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The Case of Ghana

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Agriculture and Structural Transformation in an Open Economy: The Case of Ghana*

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Abstract

Previous literature has shown that in poor countries with no access to international markets, low agricultural productivity implies that large fractions of the workforce must be employed in food production. Until a country can escape what Schultz (1953) termed "the food problem," it is difficult for the economy to begin the process of releasing workers and productive resources to other sectors of the economy. This paper argues that, even in an open economy, the same dynamics can apply – and that low agricultural productivity can constrain the process of structural transformation. The key insight is that domestic transport costs make it expensive to supply food to rural areas, implying that many rural people will remain engaged in subsistence food production even through their productivity is quite low. We use a multi-region multi-sector model, calibrated to data from Ghana, to argue that high domestic transportation costs can reduce the benefits of openness.

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1. Introduction

In many of the poorest countries in the world, large fractions of the workforce live in rural areas and devote themselves to producing staple foods for home consumption or for local markets. Productivity levels in subsistence food production can be shockingly low. Previous studies have argued that this phenomenon can be explained by what Schultz (1953) termed "the food problem." In this view, because of non-homotheticities in preferences, closed economies must find ways to satisfy their food needs through domestic agricultural production before they can release labor and other productive resources into other sectors. As a result, we should expect that in closed economies with low agricultural productivity, many people will work in agriculture. High domestic transport costs compound this problem; as Gollin and Rogerson (2012) have argued, in a high transaction cost environment, we will find further that many people produce food for their own consumption.

But this logic does not seem to apply to open economies. For poor economies with low agricultural productivity, a natural question is why we should still find many people in the agricultural sector. From a Ricardian perspective, it would seem to make sense for these economies to import food and to export some other goods – for example, low-skill manufactures – that they can produce with some comparative advantage. Why then do we see such large fractions of the population in subsistence or quasi-subsistence agriculture, even in countries with good access to international markets? This paper considers the case of Ghana, a coastal economy in West Africa that has excellent links to international markets (and that trades quite heavily). Ghana is a significant exporter of cocoa and other agricultural and non-agricultural commodities, including gold. Why, then, are so many households in Ghana engaged in subsistence agricultural production?

This paper seeks to address the question by examining the logic of the subsistence agricultural economy in a country with good access to international markets. A central theme in the paper is that agricultural goods are costly to move across space, meaning that even in an open economy, there may be areas of the country where the import parity price of food may be substantially above the cost of production. While some people may migrate to coastal cities to seek non-agricultural jobs and to eat imported food, others may find that they can achieve comparable levels of utility by remaining in rural areas and home producing their own food and other goods.

We explore these issues using a dynamic model of a small open economy, in which domestic markets are in general equilibrium but in which certain international prices are taken as given. We believe that this is a useful framework for thinking about Ghana. Although the model is perforce somewhat stylized, we have designed the model economy to display some of the principal features of the Ghanaian economy, and the model itself reproduces key moments of the data. As a result, we believe that the experiments we conduct on the model economy can be viewed as having some validity for thinking about the policy issues facing Ghana.

This paper is organized as follows. In a brief introduction, we describe some of the salient features of the Ghanaian economy, emphasizing the linkages between urban and rural sectors. This is followed by a discussion of related literature, focusing on the contributions of our paper. We then describe our model economy and explain its properties. From this, we move to a discussion of the calibration of a benchmark economy, including an explanation of the parameter values that we use and an assessment of the model economy and its properties. We then report on the results of a series of experiments conducted on the model economy. We argue that the outcomes of these experiments can shed light, with plausible exeternal validity, on the real Ghanaian economy. The paper ends with a discussion of our research findings and the directions for future research.

2. Background

Ghana is a poor and largely rural economy. This section of the paper sketches out some of the key features of the Ghanaian economy that we will attempt to model. We focus here on the issues of primary relevance for our research questions: the characteristics of the rural and agricultural economy, the differences in living standards between rural and urban areas, the productivity of the agricultural and non-agricultural sectors, and the transportation and transaction costs that impede the movement of goods between different regions of the country.

A. Basic demographics and population characteristics

The fifth round of the Ghana Living Standards Survey (GLSS5), a nationally representative household survey completed in 2005-06, estimated that 13.8 million of Ghana's 22.2 million (62 percent) lived in rural areas (Ghana Statistical Service 2008, p. 4). Most rural households, and some defined as non-rural, operated farm enterprises; the survey suggested that 3.4 million households operated farms in 2005-06, out of a total of 5.5 million households (64 percent).

Labor force participation rates vary by age and location, but they are higher at all ages for rural areas than for urban areas. Over 85 percent of those aged 25-64 report being economically active in the GLSS5 data, with participation rates in rural areas over 90 percent. Rural areas are also characterized by relatively high rates of economically active children, with 19.0 percent of the population 7-14 economically active. Women in Ghana are generally engaged in economic activity, with labor force participation rates for the country as a whole of 53.4 percent compared with 54.9 percent for men. Over 80 percent of women age 25-64 were economically active (pp. 35-36).

Most Ghanaians work either for themselves or in family enterprises, with only 17.6 percent classified as employees and 75.4 percent classified as own account workers or "contributing family members". More than half of the currently employed population aged 15-64 (55.7 percent) were engaged in agriculture, with most either self-employed or contributing family workers. Non-agricultural employment looks fairly similar; 25.4 percent of non-agricultural workers were either self-employed or worked in household enterprises (p. 36).

Large fractions of the population have low levels of education; about one-third of the population aged 15 and above had never been to school, according to the data (30.8 percent), with higher rates for women (38.3 percent). Only 13.6 percent of the population aged 15 and above had completed secondary school or higher, according to the GLSS5 (p. 11). Partly in consequence, adult literacy rates were relatively low, with only 50.9 percent of adults able to read and write (in either English or a local language). In rural areas, the rates were even lower, with only 38.2 percent of the adult population literate. Certain areas of the country had even lower literacy rates, with the northern savannah zone having adult literacy rate of 22.2 percent (GLSS5, pp. 13-14).

There were large differences in educational attainment between workers in agriculture and non-agriculture. Only 2.2 percent of those working in agriculture or fisheries had completed secondary school, compared to 9.4 percent of all workers

(p. 39). There were also large differences in hours worked between agriculture and other sectors. Gollin, Lagakos, and Waugh (2012) report that average hours worked per worker were 33.0 in non-agriculture and 31.3 in agriculture.

This paper will pay close attention to the differences between rural and urban areas and will attempt to model migration flows from rural to urban areas. Migration is a widespread phenomenon across all regions of Ghana. Rural-to-urban migration has been widespread, but there have also been substantial flows in recent years of rural migrants moving from the (relatively poor) northern savannah zone to the (relatively rich) coastal and forest zones. These rural-to-rural migrant workers provide seasonal labor in agriculture, construction, and other labor-intensive activities.

The GLSS5 surveys asked respondents to identify their place of birth. Individuals in the data are classified as in-migrants to a place if they were born in a different location from where they are currently living. The data also document people who have moved away from their birthplace for at least a year but have then returned; these are classified as return migrants. Both in-migrants and return migrants are classified as migrants.

According to the GLSS5 data (p. 50), 51.6 percent of the population aged seven and above were migrants, but this included large numbers of return migrants (32.8 percent of the population). The key regions for in-migration were the regions with large urban populations: Greater Accra (38.7 percent in-migrants), Central Region (22.7 percent in-migrants), and Ashanti Region (25.9 percent in-migrants). By contrast, the poor northern regions (Upper East and Upper West) had the highest proportions of non-migrants, meaning people who have never lived outside their place of birth for a year or longer. The more detailed data suggest that relatively few people migrate directly from rural areas to Accra; instead, Accra's in-migrants are typically coming from other urban centers, with 89.4 percent of Accra's migrants having previously lived in other urban areas (pp. 52-53).

B. Rural and urban living standards

It is difficult to assess differences in living standards between rural and urban areas. Because most people are self-employed or work in household enterprises, it is not straightforward to compare wages or salaries. Expenditure data are available in the GLSS5 (and will be discussed below), but it is difficult to find appropriate price baskets with which to make rural-urban comparisons. Perhaps the most useful approach is to compare realizations of non-monetary outcomes and anthropometric evidence.

The GLSS5 data include a number of useful metrics that proxy for living standards. For instance (and unsurprisingly), rural households have far less access to grid electricity than urban households, with only 26.9 percent of rural households reporting use of grid electricity, compared to 78.5 percent of urban households (p. 71). Rural households instead rely on keorsene for light and wood for cooking fuel.[1] About 30 percent of rural households lack any toilet facilities, compared to 5 percent of urban households; in Accra, the figure is 1.1 percent.[2]

C. Agriculture

The vast majority of rural households (85 percent) operate farms or keep livestock; this is highest in the poor savannah regions of the north, where the rate risses to 92 percent. Perhaps surprisingly, 28 percent of urban households also report that they engage in farming or keep livestock. Farms are small and almost all produce staple foods, including maize (in all zones), sorghum and millet (in dryer zones), and a variety of root crops (e.g., cassava, yam, sweet potato). Plantains represent another important starch staple. In addition, a variety of fruit and vegetable crops are important crops, both for home consumption and for cash sales. Peppers, tomatoes, okra, and leafy vegetables are widely grown.

In all regions, farm households grow food for their home consumption, but they also sell both food crops and non-food crops into cash markets. The extent to which farms are engaged in the market varies by region. In the poorer and more remote savannah zone, large fractions of the output of staple crops are consumed on the farm: only 19 percent of maize produced in the savannah zone is sold, and the same figure applies to sorghum and millet. But even this region is well integrated into cash markets, with substantial sales of groundnut (58 percent of production)

[1]Urban households use charcoal and gas for cooking fuel, with substantially less use of wood. This reflects the high transport costs of wood, with its relatively high water content. Charcoal is essentially a slow-cooked form of wood, in which the moisture is baked away leaving the carbon. As a result, it is far easier and cheaper to transport.

[2]The GLSS5 report discreetly suggests "bush, beach" as alternatives that are included in the "no toilet facility" category.

and cotton, among other crops.

Cocoa is the most important export crop for the country. Over 21 percent of farm households grew some cocoa, primarily in the forest zone. But a number of other crops are sold onto world markets as well, including rubber, cotton, and fruits. Ghana is one of the world's leading producers of cocoa, and it consequently implies a close linkage between Ghana's agricultural sector and the world economy. In recent years, cocoa has accounted for about 15 percent of Ghana's agricultural GDP and about 28 percent of the country's exports. Although Ghana now exports significant quantities of other agricultural goods, cocoa remains the mainstay of the agricultural export economy.

Agriculture in Ghana, including in the cash crop sector, tends to use few purchased inputs and to be relatively extensive. Household labor and land are the principal factors of production. It is reasonably common – especially in the forest and coastal zones – for farms to hire seasonal or temporary labor, with more than half of farm households doing so. Other purchased inputs are relatively rare, however – with the lone exception of locally produced tools, such as hoes and cutlasses (i.e., machetes). Only 20 percent of households purchased fertilizer in the course of the year preceding the GLSS5 survey, while slightly smaller percentages reported purchasing insecticides(18 percent) and herbicides (18 percent). Only 6 percent reported purchasing any petrol, diesel, or oil as an input into agricultural production; this gives an idea of the limited extent of mechanization and the low use of purchased intermediate goods.

D. Remoteness, transport costs, and transaction costs

Many of Ghana's farmers operate in relatively remote areas of the country. About 10 percent of Ghana's rural population lives five hours or more from a market center, and about 57 percent live two or more hours away. For farmers at these distances from market, transportation and transaction costs become highly significant in shaping decisions about what to produce and how to produce it. Purchased inputs need to be carried in, and agricultural output needs to be shipped out. The "last mile" problem of transport is well recognized; the unit cost of moving goods typically increases at the end of the transport chain, as the modes of transportation become successively less efficient and the quantities become smaller.

Hine and Ellis (2001) argue that human food transport of agricultural goods ("head loading"), which is the dominant means of transporting goods from the farmgate to roadsides and markets in rural Ghana, is inefficient and costly compared to many other means of transport (p. 10, Table 3). Hine and Ellis also argue that the inefficiencies of head loading become more acute as the volumes to be transported increase; thus, while it may work reasonably well in low output systems where the marketable surpluses are small, the cost of head loading soars as the quantities of output rise. Porter (2002) discusses the prevalence of head loading in rural Ghana and notes that investments in other forms of transport are often costly and require substantial amounts of up-front capital. But in this environment, it is not surprising that rural areas produce their own food rather than consuming imports and specializing fully in the production of cash crops.

3. Previous literature

Our paper follows a strand of recent literature that looks at the microeconomic and macroeconomic consequences of high transportation costs in developing countries. A central question in this literature is how to conceptualize and measure the long-run impact of transportation infrastructure on development. A problem in this literature is that transportation infrastructure – roads, railroads, canals, etc. – are very rarely placed randomly. They are instead constructed to serve existing or anticipated economic activity. This means that if we find a correlation in the data between road construction and the levels or growth rates of economic activity, we cannot readily interpret it as a causal relationship. These problems will be particularly acute in the short run, but even in the long run, it will be difficult to identify any causal impact of infrastructure construction. As Gollin and Rogerson (2010, 2012) show, there are likely to be large general equilibrium effects from reducing transportation costs. When an economy undergoes large changes in the transport cost environment, we can expect to see a major reallocation of economic activity and factors of production. Gollin and Rogerson (2010) show this for the case of Uganda, in a calibrated model. Herrendorf et al. (2012) focus on similar general equilibrium effects for the case of the United States in the 19th century.

Perhaps more relevant to the current study, Jedwab and Moradi (2011) examine the impact of railroads that were constructed in Ghana during the early part of the 20th century. They find evidence that the construction of railroads drove up land rents by expanding the area under cocoa cultivation, which was a highly profitable export opportunity. In effect, they show that as railroads expanded through the forest zone of Ghana, economic activity switched from subsistence food production to export-oriented cash cropping. Their work follows that of Donaldson (2010) who looks at the economic impacts of railroad construction in British India. Both of these papers look for general equilibrium impacts of transportation improvements in a long historical panel. There are also papers (e.g., Adamopoulos 2006) that look for general equilibrium impacts in a cross-section of countries.

Our work also relates to a large empirical literature that seeks to measure the impact of transportation improvements on agriculture (or conversely, the costs of remoteness) using cross-section or panel data. This work is severely constrained by the difficulty of establishing econometric identification; i.e., showing clear causal links between transportation improvements and outcomes. The literature offers a number of different approaches to identification. Some recent works include: Dorosh et al. 2008, Fan and Kang-Chan 2004, Fan and Hazell 2001, Renkow et al. 2004, Stifel and Minten 2008, Zhang and Fan 2004.

Finally, this paper also relates to a policy-oriented literature on the problems of African transportation infrastructure. As the international public sector focuses on issues of African development, infrastructure investments have been widely discussed as necessary ingredients of public strategies.[3] This literature includes numerous positive assessments of infrastructure's development impacts, but there are also important skeptical voices who note the high cost of road construction (at up to $1.5 million per km of paved road) and the wide dispersion of Africa's rural populations. There is also considerable skepticism about the relationship between the high cost of transport and the quality of roads, with some (e.g., Teravaninthorn and Raballand 2008) arguing that collusion among truckers and anti-competitive regulatory regimes may be a more serious problem than the quality of the physical infrastructure. In this context, it is not clear whether road investments can generate reasonable economic returns. Our paper contributes indirectly to this policy debate. Although we do aim to model the impact of improvements in transportation infrastructure, we do not model the cost of these improvements nor do we discuss the political economy and implementation problems (e.g., corruption) that

[3] See, for example, Calderon 2009, Carruthers et al. 2008, Platteau 1996, Raballand and Macchi 2008, Raballand et al. 2009, Teravaninthorn and Raballand 2008, Torero and Chowdhury 2005, UN Economic and Social Council and UN Economic Commission for Africa 2009.

have long been associated with road construction and maintenance. As a result, our paper may not provide a sufficient level of detail for current policy debates.

4. Model

We model this economy using a dynamic general equilibrium model in which different goods can be produced in different regions of the country. In contrast to recent papers such as Gollin and Rogerson (2012), however, the model economy is a small, open economy in which a subset of goods can be traded internationally at prices determined in world markets. There are transport costs associated with imports and exports, as well as domestic transport costs.

Individuals in the model economy can move across regions, but there are costs associated with this migration. We abstract from the international movement of people; in the model economy, there is no international migration. We also abstract from fertility behavior and population dynamics, although these are important features of the actual Ghanaian economy.[4]

The geography of our model economy is simple. We envision an urban area that is effectively the economy's portal to world trade. All imports enter through the city, and all exports leave through the city. Both imports and exports potentially face some transaction costs at the border. The urban area produces goods and serves as an entrepot for international trade. It is surrounded by a rural area, which produces agricultural goods. We consider both a food good and a "cash crop" good, which can be produced on the same land but face different markets. For simplicity, we assume that the cash crop has no domestic market, while the food crop can be consumed domestically or exported. In reality, the distinction between food and cash crops is somewhat blurred; even a crop like cocoa in Ghana has a modest domestic demand, but our results would not be significantly altered by allowing for a very small amount of domestic consumption of the cash crop.

The urban area produces a non-tradable good, which we conceptualize as a bundle of urban services and non-tradable manufactures. Although this may at first glance seem counter-intuitive (since many models view manufacturing as a highly

[4] In particular, there are differences in fertility rates between urban and rural households; since this pattern has potential impacts on migration flows, we recognize that this may not be an innocuous omission.

tradable sector), we emphasize that there are very few traded goods produced in Ghana's cities or in the other cities of sub-Saharan Africa. Manufacturing is present, but it tends to consist of activities such as food processing for domestic markets, or carpentry and metal work intended for local sale. In this respect, we treat urban areas as "consumption cities," in the spirit of Jedwab (2012), who argues that Ghana's cities reflect agglomeration advantages related to consumption, as opposed to the agglomeration benefits of production. These cities do not emerge because of sources of energy or power; they do not necessarily arise because of pockets of highly skilled labor. Instead, they grow up around administrative capitals or transportation hubs, where the demand for goods with high income elasticities can be satisfied more easily. Hence, the economic activities in Ghana's cities include tailoring, wholesale and retail trade, bars, hotels, government services, and relatively low levels of manufacturing.

To summarize, then, there are three goods produced in the model economy. Rural areas can produce both food crops and cash crops. Urban areas produce a mix of services and manufacturing. All of the goods are tradable domestically. Cash crops and food crops can be sold from the rural area to the urban area, subject to a transportation cost. From there, they can potentially then be exported. The urban good can be sold to the rural areas, but there is a transport or transaction cost associated with this flow, too; this might correspond to the travel costs that rural people face in traveling to urban areas when they want to enjoy urban goods or amenities.

Our model is organized as follows. Let F denote the food crop; let C denote the cash crop; and let N denote the non-agricultural goods and services produced in urban areas. Consumers in the model economy do not derive utility from the cash crop, but they consume both F and N. Utility is given by the function $U\left(F^i, N^i\right)$, where i indexes consumers such that $i\varepsilon\{r,v\}$where r denotes residents of rural and v denotes urban ("village") inhabitants.

We follow the widespread practice of assuming that there is a minimum consumption requirement for food, such that consumers of type i have preferences that can be represented by the a simple Stone-Geary type utility function of the form: $U\left(F^i, N^i\right) = \alpha log(F^i - \overline{F}) + (1-\alpha) log(N^i)$.

Individuals are endowed with one unit of time, which is supplied inelastically to the market. There is also one unit of land in the rural areas, which is divided equally among all rural residents.

I. Prices

Due to transportation cost, price of the same physical good varies across regions. We denote these prices as follows P_j^k, where $k\varepsilon\{r, v, w\}$, corresponding to rural, urban, and world markets respectively; and where $j\varepsilon\{F, N, C\}$, corresponding to food, urban services, and cash crops, respectively. Prices will vary across rural and urban areas. In the interior case, prices would differ only because of transportation cost wedges; however, we will need to consider a number of corner solutions in which not all the goods move across locations.

II. Transportation Costs

We assume that the transportation costs in the model follow an iceberg-type process. Thus it requires δ (> 1) units of a good at origin to deliver one unit of the same good at the destination. We assume that transportation costs differ across the types of goods. For simplicity, however, we assume that these costs are symmetric; that is, the values of δ are the same for a good moving from the rural area to the city and for the same good moving in the opposite direction, from the city to the rural area. The reverse flows are perhaps counter-intuitive, but recall that food is internationally traded in this model; under some scenarios, it might be optimal to produce only cash crops and to import all of the country's food. Our treatment of transportation costs allows for the cost of moving food to differ from that of moving cash crops (which might, for example, be more or less perishable than food crops). However, we assume that cash crops face the same iceberg costs as they move in either direction. Thus, we define the following iceberg costs.

- Food faces a transport cost $\delta_f^{r,v}$ between rural and urban areas; there is also a cost wedge $\delta_f^{v,w}$ between the urban area and the rest of the world.
- Cash crops face the cost $\delta_c^{r,v}$ between rural and urban areas; they also face the cost $\delta_c^{v,w}$ between the urban area and the rest of the world.
- The urban good can only move from the urban area to the rural area; this flow is subject to the cost $\delta_n^{r,v}$.

A. Consumer's problem

Individuals in our model economy live for a single period. The utility maximization problem of a consumer in location $i\varepsilon\{r,v\}$can then be written as:

$$\max_{\{F^i,U^i\}} \qquad U(F^i,N^i) = \alpha log(F^i - \overline{F}) + (1-\alpha)\,log(N^i) \tag{1}$$

$$s.t. \qquad P_f^i F^i + P_n^i N^i \leq W^i,$$

where W^irepresents the consumer's full income. Note that the prices faced by a consumer in a particular area will in equilibrium include all the relevant transport costs.

B. Producers' problems

We assume that goods producers in all regions and all sectors are profit-maximizing and that markets are competitive. This may not be an entirely adequate description of the industrial structure in places like Ghana, but we would argue that barriers to entry are relatively small and are difficult to enforce in this environment. As a result, we model the production side of the economy as represented by the following categories of firms.

I. Food Farmers

Farmers who choose to produce food in the rural area will solve the profit-maximization problem given by:

$$\max_{\{L_f,T_f\}} \qquad P_f^r G_f(A_f,L_f,T_f) - W^r L_f - R^r T_f \tag{2}$$

where $G_f(A_f,L_f,T_f)$ is the food production function, and A_f, L_f, and T_f are respectively the productivity parameter, the labor used in food production, and the land used in food production. With a competitive market structure, we take individual firms to face constant returns production technologies, and we can equivalently treat the sector as one facing an aggregate production technology of the same form. In this sector, W^r and R^r respectively are the wage rate and land rental rate in the rural area.

II. Cash-crop Farmers

Similarly, we model the profit-maximization problem of a cash crop farmer as:

$$\max_{\{L_c,T_c\}} \qquad P_c^r G_c(A_c, L_c, T_c) - W^r L_c - R^r T_c \tag{3}$$

where $G_c(A_c, L_c, T_c)$ is the cash crop production function, A_c, L_c, and T_c are respectively are the productivity parameter, labor, and land used in cash crop production. As for food production, we assume constant returns to scale in the production technology. Note that the wage and land rental rate for cash crop farmers must be the same as those for food crop production, since both food and cash crops are produced in the rural areas and the factors of production are fully mobile between the two outputs.

III. Urban Firms

Those firms situated in urban areas produce an urban bundle of goods and services. Their problem is described by the profit-maximization problem:

$$\max_{\{L_n,T_n\}} \qquad P_n^v G_n(A_n, L_n, T_n) - W^v L_n - R^v T_n \tag{4}$$

where $G_n(A_n, L_n, T_n)$ is the goods production function for urban non-agricultural goods, with A_n, L_n, and T_n denoting respectively the productivity parameter, labor force, and land used in urban goods production. W^v, R^v respectively are the wage rate and land rental rate in urban area.

IV. Government

For analytical convenience, land is assumed to be owned by the government. We assume that the government converts the land rents into a bundle of services that do not enter the utility function of individuals in the economy and that do not implicate other productive activities. We could obviously model rents in a more complex way, such as by redistributing them to the population following some criteria, but we abstract from this issue for simplicity.

C. Migration dynamics

In the model economy, individuals may move between locations, and we assume that this migration is driven by differences in the returns to labor. We also assume that the model may initially be in a disequilibrium, in the sense that wages may differ across locations. In the model economy, however, we take seriously the idea that there are migration frictions that may prevent the disequilibrium from being eliminated instantaneously. This is motivated by the real-world observation that rural-urban migration normally occurs through a steady and sustained flow, rather than as a momentary rush for the exits. Many real-world frictions limit mobility and impose frictions to the migration process. These include age-related issues (the old do not normally migrate except under duress), location-specific ties and networks that provide valuable services to those in rural communities (and cannot easily be transferred to new locations), and the sheer disutility of moving, among other forces. We do not try to represent these different components of migration frictions in this paper, but we are interested in observing the ways in which migration flows might take place over time and in seeing how other exogenous and endogenous variables may affect the transition dynamics in this economy.

The mechanics of the migration process are as follows. In each period, only a fraction θ_t of the rural population can migrate, where this fraction is bounded above by the exogneous parameter $\overline{\theta}$. Then the laws of motion for rural and urban populations are given by:

$$L_t^r = (1-\theta_t)L_{t-1}^r \tag{5}$$

$$L_{v,t} = L_{v,t-1} + \theta_t L_{t-1}^r \tag{6}$$

where L_{t-1}^r and $L_{v,t-1}$ respectively are labor force in rural area and urban area at time $t-1$ (or at the beginning of period t). The fraction θ_t denotes the proportion of rural emigrants in period t and is determined endogenously, subject to the constraint $0 \leq \theta_t \leq \overline{\theta}$ for all t.

D. Equilibrium

Although our model is dynamic, it reduces to a series of static single-period problems. In each, we can solve for the competitive equilibrium of this economy, taking the allocation of labor across locations as given. Migration happens between periods.

The competitive equilibrium is relatively straightforward. The labor market and land market in the rural areas are competitive and allocatively efficient, giving rise to the following first-order conditions:

$$P_f^r G_{f,L}(L_f, T_f) = P_c^r G_{c,L}(L_c, T_c) = W^r \tag{7}$$

$$P_f^r G_{f,T}(L_f, T_f) = P_c^r G_{c,T}(L_c, T_c) = R^r \tag{8}$$

where $G_{f,L}(L,T)$ and $G_{c,L}(L,T)$ are the partial derivatives of the food and cash crop production functions with respect to labor L, and similarly $G_{f,T}(L,T)$ and $G_{c,T}(L,T)$ are the partial derivatives of the food and cash crop production functions with respect to land T.

In urban areas, factor markets also clear, giving:

$$P_n^v G_{n,L}(L_v, T_v) = W^v \tag{9}$$

$$P_n^v G_{n,T}(L_v, T_v) = R^v \tag{10}$$

Note, however, that the restrictions imposed on migration imply that the urban wage W^v and the rural wage W^r will not in general be equated, nor will urban and rural land rental rates.

Domestic demand functions for food and urban goods can be obtained from the consumer's problems of Equation 1.

$$F^i(P_f^i, W^i) = (1-\alpha)\overline{F} + \alpha \frac{W^i}{P_f^i} \tag{11}$$

$$N^i(P_n^i, P_f^i, W^i) = -(1-\alpha)\frac{P_f^i}{P_n^i}\overline{F} + (1-\alpha)\frac{W^i}{P_n^i}, \tag{12}$$

(where $i = v, r$).

We also have the following market-clearing conditions:

- In the cash crop market, domestic production must equal exports; thus, $C^{export} =$

$F(A_c, L_c, T_c)$.

- In the urban goods market, the quantity demanded in urban areas plus the quantity demanded in rural areas, adjusted for transport costs, must clear the market: $N^v + \delta_n^{v,r} N^r = G_n(A_n, L_n, T_n)$.
- In the rural labor market, we have $L_f + L_c = L^r$.
- In the rural land market, we have $T_f + T_c = T^r$.

The market-clearing condition for the food market will depend considerably depending on whether the economy is at an interior solution or a corner; this is discussed in greater detail below.

I. Prices

For the cash crop, the domestic price is determined by the world price plus a transport cost at the border. This is the only good for which the domestic price is fully determined exogenously, however. The price of food is more complicated. Although food is tradable, the world price does not entirely determine the price in the domestic market; instead, the world price plus a series of transport cost wedges will define a maximum price in the domestic market, and in the same spirit, the world price minus the same transport cost wedges will set a lower bound on the domestic price of food. The price may also fall somewhere between these bounds.

We begin by noting that P_c^w and P_f^w are exogenously given. From these, the price of the cash crop in the urban and rural areas can be determined trivially: $P_c^v = \frac{1}{\delta_c^{v,w}} P_c^w$, and $P_c^r = \frac{1}{\delta_c^{r,v} \delta_c^{v,w}} P_c^w$.

In the same way, the price of the non-agricultural good in urban and rural locations is determined endogeneously in the model, with the following relationship: $P_n^r = \delta_n^{r,v} P_n^v$.

The price of food is discussed below. We consider a number of cases, in which the relationships between P_f^v, P_f^r, and P_f^w will vary with the pattern of trade in food.

Armed with these expressions, we can solve for the static equilibrium of the model economy.

Given technology $\{A_f, A_c\}$, labor force $\{L^r\}$, land $\{T^r\}$, and prices $\{P_f^r, P_c^r\}$ }, the corresponding equilibrium $\{L_f, L_c, T_f, T_c, W^r, R^r\}$ can be calculated by

$$P_f^r G_{f,L}(A_f, L_f, T_f) = P_c^r G_{c,L}(A_c, L_c, T_c) = W^r \tag{13}$$

$$P_f^r G_{f,T}(A_f, L_f, T_f) = P_c^r G_{c,T}(A_c, L_c, T_c) = R^r \tag{14}$$

$$L_f + L_c = L^r \tag{15}$$

$$T_f + T_c = T^r \tag{16}$$

Equilibrium values of$\{F, C\}$ are then determined by:

$$F = G_f(A_f, L_f, T_f) \tag{17}$$

$$C = G_c(A_c, L_c, T_c) \tag{18}$$

Given technology $\{A_n\}$, labor force $\{L_n\}$, land $\{T_n\}$, and prices $\{P_f^r, P_f^v\}$ }, the corresponding equilibrium $\{W^v, R^v, P_n^v, P_n^r\}$ can be calculated by

$$P_n^v G_{n,L}(A_n, L_n, T_n) = W^v \tag{19}$$

$$P_n^v G_{n,T}(A_n, L_n, T_n) = R^v \tag{20}$$

$$N^v(P_n^v, P_f^v, W^v) + N^r(P_n^r, P_f^r, W^v) = G_n(A_n, L_n, T_n) \tag{21}$$

$$P_n^r = \delta_n^{r,v} P_n^v \tag{22}$$

And equilibrium $\{N\}$ is

$$N = G_n(A_n, L_n, T_n). \tag{23}$$

Prices of food P_f^v and P_f^r depend on the pattern of trade in food. There are five possible cases for this model.

1. **Both urban and rural areas import food from rest of the world.**

   - P_f^v and P_f^r are determined by P_f^w
   - $P_f^v = \delta_f^{w,v} P_f^w$
   - $P_f^r = \delta_f^{v,r} \delta_f^{w,v} P_f^w$

- Food market clearing condition:
  $-F^{imports}/\delta_f^{w,u} = F^v(P_f^v, W^v) + \delta_f^{v,r}\left(F^r(P_f^r, W^r) - G_f(A_f, L_f, T_f)\right)$

2. **Urban areas import some (but not all) food from rest of the world; rural sells food to urban.**

   - P_f^v and P_f^r are determined by P_f^w
   - $P_f^v = \delta_f^{w,v} P_f^w$
   - $P_f^r = \frac{\delta_f^{w,v}}{\delta_f^{r,v}} P_f^w$
   - Food market clearing condition:
     $-F^{imports}/\delta_f^{w,v} = \left(G_f(A_f, L_f, T_f) - F^r(P_f^r, W^r)\right)/\delta_f^{w,v}$

3. **Urban areas import food from rest of the world; rural is self-sustained in food.**

   - P_f^v is determined by P_f^w
   - $P_f^v = \delta_f^{w,v} P_f^w$
   - Food market clearing condition: $-F^{imports}/\delta_f^{w,v} = F^v(P_f^v, W^v)$
     and $G_f(A_f, L_f, T_f) = F^r(P_f^r, W^r)$.
   - P_f^r is determined by food market clearing condition:

$$F^r(P_f^r, W^r) = G_f(A_f, L_f, T_f) \tag{24}$$

   - And we must have $\frac{1}{\delta_f^{v,r}} P_f^v < P_f^r < \delta_f^{v,r} P_f^v$.

4. **Urban areas do not import food from rest of the world; urban area is fully supplied by rural areas.**

   - Since $F^{imports} = 0$ in this case, P_f^v and P_f^r are determined by food market clearing condition:

$$F^v(P_f^v, W^v) + F^r(P_f^r, W^r) = G_f(A_f, L_f, T_f) \tag{25}$$

$$P_f^v = \delta_f^{r,v} P_f^r \tag{26}$$

   - Food market clearing condition: $F^{nx} = 0$
     and $F^v(P_f^v, W^v) = \left(G_f(A_f, L_f, T_f) - F^r(P_f^r, W^r)\right)/\delta_f^{w,v}$.

- And we must have $\frac{1}{\delta_f^{v,w}} P_f^w < P_f^v < \delta_f^{w,v} P_f^w$

5. **Case 5: Urban exports food to rest of the world, rural sells food to the urban**

   - P_f^v and P_f^r are determined by P_f^w
   - $P_f^v = \frac{1}{\delta_f^{v,w}} P_f^w$
   - $P_f^r = \frac{\delta_f^{r,v}}{\delta_f^{v,w}} P_f^w$
   - Food market clearing condition:
     $\delta_f^{w,v} \delta_f^{v,r} F^{nx} + \delta_f^{v,r} F^v(P_f^v, W^v) + F^r(P_f^r, W^r) = G_f(A_f, L_f, T_f)$

5. Quantitative Analysis

Armed with this model framework, we proceed to calibrate the model to data from Ghana. The calibration is a loose one, but we aim for the model economy to replicate the data approximately in terms of the initial fractions of the population in rural areas; the relative importance of food and cash crops; and the share of food that is imported. Having satisfied these benchmark values, we can then ask how the model economy would respond to a series of changes in parameter values. The changes include both the one-shot static changes and also the rates of migration and the transition dynamics that would be expected to take place over time. Because the model economy is solved in general equilibrium, we can observe the full impacts of these interventions, in a way that would be difficult in a less complete model environment.

A. Calibration

We choose parameters for the model economy to match a set of calibration targets. These are values that the benchmark model economy should replicate, to a reasonable degree.

- Rural population fraction of total population: 0.56, implying urban share of population 0.44. (Data based on FAOSTAT value for economically active population in agriculture as share of totally economically active population.)

- Agriculture share of GDP: 0.30, implying non-agriculture share of 0.70. (World Development Indicators; 2010 value of 30.2%)

- Export share of agricultural GDP: 0.30. (Based on World Development Indicators: food and non-food agricultural exports as a fraction of total merchandise exports; merchandise exports as share of GDP.)

- Imports of food as share of total food: 0.10. (Alternatively, net imports of calories as share of total calories: 0.15.) The first figure comes from World Development Indicators on food imports as share of merchandise imports, combined with merchandise imports in value terms. This is combined with FAOSTAT data on the value of food production. Taken together, the two numbers give the import share of the value of food. The second figure is taken from FAO Food Balance Sheets, which show the production, imports, and utilization of each food commodity group. These can be totaled to give the calorie-weighted share of imports in total food consumption.

- Rural price of food relative to urban price of food: 0.55 (Natural Resources Institute study cited in World Bank 2007, Figure 5.1, p. 119.) An alternative estimate would be 0.36 (based on WABS Consulting 2008, p. 20; this value chain analysis reported an average farmgate price of white maize for human consumption of 29 Ghanaian cedis per 100 kg, compared with an average retail price of 80 GhC/100kg).

- Urban price of food relative to world price: 1.75 for rice imports. Based on a comparison of recent prices from Ghana

- Food budget share of high-income countries (i.e., utility parameter representing the food share of expenditure when the subsistence requirement becomes asymptotically unimportant): 0.20. This reflects the average share of food in expenditure for high-income countries, based on 2005 data from the ICP.[5]

- Annual rate of migration: Urban population growth rate for 1990-2010 was 4.2% annually, compared with overall population growth of 2.5%.[6] Along with the urban share of population at 0.44, this implies a of rural-urban migration of about 0.5% annually.

- Production function parameters:

These targets allow us to parameterize the model as follows.

[5] Data at: available at http://www.ers.usda.gov/Data/InternationalFoodDemand/DATA_TABLES/Table9.xls.
[6] See UNICEF country statistics at: http://www.unicef.org/infobycountry/ghana_statistics.html.

B. Benchmark equilibrium

The benchmark equilibrium of the model economy can be summarized by the values shown in Table 1. By construction, the model economy replicates the data in certain key respects. We can gather data on the model economy, including a number of variables to which we do not directly calibrate. The values generated by the model with respect to these "accidental" benchmark values offer us one means of examining the model's external validity. To the extent that the model generates values that are broadly consistent with the data, we can place more confidence in it.

C. Scenarios

We consider seven alternative scenarios, which can be construed as experiments run on the model economy. In these scenarios, we alter one or more of the parameters of the benchmark economy to ask how the economic outcomes will change. Unlike an exercise based on empirical observations of existing economies, we do not have to worry about the causal relationships involved in what we see; we know that all the observed changes result from our experimental design. The scenarios can to some degree be viewed as heuristic devices, in the sense that they allow us to understand better the interconnections and linkages that characterize the economy. In this sense, they allow us to understand the sensitivity of the model to a variety of assumptions – not just with respect to parameter values, but also to functional forms and other specifications of the model and the model environment.

We might also like to view the scenarios as providing information about the consequences of some real-world interventions that might affect the Ghanaian economy in a way consistent with our model scenarios. For instance, we might treat a scenario in which domestic transportation costs are reduced as informing us about the consequences of a program to build roads; the scenarios in which world prices of certain goods increase are easy to relate to similar real-world events.

The seven scenarios that we model here are briefly described as follows:

- A 10% increase in total factor productivity (TFP) in the food sector.
- A 10% increase in TFP in the cash-crop sector.

Table 1: Benchmark values for model economy

Variables	Benchmark case
output of food	0.48
Net Export of food	-0.07
rural consumption of food per capita	0.39
urban consumption of food per capita	0.44
output of cash-crop	0.15
service output	0.36
rural consumption of service per capita	0.17
urban consumption of service per capita	0.50
rural wage rate	1.17
urban wage rate	4.32
land rent per capita	2.20
rural income per capita	3.37
urban income per capita	6.52
urban labor force	0.44
rural labor force	0.56
food labor force	0.54
cash-crop labor force	0.02
urban land	0.30
rural land	0.70
food land	0.50
cash-crop land	0.20
migration rate	0.0048
world food price	1.75
urban food price	2.98
rural food price	1.75
world cash-crop price	2.00
urban cash-crop price	1.25
rural cash-crop price	0.78
urban service price	10.47
rural service price	15.71

Table 2: Scenario results: sectoral output

	Output		
Scenario	Food	Cash Crops	Urban Services
Benchmark case	0.48	0.15	0.36
+10% food TFP	0.54	0.12	0.36
+10% cash-crop TFP	0.46	0.19	0.36
+10% agri+non_agri TFP	0.53	0.16	0.40
-10% transport costs	0.45	0.21	0.36
+20% world price of food	0.50	0.10	0.36
+20% world price of cash-crop	0.45	0.20	0.36
+20% world price all traded goods	0.48	0.15	0.36

- A 10% increase in TFP in all sectors of the economy.
- A 10% reduction in transport costs.
- A 20% increase in the world price of food.
- A 20% increase in the world price of the cash crop.
- A 20% increase in the world price of all traded goods (i.e., food and cash crops).

Table 2 summarizes the findings of the exercises with respect to sectoral output under the different scenarios. In all cases, the variables are shown for the first period after the change; we do not illustrate here the time paths of variables over time, as labor reallocates. As a result, this table underestimates the impact of the changes due to these scenarios. We can view the consumption allocations associated with the different scenarios in Table 3, which shows domestic consumption of food and urban services on a per capita basis for people in each of the two regions of the model economy.

Table 3: Results of scenarios: consumption allocations in the model economy

	Food Per Capita		Urban Services Per Capita	
Scenario	Rural	Urban	Rural	Urban
Benchmark case	0.39	0.44	0.17	0.50
+10% food TFP	0.42	0.48	0.17	0.50
+10% cash-crop TFP	0.39	0.45	0.17	0.50
+10% agri+non_agri TFP	0.42	0.48	0.19	0.55
-10% transport costs	0.39	0.51	0.19	0.50
+20% world price of food	0.38	0.43	0.17	0.50
+20% world price of cash-crop	0.39	0.45	0.17	0.50
+20% world price all traded goods	0.39	0.44	0.17	0.50

One interesting finding from the scenarios relates to sectoral output relative to the benchmark economy. The output of urban services is highly inelastic to changes in the agricultural sector. Increases and decreases in the productivity and prices facing the agricultural sector have almost no effect on the urban sector, including on its labor force and output. In large part, this reflects the fact that the urban sector is dependent on imported food, so that the urban area is effectively disarticulated from the surrounding rural area. This is a phenomenon that has been frequently described in the Ghanaian context – as in other modern African cities. Because of this, changes in domestic agricultural productivity – whether food or cash-crop productivity – do not affect the output of urban services. By the same token, a reduction in domestic transport costs has little effect on the urban service sector.

The agricultural economy is quite sensitive to changes in world prices. An increase in the world price of food will drive up production – but by a relatively modest amount; the implied supply elasticity of food production with respect to world prices is about 0.20. This reflects the fact that the price increase on world markets does not necessarily translate into a larger share of the domestic market for farmers, because urban consumers can still access the international market. The price increase does, however, induce a shift out of cash crop production into food crop production.

Table 3 shows in the same vein how small an effect on urban consumption results from a 20% increase in the world price of food; in this scenario, urban consumption of food per capita falls from 0.44 to 0.43. This is a very small effect. There is also a small reduction in rural areas, from 0.39 to 0.38. Mostly the increase in world prices is offset by a shift in domestic agricultural production from cash crops to food crops.

6. Conclusion

The model economy offers some insights into the behavior of a small open economy in which high transport costs, both at the border and within the domestic market, mediate the transmission of prices through the economy. In this economy, changes in world prices may have relatively modest effects on domestic production and consumption decisions, even for tradable goods.

Agricultural productivity increases may equally have limited impact on local output and prices, because in this case, the increased production increases do not find their way costlessly onto the domestic market.

The end result is that we may find that the small open economy is remarkably sticky in terms of its behavior. The interventions that most significantly alter the allocations within the economy are likely to be those that affect transport costs and marketing margins. These may in the end prove more important than changes in exchange rates or world prices, on the one hand, or changes in domestic productivity, on the other hand.

Overall, the model offers some useful insights into an economy like that of Ghana. Although it is common to model economies as either "open" or "closed," in some binary sense, this may not be a particularly useful distinction if the domestic transportation and transaction cost wedges are very high.

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