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INTERGENERATIONAL CONTRACTS, REMITTANCES, AND GROWTH

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RÉSUMÉ

Nous développons un modèle d'équilibre général à deux secteurs afin d'étudier la migration et les envois de fonds entre le secteur agricole et le secteur urbain, les liens entre la migration et la croissance, ainsi que les conditions sous lesquelles la migration intersectorielle débute et termine. Le processus de migration, dans notre modèle, se fait à travers les contrats intergénérationnels / intra-familiaux introduits dans la littérature par Stark et Lucas. Le processus de croissance endogène dans le secteur urbain diffère du traitement standard [comme dans Lucas (1988)] : dans notre modèle, les individus (qui ont une durée de vie finie) divisent leur revenu de première période entre l'accumulation de capital humain et la consommation. Notre modèle donne : (i) un "seuil migratoire endogène"; (ii) des écarts salariaux intersectoriels qui ne reposent pas sur l'existence du chômage comme dans le modèle standard de Harris et Todaro.

Mots clés : envois de fonds, contrats intergénérationnels, croissance endogène, générations imbriquées, croissance duale

ABSTRACT

In this paper, we develop a two sector general equilibrium overlapping generations model to study migration and remittances between the countryside and the city, the links between migration and growth, as well as the conditions under which intersectoral migration begins and ends. The migration process in our model is mediated through optimal intergenerational / intrafamily contracts, introduced by Stark and Lucas, which result in remittances. The endogenous growth process in the urban sector is driven by a human capital accumulation process which differs from the standard treatment such as that in Lucas (1988) : in our model, individuals (finitely lived), divide their first-period *income* between the accumulation of human capital and consumption. Our model yields : (i) an "endogenous migration threshold"; (ii) "wage gaps" between the agricultural sector and the urban sector which do not depend upon the existence of unemployment as in the standard Harris-Todaro treatment.

Key words : remittances, intergenerational contracts, endogenous growth, overlapping generations, dualistic growth

In this paper, we develop a theoretical two sector general equilibrium overlapping generations model to study migration and remittances from countryside to city, the links between migration and growth, as well as the conditions under which intersectoral migration begins and ends. We also simulate the dynamics of the model numerically. The model departs from the usual dualistic and endogenous growth models in a number of important respects, both in terms of assumptions, and in terms of results:

(i) our model yields an "endogenous migration threshold," meaning that migration begins spontaneously when certain conditions in the urban and agricultural sectors are satisfied; this leads to a fundamental change in the dynamics of the economy, and is in contrast to other model of threshold effects, such as Azariadis and Drazen (1990) where the threshold is derived by *assuming* a functional form (in their case, a level effect of human capital) which yields a bifurcation in the dynamics; our model also yields an "endogenous end-of -migration threshold," where the state variables in the two sectors are such that migration stops;

(ii) our model yields "wage gaps" between the agricultural sector and the urban sector which do not depend upon the existence of unemployment (indeed, there is no unemployment in our model) as in the standard Todaro (1969) or Harris-Todaro (1970) treatment of the migration process; the wage gaps in our model stem from (a) the explicitly intertemporal nature of the migration decisionmaking process (individuals live three periods and compare additively separable indirect utility functions in taking their migration decisions), and (b) the fact that we do not impose the unrealistic assumption, which is key to the tractability of the standard model (see Eaton (1988), for a recent example), that a representative agent divides her time between the two sector so as to equate marginal returns to labor in the two sectors. This implies that migration does *not* result in intersectoral wage equalization —quite the contrary.

(iii) the migration process in our model is mediated through optimal intergenerational/intrafamily contracts, introduced into the development literature by Stark (1981a, 1981b), Lucas and Stark (1985), which result in financial flows between the agricultural and urban areas —in other words, *remittances*; again, this contrasts with the standard treatment in dual growth models where the phenomenon of remittances is ignored;

(iv) the endogenous growth process in the urban sector is driven by a human capital accumulation process which differs from the standard treatment such as that in Lucas (1988), where an (infinitely-lived) individual divides his *time* between learning and doing; in our model, (finitely-lived) individuals divide their first period *income* between the accumulation of human capital and consumption;

(v) the numerical simulations of our model predict: (a) an increasing *rate* of migration, once the endogenous migration threshold is crossed, which falls abruptly to zero once the end-of-migration threshold is reached; (b) relatively stable migration contracts between parents and children during the phase of the model where migration obtains, (c) a hump-shaped pattern over time of aggregate remittances from the urban sector to the agricultural sector; (d) relatively low levels of human capital accumulation by migrants (as compared with native urbanites) leading to what is observationally equivalent to a two-tiered labor market in which highly qualified urbanites co-exist side-by-side with relatively unqualified migrant workers; (e) a "Kuznets process" in which the relative degree of inequality in the economy increases as migration picks up, reaches a maximum, and then decreases to approximately its initial, pre-migration level, when migration stops, and remains stable thereafter; (f) a typical logistic curve pattern of urban growth. In discussing our simulation results, we will be highlighting their coherence with available empirical data, and where no stylized facts exist in the literature, we will be formulating conjectures which can be confronted with empirical evidence, should it become available.

The recent literature on migration (Stark (1981a, 1981b), Lucas and Stark (1985)) has stressed that migration and the flows of remittances which are associated with it are the result of intergenerational contracts between parents who remain in the countryside and children who move to the city in search of employment opportunities. This is in contrast with the traditional development economics literature typified by the influential work of Harris and Todaro (1970), which holds that the migration decision is based upon an individual expected utility maximization problem: the question of the relationship between parents and children —and thus the rationale behind remittances themselves— was not touched upon.[1] The Harris-Todaro model does have the advantage of being a direct descendant of the dualistic models of development pioneered by Lewis (1954), Dixit (1969) and Jorgenson (1970) (see the excellent survey by Kanbur and McIntosh, 1988) and is thus easily solved analytically within a general equilibrium context. Recently, the simple expected utility hypothesis of the Harris-Todaro school has been replaced by general equilibrium models based on much more satisfactory and explicit search-theoretic arguments (Vishwanath, 1990).

In this paper, however, we eschew the search-theoretic setup in favor of a three period overlapping generations model in which we explicitly incorporate the intra-family/inter-generational contracts proposed in a partial equilibrium framework by Lucas and Stark (1985). We do so for several reasons. First, we believe, as do Lucas and Stark, that intra-family/intergenerational contracts are an important piece of the migration puzzle which is worth investigating analytically in a general equilibrium framework. Second, the search-theoretic approach, while important in terms of understanding the insertion of the migrant into the urban labor force, is not geared towards the analysis of the phenomenon of remittances.[2] Third, we believe that the intra-family/inter-generational contract may be an important manner for agricultural households that

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[1] See the more recent extensions of the model by Zarembka (1972), Stiglitz (1974), Corden and Findlay (1975), Cole and Sanders (1985).

[2] As pointed out to us by Camillo Dagum, the first two points (intergenerational contracts and remittances) are particularly important for the African and Asian contexts; the model is less applicable to the Latin American case in which migration to the cities results in "cinturas de pobredad" (poverty belts) around urban areas.

remain in the countryside to smooth their intertemporal consumption profile, particularly when access to financial institutions in rural areas is limited or is fettered by government interference. An overlapping generations framework is the most obvious manner of treating such intergenerational issues, as evidenced in the work on intergenerational exchange (see, e.g., Zang and Nishimura (1993)). Finally —and this is linked to the previous point— the potential "savings" for the old age of households which remain in the countryside that is provided by remittances from children who move to the urban area is another example of the "children as old age security" hypothesis (Cain, 1983).

The paper is organized as follows. In part 1, we describe the timing of the model from the perspective of the three classes of agents. In part 2, we formulate and solve the intertemporal optimization problems of each of the three classes of consumers. In particular, we specify our human capital accumulation process which, as noted in the introduction, differs from the standard treatment in the existing literature. In part 3, we spell out the details of our formulation of the optimal migration contract, derive conditions for its existence (which is equivalent to defining the conditions under which the endogenous migration threshold is reached), and solve for the optimal migration contract. We then introduce heterogeneity among agricultural offspring in their migration costs and derive the proportion of offspring who will self-select into an optimal migration contract with their parents. In part 4 we specify the production technologies in the two sectors, discuss the externalities which we introduce into the production processes, and characterize the optimality conditions in production. In part 5 we spell out the market-clearing conditions and then solve for the steady-state growth rate and capital stock per efficiency unit of labor, where the steady-state is defined as a situation in which (i) all agents are optimizing, (ii) all variables are growing at a common constant rate and capital per efficiency unit is constant, and (iii) migration has fallen to zero. In part 6 we present numerical simulations of the model which trace out the transitional dynamics of a number of key variables before, during, and after the migration process. Part 7 concludes.

1. Preliminaries

The basic model is a three period life OLG model with accumulation of physical and human capital. Apart from our assumption of finite lives, it is worth noting immediately that the manner in which human capital is accumulated in this model differs significantly from the standard treatment in the literature (e.g., Lucas (1988), Azariadis and Drazen (1990)) in which individuals divide a fixed endowment of time between working (earning income) and accumulating human capital. In our model, in contrast, individuals divide first period *income* between consumption and investment in human capital which increases their second period income.

Timing

The timing of the model is as follows. There are three classes of individuals, (i) agricultural workers, (ii) migrants, and (iii) urbanites, who live for three periods. Individuals do not work in the first period of their lives, work in the second period, and are retired in the third period. The environment facing different classes of individuals differs most importantly in the possibilities available for the intertemporal smoothing of consumption. More precisely, there is assumed to exist a storage technology available in the urban sector (and thus accessible to urbanites and migrants) which allows urban dwellers to smooth their intertemporal consumption profiles and provide for old age. Such a storage technology is not available to agricultural households. We are thus assuming that financial markets do not exist in the countryside, or at least, are dominated in agricultural areas by other means of smoothing consumption intertemporally.

Individuals born at time t who decide to spend their lives in the agricultural sector are supported by their parents in the first period of their lives, receiving a lump sum payment $d>0$ from them which they consume entirely. This sum, d, can be thought of either as the real cost of raising a child in the agricultural sector (a cost which is invariant over time), or as the income necessary to sustain a minimum level of consumption. Whichever interpretation one prefers, we make this assumption in order to focus attention on the individually rational elements in the migration contract (more on this below) which would be obscured if we explicitly incorporated intergenerational altruism and gift-giving into the model (see Zang and Nishimura, 1993, for an OLG model with altruism). Income is allocated between consumption of the agricultural good and consumption of the urban good.

In the second period of their lives $(t+1)$, the agricultural population reproduces itself (for simplicity, the growth rate of the population is zero) and agricultural workers earn a wage w^a_{t+1}. This wage is used to finance (i) a proportion m_{t+1} of the individual's offspring who migrate to the urban area (if the optimal migration contract exists), each migrating offspring receiving a sum z_{t+1}, (ii) the upbringing of the proportion $1-m_{t+1}$ of the individual's offspring who remain in the countryside, each remaining offspring receiving the fixed sum d, (iii) the purchase of l_{t+1} units of land at unit price p^T_{t+1}, and (iv) the consumption of the agricultural and urban goods. Note that it is assumed that only inhabitants of the agricultural sector can purchase land (this is in contrast to other recent dual models based on intertemporal optimization, such as Eaton (1988) where a representative consumer allocates his time between employment in the two sectors, and physical capital and land are two substitutable assets). Note also that we assume that individuals in the agricultural sector cannot accumulate human capital.

In the third period of their lives $(t+2)$, agricultural households receive a remittance v_{t+2} from each of the m_{t+1} offspring who now inhabit the city. Their l_{t+1} units of land yield a rent r^T_{t+2} per unit. After receiving the rent on their land, they sell it at price p^T_{t+2}. The rate of return on land purchased at time $t+1$ is therefore $(r^T_{t+2}+p^T_{t+2})/p^T_{t+1}$. They then use this income to finance their third period consumption. For simplicity, we will eschew bequest issues and focus instead on the determination of the optimal intergenerational contract (z_{t+1}, v_{t+2}) between the agricultural parent and his migrating offspring which has been the focus of recent research by Lucas

and Stark (1985).[3] As will become clear in the exposition of the model, it is the absence of a storage technology in the agricultural sector, and the difference in rates of return on investment in land and "investment" in migrating offspring, which drives the intergenerational migration contract as a means for agricultural parents to smooth their intertemporal consumption profile. It is also what drives our "endogenous threshold effect" in which migration only begins once it becomes worthwhile for the parents to invest in their offsprings' migration to the urban sector.

An individual born in the agricultural sector at time $t+1$ who migrates to the urban area receives a transfer z_{t+1} from his parents which he uses to finance (i) the accumulation of human capital e^m_{t+1} and (ii) his consumption. Given that the migrant has just arrived in the urban area, we assume that he does not have access to the urban financial market immediately upon arrival: he therefore does not save at time $t+1$ and is not able to borrow against future income in order to finance his consumption and education at time $t+1$, which must be financed entirely out of the sum z_{t+1} that he received from his parents.

At time $t+2$, the migrant enters into the urban labor force, receiving a wage $\hat{w}^m_{t+2}$ which is a function (among other things) of his level of human capital e^m_{t+1}. He then uses this income to finance (i) a remittance v_{t+2} which he sends back to his parents in the agricultural sector, (ii) saving s^m_{t+2}, and (iii) his period $t+2$ consumption. At time $t+3$, the migrant worker retires and finances his consumption through his period $t+2$ saving, which is returned to him through a storage technology which yields him $s^m_{t+2}(1+r_{t+3})$.

An urbanite born at time t has full access to the urban financial sector and therefore behaves as in a standard three period OLG model. At time t, he borrows b_t against future income. He then allocates b_t between (i) consumption and (ii) the accumulation of human capital e^u_t. At time

[3] One can extend the model to encompass bequest issues, but this entails moving to four period lives for one to be able to have operative bequests as well as remittances. At the suggestion of François Bourguignon we have replaced the bequest issue by a social sanction (see below). This considerably clarifies the workings of the model although it does entail a loss of generality.

$t+1$, he enters into urban employment, and receives a wage rate $\hat{w}^u_{t+1}$ which is (as in the case of the migrant worker) a function of his level of human capital. He uses this income to (i) consume, (ii) repay his period t loan (the repayment being $b_t(1+r_{t+1})$), and (iii) save s^u_{t+1}. In the third period of his life (time $t+2$), he finances his consumption through his savings $s^u_{t+1}(1+r_{t+2})$.

The effect of human capital on productivity

Production in the urban sector is carried out through an aggregate production function, homogeneous of degree one in physical capital and effective labor input, which takes the form $Y_t = AF(K_t, L_t) = AK_t^{\alpha}L_t^{1-\alpha}$, $\alpha \in (0,1)$, $A > 0$. The effective labor input of an individual of type $i = m,u$ is given by $L_t^i = h(e^i_{t-1}, \bar{e}_{t-2}) = (e^i_{t-1})^{\lambda}(\bar{e}_{t-2})^{1-\lambda}$, $\lambda \in (0,1)$. The term in $\bar{e}_{t-2}$ reflects human capital *inherited* by the current urban dwellers (be they migrants or native urbanites) from their predecessors, where $\bar{e}_{t-2}$ represents the average level of human capital in the urban sector during the previous period, and where the averaging is performed over migrant workers and natives of the urban sector. The number of *hours* of labor input is assumed to be inelastically supplied and is normalized to one. Total effective labor supply at time t is therefore given by $L_t = (e^u_{t-1})^{\lambda}(\bar{e}_{t-2})^{1-\lambda}N^u_{t-1} + (e^m_{t-1})^{\lambda}(\bar{e}_{t-2})^{1-\lambda}M_{t-1}$, where M_{t-1} represents the previous period's crop of migrants. Given that urban sector firms do not take the externalities into account when maximizing profits, the FOCs for profit maximization in urban production yield the wage rates for both classes of labor: $\hat{w}^u_t = A(1-\alpha)k_t^{\alpha}(e^u_{t-1})^{\lambda}(\bar{e}_{t-2})^{1-\lambda}$ and $\hat{w}^m_t = A(1-\alpha)k_t^{\alpha}(e^m_{t-1})^{\lambda}(\bar{e}_{t-2})^{1-\lambda}$.

2. CONSUMERS

The intertemporal utility of consumers is given by a three period additively separable form, where we pick the logarithmic specification in order to abstract from interest-elasticity of saving effects.[4]

[4] The notational convention adopted for subscripts on consumption follows Blanchard and Fischer (1988), with the first number denoting the age and the subsequent notation denoting the period.

$$(1) \qquad U_t^j = \sum_{s=1}^{s=3}\beta^{s-1}\ln\left(c^j_{s,t+s-1}\right),\ j = a,m,u.$$

For simplicity, we assume that the agricultural and urban goods are perfect substitutes in consumption so that the within-period subutility function is given by $c^j_{it} = x^j_{it} + y^j_{it}$ (see Drazen and Eckstein (1989) for a similar use of perfect substitutability). Use of the perfect substitutability assumption allows us to abstract from terms of trade effects and concentrate our attention on the impact of the intra-family intergenerational migration contracts. Note that this assumption is also akin to assuming that this is a "small open economy" in that international prices determine the intersectoral terms of trade.[5]

The urban worker

We begin with the representative urban worker who, since he has full access to the urban credit market for both borrowing and saving purposes, behaves as in the standard three-period OLG framework. Recalling the discussion in Part 1, we can write the within-period budget constraints as

$$(2) \qquad \begin{aligned} c^u_{1t} &= b_t - e^u_t, \\ c^u_{2t+1} &= \hat{w}^u_{t+1} - s^u_{t+1} - R_{t+1}b_t, \\ c^u_{3t+2} &= R_{t+2}s^u_{t+1}, \end{aligned}$$

where $R_{t+2} = 1 + r_{t+2}$. The urban consumer maximizes (1) subject to (2). The solution to his problem is given by:

[5] It is worth pointing out that a number of authors do not assume linear subutility, relying on the small open economy assumption instead (see Eaton, 1988, for an example), but then fail to take this into account when specifying the capital accumulation equation in particular and national income accounting identities in general. We prefer to explicitly incorporate the linear subutility assumption in order to avoid "international" complications.

$$e_t^m = \frac{\lambda}{R_{t+1}}\hat{w}_{t+1}^m,\ b_t = \frac{\gamma}{R_{t+1}}\hat{w}_{t+1}^m,\ s_{t+1}^m = \beta^2(\gamma-\lambda)\hat{w}_{t+1}^m = \beta\frac{1-\gamma}{1+\beta}\hat{w}_{t+1}^m,$$
$$\text{where } \gamma = \frac{1+\beta\lambda+\beta^2\lambda}{1+\beta+\beta^2}.$$

Thus, as in the standard model, the optimal expenditure on the accumulation of human capital, the optimal level of first period borrowing, and optimal saving are all fractions of the level of discounted second period employment income.

The migrant worker

Recall that the migrant worker is an agricultural offspring who decides (the conditions under which this decision obtain will be spelled out in greater detail below) to accept an intergenerational/intra-family contract (if such a contract exists) and migrate to the urban area. We will assume for the moment that the contract is enforced (more on the conditions which ensure this below). We will also assume that the migrant must incur costs $\psi > 0$ in remitting to his parents in the countryside. These may be transactions costs associated with, say, purchasing a postal money order to be sent to the parents, or "shoe-leather" costs associated with the time and effort spent on devising a manner of getting the remittance back safely to the parents in the countryside. In many LDCs, where the financial sector in the agricultural areas is poorly organized or non-existent, or where the transportation costs involved in getting anything from urban areas to the countryside are relatively large, such transactions cost are likely to be non-negligible. For simplicity we assume that these costs are constant, although the model can be extended, with considerable loss in tractability, to the case where the costs are a function of the magnitude of the remittance.

Keeping the preceding discussion in mind, the within period budget constraints for the migrant worker are given by

$$\begin{aligned} &c_{1t}^m = z_t - e_t^m,\\ (3)\quad &c_{2t+1}^m = \hat{w}_{t+1}^m - s_{t+1}^m - (v_{t+1}+\psi),\\ &c_{3t+2}^m = R_{t+2}s_{t+1}^m. \end{aligned}$$

Solving the FOCs stemming from the maximization of (1) subject to (3) with respect to investment in human capital and saving yields

$$e_t^m = \frac{\beta\lambda\hat{w}_{t+1}^m z_t}{\hat{w}_{t+1}^m\left(\frac{1}{1+\beta}-\beta\lambda\right)-\left(\frac{1}{1+\beta}\right)(v_{t+1}+\psi)},\quad s_{t+1}^m = \frac{\beta}{1+\beta}\left(\hat{w}_{t+1}^m - v_{t+1} - \psi\right).$$

When we consider the migration decision below, we will need the indirect utility function of the potential migrant as a function of the terms of the migration contract and the state of the economy over the following two periods. In order to write this indirect utility compactly, define the income of the migrant in period t, *net of saving*, as I_t^m. Then we can write

$$\begin{aligned} &I_{1t}^m = z_t - e_t^m\\ &I_{2t+1}^m = \hat{w}_{t+1}^m - (v_{t+1}+\psi)\\ &I_{3t+2}^m = 0 \end{aligned}$$

and the indirect utility of the migrant can be written in short-hand notation as

$$\begin{aligned} (4)\quad V_t^m = &\log I_t^m + \beta(1+\beta)\log I_{t+1}^m\\ &+\beta\log\left(\frac{1}{1+\beta}\right)+\beta^2\log\beta+\beta^2\log\left(\frac{1}{1+\beta}\right)+\beta^2\log R_{t+2}. \end{aligned}$$

The agricultural worker

In the case of the agricultural worker, and taking the terms of the migration contract as given for the time being, the only variable with respect to which he must optimize is land purchases during the second period of his life. Recall, from the discussion given in Part 1, that the within period budget constraints of the agricultural worker are given by

$$
(5)\quad
\begin{aligned}
c^a_{1t} &= d,\\
c^a_{2t+1} &= w^a_{t+1} - p^T_{t+1} l^a_{t+1} - m_{t+1} z_{t+1} - (1-m_{t+1})d,\\
c^a_{3t+2} &= \left(r^T_{t+2} + p^T_{t+2}\right) l^a_{t+1} + m_{t+1} v_{t+2}.
\end{aligned}
$$

As in the case of the migrant worker, define the income of the agricultural worker net of intertemporal substitution concerns (in this case, land purchases) as

$$
\begin{aligned}
I^a_{1t} &= d,\\
I^a_{2t+1} &= w^a_{t+1} - m_{t+1} z_{t+1} - (1-m_{t+1})d,\\
I^a_{3t+2} &= m_{t+1} v_{t+2}.
\end{aligned}
$$

Then we can write the solution to the FOC (of the maximization of (1) subject to (5)) with respect to land purchases as

$$
l^a_{t+1} = \left(\frac{\beta}{1+\beta}\right)\frac{I^a_{1t+1}}{p^T_{t+1}} - \left(\frac{1}{1+\beta}\right)\frac{I^a_{2t+2}}{r^T_{t+2}+p^T_{t+2}}.
$$

Plugging into the budget constraints and substituting into the utility function yields the indirect utility of the agricultural worker:

$$
(6)\quad
\begin{aligned}
V^a_t = {} & \log d + \beta(1+\beta)\log\left(w^a_{t+1} - m_{t+1} z_{t+1} - (1-m_{t+1})d + \frac{p^T_{t+1}}{r^T_{t+2}+p^T_{t+2}} m_{t+2} v_{t+2}\right)\\
& + \beta^2 \log\left(\frac{r^T_{t+2}+p^T_{t+2}}{p^T_{t+1}}\right) + \beta(1+\beta)\log\left(\frac{1}{1+\beta}\right) + \beta^2 \log\beta
\end{aligned}
$$

TABLE 1 summarizes the notation and timing of the consumer side of the model.

TABLE 1
A Summary of the Specification of the Consumer Side of the Model

Period	t	$t+1$	$t+2$
Agricultural Household	born, decides to stay in the countryside	reproduces (i.e., has one child), a proportion m_{t+1} of which leave for the city, $1-m_{t+1}$ of which remain in agriculture	retires, receives remittances from children in the city, sells land holdings, dies at the end of the period
Income net of cost of supporting children and land purchases	d	$w^a_{t+1} - p^T_{t+1} l^a_{t+1}$ $- m_{t+1} z_{t+1} - (1-m_{t+1})d$	$(r^T_{t+2}+p^T_{t+2}) l^a_{t+1} + m_{t+1} v_{t+2}$
Consumption	c^a_{1t}	c^a_{2t+1}	c^a_{3t+2}
Land purchase	0	l^a_{t+1}	$-l^a_{t+1}$
Migrant Household	born, decides to move to the city, receives help from parents, and accumulates human capital	has one child, sends remittances to his parents in the countryside, works, saves	retires, lives off accumulated savings, dies at the end of the period
Income net of saving and human capital accumulation	$z_t - e^m_t$	$\hat{w}^m_{t+1} - s^m_{t+1} - (v_{t+1}+\psi)$	$(1+r_{t+2}) s^m_{t+1}$
Consumption	c^m_{1t}	c^m_{2t+1}	c^m_{3t+2}
Saving	0	s^m_{t+1}	0
Human capital accumulation	e^m_t	0	0
Urban Household	born, borrows against future earnings, accumulates human capital	has one child, repays educational loan, works, saves	retires, lives off income from saving, dies at the end of the period
Income net of saving and borrowing	$b_t - e^u_t$	$\hat{w}^u_{t+1} - s^u_{t+1} - (1+r_{t+1})b_t$	$(1+r_{t+2}) s^u_{t+1}$
Consumption	c^u_{1t}	c^u_{2t+1}	c^u_{3t+2}
Saving	0	s^u_{t+1}	0
Human capital accumulation	e^u_t	0	0

3. THE INTRAFAMILY-INTERGENERATIONAL CONTRACTS

We now turn to the specification of the intergenerational/intrafamily migration contract through which the migration process will be mediated. Our specification closely follows the approach suggested in a partial equilibrium setting by Lucas and Stark (1985).[6] The intuition of their approach is extremely simple, and may be explained in terms of a three-period discussion.

In period one, the parents present those among their offspring who decide to migrate with a "gift" which allows them to migrate to the city, accumulate human capital, and consume a sufficient amount to survive. In period two, the migrant secures an urban sector job with probability one (note the difference with the Harris-Todaro approach) and remits to his parents in the countryside. For this arrangement to be *self-enforcing* however (altruism is assumed away here so as to focus on what is individually rational), it must be the case that the migrant's parents hold a "sword of Damocles" over his head were he to fail to remit. Otherwise, it would not be individually rational for the offspring to remit in the second period and, knowing this, the parents would not have extended the initial payment in the first period to begin with, thus unraveling the whole migration process from back to front. The existence of the last period threat available to the parents in the case where the migrant does not remit is thus the key to the whole Lucas-Stark approach.

There are a number of social structures which may easily furnish the parents of a migrant with credible threats. These include the potential return to the village of the migrant in the final period of his life (either to retire, or, as was suggested to us by a Cameroonian student, to be buried), the desire by the migrant (who is usually a young male) to eventually wed a woman from his native village, or the eventual bequest of part of the

[6] Our model is deterministic and therefore the co-insurance aspect of the models proposed by Lucas and Stark are ignored. Similarly, we do not incorporate their argument regarding the financing by remittances of the adoption of new technologies in the agricultural sector.

parents' assets to the migrant. The precise form of the threat is likely to differ across cultures: what matters is that it exists, for it is the threat which eventually sustains the entire process, if one abstracts from altruism.

In order to be able to integrate their approach in a tractable manner into our growth model, we will assume that the failure to remit results in the guilty offspring being subject to a "social sanction" which causes him a loss of utility which is an increasing function of the magnitude of the initial gift he was provided with by his parents in order to allow him to migrate to the urban area. Let $\phi(z_{2t+1}), \phi'>0$ designate that social sanction, expressed in terms of utility.

It is interesting to note that this specific assumption is not crucial to the analysis which follows, although it does make the algebra more straightforward. For example, we could derive results similar to those which follow if we extended the lives of agents to four periods and allowed for bequests. Failure to remit would then result in the parents disinheriting the guilty child. The cost involved with such a specification is the added notation rendered necessary by the addition of one more period of intertemporal consumption decisions to the optimization problem of each agent. For ease of exposition, we will therefore confine our presentation to the social sanction specification. Note that the precise formulation of the social sanction will determine the quantitative nature of the results but that deviation (off the equilibrium path behavior) will never be observed since (i) the contract will be constructed so as to be self-enforcing and, (ii) there is no uncertainty.

The migration contract

The optimal contract offered by the agricultural parent to a potentially migrating child is the solution to the following constrained optimization problem:[7]

[7] We are more specific with the subscripts here in order to make it perfectly clear who takes what decision and the age at which he takes that decision, thus, for example, we write

$$z_{2t+1} = \arg\max_{\{z_{2t+1}\}} U_t^o(z_{2t+1}, v_{2t+2}, \ldots)$$

s.t. (C1) $V_t^o(z_{2t+1}, v_{2t+2}, \ldots) \geq V_t^o(0,0,\ldots)$
(IR: "individual rationality of contract for parent")

(C2) $V_t^m(z_{2t+1}, v_{2t+2} - \psi, \ldots) \geq V_t^m(z_{2t+1}, \phi(z_{2t+1}), \ldots)$
(IC: "no cheating by offspring")

(C3) $V_t^m(z_{2t+1}, v_{2t+2} - \psi, \ldots) - V_t^m(z_{2t+1}, \phi(z_{2t+1}), \ldots) \geq \Delta \overline{V}_t^m$
("relative bargaining power of the parties to the contract")

The individual rationality constraint for the parent (C1) states that the parent will not propose a contract if it yields less than not offering one at all. This is the key to the endogenous migration threshold effect, for if no solution to the optimization problem can be found which satisfies this condition, the parents will not offer any contracts. In some sense, calling this an individual rationality constraint is a bit of a misnomer since it actually defines the optimal response of the offspring to the parents offer, that is, it defines $v_{2t+2} = v_{2t+2}(z_{2t+1}, \ldots)$.

The incentive compatibility constraint (C2) says that it must be in the interest of the offspring to abide by the contract rather than pocketing the help from his parents in period $t+1$ and then bidding them farewell once he has a job in the city. This constraint will ensure that the contract will be *self enforcing*.

The final constraint (C3) tells us how the relative bargaining power of the two parties to the contract affects the outcome. In other words, it picks a point on the contract curve which corresponds to the solution to the

z_{2t+1} in order to make it clear that the parent takes this decision at time $t+1$ when he is of age 2, while we write v_{2t+2} so as to indicate that it is the offspring who takes this decision at time $t+2$ when he is of age 2.

problem. The greater is $\Delta \overline{V}_t^m$, the greater will be the "surplus" extracted by the offspring. Of course, there are bounds imposed upon the range over which $\Delta \overline{V}_t^m$ may vary, bounds which are defined by the preservation of the first two inequalities.

Substitution of the indirect utility function of the parent into (C1) yields, following some tedious manipulations, the following inequality:

$$(7) \qquad v_{2t+2} \geq \left(\frac{r_{t+2}^T + p_{t+2}^T}{p_{t+1}^T} \right) z_{2t+1},$$

while (C2), by a similar substitution, yields

$$(8) \qquad v_{2t+2} \leq \phi(z_{2t+1}) - \psi .$$

In order to derive closed form solutions to the problem, we will assume that the social sanction function takes the following simple form.

ASSUMPTION: $\phi(z_{2t+1}) = c z_{2t+1}^{\rho}$, with $\rho < 1$.[8]

Under this Assumption, Figure 1 provides a graphical illustration of equations (7) and (8) in (z_{2t+1}, v_{2t+2}) space. Intuitively, the contract curve is given by the locus of points at which the slope of the parent's indifference curve (C1) is equal to the slope of the offspring's indifference curve, as one varies $\Delta \overline{V}_t^m$ between zero and its upper bound. Consider the solution in z_{2t+1} to the pair of equations

$$\begin{cases} v_{2t+2} = \left(\dfrac{r_{t+2}^T + p_{t+2}^T}{p_{t+1}^T} \right) z_{2t+1} \\ v_{2t+2} = c z_{2t+1}^{\rho} - \psi \end{cases}$$

[8] Inspection of the results which follow should convince the reader that concavity is an assumption which is important in order to derive interesting and meaningful results. Convexity yields a feasible set which results in migration contracts which are determined solely by the resource constraints of the parties and do not follow from FOCs. This loss of generality is the price one has to pay to avoid use of a model with four period lives, which, we have found, is much less tractable.

which is equivalently expressed as the solution to the polynomial in z_{2t+1}:

$$\left(\frac{r_{t+2}^{T}+p_{t+2}^{T}}{p_{t+1}^{T}}\right)z_{2t+1}-cz_{2t+1}^{\rho}+\psi=0.$$

The solutions to this equation are the intersections of the line and the curve. There will be an optimal contract when the line emanating from the origin has at least one intersection with positive z_{2t+1} with the curve traced out by the IC constraint, and when the curve lies above the line. This is equivalent to saying that, for a given z_{2t+1}, the corresponding value of v_{2t+2} must be larger on the curve than on the line through the origin, for all z_{2t+1} which lie between the two intersections in the positive orthant (this is necessarily the case because of the strict concavity of the curve). This may be expressed as

$$\left(\frac{r_{t+2}^{T}+p_{t+2}^{T}}{p_{t+1}^{T}}\right)z_{2t+1}\leq cz_{2t+1}^{\rho}-\psi.$$

For the optimal contract to exist, this must necessarily be the case for a value of z_{2t+1} where the slope of the curve is equal to the slope of the line. Thus, substituting for the value of z_{2t+1} such that the slopes are equal into the above inequality, we obtain

$$\text{(9)}\qquad \psi\leq\rho^{\frac{\rho}{1-\rho}}\left(1-\rho^{\frac{\rho}{1-\rho}}\right)c^{\frac{1}{1-\rho}}\left(\frac{p_{t+1}^{T}}{r_{t+2}^{T}+p_{t+2}^{T}}\right)^{\frac{\rho}{1-\rho}}.$$

We state this as the following CONDITION:

CONDITION 1 (EXISTENCE OF AN OPTIMAL MIGRATION CONTRACT): An optimal intergenerational-intra-family migration contract exists only if

$$\frac{r_{t+2}^{T}+p_{t+2}^{T}}{p_{t+1}^{T}}\leq\psi^{\frac{\rho-1}{\rho}}c^{\frac{1}{\rho}}\rho^{-1}\left(1-\rho^{\frac{\rho}{1-\rho}}\right)^{\frac{\rho-1}{\rho}}.$$

When CONDITION 1 is satisfied, there will be at least one intersection between the line and the curve, and therefore at least one point which can be an optimal contract. The C1 curve for which CONDITION 1 just holds with equality is labeled C1 1 in Figure 1. We can summarize the preceding discussion in the following PROPOSITION.

PROPOSITION 1: The contract curve which describes the locus of equilibrium migration contracts $(z_{2t+1}^{*},v_{2t+2}^{*})$ between parents and offspring who satisfy the self-selection constraint is given by:

(i)

$$z_{2t+1}^{*}=(\rho c)^{\frac{1}{1-\rho}}\left(\frac{p_{t+1}^{T}}{r_{t+2}^{T}+p_{t+2}^{T}}\right)^{\frac{1}{1-\rho}}$$

$$v_{2t+2}^{*}\in\left[(\rho c)^{\frac{1}{1-\rho}}\left(\frac{p_{t+1}^{T}}{r_{t+2}^{T}+p_{t+2}^{T}}\right)^{\frac{\rho}{1-\rho}},\ \rho^{\frac{\rho}{1-\rho}}c^{\frac{1}{1-\rho}}\left(\frac{p_{t+1}^{T}}{r_{t+2}^{T}+p_{t+2}^{T}}\right)^{\frac{\rho}{1-\rho}}-\psi\right]$$

when CONDITION 1 is satisfied.

(ii) $(z_{2t+1}^{*},v_{2t+2}^{*})=(0,0)$ when CONDITION 1 is not satisfied.

Suppose that all the bargaining power is placed in the hands of the parent. Then the solution to the parent's constrained optimization program is given by that combination of z_{2t+1} and v_{2t+2} such that the slope of the no-cheating constraint is equal to the slope of the (C1) curve. This corresponds to collapsing the contract curve to a single point with coordinates given in (z, v) space by the value of z_{2t+1} from PROPOSITION 1, while the value of v_{2t+2} is equal to the upper bound given in PROPOSITION 1. Because of the concavity of the social sanction function $\phi(.)$ and the linearity of (C1) of the parent, this solution is unique. We summarize the optimal contract when all of the bargaining power is placed in the hands of parents in the following PROPOSITION, which is simply a special case of PROPOSITION 1:

PROPOSITION 2: When all the bargaining power is placed in the hands of the parents, the equilibrium migration contract (z^*_{2t+1}, v^*_{2t+2}) between parents and offspring who satisfy the self-selection constraint is given by:

(i) $$(z^*_{2t+1}, v^*_{2t+2}) = \left((\rho c)^{\frac{1}{1-\rho}} \left(\frac{p^T_{t+1}}{r^T_{t+2} + p^T_{t+2}} \right)^{\frac{1}{1-\rho}}, \rho^{\frac{\rho}{1-\rho}} c^{\frac{1}{1-\rho}} \left(\frac{p^T_{t+1}}{r^T_{t+2} + p^T_{t+2}} \right)^{\frac{\rho}{1-\rho}} - \psi \right)$$

when CONDITION 1 is satisfied.

(ii) $(z^*_{2t+1}, v^*_{2t+2}) = (0,0)$ when CONDITION 1 is not satisfied.

In what follows, and without loss of generality, we will consider only the case where all of the bargaining power is placed in the hands of the parents.

Migration

We must now determine the proportion of offspring in each period where CONDITION 1 holds who accept the migration contract offered by their parents, and who therefore will leave the countryside and migrate to the city. We therefore introduce a degree of heterogeneity among offspring in terms of their disutility of migrating:

ASSUMPTION: each individual is parametrized by his disutility of migration, ω, which is distributed according to the p.d.f. $f(\omega)$ over the interval $[0,+\infty)$ (without loss of generality).

Then, for each generation of agricultural offspring who face an environment where CONDITION 1 holds, we can define the "limit offspring", parametrized by ω^*, who is indifferent between remaining in the countryside and migrating to the city. More formally, introducing the heterogeneity in an additively-separable form, the value of ω^* is defined as

$$(10) \quad \omega^*_{t+1} = \left\{ \omega \ s.t. \ V^m_{t+1}(z^*_{t+1}, v^*_{t+1} - \psi, \ldots) - \omega = V^a_{t+1}(d, 0, \ldots) \right\}.$$

Note that for given values of the indirect utilities in the two sectors, there may be no individual who is indifferent between migrating and remaining in the countryside, i.e., there may be no offspring who choose to migrate although an optimal contract with strictly positive values of z_{2t+1} and v_{2t+2}, as given by PROPOSITION 1, exists (that is, CONDITION 1 is satisfied). The proportion of offspring who migrate is given by

$$(11) \quad m_{t+1} = \int_0^{\omega^*_{t+1}} f(\omega) d\omega = F(\omega^*_{t+1})$$

where $F(.)$ is the c.d.f. of the ω's.

Assume for simplicity that the ω's are distributed exponentially, so that

$$m_{t+1} = 1 - \exp(-\omega^*_{t+1}));$$

then substituting the expressions for the indirect utilities into the definition of ω^*_{t+1} yields (exploiting the logarithms in the utility function and the exponential in the cumulative density) the extremely tractable expression

$$(12) \quad m_t = 1 - \frac{d}{z^*_t - e^m_t} \left(\frac{w^e_{t+1} - (1 - m_{t+1})d}{\hat{w}^m_{t+1} - v^*_{t+1} - \psi} \right)^{\beta(1+\beta)} \left(\frac{r^T_{t+2} + p^T_{t+2}}{p^T_{t+1} R_{t+2}} \right)^{\beta^2}.$$

We can now provide a formal definition of the endogenous migration threshold.

ENDOGENOUS MIGRATION THRESHOLD: the endogenous migration threshold is defined as a time t^* at which the state of the system is such that (i) CONDITION 1 is satisfied, and (ii) given that CONDITION 1 is satisfied, we have $\omega^*_{t^*} \geq 0$.

It is worth noting that zero migration $(m_t = 0)$ does not entail wage equalization between the two sectors, indeed (as will be shown below), steady-state growth is associated with increasing divergence between sectoral wage rates. More importantly, the existence of a wage gap between the agricultural and urban areas is not dependent upon the existence of urban unemployment (as in Harris-Todaro type models) but rather is a result of (i) the explicitly intertemporal nature of the indirect utility comparisons inherent in the migration equation, and (ii) the presence of the "wedge" induced by the optimal migration contract.

4. PRODUCTION

We now specify the production side of the model. This largely follows standard lines, although we will highlight certain assumptions which depart from the dualistic growth literature.

Production

Recall from Part I that production in the urban sector is carried out through an aggregate production function, homogeneous of degree one, which takes the form

$$(13)\quad Y_t = AF(K_t, L_t) = AK_t^{\alpha} L_t^{1-\alpha},\ \alpha \in (0,1),\ A > 0,$$

and where each individual laborer of type $i = m,u$ furnishes

$$(14)\quad L_t^i = h(e_{t-1}^i, \bar{e}_{t-2}) = (e_{t-1}^i)^{\lambda} (\bar{e}_{t-2})^{1-\lambda},\ \lambda \in (0,1)$$

units of "effective" labor. The evolution of the urban population is given by

$$(15)\quad N_t^u = N_{t-1}^u + M_{t-1}.$$

Production in the agricultural sector is given by

$$(16)\quad X_t = BG(T, N_t^a)\bar{e}_{t-1}^{\theta} = BT^{\delta}(N_t^a)^{1-\delta}\bar{e}_{t-1}^{\theta}$$

with the evolution of the rural population given by

$$(17)\quad N_t^a = N_{t-1}^a - M_{t-1}.$$

The term $\bar{e}_{t-1}^{\theta}$ represents a spillover to the agricultural sector stemming from the average level of human capital in the urban sector in the preceding period. Although this assumption is not critical to the structure of the model and the qualitative nature of the results which follow, it is an important determinant of the magnitude and rate of expansion of intersectoral wage gaps. The spillover is assumed to arise because higher levels of human capital in the urban area lead to improvements in agricultural technology (both biological, such as the new seed varieties of the Green Revolution, and mechanical, such as more efficient harvesting equipment). It should be obvious, since it increases the marginal productivity of labor in agriculture, that a sustained increase in the spillover effect will reduce the magnitude of the wage gap, but that unless the spillover is linearly homogeneous, wage gaps will inevitably emerge and grow over time. Finally, note that the stock of land is given by T and is fixed. The FOCs for profit maximization in urban and agricultural production yield:

native urban labor: (18) $\hat{w}_t^u = AF_{N^u} = A(1-\alpha)k_t^{\alpha}(e_{t-1}^u)^{\lambda}(\bar{e}_{t-2})^{1-\lambda}$,
migrant labor: (19) $\hat{w}_t^m = AF_M = A(1-\alpha)k_t^{\alpha}(e_{t-1}^m)^{\lambda}(\bar{e}_{t-2})^{1-\lambda}$,
agricultural labor: (20) $w_t^a = p_t BG_{N^a} = p_t B(1-\delta)T^{\delta}(N_t^a)^{-\delta}\bar{e}_{t-1}^{\theta}$,
physical capital: (21) $1 + r_t = R_t = AF_K = A\alpha k_t^{1-\alpha}$,

while the rental rate on land is given by

$$(22)\quad r_t^T = \frac{p_t BT^{\delta}(N_t^a)^{1-\delta}\bar{e}_{t-1}^{\theta} - w_t^a N_t^a}{T}.$$

5. AGGREGATION, EQUILIBRIUM AND STEADY STATE GROWTH

Equilibrium in the two goods markets at time t (given the linear within-period utility functions) is given by

$$X_t + Y_t = \sum_{j=1}^{j=3} N^u_{t-j+1}\left(y^u_{jt} + x^u_{jt}\right) + \sum_{j=1}^{j=3} N^a_{t-j+1}\left(y^a_{jt} + x^a_{jt}\right) + \sum_{j=1}^{j=3} M_{t-j+1}\left(y^m_{jt} + x^m_{jt}\right) + K_{t+1} + N^u_t e^u_t + M_t e^m_t \tag{23}$$

where the L.H.S. is aggregate supply, the R.H.S. is the usual national income accounting identity of aggregate consumption plus investment in physical and human capital, and where the individual demands for each class of agent at each age are given by

$$y^u_{1t} + x^u_{1t} = (\gamma - \lambda)\frac{\hat{w}^u_{t+1}}{R_{t+1}}; \tag{24}$$

$$y^u_{2t} + x^u_{2t} = \frac{1-\gamma}{1+\beta}\hat{w}^u_t; \tag{25}$$

$$y^u_{3t} + x^u_{3t} = R_t\frac{\beta(1-\gamma)}{1+\beta}\hat{w}^u_{t-1}; \tag{26}$$

$$y^a_{1t} + x^a_{1t} = d; \tag{27}$$

$$y^a_{2t} + x^a_{2t} = \frac{1}{1+\beta}\left(w^a_t - m_t z_t - (1-m_t)d + \frac{p^T_t}{r^T_{t+1} + p^T_{t+1}} m_t v_{t+1}\right); \tag{28}$$

$$y^a_{3t} + x^a_{3t} = \frac{\beta}{1+\beta}\left(\left(\frac{r^T_t + p^T_t}{p^T_{t-1}}\right)\left(w^a_{t-1} - m_{t-1}z_{t-1} - (1-m_{t-1})d\right) + m_{t-1}v_t\right); \tag{29}$$

$$y^m_{1t} + x^m_{1t} = z_t\left(1 - \frac{\beta\lambda\hat{w}^m_{t+1}}{\hat{w}^m_{t+1}\left(\frac{1}{1+\beta} - \beta\lambda\right) - \left(\frac{v_{t+1}+\psi}{1+\beta}\right)}\right); \tag{30}$$

$$y^m_{2t} + x^m_{2t} = \frac{1}{1+\beta}\left(\hat{w}^m_t - v_t - \psi\right); \tag{31}$$

$$y^m_{3t} + x^m_{3t} = \frac{\beta R_t}{1+\beta}\left(\hat{w}^m_{t-1} - v_{t-1} - \psi\right); \tag{32}$$

$$e^u_t = \frac{\lambda}{R_{t+1}}\hat{w}^u_{t+1}; \tag{33}$$

$$e^m_t = \frac{\beta\lambda\hat{w}^m_{t+1}z_t}{\hat{w}^m_{t+1}\left(\frac{1}{1+\beta} - \beta\lambda\right) - \left(\frac{v_{t+1}+\psi}{1+\beta}\right)}. \tag{34}$$

Finally, equilibrium on the market for land is given by

$$\bar{T} = N^a_t l^a_t. \tag{35}$$

Capital market equilibrium

Net aggregate wealth in this economy at time t is equal to the sum of the wealth of age two urbanites and migrants, *minus* the debt of age one urbanites. This can be written as

$$W_t = N^u_{t-1}\left(\frac{\beta(1-\gamma)}{1+\beta}\hat{w}^u_t - \frac{\gamma}{R_{t+1}}\hat{w}^u_{t+1}\right) + M_{t-1}\left(\frac{\beta}{1+\beta}\hat{w}^m_t - v_t - \psi\right). \tag{36}$$

Assuming full depreciation of physical capital each period (partial linear depreciation adds nothing to the model), the capital market equilibrium condition can be written as

$$K_{t+1} = W_t. \tag{37}$$

Note that Walras's law ensures that the labor market is necessarily in equilibrium as well.

Steady-State Growth

We now examine a balanced growth path, which we are able to define analytically. The transitional dynamics of the migration process itself will be dealt with in the next section which presents numerical simulations of the model.

DEFINITION: a balanced growth path is defined as a situation in which (i) all agents are optimizing, (ii) all variables in the urban sector grow at a common constant rate, (iii) all variables in the agricultural sector grow at a (different, because of the concavity of the spillover effect from the urban area) common constant rate, and (iv) migration is zero: $m_t = M_t = 0$.

Portions (ii) and (iii) of the definition of a balanced growth path can be written

$$(38)\quad \frac{K_{t+1}}{K_t}=\frac{L^u_{t+1}}{L^u_t}=\frac{\hat{w}^u_{t+1}}{\hat{w}^u_t}=\frac{Y_{t+1}}{Y_t}=\left(\frac{X_{t+1}}{X_t}\right)^{\frac{1}{\theta}}=\left(\frac{r^T_{t+1}}{r^T_t}\right)^{\frac{1}{\theta}}=\left(\frac{w^a_{t+1}}{w^a_t}\right)^{\frac{1}{\theta}}=g,$$

where g is the common growth rate, and it is worth recalling that $\theta \in (0,1)$ is the exponent on the spillover effect from the accumulation of human capital in the urban area to the agricultural sector.

Define capital per capita in terms of efficiency units of labor as

$$(39)\quad k_t=\frac{K_t}{N^u_t e^{\lambda}_t e^{1-\lambda}_{t-1}}.$$

Then substituting into the capital market equilibrium condition (equation 37) and applying the steady-state conditions yields

$$(40)\quad g=\frac{\beta(1-\gamma)}{1+\beta}A(1-\alpha)k_t^{\alpha-1}\frac{1}{\left(1+\frac{\gamma(1-\alpha)}{\alpha}\right)}.$$

The balanced growth path condition applied to the accumulation of human capital yields

$$(41)\quad \frac{e_t}{e_{t-1}}=g=\left(\frac{\lambda(1-\alpha)}{\alpha}k\right)^{\frac{1}{1-\lambda}}.$$

Solving equations (40) and (41) simultaneously yields the steady-state values of the growth rate of variables ($\bar{g}$) and of the level of the capital stock per efficiency unit of labor ($\bar{k}$):

$$(42)\quad \bar{g}=\left(\frac{\lambda(1-\alpha)}{\alpha}\right)^{\frac{1}{1-\lambda}}\left(\frac{\frac{\beta(1-\gamma)}{1+\beta}A(1-\alpha)}{\left(1+\frac{\gamma(1-\alpha)}{\alpha}\right)\left(\frac{\lambda(1-\alpha)}{\alpha}\right)^{\frac{1}{1-\lambda}}}\right)^{\frac{1}{1+(1-\alpha)(1-\lambda)}};$$

$$(43)\quad \bar{k}=\left(\frac{\frac{\beta(1-\gamma)}{1+\beta}A(1-\alpha)}{\left(1+\frac{\gamma(1-\alpha)}{\alpha}\right)\left(\frac{\lambda(1-\alpha)}{\alpha}\right)^{\frac{1}{1-\lambda}}}\right)^{\frac{1-\lambda}{1+(1-\alpha)(1-\lambda)}}.$$

Note that the economy goes through three phases during the growth process: (i) a "preliminary balanced growth" phase in which there is no migration and, given initial conditions, the dynamics are described by equations (42) and (43); (ii) once the conditions for the endogenous growth threshold (given above in CONDITION 1) are satisfied, migration begins and the transitional dynamics eventually bring one to (iii) the final balanced growth path described once again by equations (42) and (43).

While the dynamics are apparently complex, the intuition behind this sequence is extremely straightforward. In the initial phase, the level of human capital in the urban areas is so low that the return to parents from investing in migrating children is lower than the return to investing in land. Therefore no strictly positive optimal migration contract exists (in terms of Figure 1, there is no intersection between the concave curve and the line, that is, the C1 line is strictly steeper than C1$_1$) and no migration takes place. In the second phase, the endogenous migration threshold is reached (which, in Figure 1, corresponds to C1$_1$). The threshold essentially corresponds to a critical level of human capital in the urban area such that it now becomes optimal for the parents to invest in migrating children (at the threshold itself, they are just indifferent). Note that, even with a strictly positive optimal migration contract as given by PROPOSITION 2, there may be no children who self-select into the contractual relation —it all depends upon the distribution of the costs to migrating (more particularly, on their lower bound). Thus, CONDITION 1 is a necessary but not a sufficient condition for the beginning of migration (we have constructed the figure for the case where we are to the left of the $m=0$ curve which corresponds to the state of the system at that time, so that $m>0$ if CONDITION 1 is satisfied). Once migration begins, the progressive transfer of the population out of the agricultural areas raises the agricultural wage (in Figure 1, this corresponds to C1 lines between

$C1_1$ and $C1_{SS}$). Eventually, even the increase in urban human capital (and thus the urban wage) is not sufficient to outweigh the effect of labor scarcity in the agricultural areas. While the parents continue to offer a strictly positive optimal migration contract to their children, there will eventually be no children who satisfy the self-selection condition. Migration then stops (in Figure 1, we have reached $C1_{SS}$ where the corresponding $m = 0$ curve passes through the point which represents the optimal migration contract) and the economy proceeds along the balanced growth path described by equations (42) and (43) (to the right of the steady-state $m = 0$ curve, migration is by definition equal to zero).

6. The Transitional Dynamics of the Migration Process: Simulation Results for the Model

We now proceed to study the transitional dynamics of the model through the use of dynamic simulations.[9] This allows us to map out the dynamics of a number of key variables and ratios which have been the subject of considerable debate in the development literature, both in terms of theoretical investigations and in terms of empirical work. For the purpose of comparing the results of our model with the stylized empirical facts, we have organized our discussion into five themes: (i) the pattern of urban growth, (ii) the pattern of remittances over time, (iii) wage gaps, both between sectors and between native urbanites and migrants, (iv) the evolution of relative inequality over time, (v) patterns of growth and structural change. When no empirical facts exist which can confirm or disprove the results of our simulations, we formulate simple conjectures which could be tested empirically should the necessary data become available. The parametrization of our system (available upon request from the authors) yields an endogenous migration threshold in the sixth period, while migration ends in the forty-eighth period. It is worth noting that we plot variables associated with migration for the initial six periods, even though migration does not occur: this is because these are the *potential*

[9] Simulations were performed in the C programming language. Approximately 4000 lines of code were necessary and simulations were performed on a Silicon Graphics workstation.

values of those variables before it is in the interest of any potential migrant to accept the migration contract. As an illustration of the correspondence between theory and the numerical simulations, Figure 1a plots the simulated counterpart to Figure 1.[10]

The pattern of urban growth

Figure 2 plots the evolution of the urban population and the agricultural population. Note that the urban population follows the standard logistic curve pattern which has been observed for city growth in a number of contexts (see Preston (1979), United Nations (1980), as well as the classics by Hoselitz (1955, 1957) and Bairoch (1975)). It is also worth recalling that this is the portion of urban growth attributable to migration (since we have assumed a zero population growth rate). The logistic pattern implies that the number of migrants increases at an increasing rate until the inflection point is reached, and then increases at a decreasing rate until migration stops. Thus our model is consistent with the observed empirical pattern of city growth.

Another empirical question is whether the pattern of city *growth rates* is consistent with our model based on intergenerational/intrafamily migration contracts. If this is the case, LDCs where the remittance issue is important should follow the pattern suggested by our model whereas other areas should not. Broadly speaking, and as noted in the introduction, the remittance issue is relevant for Africa, East Asia, and South Asia. It is not a key factor in rural to urban migration in Latin America. Figure 3 plots the growth rate of the urban population over time, and displays a hump-shaped pattern. Table 2 gives city growth rates for the regions of the world which were mentioned above, based upon available data and United Nations projections.

[10] It is worth noting that the approximate range of the optimal migration contracts we have simulated is relatively limited. Since there is no empirical time series evidence with which this finding can be compared, it will form the basis for one of our conjectures.

Table 2
City growth rates (percentage per annum)

Time period	1950-1960	1960-1970	1970-1975	1975-1980	1980-1990	1990-2000
Africa	4.42	4.85	4.97	5.10	5.00	4.56
East Asia	4.16	5.20	4.52	4.00	3.33	2.36
South Asia	3.37	3.91	4.01	4.33	4.47	4.27
Latin America	4.57	4.21	4.01	3.86	3.56	3.06

Source: United Nations (1980).

Note that Africa, East Asia (except for China and Japan) and South Asia all follow (or will follow, according to the best projections available) the hump-shaped pattern predicted by our model, whereas Latin America does not. Indeed, in Latin America the growth rate of the urban population is steadily decreasing over time. It is of course possible that Latin America does follow a hump-shaped pattern and that if pre-1950 data were available, we could detect it. On the other hand, the rural to urban migration issue in LDCs is essentially a post-World War II phenomenon, and it thus seem plausible to infer that our model does provide an explanation of the evolution of urban growth rates for those regions of the world where the remittance issue is important, while it is not consistent with the data from the one region of the world where, *a priori*, one would not expect it to work.

The pattern of remittances

The available empirical evidence on individual remittances is relatively scant (see Johnson and Whitelaw (1974), Knowles and Anker (1981), Stark (1980a), Stark (1981), Lucas and Stark (1985)). What evidence there is suggests that remittances represent a sizable portion of migrant incomes. In their survey of the issue, Rempel and Lobdell (1978) arrive at figure of 10-13% in the case of Africa. Papola (1981) suggests a similar figure for South Asia. While the above-mentioned studies do provide snapshots of the level of individual remittances in a number of contexts, there is very little time series evidence on this issue. Figure 4 plots the pattern over time of individual remittances, the initial sum brought by the migrants to the city, and the difference between the two. Figure 5 plots similar graphs for the corresponding aggregate figures. These two figures allow us to formulate two conjectures:

CONJECTURE 1: the magnitude of remittances from the countryside at the individual level is roughly constant during the migration process, as is the sum brought by migrants with them from the countryside to begin with, and as are *net* remittances.

CONJECTURE 2: the patterns of aggregate remittances is hump-shaped over the duration of the migration process; the same is true of aggregate *net* remittances.

CONJECTURE 1 puts us down squarely in the camp of Stark (1980a) and Lucas and Stark (1985) in the debate over net remittances, since these authors hold that net remittances are important, while the opposite view (that net remittances are roughly zero, that is, that z and v cancel out) is held by Rempel and Lobdell (1978). CONJECTURE 2, on the other hand, must await additional time series empirical evidence.

Wage gaps

A central premise of the Harris-Todaro (1970) model is increasing wage gaps at the intersectoral level. Given the endogenous growth framework adopted in this paper and the fact that the productivity spillover from urban areas to rural areas is not homogeneous of degree one, it would be surprising if one found anything but increasing intersectoral wage gaps in our simulations. This is indeed the case and is shown in Figure 6, which plots the logarithms of agricultural, migrant, and native urbanite wages over time (as noted above, the migrant wage in periods one to six is the wage that they would *potentially* have earned if they had decided to migrate).

Empirical evidence on wage gaps is mixed. Williamson (1985a) finds increasing wage gaps during the English Industrial Revolution but, as with all empirical work done on this topic, the problem of the appropriate deflator or cost of living index to be applied to nominal urban *versus* nominal rural wages remains. Similar evidence on increasing nominal rural-urban wage gaps for LDCs is provided by Kannappan (1985), Gregory (1975), and Glytsos (1977). Thus, while our simulation results are consistent with the available empirical evidence, the empirical evidence itself is open to question.

A question more amenable to empirical verification is the difference between the wages of migrants and native city dwellers. Essentially the issue boils down to whether migrants earn more or less than native urbanites, and whether any observed differences stem from migrant status *per se* of from other factors, such as differences in human capital levels. In her 1977 survey, Yap concludes that migrants do indeed on average earn less than native city dwellers. The difference, however, is not determined by migrant status as such. Indeed Yap (1976, 1977) suggests that "incomes of urban dwellers are more a function of education and skill levels than of migration status." In our model this is indeed the case, and it is so *by the very construction of the model*. This is because migration status determines the level of human capital accumulation, which in turn determines the extent of the wage gap between migrants and native urbanites. Thus, one would expect in our model that wage gaps should be smaller when one controls for human capital, although a wage gap should still remain because of differences in first period income. This is confirmed in Figure 7 which plots the percentage of the wage gap between migrants and native urbanites which is not explained by differences in individual human capital. In the first period in which migration begins (period six), the portion of the wage gap unexplained by individual human capital in on the order of 8 percent, and declines steadily to approximately one percent, at which point migration ceases. Thus, our model is very much consistent with the empirical regularity on migrant-native urbanite wage gaps noted by Yap (1976, 1977).

A similar discussion applies to urban-rural wage gaps. In an empirical study of Brazilian males, Behrman and Birdsall (1983) find that controlling for human capital eliminates most of the differences in wages between urban and rural dwellers. This empirical finding is supported by the historical literature on the British Industrial Revolution (Williamson (1985b), and migration into American cities Higgs (1971), Chiswick (1979), Hannon (1982), Williamson (1982)). Figure 8 plots the portion of the rural-urban wage gap explained by migration status (versus differences in human capital accumulation; note also that on the urban side we are considering the weighted average of native urbanite and migrant wages). Apart from the first three periods of migration (periods 7 to 10), where the wage gap controlling for human capital is much greater than the wage gap when one does not control for human capital, the portion of the urban-rural wage gap left unexplained by differences in human capital varies between 2 percent and 33 percent, and stabilizes, once migration ends and one is in balanced growth, at around 8 percent. Thus our model is consistent with the available empirical evidence which attributes most of rural-urban wage gaps to differences in human capital.

Finally, note that Figure 6 confirms that, once migration has begun (i.e., after the endogenous migration threshold has been passed) migrants improve their earnings over their rural options, one of the few empirical regularities which does not appear to be open to question (see Yap (1977), Nelson (1979), and Mohan (1980)).

Relative inequality and the Kuznets hypothesis

Figure 9 plots the degree of relative inequality in the economy over time. As one would expect from the vast literature on development and inequality beginning with Lewis (1954), we find an inverted-U shaped pattern of inequality following the beginning of the migration process (inequality is decreasing in the period preceding the beginning of migration).[11] Thus, our model yields a Kuznets process in which the degree of relative inequality follows a hump-shaped pattern over time.

Patterns of growth and structural change

Figure 10 plots the growth rate of GDP per capita over time. Note how the growth rate increases from the beginning of migration and stabilizes once we reach period 25. If we define the simulated economy to be "low income" during the first 25 periods and "middle income" from then until migration ends, then our results are consistent with the available evidence. Such evidence as there is stems largely from cross-sectional work (see Syrquin (1986) and the work cited therein) and indicates that middle income countries grow at significantly higher rates than low income countries.

Figure 11 plots the sectoral distribution of output. As one would expect, given the behavior of the rural and urban populations over time (Figure 2), the proportion of GDP accounted for by the urban area increases rapidly, more rapidly indeed than its share of the total working-age population. The reason behind this is not hard to find and is displayed in
Figure 12 which displays *sectoral* output growth rates. Here we find that the growth rate of the urban sector is always greater than the growth rate of the agricultural sector (this stems from the intersectoral productivity spillover which is homogeneous of degree less than one). Thus, the pattern over time of the growth rate of per capita GDP is determined by (i) changes in sectoral shares and (ii) differences in sectoral rates (this is the crux of the conclusion reached in the empirical literature on this topic; for the LDCs, see Syrquin (1986), Chenery and Syrquin (1986a, 1986b); for the historical evidence, see Kuznets (1966, 1971), Adelman and Morris (1984), and Crafts (1984)). Moreover, as one would expect in a model where endogenous growth is driven by the accumulation of human capital, the capital stock per efficiency unit of labor tends towards a steady (and constant) level as the final balanced growth path is approached. This is

[11] See, however, Anand and Kanbur (1993a, 1993b) for a recent reappraisal.

shown in Figure 13, and is consistent with the recent empirical evidence linking growth, investment, and human capital (see Barro (1991)). Thus, based upon the examination of our simulation results, our model is broadly consistent with the observed patterns of growth and structural change.

7. Concluding Remarks

The overlapping generations model presented in this paper, which incorporates the optimal migration contract framework developed by Lucas and Stark, is the first model we are aware of in the literature which derives, to paraphrase the term coined by Azariadis and Drazen (1990), an *endogenous* "threshold externality." Instead of *imposing* a bifurcation in the dynamics of the model by assuming, in an *ad hoc* fashion, that there exists a critical level of human capital, we have derived such an effect *as the consequence of the optimizing behavior of rational agents.* The conditions under which migration begins were shown to depend critically upon the level of human capital in the urban area, as well as upon the return to investing in land in agricultural areas. As such, we have demonstrated, in the context of a dynamic model solved for general equilibrium, that migration can be seen as the consequence of agricultural parents seeking to smooth their intertemporal consumption profile by "investing" in offspring who migrate to urban areas.

Moreover, we have compared the dynamics of a number of key variables generated through numerical simulations of the model with their empirical counterparts and with the received wisdom of the development literature. We found our model to be broadly consistent with those facts. Other models in the dualistic growth literature are similarly consistent with *some* of those facts, but they do not incorporate the phenomenon of remittances explicitly, and thus cannot generate the interesting dynamics of migration yielded by our model, and which, historically speaking, appear to be correct.

Does this model provide an explanation for migration and dualistic growth at all times and in all countries? The answer is surely no, because remittances in and of themselves are a phenomenon associated with certain regions of the world, and not with others. As mentioned above, our model appears to be extremely well-suited to Africa, as well as to East and South Asia. For Latin America some other explanation must be sought, and it is certainly not to be found in intergenerational/intrafamily contracts. Perhaps, and this leads us to possible extensions of our basic model, altruism is part of the answer. Were one to substitute optimal migration contracts with intergenerational gifts motivated by altruism (see Zang and Nishimura (1993) for a recent example), the dynamics of the system would almost certainly be vastly different. Comparing the numerically simulated dynamics of such a model with those of the migration contract-based model and with the stylized facts presented above would allow one to begin answering the vexing question of whether it is altruism or individually rational concerns which provide a better explanation for the observed pattern of migration and development over the past two centuries.

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Figure 1
An Illustration of Condition 1,
Proposition 1 and Proposition 2

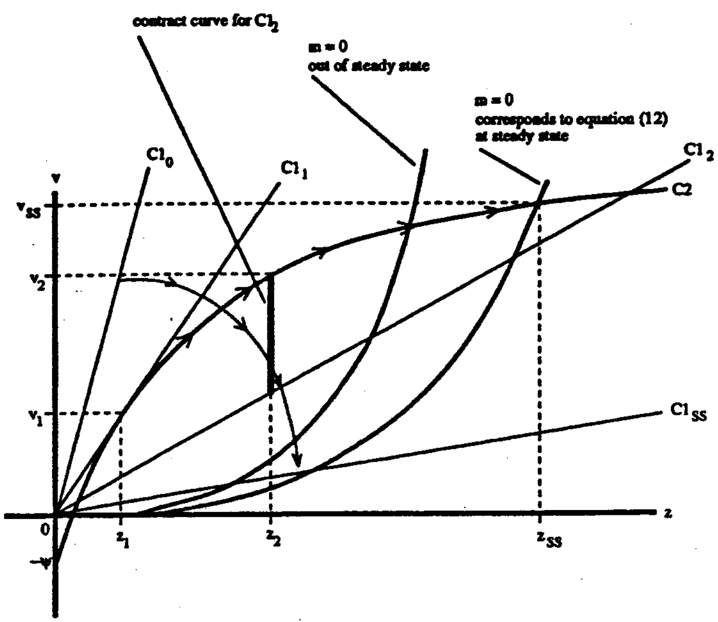


Figure 1a
An illustration of Proposition 2:
comparison between theoretical
and simulated optimal contracts

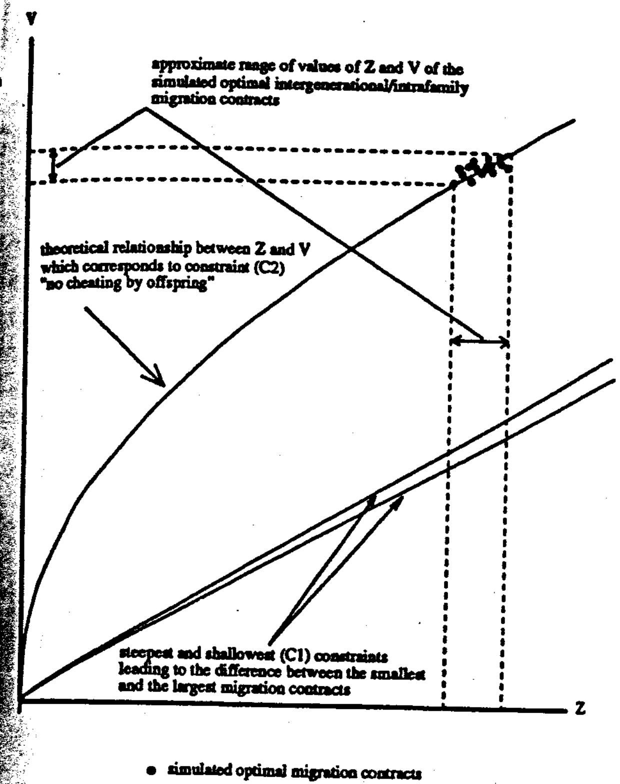


Figure 2: evolution of urban and agricultural populations

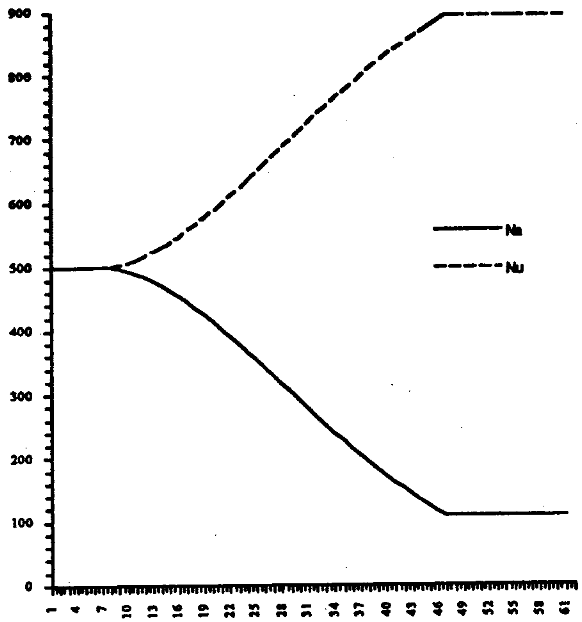


Figure 3: evolution of the growth rate of the urban population

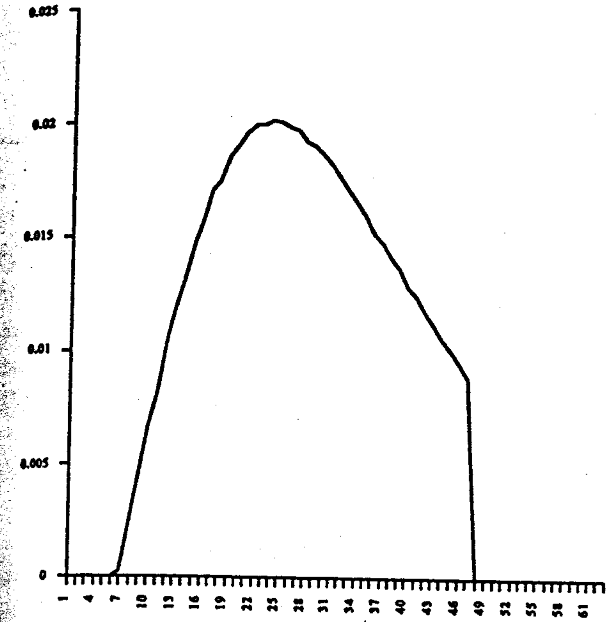


Figure 4: evolution of initial parental paymen' remittances, and net remittances

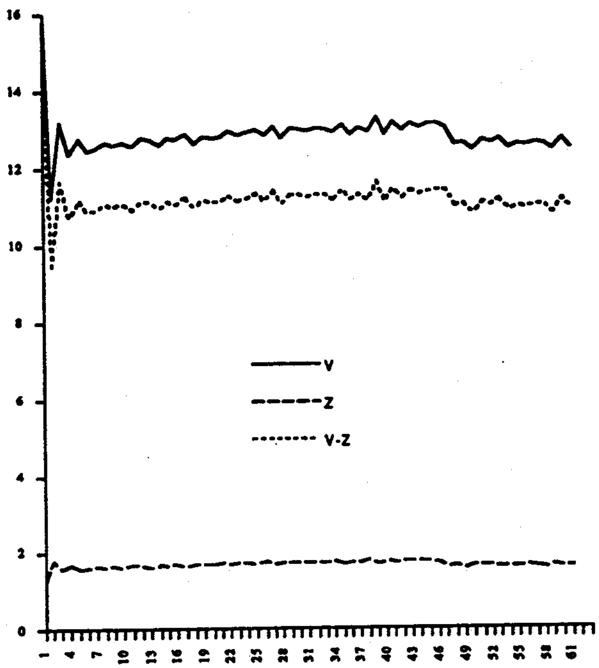


Figure 5: evolution of aggregate initial parental payments, aggregate remittances, and aggregate net remittances

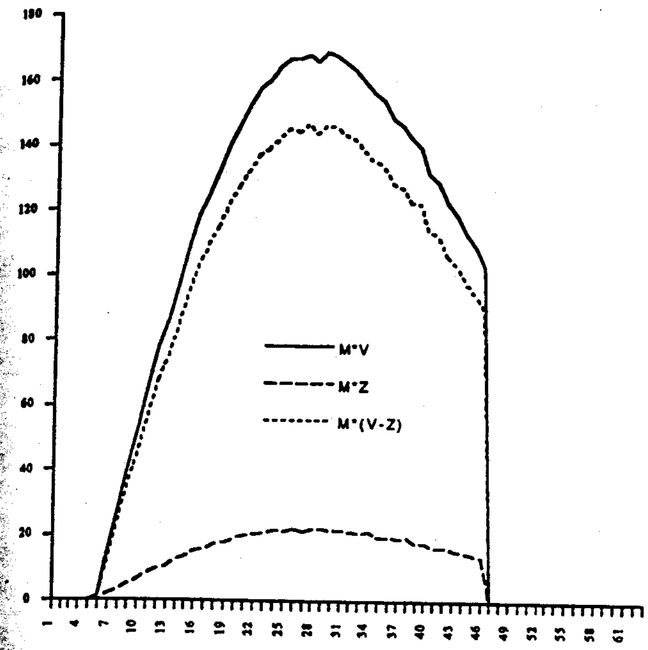


Figure 6: logarithms of agricultural, migrant, and native urbanite wages

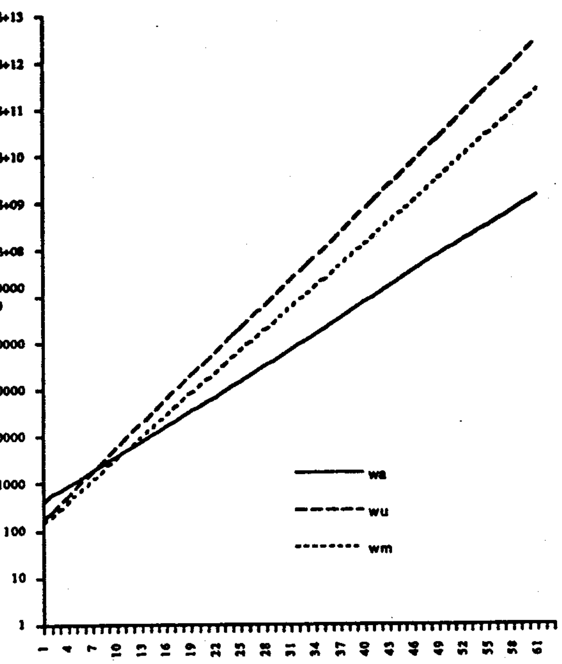


Figure 7: percentage of wage gap between migrants and native urbanites unexplained by differences in individual human capita

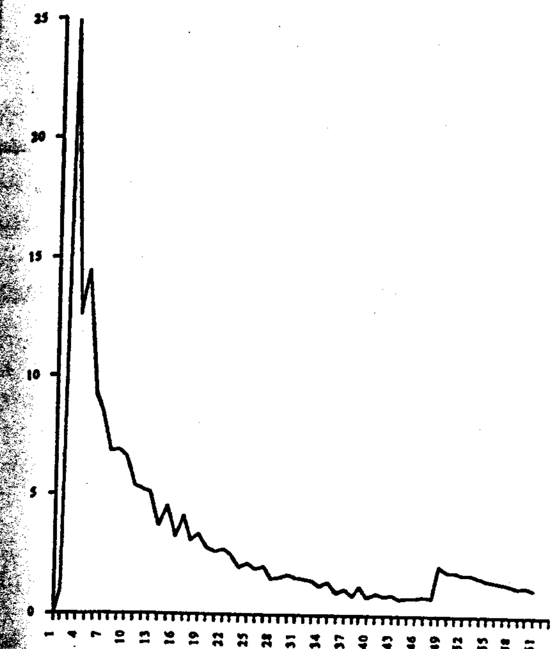


Figure 10: growth rate of GDP per capita

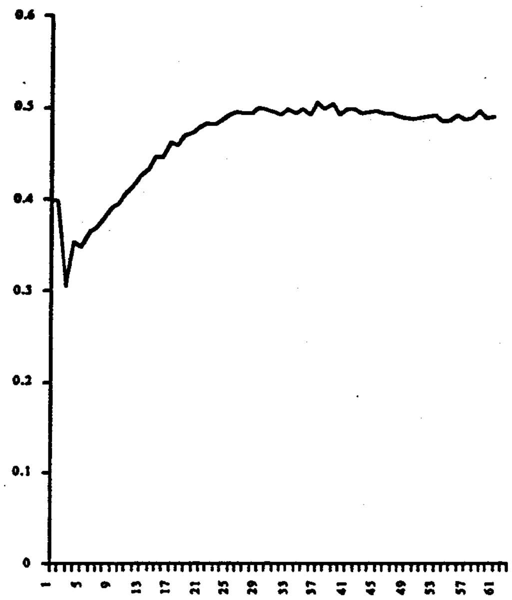


Figure 11: agricultural and urban sectors as proportions of GDP

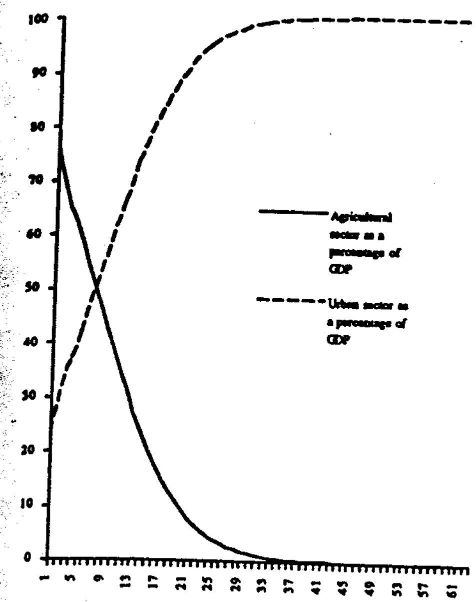


Figure 12: growth rates of agricultural and urban sectors

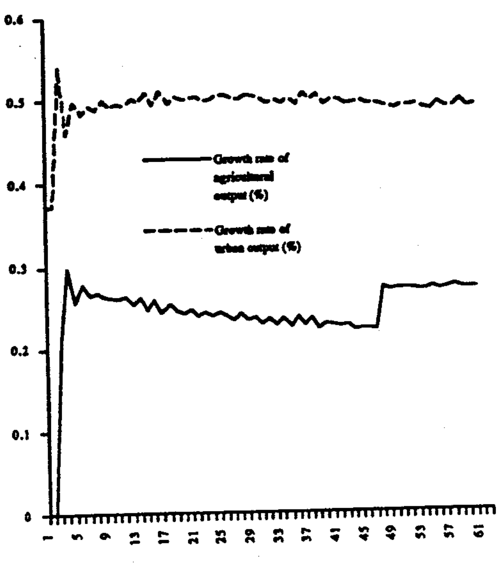
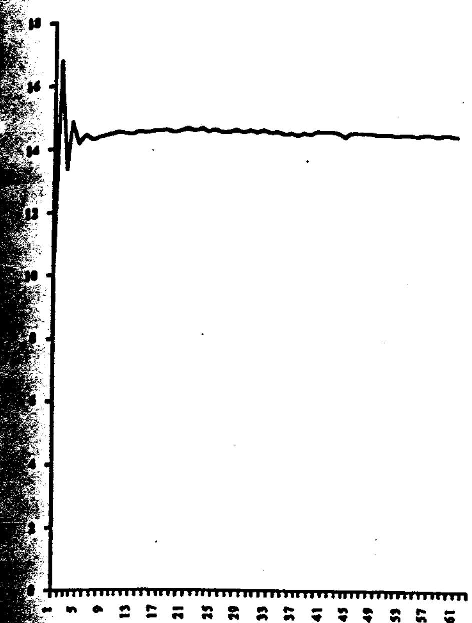


Figure 13: capital stock per efficiency unit of labor (K/Lu)



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