrium models (but see Heller, 1975), government spending is *not* exogenously given in our model. Such a hypothesis would not only be at variance with the empirical literature (Gandhi, 1971; Kelley, 1973, 1976a; Thorn, 1967), but is also unappealing for a model that accounts for the sources of growth and structural change in the long run. The present model attempts, albeit in a highly simplified fashion, to capture aspects of government spending over time by appealing to the same forces that determine private consumption and saving behavior. The government is assumed to allocate its budget to saving, G_S, in response to increments in the resources available to it from taxes and foreign sources, and in response to demographic and urban pressures – by assumption, the main source of public investment demands. Thus,

$$G_S = \alpha_G + \beta_G[T + \bar{F}] + \gamma_G[\dot{N}_U(-1)] \tag{57}$$

$$G_{KS} = [T + \bar{F}] - G_S \tag{58}$$

We anticipated that the government's marginal propensity to save, β_G, would exceed that of the private sector, based on the literature accumulated to date on this issue (Mikesell and Zinser, 1973; Yotopoulos and Nugent, 1967; Williamson, 1979). We also expected, contrary to the Coale and Hoover (1958) hypothesis, that public saving would be positively related to increasing urban populations, $\gamma_G > 0$. Some analysts, like Michael Lipton (1976), would view this prediction as an accurate reflection of the realities of the "urban bias in world development." A pooled sample of "representative" Third World economies covering the 1960s and early 1970s confirms both expectations. Indeed, $\hat{\beta}_G$ and $\hat{\gamma}_G$ are estimated as 0.334(9.19) and 0.484(4.06), respectively (*t*-statistics in parentheses). This result is not conditional on our definition of saving since similar results are forthcoming when expenditures on education are excluded from government saving, although both $\hat{\beta}_G$ and $\hat{\gamma}_G$ are somewhat lower when G_S is defined to exclude educational expenditures.

Finally, since $\hat{\beta}_G < 1$, changes in the levels of foreign aid do not augment the domestic saving pool by an equal amount, but by only $\beta_G \cdot d\bar{F}$. This places us squarely in the "revisionist" foreign aid camp discussed in Section 2.9.

2.11 Household Demand, Saving, and Migrant Remittances

One of the ironies of the development planning literature is the relative paucity of investigations of the role of demand in the process of growth and structural change. By this we mean that there are few models that admit prices as an influence on demand, and that simultaneously permit demand to influence prices.* While the incorporation of Engel effects provides a first approximation, such demand influences do not adequately capture the systematic influence of price as development takes place. We agree with Lluch, Powell, and Williams (1977) who note:

> . . . the bulk of models of economic development have been based on the assumption that commodity prices are of little or no significance in determining the crucial aspects of economic behavior. The oil crises may or may not constitute a convincing rebuttal of this proposition, but investigation of the role of prices remains high on the list of priorities in economic development modeling. Prices cannot be investigated meaningfully without also examining the structure of demand. (p. xxii.)

To explore the issues surrounding the role of demand in economic development, we have selected the Extended Linear Expenditure System (ELES), recently elaborated and empirically investigated by Lluch, Powell, and Williams (1977). The ELES framework captures most of the stylized demand facts associated with modern economic growth in the Third World. In particular it:

1. captures Engel effects;
2. incorporates dualistic elements in demand behavior across regions and socioeconomic classes;
3. provides an important role for demographic influences;
4. offers explicit empirical content to the concept of "subsistence" in the low-income societies.

Equally important, the framework can be derived from reasonable postulates of behavior (Goldberger, 1967; Brown and Deaton, 1972; Howe, 1975) and satisfies the "adding up" property common to several modern integrated

* This is becoming less true with the recent proliferation of computable general equlibrium models, primarily produced by World Bank economists and consultants. See, for example, Lysy and Taylor, 1977; Blitzer, Clark, and Taylor, 1975; and the recent large-scale model by Adelman and Robinson, 1978. It still remains true of economic–demographic models.

demand systems. Its only serious competitor is the direct addilog system first developed by Frisch (1959) and extended by Houthakker (1960) and Sato (1972). The ELES has the advantage, however, of having been estimated with data for Third World economies underlying our "representative economy" model.

In its simplest form, the extended linear expenditure system assumes that the household allocates its disposable income (y^*) between various commodities ($q_1, \ldots, q_n$) and savings where prices ($p_1, \ldots, p_n$) are exogenous to the household, and saving is the difference between total income and the sum of all commodity expenditures ($y^* - c$, where $c = \Sigma\, p_i q_i = \Sigma\, v_i$). The model further assumes that the household's utility function is such that each commodity potentially possesses a "minimum subsistence demand" ($\gamma_i \geqslant 0$) which must be fulfilled before the remaining "supernumerary" income ($y^* - \Sigma\, p_i \gamma_i$) is allocated at the margin between the various commodities and saving. This paradigm of household saving and spending is represented by the expenditure equations

$$\left.\begin{aligned} v_{i,j} &= P_{i,j}\gamma_{i,j} + \beta_{i,j}\{y_j^* - \sum_k P_{k,j}\gamma_{k,j}\}, \qquad k = A, C, D, T, S, H \\ c_j &= \sum_i v_{i,j} \\ s_j &= y_j^* - c_j \end{aligned}\right\} \qquad (59)$$

A graphical presentation of the ELES for the two-commodity case is provided in Figure 7. Based on utility function $u(q_1, q_2)$, and assuming $q_i > \gamma_i$, the household's expenditure and savings allocations follow directly: for q_1, γ_1 represents subsistence needs, $B - \gamma_1$ is supernumerary expenditure on this commodity, and saving is measured by the value of q_1 not consumed, S/p_1. An analogous accounting holds for q_2. Such a representation highlights the role of prices in saving–expenditure allocation decisions, a feature captured in our general equilibrium model which utilizes the ELES. By rotating the three parallel lines, alternative prices would prevail; these would elicit quite different allocations between q_i and s.

The ELES is similar to the more familiar Linear Expenditure System (LES), with one notable difference: in the extended system, total consumption out of disposable income is determined endogenously. Thus, the sum of the marginal budget shares and savings exhausts disposable *income*. In the LES, the sum of the marginal budget shares exhausts total *expenditure*.* The ELES thus does not utilize the strong separability assumption between saving and expenditure embedded in the LES, but rather views the household as determining its

* The LES is therefore a subset of the ELES, where saving is determined exogenously. To see this, sum the expenditure equations in (61) to obtain $c = (1 - \mu)\, \Sigma\, p_i\gamma_i + \mu y^*$, where $\mu = \Sigma\, \beta_i$. By obtaining an expression for y^* in terms of c, and substituting into (61), the more familiar LES results,

$$v_i = p_i\gamma_i + \hat{\beta}_i(c - \Sigma p_i\gamma_i), \qquad \text{where } \hat{\beta}_i = \beta_i/\mu$$

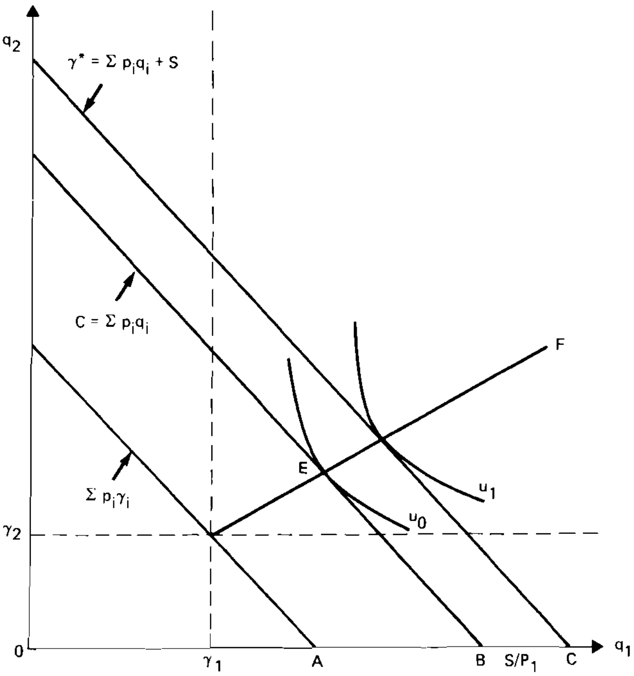

FIGURE 7 The two-commodity case of ELES.

expenditure allocation simultaneously with its total consumption decision, an appealing premise.

The ELES implies a Keynesian saving specification except that *supernumerary* disposable income is the determinant of household saving, not disposable income. While a savings specification which took account of rates of return and asset portfolio preferences would be desirable, it is too complex to incorporate into this version of our basic model and, in any case, debate still continues over the appropriate empirical characterization of interest elasticities in household saving functions. Yet, our savings specification does respond to the appeal by Mikesell and Zinser (1973) who, in their survey of the literature for developing countries, urge the exploration of savings behavior of various types of households. Compositional influences will be captured in our framework to the extent that there may be a shift in the distribution of income to higher-saving households as economic development takes place.

Our savings specification also permits commodity prices to influence saving. Based on ELES estimates of saving and expenditure allocation for 17 countries, Lluch, Powell, and Williams (1977) found that for low ranges of *per capita* income, a 1 percent rise in the price of food will elicit a 1.8 percent decline in the saving rate (p. xxv). If this quantitative result has general validity, then omitting prices from the saving decision, as would be implied by household systems based on the strong separability assumption, may provide quite misleading results concerning the role of demand in economic development.

The treatment of "subsistence" consumption is a particularly interesting feature of the ELES. The concept has many interpretations in the economic development literature, ranging from the "biological-requirements-for-survival" notion in early dualistic models (Jorgenson, 1967), to the recent policy discussions relating to "basic needs," a set of socially desired minimum consumption standards (Srinivasan, 1977; Streeten and Burki, 1978; Hopkins and Norbye, 1978). The ELES demand system provides an interpretation of subsistence which lies between these two extremes. In particular, the γ_i's are determined by the household's own preferences and thus represent an aggregation of biological requirements, individual preferences, and social norms. The composition of the γ_i's, as well as their aggregate size, may vary across individuals in society. While our model will treat the γ_i's as parameters constant to a household type, subsistence demand may change over time, due, in part, to shifts in the distribution of income across households. The γ_i's have particular relevance, therefore, to interpreting the consequences of specific types of income–expenditure distribution policies in the low-income country.

Recent empirical investigations of the ELES utilizing micro-economic data from Mexico, Korea, Chile, Yugoslavia, and several Latin American cities (Lluch, Powell, and Williams, 1977) have established differences in household demand behavior related to selected demographic characteristics, location (largely urban and rural), and socioeconomic class, even after controlling for the level of household income. Based on this and similar findings (Kelley and Williamson, 1968; Kelley, 1969, 1976b; Blitzer, Clark, and Taylor, 1975; Betancourt, 1979), we have elected to disaggregate our households into several categories: urban and rural, on the one hand, and skilled labor, unskilled labor, and property income recipients on the other. This will permit the investigation of the role of demand through systematic changes in the *composition* of households as development takes place, and in particular, the impact of urbanization, changing income distribution, and skill accumulation. The possibility that we will be able to assess the role of household final demand effects, adjusted to indirect derived demands originating through the interindustry structure, represents an interesting feature of the model. We should be able to provide at least one empirically relevant test of the competing hypothesis concerning the relative importance of demand variations, versus supply changes operating through technical change and resource availabilities, on the patterns and rates of economic change. (See Chenery, 1960; Kuznets, 1957, 1966; Clark, 1957; Chenery and Syrquin, 1975.)

A full statement of the household demand system, as well as statements summarizing their aggregation into final demand categories corresponding to our model's production structure, is provided in the appendix as equations (59)–(62). Each household's demand statement, irrespective of location or socioeconomic class, possesses the form presented above in equation (59).

In addition the appendix provides a side equation (60) for the cost of living relevant to various types of households. This statistic will be important in assessing the impact of economic policies on various aspects of household welfare, especially those policies relating to income distribution and migration.

Finally, it should be noted that incomes (except for property income recipients) are adjusted to take into account the intersectoral flow of migrants' remittances, *TRF*. (See equation (61) in the appendix.) These transfers are generally believed to be large, and Johnson and Whitelaw (1974) have confirmed that belief, at least on Kenyan data. Based on these results, we specify the transfers to rural households to be a fixed share of income, Υ:

$$TRF_{i,L} = \Upsilon(w_{i,L}), \qquad i = US, M, KS \qquad (63)\text{–}(65)$$

$$TRF_{i,S} = \Upsilon[(1-\tau_Y)w_{i,S}], \qquad i = KS, M \qquad (66), (67)$$

That share is almost surely a function of length of time since the remitting household migrated to the city, but we have had no success in securing estimates on such parameters. In any case, these transfers play a potentially important role in our model in two ways: first, they have welfare implications; second, they may have a significant impact on the structure of private consumption demand, saving, and investment allocation.

2.12 *Housing Investment and Aggregate Saving*

Aggregate saving determines accumulation possibilities in our model, and this savings pool is generated by three sources: retained after-tax corporate and enterprise profits, government saving, and household saving. (Foreign saving serves to augment government resources and thus indirectly appears as a component of government saving.) These three sources can be written as

$$\left.\begin{aligned} \text{SAVINGS} = {} & (1-\psi_M)[(1-\tau_{\Pi,M})(r_M - \delta_M \bar{P}_M)K_M] + \delta_M \bar{P}_M K_M \\ & + (1-\psi_{KS})[(1-\tau_{\Pi,KS})(r_{KS} - \delta_{KS}\bar{P}_M)K_{KS}] \\ & + \delta_{KS}\bar{P}_M K_{KS} + s_{US}L_{US} + s_M L_M + s_{KS}L_{KS} \\ & + s_R L_R + s_C C + s_S S + G_S \end{aligned}\right\} \quad (96)$$

where all parameters and variables have been previously defined.

There are three competing demands on this savings pool: investment in physical ("productive") capital, investment in human capital (training), and investment in ("unproductive") housing. Following the conventional emphasis in the development literature, physical capital accumulation is written as a residual in equation (97)

$$\bar{P}_M I_M = \text{SAVINGS} - \text{HOUSING} - \text{TRAINING COSTS} \qquad (97)$$

but it should be emphasized that these three modes of accumulation are determined simultaneously and in competition. Investment allocation rules dictating the intersectoral allocation of $\bar{P}_M I_M$ between agriculture, manufacturing, and the *KS* sector were discussed in Section 2.6; the determinants of training investment levels were described in Section 2.7. This section will focus on housing investment demand under imperfect capital markets. It will then conclude with a summary of the mechanism which dictates overall investment allocation in the model.

Following Coale and Hoover (1958), our model distinguishes between "productive" and "unproductive" investment. Unproductive investment is captured by housing requirements, a component which is sensitive to demographic and urbanization forces. Furthermore, housing investment is viewed in much the same way that subsistence consumption requirements are treated in the consumer demand system. This is, private households behave in a fashion such that housing needs receive first priority in their investment portfolios. Only after these investment needs are satisfied do households release their residual savings for "productive" accumulation purposes, through banks, nonbank financial institutions, and informal "curb" markets. This characterization is motivated by McKinnon's (1973) emphasis on "financial market fragmentation."

Since the formal mortgage market is poorly developed or nonexistent in much of the Third World, we have assumed that *none* of the three private housing sectors (rural, urban "squatter settlements," urban "luxury housing") are able to secure external finance to satisfy investment requirements. Housing investment is, therefore, self-financed by each household sector independent of other surplus-generating sectors. While this specification eliminates the possibility of *inter*sectoral housing financial flows, it does not exclude the possibility of *intra*sectoral housing financial flows. For example, fathers may loan to sons, but "middle-class" skilled households cannot loan to poor "unskilled" households. Certain sectors may, therefore, be starved for housing finance while others have a surplus which they allocate to the national saving pool for "productive" accumulation or training investment.

Under conditions of rapid population growth, it is quite possible that household savings will be fully exhausted by housing investment requirements. This potential demographic burden is reinforced in our model by rapid rates of urbanization. This follows from the fact that housing is location-specific; thus, migration of even a stable aggregate population requires new housing construction in the receiving regions, and net investment economy-wide. Furthermore, given the cost-of-living adjustment embedded in the model's migration function, rapid in-migration and urbanization may well be forestalled by the urban housing requirements that these population movements imply. An urban housing investment shortfall will result in a rise in urban rents, thereby attenuating in-migration. Alternatively, increased urban housing investment serves to inhibit the accumulation of "productive" capital, and we know that the rate of productive capital accumulation is a central determinant of the relative expansion of employment in the modern sectors.

This treatment illustrates the importance of general equilibrium paradigms in accounting for the sources of growth and structural change. Consider the analysis of intersectoral migration. The benefits of migration in reallocating labor to its highest productivity will be partially offset in our model by the costs resulting from the diversion of "productive" investment funds to "unproductive" urban housing. The rate of urbanization will tend to diminish as a result. A similar impact results from rising urban housing rental prices. Thus, rapid rates of urbanization will trigger *endogenous* forces tending to suppress "over-urbanization", a result which may provide a very different characterization of intersectoral labor transfers than would be forthcoming from partial equilibrium demographic estimates of urban change. Projections of city populations exceeding 30 million (UN, 1976) are likely to merit serious qualification in the face of economic adjustments like those contained in our model. Only general equilibrium modeling of the sort contained in our housing-cum-migration specification can capture the various countervailing forces associated with urbanization, economic growth, and structural change.

What remains is to convert these qualitative descriptions of investment demand in housing under capital market fragmentation into explicit quantifiable equations. At given prices and incomes, we specify the following type of urban housing investment demand equation:

$$I_{H,j} = \text{Min}\ \{s_j L_j P_j^{-1}, I_{H,j}^N + \delta_{H,j} H_j\},$$

$$I_{H,j} = \text{Max}\ \{0, I_{H,j}\},$$

where $s_j L_j P_j^{-1}$ is the saving generated by households consuming the jth type of housing (deflated by P_j and thus converted into housing investment quantities), $I_{N,j}^N$ is *net* investment in housing, and $I_{H,j}$ is *gross* investment in housing. The first expression simply states that household saving in sector j may be binding on housing investment in that sector. If not, dwelling investment will not exhaust the sector's household saving and a surplus will be available for accumulation in other forms. Our expectation is that rural households will consistently have a surplus available for accumulation in other forms in spite of a low *per capita* income. This may also hold for the urban skilled and property income recipient classes, but is less likely for the urban unskilled household sector. The second expression given above simply states that gross investment cannot be negative. This expression is unlikely to be binding under conditions of rapid population growth, even with substantial rural out-migration rates. Depreciation requirements are given by $\delta_{H,j} H_j$.

In discussing the determinants of net investment, $I_{H,j}^N$, it will be helpful to define the following terms, some of which are new while others are added to refresh the reader's memory:

$\hat{r}_{H,j}$ = an index of profitability of housing investment in the jth housing stock, a "benefit-cost" ratio computed as the ratio of the discounted stream of net rents to current construction costs;

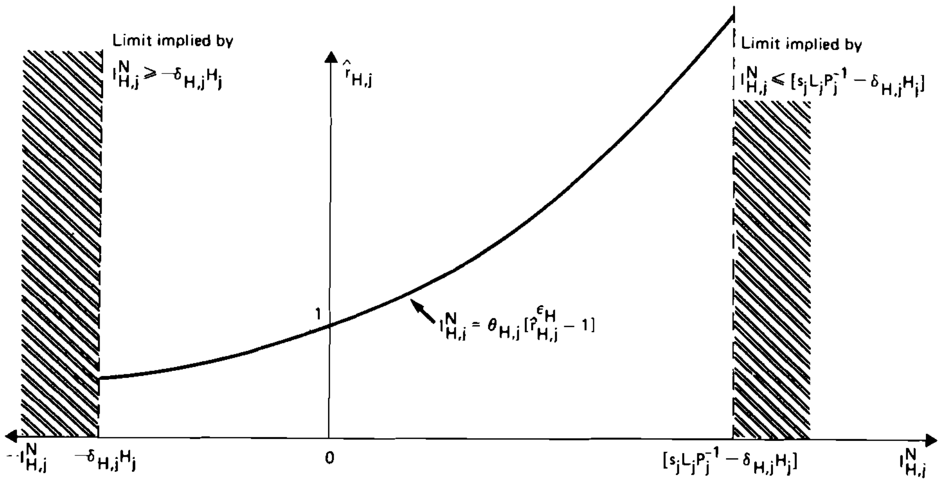

FIGURE 8 Housing investment response to own (shadow) rates of return.

P_j = per unit construction costs of H_j;

$r_{H,j}$ = per unit "structure rent" on H_j (a shadow price since owner-occupied status is assumed, and thus rents are fully flexible with no market stickiness);

i = the discount rate, or average rate of return on physical capital economy-wide;

$P_{H,j}$ = total rental price, including both the site and structure rental components.

Using these definitions, net investment in housing in the jth sector is written as

$$I^N_{H,j} = \theta_{H,j}[\hat{r}^{\epsilon H}_{H,j} - 1]$$

where $\hat{r}_{H,j}$ is the index of investment profitability:

$$\hat{r}_{H,j} = [(r_{H,j} - \delta_{H,j}P_j)i^{-1}]P_j^{-1}, \qquad j = US, KS, RS \qquad (79)\text{–}(81)$$

High values of $\hat{r}_{H,j}$ indicate high profitability with positive gaps between capitalized anticipated net rents and current construction costs.* This expression also states that net investment in housing should be zero when the benefit-cost ratio is unity, that is, where the economy-wide percentage rate of return equals the rate of return on sector j's new housing investment. Higher values of $\hat{r}_{H,j}$ imply more housing investment at the expense of alternative investment elsewhere in the economy.

It should be apparent from Figure 8 that net investment in housing can take on negative values as the benefit-cost ratio falls below unity, but since gross

* We assume naive expectations and infinite life here for simplicity. Furthermore, ϵ_H is taken to be common to all types of housing investment.

investment is restricted to non-negative values, a limit on the size of the negative values of net housing investment is implied as

$$I_{H,j}^{N} = \theta_{H,j}[\hat{r}_{H,j}^{\epsilon H} - 1] \geqslant -\delta_{H,j}H_j$$

The previous expression simply postulates that new housing investment is responsive to profitability in a nonlinear way as in Figure 8.

The housing investment demand equations for all three sectors can now be written formally as

$$\left.\begin{aligned} I_{H,RS} &= \text{Min}\{s_R L_R P_{RS}^{-1}, I_{H,RS}^{N} + \delta_{H,RS}H_{RS}\} \\ I_{H,RS} &= \text{Max}\{0, I_{H,RS}\} \\ I_{H,RS}^{N} &= \theta_{H,RS}[\hat{r}_{H.RS}^{\epsilon H} - 1] \end{aligned}\right\} \quad (76)$$

and

$$\left.\begin{aligned} I_{H,US} &= \text{Min}\{[s_{US}L_{US} + s_M L_M + s_{KS}L_{KS}]P_{US}^{-1}, I_{H,US}^{N} + \delta_{H,US}H_{US}\} \\ I_{H,US} &= \text{Max}\{0, I_{H,US}\} \\ I_{H,US}^{N} &= \theta_{H,US}[\hat{r}_{H,US}^{\epsilon H} - 1] \end{aligned}\right\} \quad (77)$$

and

$$\left.\begin{aligned} I_{H,KS} &= \text{Min}\{[s_S S + s_C C]P_{KS}^{-1}, I_{H,KS}^{N} + \delta_{H,KS}H_{KS}\} \\ I_{H,KS} &= \text{Max}\{0, I_{H,KS}\} \\ I_{H,KS}^{N} &= \theta_{H,KS}[\hat{r}_{H,KS}^{\epsilon H} - 1] \end{aligned}\right\} \quad (78)$$

As equations (79)–(81) reveal, structure rents are central to the determination of $\hat{r}_{H,j}$. Given Cobb–Douglas housing-service production functions (Section 2.8), urban structure rents are

$$r_{H,j} = \left\{\frac{A_{H,j}P_{H,j}^{S}\alpha_{H,j}^{\alpha_{H,j}}\alpha_{R,j}^{\alpha_{R,j}}}{d_{U,j}^{\alpha_{R,j}}}\right\}^{1/\alpha_{H,j}}, \quad j = US, KS \quad (82), (83)$$

Recall that $r_{H,j}$ is a shadow price since all housing is owner-occupied in our model. Note, too, the presence of $P_{H,j}^{S}$ in the expression for $r_{H,j}$. It is the total rental price *after* urban residential property taxes have been assessed and paid. (See equations (17) and (18) and the discussion in Section 2.8.) Since "wasteland" has no value in rural areas and since we assume the absence of rural property taxes, rural rents implied by the fixed coefficient production function are

$$r_{H,RS} = P_{H,RS}a_{H,RS}^{-1} \quad (84)$$

Finally, ϵ_H is an unknown parameter in (76)–(78), but we shall experiment with alternative values.

There are three sectors involved in housing construction in our model. $I_{H,RS}$ represents rural dwellings produced by the informal RS sector, perhaps even constructed by the occupying household itself and with "waste" materials.

$I_{H,US}$ represents similar low-cost urban dwellings ("shanty" housing or "squatter settlements") produced by the informal labor-intensive *US* sector, also perhaps even constructed by the occupying household itself. $I_{H,KS}$ denotes high-cost housing, produced by the formal construction sector, which, as part of *KS* activities, is relatively capital and skill intensive, and generates intermediate input demands in the primary product and manufacturing sectors. When these housing-investment requirements are valued by current construction costs, P_j, total investment demand for housing is obtained in value terms:

$$\text{HOUSING} = P_{RS}I_{H,RS} + P_{US}I_{H,US} + P_{KS}I_{H,KS} \qquad (85)$$

It might be helpful to summarize saving, accumulation, and capital-goods sector activity at this point. In terms of the majority of computable general equilibrium models, ours is unusual in its treatment of accumulation. There is not just one mode of accumulation, but rather there are three (skills, physical capital, and housing). There is not just one capital-goods sector, but rather four (*KS* producing skills; *RS*, *US*, and *KS* constructing dwellings; and *M* producing physical capital goods). Since each of these capital-goods producing sectors is characterized by quite different factor-intensities, changes in the *mix* of accumulation over time can have important implications for the structure of output, price patterns, and the derived demands for inputs. This distinguishes our model from the tradition that has flowed from Uzawa's classic contributions.

Uzawa (1961, 1963) found that a sufficient condition for uniqueness of the static equilibrium was that the consumption-goods sector be more capital intensive than the capital-goods sector. While Gordon (1961) has suggested that this assumption may not be unreasonable for higher-income economies, it appears artificial when applied to less developed societies. It seems to us more appropriate, in any case, to stress that factor-intensity even in the static model is endogenous and conditional upon the direction which the economy-wide portfolio mix takes. Shifts in favor of skills investment imply *skill-intensive* capital-goods activity (increasingly *KS*-oriented); shifts favoring conventional physical capital accumulation imply *capital-intensive* capital goods activity (increasingly *M*-oriented); shifts favoring low-cost housing imply *labor-intensive* capital-goods activity (increasingly *RS*- and *US*-oriented). These forces have potentially important implications for the distribution of income.

Note, too, that the three modes of accumulation are explicitly competitive. Skills accumulation takes place up to the point where rates of return are equated to the economy-wide rate on physical capital accumulation. Physical capital goods are allocated across the three capital-using sectors so as to minimize rate of return differentials. Dwelling investment will utilize household saving only up to the point where rates of return are equated to the economy-wide rate on physical capital accumulation. Of course, there are institutional and technological features which seriously restrict the economy's ability to equate rates of return at the margin. Any of the three dwelling markets (rural, urban "squatter settlements" and formal urban "luxury") may be starved for funds since the absence of an intersectoral mortgage market may leave housing investment requirements in excess demand. The immobility of physical capital stocks between sectors makes it possible that current physical investment allocations are insufficient to equalize rates of return to capital between A, M, and KS. Indeed, the larger are housing requirements, the smaller is the residual pool available for physical capital accumulation and the more likely that current investment allocations are insufficient to equalize sectoral rates of return. Furthermore, firms' demands for skills may be unsatisfied if the stock of "potential trainables" is insufficient to meet training investment levels which would equalize rates of return economy-wide. In short, capital market disequilibrium may well be a permanent attribute of our economy.

2.13 *Dynamics: Physical Accumulation, Land Growth, and Technological Progress*

Current net investment is equal to total gross investment minus depreciation, where depreciation is taken to be proportional to the capital stock. Thus, aggregate "productive" physical capital stocks and "unproductive" housing stocks are given by

$$K_i = (1 - \delta_i)K_i(-1) + I_{i,M}(-1), \qquad i = A, M, KS \qquad (107)\text{–}(109)$$

$$H_j = (1 - \delta_{H,j})H_j(-1) + I_{H,j}(-1), \qquad j = US, RS, KS \qquad (110)\text{–}(112)$$

where the depreciation rates are allowed to vary not only between productive capital (containing equipment of shorter life) and housing (containing structures only), but also between housing of different types (luxury housing presumably having the longer life). Land is assumed to grow at a fixed exogenous rate.

As stated in Section 2.2, factor-augmenting and disembodied technical progress are both present in our model. The factor-augmenting rates are given exogenously by

$$x = x(-1)\, e^{\lambda_K} \qquad (113)$$

$$y = y(-1)\, e^{\lambda_S} \qquad (114)$$

$$z = z(-1)\, e^{\lambda_L} \qquad (115)$$

while the disembodied rates (assumed to be zero in rural housing and in both informal service sectors) are given by

$$A_i = A_i(-1)\, e^{\lambda_i}, \qquad i = M, KS, A \qquad (116)\text{–}(118)$$

$$A_{H,j} = A_{H,j}(-1)\, e^{\lambda_{H,j}}, \qquad j = US, KS \qquad (119), (120)$$

While these propositions appear somewhat arbitrary at first glance, in reality they are consistent with important "stylized facts" regarding the factor-saving bias of technical progress, the unbalanced rate of technical progress across sectors, and the economy-wide rate of total-factor productivity growth.

The first two of these attributes of technical progress – factor-saving bias and unbalanced total-factor productivity growth – have become key developmental stylized facts and they are central to debate over economic growth and distribution in the Third World. As a result, they require considerable elaboration.

The output-raising effect of technical change has come to be known in the literature as total-factor productivity growth. These sectoral rates of total-factor productivity growth, $\overset{*}{T}_i(t)$, define the percentage rise in output, given fixed inputs, as

$$\overset{*}{T}_i(t) = \frac{\partial Q_i(t)}{\partial t}\frac{1}{Q_i(t)}, \qquad i = A, RS, US, KS, M$$

Total-factor productivity growth rates can be written for each of our eight sectors as

$$\begin{aligned}
\overset{*}{T}_A &= \lambda_A + \alpha_{A,K}\lambda_K + \alpha_{A,L}\lambda_L \\
\overset{*}{T}_M(t) &= \lambda_M + \alpha_{M,K}(t)\lambda_K + \alpha_{M,L}(t)\lambda_L + \alpha_{M,S}(t)\lambda_S \\
\overset{*}{T}_{KS}(t) &= \lambda_{KS} + \alpha_{KS,K}(t)\lambda_K + \alpha_{KS,L}(t)\lambda_L + \alpha_{KS,S}(t)\lambda_S \\
\overset{*}{T}_{RS} &= \alpha_{RS}\lambda_L \\
\overset{*}{T}_{US} &= \alpha_{US}\lambda_L \\
\overset{*}{T}_{H,j} &= \lambda_{H,j}, \qquad j = US, KS
\end{aligned}$$

and

$$\overset{*}{T}_{H,RS} = 0$$

where the $\alpha_{i,j}$ are output elasticities or factor payment shares. In agriculture, the $\alpha_{i,j}$ have no time subscripts because the production function is Cobb–Douglas and output elasticities are constant. Furthermore, land is absent there since, by assumption, land does not enjoy augmentation through technical progress.

Both modern sectors exhibit variable output shares over time because the CES production functions yield such variability as long as modern-sector inputs grow at different rates. The traditional labor-intensive service sectors have the unskilled labor augmentation rate multiplied by α_i since diminishing returns prevail there (e.g., $\alpha_i < 1$). The housing sectors are restricted to constant disembodied rates, and the empirical evidence may well warrant our setting $\lambda_{H,j} = 0$ for *all* sectors, not just rural housing.

These expressions make it possible for sectoral rates of total-factor productivity growth to diverge, a result we shall label unbalanced productivity advance. There seems to be general agreement in the literature (Kendrick, 1961, 1973; Uneo and Kinoshita, 1968; Watanabe, 1968; Massel, 1961; Baumol, 1967) that the modern sectors exhibit the most rapid total-factor productivity growth, with agriculture lagging behind in spite of "Green Revolutions" and with traditional services almost stagnant. Our model is fully capable of replicating unbalanced productivity advance of this sort. However, even better documentation is available for the *overall* rate of total-factor productivity growth for Third World economies (for recent estimates, see Christensen and

Cummings, 1974; Elias, 1978; Levy, 1978; Colosio, 1979) and this aggregate rate can be written as

$$\overset{*}{T}(t) = \sum_i \omega_i(t)\overset{*}{T}_i(t) + \overset{*}{T}_{RA}(t)$$

where $\omega_i(t)$ represents sectoral value added shares in GNP.

It should be apparent that this economy-wide rate need not be constant over time, even with all the λ's in equations (113)–(120) held constant. Indeed, economy-wide, total-factor productivity growth has two parts, both of which are endogenous. The first part, $\Sigma_i \omega_i(t)\overset{*}{T}_i(t)$, is known in the literature as *intraindustry* total-factor productivity growth. Given unbalanced total-factor productivity growth, those sectors with the favored rates tend to undergo the most dramatic decline in supply price and therefore tend to enjoy relative output expansion. It follows (under price-elastic demand conditions) that sectors with the highest $\overset{*}{T}_i(t)$ tend to enjoy rising ω's over time. $\overset{*}{T}$ tends to rise over time as a result.

The second part, $\overset{*}{T}_{RA}(t)$, is known in the literature as *interindustry* total-factor productivity growth. Interindustry total-factor productivity growth results from improved resource allocation between sectors, a source of growth of which much has been made in the development literature. Central to the labor surplus model, for example, is the premise that institutional factors tend to produce a gap in labor's marginal product between traditional agriculture and modern industry (Lewis, 1954; Fei and Ranis, 1961). Labor migration and labor absorption, therefore, tend to create economy-wide productivity gains as resources are allocated to uses of higher marginal productivity. Suppose we denote the relative share of interindustry total-factor productivity growth in the aggregate rate by the variable z. Then

$$\overset{*}{T}(t) = \sum_i \omega_i(t)\overset{*}{T}_i(t) + z(t)\overset{*}{T}(t)$$

or

$$\overset{*}{T}(t) = [1 - z(t)]^{-1} \sum_i \omega_i(t)\overset{*}{T}_i(t)$$

What do we know about the size of z? Clearly, it is a function of factor-market disequilibrium since the initial size of the discrepancies between sectoral marginal productivities influences the magnitude of the gains from improved resource allocation. It is also a function of the speed of resource reallocation, and the latter is very much constrained by the rate of accumulation in both the real world and in our model.

In other words, the economy-wide total-factor-productivity growth rate in our model is partially *embodied*. (For a similar argument with a somewhat different model, see Kelley and Williamson, 1973.) Edward Denison (1967, 1974; Denison and Chung, 1976) has offered estimates of z for advanced economies in the post-World War II period, but we would expect z to be larger in the Third World where the rate of structural change is more dramatic and, presumably, the initial factor-market disequilibria are greater. Estimates from Asia (Ezaki, 1975) and Latin America (Colosio, 1979) suggest that z may lie between a third to a half of $\overset{*}{T}(t)$.

Factor-saving can take two forms. First, a shift in the output mix may favor one or a group of inputs at the expense of others. For example, the expansion of the manufacturing sector will tend to increase demands for the two inputs used relatively intensively there, capital and skills. In other words, unskilled labor is "saved" economy-wide by this shift in output. Such "compositional" effects are likely to have important implications for income distribution, causing a relative decline in the unskilled wage and concomitant inequality trends. To the extent that such compositional changes are induced by the character of technical change itself, they can be classified unambiguously as factor-saving technological progress. Unbalanced rates of total-factor productivity growth favoring the capital-cum-skill intensive sectors, thus inducing a shift in output to those sectors enjoying the relatively rapid rates of cost reduction, would be exactly the kind of technical progress yielding that result.

The second form of factor-saving technological progress can be analyzed conveniently in terms of the Hicksian concept of neutrality. Technical progress is neutral if it leaves the capital–labor ratio unaltered at a constant ratio of factor prices. The Hicksian factor-saving bias, $B_i(t)$, is defined to be the proportionate rate of change in the marginal rate of factor substitution in that sector. In the simple two-factor case,

$$B_i(t) = \frac{\partial F_K^i}{\partial t}\frac{1}{F_K^i} - \frac{\partial F_L^i}{\partial t}\frac{1}{F_L^i}$$

where F_K^i and F_L^i are the marginal products of capital and labor, respectively. For any given capital–labor ratio in the ith sector at time t, technical progress is labor-saving in the Hicksian sense if $B_i(t) > 0$. It can be shown that the bias can also be written as

$$B_i(t) = \frac{(\lambda_L - \lambda_K)(1 - \sigma_i)}{\sigma_i}$$

Thus, the bias depends on the difference between the rates of factor augmentation through technical change and on the elasticity of factor substitution.

There is accumulating empirical evidence supporting the view that technological progress in the modern sector is non-neutral. Indeed, this has become one of the stylized facts of contemporary development in the Third World. (For a review see Morawetz, 1974; Cline, 1975; and the following econometric studies: David and Van de Klundert, 1965; Williamson, 1971a; Binswanger, 1974; Levy, 1978.) There is no need to review the explanations of the labor-saving bias in modern sectors in the Third World, but the bias has explicit implications for factor augmentation rates through technical change in our model. Since elasticities of substitution are less than unity in both the manufacturing and the modern-service sector, it follows that labor-saving can be captured by the restriction $\lambda_L > \lambda_K$. This restriction also implies another aspect of technological dualism thought to be relevant in the Third World. Namely, while labor-saving is typical of the modern sectors, it is not characteristic of traditional activities. The model is fully consistent with this asymmetry since, for example, the Cobb–Douglas production function in agriculture implies $B(t) = 0$.

In short, our model appears to capture the two central attributes of technical progress thought to be stylized facts in the Third World: it can deal effectively with both unbalanced as well as labor-saving productivity advance. It also offers an endogenous treatment of economy-wide total-factor productivity advance.

2.14 Dynamics: Demographic Change and Labor Force Growth

Advances in demographic techniques and Third World demographic data make the elaboration of the model's labor supply specification feasible and attractive. Given the initial regional distribution of labor consistent with short-run equilibrium in the economic model, given a percentage age–sex–region distribution of the total population in the initial period, and given age–sex–region labor force participation rates we can readily determine the population distribution by age, sex, and location consistent with the labor-force distributions in short-run equilibrium. Given additional information on mortality and fertility rates by region, this population stock can then be augmented in the next period. Applying the constant age–sex–region specific labor participation rates to these new population stocks, the demographic model will yield the necessary labor-force stocks to be used by the economic model in the new time period. All of this requisite demographic information is available for the countries in our representative sample. The demographic model and the necessary accounting is given in Schmidt (1979). A summary statement of the labor-force equations coming from the demographic model appears in equations (122)–(128) below. First, we assume that capitalists are a fixed proportion of the total population, N. Thus,

$$C = \dot{C} + C(-1) \tag{122}$$

$$\dot{C} = \phi_C \dot{N} \tag{123}$$

Second, the new stock of skilled labor is simply the old stock, less those lost by mortality and/or retirement, plus the (gross) numbers trained last year:

$$S = \dot{S} + (1 - m_S)S(-1) \tag{124}$$

where m_S is the "mortality" rate among the skilled. The unskilled labor force is therefore

$$L_U = \dot{L}_U + L_U(-1) \tag{125}$$

$$\left.\begin{aligned} \dot{L}_U &= \sum_i \sum_j l_{i,j,U}\dot{N}_{i,j,U} - [\dot{S} - m_S S(-1)] - \dot{C}, \\ &\qquad i = 1, \ldots, n \text{ age classes} \\ &\qquad j = 1, 2 \text{ sex classes} \end{aligned}\right\} \tag{126}$$

$$L_R = \dot{L}_R + L_R(-1) \tag{127}$$

$$\left.\begin{aligned} \dot{L}_R &= \sum_i \sum_j l_{i,j,R}\dot{N}_{i,j,R}, \\ &\qquad i = 1, \ldots, n \text{ age classes} \\ &\qquad j = 1, 2 \text{ sex classes} \end{aligned}\right\} \tag{128}$$

Two other features of the demographic accounting should be noted. First, the demographic model also keeps track of the enrollment rates by age–sex–region and thus the educational attainment levels in the regional labor stocks as well. These enrollment rates are exogenous to both the economic and demographic models, and are determined by government policy. This manifestation of government educational policy is central to the skills accumulation process in our economy described in Section 2.7. Second, the demographic model requires information on the age–sex characteristics of the rural–urban migration flows.

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Appendix

MATHEMATICAL STATEMENT OF CEM

SUBSCRIPTS

Sector subscripts (production)

A: agriculture

H, KS: urban luxury housing; housing stock originally constructed in *KS* sector

H, RS: rural housing; housing stock originally constructed in *RS* sector

H, US: urban "slum" housing: housing stock originally constructed in *US* sector

KS: capital-intensive services (electricity, gas, water, transportation and communications, defense, construction of urban "luxury" housing stock, education)

M: manufacturing (manufacturing and mining)

RS: rural labor-intensive services (domestics, personal services, construction of rural housing stock)

US: urban labor-intensive services (domestics, personal services, construction of "slum" housing stock)

Factor subscripts (production)

K: capital

L: unskilled labor

R: land

S: skilled labor

Z: imported raw materials, including fuel

Location subscripts

- R: rural
- U: urban

Commodity subscripts (demand)

- A: food (A sector)
- C: clothing (M sector)
- D: durables (M sector)
- H: rent (H sector)
- S: labor-intensive personal services (RS or US sector)
- T: transportation and communications (KS sector)

Household subscript (demand)

- C: capitalists and landlords
- KS: urban "favored" unskilled employed in KS sector
- M: urban "favored" unskilled employed in M sector
- R: rural unskilled from A and RS sectors
- S: skilled from M and KS sectors
- US: urban unskilled employed in US sector

PARAMETERS

- $a_{H,RS}$: coefficient for translating housing stock into "rental units" for rural housing
- $\alpha_{A,j}$: output elasticity (and cost share) of jth primary input in A sector, $j = K, L, R$
- α_G: intercept in the government saving function
- $\alpha_{i,F}$: output elasticity (and cost share) of composite of primary inputs in the ith sector, $i = M, KS$ (a value-added share in gross output)
- $\alpha_{i,Z}$: output elasticity (and cost share) of Z in the ith sector, $i = A, M, KS$
- $\alpha_{i,j}$: output elasticity (and cost share) of jth intermediate input in the ith sector, $i \neq j = A, M, KS$
- α_i: returns to scale parameter in the informal service sectors, $i = US, RS$
- $\alpha_{H,j}$: output elasticity (and cost share) of housing structures in urban housing production functions, $j = US, KS$
- $\alpha_{R,j}$: output elasticity (and cost share) of urban land in urban housing production function, $j = US, KS$
- β_G: marginal propensity to save out of government revenue (taxes and foreign "aid")

$\beta_{i,j}$: marginal propensity to consume the *i*th commodity out of supernumerary income, by the *j*th household type

c_k: marginal cost of training skilled workers of the *k*th (formal) educational attainment

γ_G: coefficient measuring the impact of increased urban population on government saving

$\gamma_{i,j}$: subsistence bundle, *i*th commodity, *j*th household type

$\delta_{H,j}$: depreciation rate on residential (housing) structures, $j = US, RS, KS$

δ_i: depreciation rate for physical ("productive") capital, $i = A, M, KS$

ϵ_H: elasticity parameter in the net housing investment functions

$\theta_{H,j}$: multiplicative parameter in the net housing investment function, $j = US, RS, KS$

κ: fixed "wage-gap" between unskilled labor in *M* and *KS* relative to *US*

$l_{i,j,k}$: labor force participation rate, i = age, j = sex, k = location

$\lambda_{H,j}$: rate of total-factor productivity growth in the *j*th housing sector attributable to neutral, disembodied, sector-specific technological change, $j = US, RS, KS$

λ_i: rate of total-factor productivity growth in the *i*th sector attributable to neutral, disembodied, sector-specific technological change, $i = M, KS, A$

λ_K: rate of augmentation of physical capital through technological change

λ_L: rate of augmentation of unskilled labor through technological change

λ_S: rate of augmentation of skilled labor through technological change

ξ_i: distribution parameter in the *i*th sector value-added CES production function ($Q_{i,F}$), $i = M, KS$

ξ_i': distribution parameter in the *i*th sector composite capital function (ϕ_i), $i = M, KS$

ρ: rate of land growth

σ_i: elasticity of substitution between "composite capital" ϕ and unskilled labor in the *i*th sector value-added production function ($Q_{i,F}$), $i = M, KS$

σ_i': elasticity of substitution between capital and skilled labor in the *i*th sector composite capital function (ϕ_i), $i = M, KS$

τ_M: sales-tax rate on consumption of *M* sector goods

$\tau_{A,M}$: tax (or subsidy) rate on agricultural intermediate inputs purchased from manufacturing

$\tau_{\Pi,KS}$: proportional "corporate" profit tax rate in *KS* "mixed-enterprise" sector

$\tau_{\Pi,M}$: proportional "corporate" profit tax rate in *M* sector

$\tau_{H,j}$: urban property tax rate imposed on current value according to *j*th type of residential housing, $j = US, KS$

$\tau_{T,M}$: (equivalent) *ad valorem* tariff rate on *M* goods imports

$\tau_{T,X}$: (equivalent) *ad valorem* tax rate on *A* goods exports

τ_Y: proportional income tax rate on property income and skilled earnings

Υ: share of urban migrant's income transferred to rural households, $i = M, US, KS$

ϕ_C: share of capitalists and landlords in the total population

ψ_i: after tax, "corporate" pay-out rate, $i = M, KS$

EXOGENOUS VARIABLES

$A_{H,j}$: intercept in the *j*th housing production function, $j = US, KS$

A_i: intercept in the *i*th sector's production function, $i = A, M, US, RS, KS$

C: number of capitalists and landlords

$\bar{F}$: nominal value of "foreign aid" and private capital inflow

L: total unskilled labor stock

m_S: net mortality (and retirement) rate of urban skilled workers

N: population

$N_{i,j,k}$: population, i = age, j = sex, k = location

$\bar{P}_A^W$: export price of *A* goods, f.o.b.

$\bar{P}_A$: domestic market price received by producers of *A* goods

$\bar{P}_A'$: per unit domestic value-added price of *A* goods

$\bar{P}_M^W$: world market price of *M* goods, c.i.f.

$\bar{P}_M$: domestic market price received by producers of *M* goods

$\bar{P}_M'$: per unit domestic value-added price of *M* goods

$\bar{P}_Z$: price per unit of imported raw materials

R: total land stock

x: augmentation level of physical capital through technological change

y: augmentation level of skilled labor through technological change

z: augmentation level of unskilled labor through technological change

ENDOGENOUS VARIABLES

c: marginal cost of training per skilled worker
c_j: nominal consumption, jth household
COL_j: cost-of-living in the jth household
d_A: nominal rent per hectare of farmland
d_U: nominal rent per hectare of urban land
$d_{U,j}$: nominal rent per hectare of urban land containing jth type structure, $j = US, KS$
D_A: total private consumption demand for A goods
$D_{H,j}$: total rental demand for jth type housing, $j = US, RS, KS$
D_{KS}: total private consumption demand for KS goods
D_M: total private consumption demand for M goods
D_{RS}: total private consumption demand for RS goods
D_{US}: total private consumption demand for US goods
G_{KS}: government current expenditures, net of investment in training (education) or "productive" capital
G_S: government saving available for training or "productive" capital accumulation
H_j: jth type housing stock, $j = US, RS, KS$
HOUSING: total gross investment in housing
i: economy-wide discount rate
$I_{H,j}$: gross housing investment, jth type housing, $j = US, RS, KS$
$I^N_{H,j}$: net housing investment in jth type housing $j = US, RS, KS$
$I_{i,M}$: gross sectoral investment, "productive" physical capital, $i = A, M, KS$
I_M: total gross investment, "productive" physical capital
$I_{S,KS}$: KS outputs purchased for skills investment
K_i: physical (productive) capital in the ith sector, $i = A, M, KS$
L_i: unskilled labor in the ith sector, $i = A, M, US, RS, KS$
L_R: unskilled labor in rural area
L_U: unskilled labor in urban area
$L_{U,k}$: potential stock of unskilled urban "trainables" of the kth (formal) educational attainment
M_M: net imports of M goods
$P_{H,j}$: nominal rental cost per unit of jth type of housing
$P^S_{H,j}$: net rent on urban housing units received by owner after property tax, $j = US, KS$
$P_{i,j}$: price of ith commodity paid by jth household
P_{KS}: per unit price of KS output
P'_{KS}: per unit value-added price of KS output

P_{RS}: per unit price of RS output
P_{US}: per unit price of US output
ϕ_i: "composite capital" in the ith sector, $i = M, KS$
$\phi_{S,j}$: anticipated gain in profits due to investment in skilled workers, $j = M, KS$
$Q_{H,j}$: "rental units" produced by the jth type housing stock, $j = US, RS, KS$
Q_i: output of the ith sector, $i = A, M, KS, US, RS$
$Q_{i,F}$: composite of primary inputs in the ith sector, $i = M, KS$
$Q_{i,j}$: intermediate input of jth good into the ith sector
$\hat{r}_{H,j}$: profitability index on the jth type of housing, $j = US, RS, KS$
$r_{H,j}$: structure rents on the jth type of housing, $j = US, RS, KS$
$\tilde{r}_i$: pre-tax returns to efficiency capital in ith sector, $i = A, M, KS$
$\tilde{r}_i^*$: quasi-rents per unit of efficiency capital in ith sector, $i = A, M, KS$
r_i: pre-tax returns to physical capital in ith sector, $i = A, M, KS$
$\hat{r}_{S,j}$: profitability index on skills investment in the jth industry, $j = M, KS$
$R_{U,j}$: urban land stock for the jth type housing, $j = US, KS$
R_A: land in farms
s_j: nominal saving, jth household
SAVINGS: total economy-wide savings
S: total skilled labor stock
S_i: skilled labor in the ith sector, $i = M, KS$
$\dot{S}$: total skilled workers trained
$\dot{S}_j$: skilled workers trained in the jth sector
T: total government tax revenue
TRAINING COSTS: total costs of training skilled workers
TRF_R: urban migrants' transfers per rural household
$TRF_{i,L}$: urban migrant's transfer per unskilled household, $i = US, M, KS$
$TRF_{i,S}$: urban migrant's transfer per skilled household, $i = M, KS$
V_A: value of farmland, per hectare
$V_{H,j}$: value of urban residential property per dwelling
$v_{i,j}$: nominal expenditures by jth households on ith commodity.
$\tilde{w}_{i,L}$: efficiency wage, unskilled labor in ith sector
$w_{i,L}$: annual earnings, unskilled labor in ith sector
$\tilde{w}_{i,S}$: efficiency wage, skilled labor in ith sector
$w_{i,S}$: annual earnings, skilled labor in ith sector

$\tilde{w}_U$: expected urban unskilled earnings facing potential out-migrant

X_A: net exports of A goods

y_j^*: disposable income, jth households

Z_i: raw material (imported) inputs used in the ith sector, $i = A, M, KS$

PRODUCTION

$$\left.\begin{aligned} Q_i &= A_i Q_{i,F}^{\alpha_{i,F}} Z_i^{\alpha_{i,Z}} \prod_{j=A,M,KS} Q_{i,j}^{\alpha_{i,j}}, \qquad i = M, KS \neq j \\ Q_{i,F} &= \{\xi_i \phi_i^{(\sigma_i-1)/\sigma_i} + (1-\xi_i)[zL_i]^{(\sigma_i-1)/\sigma_i}\}^{\sigma_i/(\sigma_i-1)}, \\ &\qquad i = M, KS \\ \phi_i &= \{\xi_i'[xK_i]^{(\sigma_i'-1)/\sigma_i'} + (1-\xi_i')[yS_i]^{(\sigma_i'-1)/\sigma_i'}\}^{\sigma_i'/(\sigma_i'-1)}, \\ &\qquad i = M, KS \\ \textstyle\sum \alpha_{i,j} &= 1, \qquad i = M, KS \neq j = F, Z, A, M, KS \end{aligned}\right\} \quad (1), (2)$$

$$\left.\begin{aligned} Q_A &= A_A [xK_A]^{\alpha_{A,K}} [zL_A]^{\alpha_{A,L}} R_A^{\alpha_{A,R}} Z_A^{\alpha_{A,Z}} \prod_{j=M,KS} Q_{A,j}^{\alpha_{A,j}} \\ \textstyle\sum \alpha_{A,j} &= 1, \qquad j = K, L, R, M, KS, Z \end{aligned}\right\} \quad (3)$$

$$Q_i = A_i [zL_i]^{\alpha_i}, \; 0 < \alpha_i < 1, \; i = US, RS \qquad (4), (5)$$

$$Q_{H,j} = A_{H,j} H_j^{\alpha_{H,j}} R_{U,j}^{\alpha_{R,j}}, \; \alpha_{H,j} + \alpha_{R,j} = 1, \qquad j = US, KS \qquad (6), (7)$$

$$Q_{H,RS} = H_{RS}/a_{H,RS} \qquad (8)$$

COMMODITY, SERVICE, AND LAND PRICE RELATIONSHIPS

$$\bar{P}_M = \bar{P}_M^W (1 + \tau_{T,M}) \qquad (9)$$

$$\bar{P}_M' = \bar{P}_M - \bar{P}_Z \frac{Z_M}{Q_M} - \bar{P}_A \frac{Q_{M,A}}{Q_M} - P_{KS} \frac{Q_{M,KS}}{Q_M} \equiv \alpha_{M,F} \bar{P}_M \qquad (10)$$

$$\bar{P}_A = \bar{P}_A^W (1 + \tau_{T,X})^{-1} \qquad (11)$$

$$\begin{aligned} \bar{P}_A' &= \bar{P}_A - \bar{P}_Z \frac{Z_A}{Q_A} - \bar{P}_M (1 + \tau_{A,M}) \frac{Q_{A,M}}{Q_A} - P_{KS} \frac{Q_{A,KS}}{Q_A} \\ &\equiv (\alpha_{A,K} + \alpha_{A,L} + \alpha_{A,R}) \bar{P}_A \end{aligned} \qquad (12)$$

$$P_{KS}' = P_{KS} - \bar{P}_Z \frac{Z_{KS}}{Q_{KS}} - \bar{P}_M \frac{Q_{KS,M}}{Q_{KS}} - \bar{P}_A \frac{Q_{KS,A}}{Q_{KS}} \qquad (13)$$

$$V_A = \frac{d_A}{i} \tag{14}$$

$$V_{H,j} = \frac{P_{H,j}}{(i + \tau_{H,j})}, \qquad j = US, KS \tag{15), (16}$$

$$P^S_{H,j} = \left[\frac{i}{(i + \tau_{H,j})}\right] P_{H,j}, \qquad j = US, KS \tag{17), (18}$$

PRIMARY FACTOR MARKETS

Labor markets

$$\left.\tilde{w}_{i,L} = P_i' \frac{Q_i}{Q_{i,F}} (1 - \xi_i) \left[\frac{Q_{i,F}}{zL_i}\right]^{1/\sigma_i} = \frac{w_{i,L}}{z},\right\} \quad i = M, KS, \text{ and where } P_M' = \bar{P}_M' \tag{19), (20}$$

$$\tilde{w}_{A,L} = \bar{P}_A \alpha_{A,L} \left[\frac{Q_A}{zL_A}\right] = \frac{w_{A,L}}{z} \tag{21}$$

$$\tilde{w}_{i,L} = \frac{P_i Q_i}{zL_i} = \frac{w_{i,L}}{z}, \qquad i = US, RS \tag{22), (23}$$

$$\left.\tilde{w}_{i,S} = P_i' \frac{Q_i}{Q_{i,F}} \xi_i (1 - \xi_i') \left[\frac{Q_{i,F}}{\phi_i}\right]^{1/\sigma_i} \left[\frac{\phi_i}{yS_i}\right]^{1/\sigma_i'} = \frac{w_{i,S}}{y},\right\} \quad i = M, KS, \text{ and where } P_M' = \bar{P}_M' \tag{24), (25}$$

Labor migration

$$w_{A,L} = w_{RS,L} \tag{26}$$

$$w_{M,S} = w_{KS,S} \tag{27}$$

$$w_{M,L} = w_{KS,L} = \kappa w_{US,L} \tag{28}$$

$$\frac{w_{A,L}}{COL_R(-1)} = \frac{w_U}{COL_{US}(-1)} \tag{29}$$

$$\left.\begin{aligned} w_U = {} & [(1 - \tau_y) w_{M,S}] \left[\frac{\dot{S}(-1)}{L_U(-1)}\right] + \left[1 - \frac{\dot{S}(-1)}{L_U(-1)}\right] \\ & \left[w_{M,L} \frac{L_M(-1)}{L_U(-1)} + w_{KS,L} \frac{L_{KS}(-1)}{L_U(-1)} + w_{US,L} \frac{L_{US}(-1)}{L_U(-1)}\right] \end{aligned}\right\} \tag{30}$$

Capital markets

$$\bar{r}_i = P_i' \frac{Q_i}{Q_{i,F}} \xi_i' \xi_i \left[\frac{Q_{i,F}}{\phi_i}\right]^{1/\sigma_i} \left[\frac{\phi_i}{xK_i}\right]^{1/\sigma_i'} = \frac{r_i}{x}, \Bigg\} \quad \begin{matrix} i = M,\ KS, \text{ and where } P_M' = \bar{P}_M' \end{matrix} \qquad (31), (32)$$

$$\bar{r}_A = \bar{P}_A \alpha_{A,K} \left[\frac{Q_A}{xK_A}\right] = \frac{r_A}{x} \qquad (33)$$

Investment allocation

$$\left.\begin{aligned} &\underset{I_{i,M}}{\text{MINIMIZE}} \left[\begin{aligned} \text{RETURN DIFFERENTIALS} = &|[\bar{r}_A^* - \bar{r}_M^*(1-\tau_{\Pi,M})]| \\ &+ |[\bar{r}_A^* - \bar{r}_{KS}^*(1-\tau_{\Pi,KS})]| \\ &+ |[\bar{r}_M^*(1-\tau_{\Pi,M}) - \bar{r}_{KS}^*(1-\tau_{\Pi,KS})]| \end{aligned}\right] \\ &\text{such that} \\ &I_M = \sum_i I_{i,M}, \qquad i = A, M, KS \\ &\text{where} \\ &\bar{r}_i^* = \left\{\bar{r}_i + \frac{\partial r_i}{\partial K_i}\bigg|_{K_i} [I_{i,M} - \delta_i K_i]\right\} - \delta_i \bar{P}_M, \qquad i = A, M, KS \end{aligned}\right\} \qquad (34)$$

$$i = \left[\sum_i (1-\tau_{\Pi,i}) x K_i (\bar{r}_i^*)\right] \left[\bar{P}_M \sum_i K_i\right]^{-1}, \quad i = A, M, KS \qquad (35)$$

Intermediate input markets

$$\bar{P}_Z = \bar{P}_i \alpha_{i,Z} \frac{Q_i}{Z_i}, \qquad i = A, M \qquad (36), (37)$$

$$\bar{P}_Z = P_{KS} \alpha_{KS,Z} \frac{Q_{KS}}{Z_{KS}} \qquad (38)$$

$$P_{KS} = \bar{P}_i \alpha_{i,KS} \frac{Q_i}{Q_{i,KS}}, \qquad i = A, M \qquad (39), (40)$$

$$\bar{P}_M = P_{KS} \alpha_{KS,M} \frac{Q_{KS}}{Q_{KS,M}} \qquad (41)$$

$$\bar{P}_M (1 + \tau_{A,M}) = \bar{P}_A \alpha_{A,M} \frac{Q_A}{Q_{A,M}} \qquad (42)$$

$$\bar{P}_A = \bar{P}_M \alpha_{M,A} \frac{Q_M}{Q_{M,A}} \quad (43)$$

$$\bar{P}_A = P_{KS} \alpha_{KS,A} \frac{Q_{KS}}{Q_{KS,A}} \quad (44)$$

Land markets

$$d_A = \bar{P}_A \alpha_{A,R} \frac{Q_A}{R_A} \quad (45)$$

$$d_{U,j} = P^S_{H,j} \alpha_{R,j} \frac{Q_{H,j}}{R_{U,j}}, \qquad j = US, KS \quad (46), (47)$$

$$d_A = d_{U,j} = d_U, \qquad j = US, KS \quad (48), (49)$$

Factor employment

$$L_U = L_M + L_{KS} + L_{US} \quad (50)$$

$$L_R = L_A + L_{RS} \quad (51)$$

$$L = L_U + L_R \quad (52)$$

$$S = S_M + S_{KS} \quad (53)$$

$$R = R_{U,US} + R_{U,KS} + R_A \quad (54)$$

FOREIGN TRADE SECTOR

$$[\bar{P}^W_M M_M + \bar{P}_Z (Z_{KS} + Z_M + Z_A)] - [\bar{P}^W_A X_A + \bar{F}] = 0 \quad (55)$$

GOVERNMENT SECTOR

Government taxes

$$\left. \begin{aligned} T = {} & \tau_M [\bar{P}_M D_M] + \tau_{H,US} V_{H,US} Q_{H,US} + \tau_{H,KS} V_{H,KS} Q_{H,KS} \\ & + \tau_{A,M} [\bar{P}_M Q_{A,M}] + \tau_Y [\psi_M (1 - \tau_{\Pi,M})(r_M - \delta_M \bar{P}_M) K_M \\ & + \psi_{KS} (1 - \tau_{\Pi,KS})(r_{KS} - \delta_{KS} \bar{P}_M) K_{KS} + r_A K_A + d_A R_A \\ & + (w_{M,S} S_M + w_{KS,S} S_{KS})] + \tau_{\Pi,M} (r_M - \delta_M \bar{P}_M) K_M \\ & + \tau_{\Pi,KS} (r_{KS} - \delta_{KS} \bar{P}_M) K_{KS} + \tau_{T,M} [\bar{P}^W_M M_M] + \tau_{T,X} [\bar{P}_A X_A] \end{aligned} \right\} \quad (56)$$

Government spending and saving

$$G_S = \alpha_G + \beta_G [T + \bar{F}] + \gamma_G [\dot{N}_U (-1)] \quad (57)$$

$$G_{KS} = [T + \bar{F}] - G_S \quad (58)$$

$$\left.\begin{aligned} v_{i,j} &= P_{i,j}\gamma_{i,j} + \beta_{i,j}\left\{y_j^* - \sum_k P_{k,j}\gamma_{k,j}\right\}, \qquad k = A, C, D, T, S, H \\ c_j &= \sum_i v_{i,j} \\ s_j &= y_j^* - c_j \end{aligned}\right\} \quad (59)$$

$$COL_j = \sum_i P_{i,j}\frac{v_{i,j}}{c_j} \quad (60)$$

where the *commodity index* is:

$i = A \equiv$ food (A sector)
$C \equiv$ clothing (M sector)
$D \equiv$ durables (M sector)
$T \equiv$ transportation and communications (KS sector)
$S \equiv$ labor-intensive personal services (RS or US sector)
$H \equiv$ rent (imputed to housing sectors)

and the *household index* is:

$j = R \equiv$ rural (L_A and L_{RS}) households
$US \equiv$ urban unskilled (L_{US}) households
$M \equiv$ urban favored unskilled (L_M) households
$KS \equiv$ urban favored unskilled (L_{KS}) households
$S \equiv$ skilled (S_M and S_{KS}) households
$C \equiv$ capitalist and landlord households

and where *household incomes* are: (61)

$$y_R^* = w_{RS,L} + \frac{P_{H,R}Q_{H,RS}}{L_R} + TRF_R$$

$$= w_{A,L} + \frac{P_{H,R}Q_{H,RS}}{L_R} + TRF_R$$

and where

$$TRF_R = \frac{\sum_{i=US,KS,M}[TRF_{i,L}L_i] + \sum_{i=M,KS}[TRF_{i,S}S_i]}{L_R}$$

$$y_{US}^* = w_{US,L} + \frac{P_{H,US}^S Q_{H,US}}{L_U} - TRF_{US,L}$$

$$y_M^* = w_{M,L} + \frac{P_{H,US}^S Q_{H,US}}{L_U} - TRF_{M,L}$$

$$y_{KS}^* = w_{KS,L} + \frac{P_{H,US}^S Q_{H,US}}{L_U} - TRF_{KS,L}$$

$$y_S^* = (1-\tau_Y)w_{M,S} + \frac{P_{H,KS}^S Q_{H,KS}}{C+S} - TRF_{M,S}$$

$$= (1-\tau_Y)w_{KS,S} + \frac{P_{H,KS}^S Q_{H,KS}}{C+S} - TRF_{KS,S}$$

$$y_C^* = (1-\tau_Y)\left\{\frac{\psi_M[(1-\tau_{\Pi,M})(r_M - \delta_M \bar{P}_M)K_M]}{C}\right.$$

$$\left. + \frac{\psi_{KS}(1-\tau_{\Pi,KS})(r_{KS} - \delta_{KS}\bar{P}_M)K_{KS} + r_A K_A + d_A R_A}{C}\right\}$$

$$+ \frac{P_{H,KS}^S Q_{H,KS}}{C+S}$$

and *households face the following prices*: (62)

$P_{A,j} = \bar{P}_A$	for all j	
$P_{i,j} = \bar{P}_M(1+\tau_M)$	for all j, $i = C, D$	
$P_{T,j} = P_{KS}$	for all j	
$P_{S,R} = P_{RS}$		
$P_{S,j} = P_{US}$	for $j = US, M, KS, S, C$	
$P_{H,j} = P_{H,KS}$	for $j = S, C$	
$P_{H,j} = P_{H,US}$	for $j = US, M, KS$	
$P_{H,R} = P_{H,RS}$		

MIGRANTS' REMITTANCES

$$TRF_{i,L} = \Upsilon(w_{i,L}), \qquad i = US, M, KS \qquad (63)\text{–}(65)$$

$$TRF_{i,S} = \Upsilon[(1-\tau_Y)w_{i,S}], \qquad i = KS, M \qquad (66), (67)$$

PRIVATE CONSUMPTION DEMAND

$$\bar{P}_A D_A = v_{A,R}L_R + v_{A,US}L_{US} + v_{A,M}L_M + v_{A,KS}L_{KS} + v_{A,S}S + v_{A,C}C \qquad (68)$$

$$\left.\begin{aligned}(1+\tau_M)\bar{P}_M D_M = {} & [v_{C,R} + v_{D,R}]L_R + [v_{C,US} + v_{D,US}]L_{US} \\ & + [v_{C,M} + v_{D,M}]L_M + [v_{C,KS} + v_{D,KS}]L_{KS} \\ & + [v_{C,S} + v_{D,S}]S + [v_{C,C} + v_{D,C}]C\end{aligned}\right\} \qquad (69)$$

$$P_{KS}D_{KS} = v_{T,R}L_R + v_{T,US}L_{US} + v_{T,M}L_M + v_{T,KS}L_{KS} + v_{T,S}S + v_{T,C}C \qquad (70)$$

$$P_{US}D_{US} = v_{S,US}L_{US} + v_{S,M}L_M + v_{S,KS}L_{KS} + v_{S,S}S + v_{S,C}C \quad (71)$$

$$P_{RS}D_{RS} = v_{S,R}L_R \quad (72)$$

$$P_{H,RS}D_{H,RS} = v_{H,R}L_R \quad (73)$$

$$P_{H,US}D_{H,US} = v_{H,US}L_{US} + v_{H,M}L_M + v_{H,KS}L_{KS} \quad (74)$$

$$P_{H,KS}D_{H,KS} = v_{H,S}S + v_{H,C}C \quad (75)$$

INVESTMENT AND SAVINGS

Housing investment

$$\left.\begin{aligned} I_{H,RS} &= \text{Min}\,\{s_R L_R P_{RS}^{-1}, \quad I_{H,RS}^N + \delta_{H,RS}H_{RS}\} \\ I_{H,RS} &= \text{Max}\,\{0, I_{H,RS}\} \\ I_{H,RS}^N &= \theta_{H,RS}[\hat{r}_{H,RS}^{\epsilon H} - 1] \end{aligned}\right\} \quad (76)$$

$$\left.\begin{aligned} I_{H,US} &= \text{Min}\,\{[s_{US}L_{US} + s_M L_M + s_{KS}L_{KS}]P_{US}^{-1}, \quad I_{H,US}^N \\ &\quad + \delta_{H,US}H_{US}\} \\ I_{H,US} &= \text{Max}\,\{0, I_{H,US}\} \\ I_{H,US}^N &= \theta_{H,US}[\hat{r}_{H,US}^{\epsilon H} - 1] \end{aligned}\right\} \quad (77)$$

$$\left.\begin{aligned} I_{H,KS} &= \text{Min}\,\{[s_S S + s_C C]P_{KS}^{-1}, \quad I_{H,KS}^N + \delta_{H,KS}H_{KS}\} \\ I_{H,KS} &= \text{Max}\,\{0, I_{H,KS}\} \\ I_{H,KS}^N &= \theta_{H,KS}[\hat{r}_{H,KS}^{\epsilon H} - 1] \end{aligned}\right\} \quad (78)$$

$$\hat{r}_{H,j} = \frac{r_{H,j} - \delta_{H,j}P_j}{iP_j}, \qquad j = US, KS, RS \quad (79)\text{–}(81)$$

$$r_{H,j} = \left\{\frac{A_{H,j}P_{H,j}^S \alpha_{H,j}^{\alpha_{H,j}} \alpha_{R,j}^{\alpha_{R,j}}}{d_{U,j}^{\alpha_{R,j}}}\right\}^{1/\alpha_{H,j}}, \qquad j = US, KS \quad (82), (83)$$

$$r_{H,RS} = \frac{P_{H,RS}}{a_{H,RS}} \quad (84)$$

$$\text{HOUSING} = P_{RS}I_{H,RS} + P_{US}I_{H,US} + P_{KS}I_{H,KS} \quad (85)$$

Training and skills investment

$$\phi_{S,j} = K_j[1 - \tau_{\Pi,j}]\left.\frac{\partial r_j}{\partial S_j}\right|_{S_j + \dot{S}_j}, \qquad j = M, KS \quad (86), (87)$$

$$\hat{r}_{S,j} = \frac{\phi_{S,j}}{i}, \qquad j = M, KS \qquad (88), (89)$$

$$c = \begin{cases} c_0, & 0 \leqslant \dot{S} \leqslant L_{U,0}, & k = 0, \quad Ed > n \text{ years} \\ c_1, & L_{U,0} < \dot{S} \leqslant L_{U,1}, & k = 1, \quad n-1 < Ed \leqslant n \\ \vdots & & \vdots \\ c_n, & L_{U,n-1} < \dot{S} \leqslant L_{U,n}, & k = n, \quad Ed = 0 \end{cases} \qquad (90)$$

$$\hat{r}_{S,j} = c, \qquad j = M, KS \qquad (91), (92)$$

$$\dot{S} = \sum_j \dot{S}_j \leqslant L_U, \qquad j = M, KS \qquad (93)$$

where l = optimal class trained satisfying (91) and (92), we can define

$$\text{TRAINING COSTS} = \sum_k c_k L_{U,k} + c_l \left[\dot{S} - \sum_k L_{U,k} \right], \qquad k = 0, \ldots, l-1 \qquad (94)$$

$$\text{TRAINING COSTS} = P_{KS} I_{S,KS} \qquad (95)$$

Aggregate savings

$$\left. \begin{aligned} \text{SAVINGS} = {} & (1 - \psi_M)[(1 - \tau_{\Pi,M})(r_M - \delta_M \bar{P}_M) K_M] + \delta_M \bar{P}_M K_M \\ & + (1 - \psi_{KS})[(1 - \tau_{\Pi,KS})(r_{KS} - \delta_{KS} \bar{P}_M) K_{KS}] + \delta_{KS} \bar{P}_M K_{KS} \\ & + s_{US} L_{US} + s_M L_M + s_{KS} L_{KS} + s_R L_R + s_C C + s_S S + G_S \end{aligned} \right\} \qquad (96)$$

$$\bar{P}_M I_M = \text{SAVINGS} - \text{HOUSING} - \text{TRAINING COSTS} \qquad (97)$$

MARKET CLEARING

$$Q_M + M_M = D_M + I_M + Q_{A,M} + Q_{KS,M} \qquad (98)$$

$$Q_A = D_A + X_A + Q_{M,A} + Q_{KS,A} \qquad (99)$$

$$Q_{KS} = D_{KS} + \frac{G_{KS}}{P_{KS}} + I_{H,KS} + Q_{M,KS} + Q_{A,KS} + I_{S,KS} \qquad (100)$$

$$Q_{US} = D_{US} + I_{H,US} \qquad (101)$$

$$Q_{RS} = D_{RS} + I_{H,RS} \qquad (102)$$

$$Q_{H,US} = D_{H,US} \qquad (103)$$

$$Q_{H,RS} = D_{H,RS} \qquad (104)$$

$$Q_{H,KS} = D_{H,KS} \qquad (105)$$

$$GDP = \bar{P}_M Q_M + P_{KS}Q_{KS} + \bar{P}_A Q_A + P_{US}Q_{US} + P_{RS}Q_{RS} + \sum_j P_{H,j}Q_{H,j},$$
$$+ \tau_M(\bar{P}_M D_M) + \tau_{T,M}(\bar{P}_M^w M_M) + \tau_{T,X}(\bar{P}_A X_A) j = KS, US, RS \quad (106)$$

DYNAMIC EQUATIONS

Accumulation of capital and residential structures

$$K_i = (1 - \delta_i)K_i(-1) + I_{i,M}(-1), \qquad i = A, M, KS \quad (107)–(109)$$

$$H_j = (1 - \delta_{H,j})H_j(-1) + I_{H,j}(-1), \qquad j = US, RS, KS \quad (110)–(112)$$

Land growth and technological progress

$$x = x(-1)\, e^{\lambda_K} \quad (113)$$

$$y = y(-1)\, e^{\lambda_S} \quad (114)$$

$$z = z(-1)\, e^{\lambda_L} \quad (115)$$

$$A_i = A_i(-1)\, e^{\lambda_i}, \qquad i = M, KS, A \quad (116), (117), (118)$$

$$A_{H,j} = A_{H,j}(-1)\, e^{\lambda_{H,j}} \qquad j = US, KS \quad (119), (120)$$

$$R = (1 + \rho)R(-1) \quad (121)$$

Labor force growth and skill accumulation

$$C = \dot{C} + C(-1) \quad (122)$$

$$\dot{C} = \phi_C \dot{N} \quad (123)$$

$$S = \dot{S} + (1 - m_S)S(-1) \quad (124)$$

$$L_U = \dot{L}_U + L_U(-1) \quad (125)$$

$$\dot{L}_U = \sum_i \sum_j l_{i,j,U}\dot{N}_{i,j,U} - [\dot{S} - m_S S(-1)] - \dot{C}, \quad \left.\begin{array}{l} i = 1, \ldots, n \text{ age classes} \\ j = 1, 2 \text{ sex classes} \end{array}\right\} \quad (126)$$

$$L_R = \dot{L}_R + L_R(-1) \quad (127)$$

$$\dot{L}_R = \sum_i \sum_j l_{i,j,R}\dot{N}_{i,j,R}, \quad \left.\begin{array}{l} i = 1, \ldots, n \text{ age classes} \\ j = 1, 2 \text{ sex classes} \end{array}\right\} \quad (128)$$

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