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Rural-Urban Linkages, Public Investment and Transport Costs:

The Case of Tanzania*

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Abstract

We develop a multi-sector spatial applied general equilibrium model calibrated to the 2001 Tanzanian Social Accounting Matrix to examine the impact of public investment on household welfare. We examine how different public investment packages combined with reforms in the transport sector alter the equilibrium structure and location of economic activity. The choice of financing arrangements also matters for welfare, since tax incidence, relative price and real exchange rate movements are non-neutral. We also note that welfare gains are generated by the movement of rural workers out of quasi-subsistence agriculture into higher-productivity jobs in other sectors and locations.

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1 Introduction

Tanzania's economy, like those of many other sub-Saharan African countries, displays strong geographic and locational disparities. In a stylized sense, it can be thought of as consisting of several distinct components, spatially separate and imperfectly connected. The capital, Dar es Salaam, is a vibrant urban economy with a strong government presence; given its location as a port on the Indian Ocean, it is reasonably well integrated into the global economy. At the opposite extreme, many interior rural regions are heavily agricultural and are poorly linked to national or global markets. Households in these rural areas consume much of what they produce, and they produce much of what they consume; they sell modest fractions of their agricultural output and purchase manufactured goods and services. In between the urban economy of Dar es Salaam and these quasi-subsistence rural regions lies a mixture of secondary cities, market towns, and well-connected commercially-oriented rural areas. They have better access to markets in Dar es Salaam and the rest of the world than do the more remote rural areas, although they still face consequential transport and transaction costs with respect to those markets.

These spatial patterns are associated with corresponding differences in the patterns of production and consumption. They also are associated with substantial differences in prices, wages, and living standards. The spatial disparities create a variety of seeming paradoxes: an economy that is simultaneously open (in Dar) and closed (in rural areas), with respect to world trade; an economy that is subsistence oriented coexisting with one that is highly commercial; and an economy in which people are free to migrate but in which there are substantial differences in standards of living across locations.

Within an economy like this, public investments targeted to different sectors or locations can have different effects on national income and on welfare. This paper uses an applied general equilibrium model to explore the impact of a set of government policies on household welfare, taking seriously the spatial and sectoral differentiation of the Tanzanian economy. In particular, we focus on public infrastructure investments that may differentially affect the agricultural sector and on reforms that directly reduce transport costs. The model, which is calibrated to Tanzania's 2001 Social Accounting Matrix, pays particular attention to inter-regional transaction costs and rural-urban linkages. We view the resulting model as occupying a middle ground between a highly stylized but equally transparent model (as in Gollin and Rogerson 2014) and the highly detailed CGE models sometimes used for policy analysis, such as the 58-sector model deployed in Pauw and Thurlow (2010). The former are perhaps too stylized to be useful for realistic policy analysis, whereas the latter by necessity

build in a high degree of structure that limit their usefulness in thinking about policies that might alter the underlying organization of the economy.

Our model generates a set of stylized but important insights. We show how different programs of investment generate substantially different impacts on the economy and also have different effects on the well-being of unskilled workers. In general, we find that the benefits of public investment are often felt in sectors other than those that are the primary target of the interventions. For example, although a large fraction of the unskilled labor force resides in rural areas and works in agriculture, we find that increasing public investment in the agricultural sector generally does not improve the well-being of those unskilled workers who remain in agriculture. It does, however, result in an outflow of workers from agriculture to other sectors. Similarly, we show that increased public investment in urban areas, particularly in secondary cities, may lead to welfare benefits for rural households.

The second key message from the paper is that the poverty impacts of different interventions are highly sensitive to the ways in which these are financed. As in Adam and Bevan (2006, 2014), outcomes are sensitive to government choices with respect to financing mechanisms. In our analysis, interventions can be financed through taxes or other forms of domestic revenue collection (e.g., tariffs). Alternatively, they can be financed through aid inflows – essentially gifts from abroad – or ‘deficit financed’ which entails the direct crowding-out of private investment. All of these sources of finance create impacts on the economy and on the distribution of well-being. Taxes create obvious effects on the absolute and relative well-being of different households and locations through differential incidence; the same is true for tariffs. Foreign assistance appears at first glance to be relatively neutral as a source of financing, but the capital inflows associated with foreign aid lead to exchange rate effects and relative price effects that can impact the poor. We argue that the choice of financing arrangement, no less than the location or sector in which the public sector invests, will affect income distribution, and by extension the poverty impacts of public policies.

A third finding of the paper is that we estimate the potential welfare gains associated with interventions that *directly* reduce the transport costs that sustain the disintermediation of the economy. While it is impossible to accurately cost these interventions in the context of our stylized model, we show that reduction in the transport cost wedge directly accelerates processes of structural transformation. This process may be complicated, however, if transport costs represent rents to monopoly providers. In this case, policy reforms have potentially large effects on the pattern of domestic demand; the ‘pure’ gains from transport cost reductions are mediated by the loss in rents to the transport sector.

Finally, we note that an important channel for these effects is through the sectoral and regional reallocation of labour. This finding is consistent with numerous recent papers suggesting that structural transformation and migration are important channels for welfare improvement – as opposed to increases in income for workers within sectors; e.g., Beegle et al. (2010), Christiaensen et al. (2013). Different interventions may lead low-skill workers to move across sectors or regions. Where there are important sectoral differences in income or productivity (e.g., Gollin et al. 2014, Young 2013), sectoral movements have the potential to increase output and income considerably. Such welfare gains can easily be overlooked in household surveys that maintain constant sampling frames and do not track individuals or households that migrate.

2 Background

Tanzania is a country with strong spatial patterns of economic activity. Almost 80% of the population lives in rural areas and approximately the same proportion of the labour force works primarily in agriculture. Most households depend for their livelihoods on farming small plots of land, where they primarily produce food for home consumption. Small amounts of food (and non-food agricultural goods) are sold to market. Productivity in the agricultural sector is generally very low. Agriculture’s share of GDP is estimated at 45%, which implies – if the numbers are taken at face value – that output per worker in agriculture is only about one fourth as high as in the rest of the economy.¹ This translates into large differences in urban-rural levels of poverty and deprivation. For instance, the poverty incidence in Dar es Salaam is one third of that in Singida (one of the more remote regions) while under-5 child mortality varies from a low of 58 per 1000 in Arusha to more than four times that in Mbeya.² Confronted with large differences between urban and rural areas in poverty and well-being, standard economic models predict that there should be rapid movement of people across locations. While rural-urban migration has been an important feature of the economy, the pace has not until now been sufficient to equalize social or economic outcomes across regions. In this paper, we focus on the role of transport costs in sustaining these large differences in outcomes.

¹As pointed out in Gollin, Lagakos, and Waugh (2014), measurement issues here are acute; neither labor in agriculture nor value added in agriculture is measured with great precision.

²Tanzania National Strategy for Growth and Reduction of Poverty (2006)

Evidence on transport costs

Tanzania's roads and transport system are arguably better than those found in some other parts of sub-Saharan Africa, but nonetheless large fractions of the country's area and population are poorly served by the road network. Aggregate data show that the density of paved roads was well below the norm for low-income countries, with 47 km of paved roads per 1000 km² of arable land, compared to the average for low-income countries, which was 87 km/1000 km², and for middle-income countries, which was 507 km/1000 km².³ In spite of the low density and low quality of roads, almost all goods move by road. Although major trunk roads are adequate, minor roads and rural roads can be poorly maintained and impassable at certain times of the year. As a result, many of the country's rural areas are substantially remote from markets. This affects the opportunities that farmers have to sell their products, and it also influences the prices that rural households pay for goods purchased from other parts of the country. Even Tanzania's secondary cities can face substantial transport costs, creating large price wedges with respect to markets in Dar es Salaam.

Although the economy is nominally open to food imports, relatively small fractions of staple foods are imported. For example, Tanzania imports less than two percent of its maize and is almost entirely self-sufficient in virtually all agricultural commodities. Prices throughout the country co-move across locations, suggesting a reasonably high degree of cross-market integration; but there are nevertheless large price wedges across markets.

Derksen-Schrock et al. (2011) cite data showing that nearly two-thirds of Tanzanian farmers sell their produce from the farm gate rather than carrying it to a nearby market, largely because of the high transaction and transportation costs. Since many farmers have very small marketable quantities, the returns from carrying these quantities to market are limited, and the travel time and expense are effectively fixed costs. Moreover, historically, large numbers of farmers have found themselves with "stranded" crops that they were unable to market because of transportation failures at key moments. Anecdotally, this problem remains today; during the rainy season, farmers in some parts of the country may be effectively cut off from markets. This affects crop choices (reducing the attractiveness of perishable fruits and vegetables, for example) and input use, as well as the profitability of harvested commodities.

There are no straightforward ways of measuring transport and transaction costs. Traders and those involved in the physical movement of goods may have strong incentives to under-report the prices and margins that they charge. Cross-location price differences are not easy

³Africa Infrastructure Country Diagnostic (2010).

to interpret. In a perfect competition setting, these price differences and a no-arbitrage condition should imply that the price wedges correspond to transaction costs; but in reality, there may be differences in location-specific demand or supply, and the no-arbitrage condition may not apply to markets that are relatively thin. (See Atkin and Donaldson 2015.) Nevertheless, the data for Tanzania show large and consistent spreads in the prices of commonly consumed goods across major market centers (for example, Eskola, 2005; Kweka, 2006; Carleton, 2013; and Mkenda and van Campenhout, 2011).

Thus, we take it as a starting point for our research that transport costs represent an important feature of Tanzania’s economy and contribute to important price wedges across locations. In our model, we treat transport costs as an amalgamation of rents, fuel costs, and a pure iceberg cost, consistent with much previous literature on international and domestic trade. The iceberg cost implies that when goods move from one location to another, a fraction of the initial quantity simply “melts” en route to the destination. In keeping with a large literature on agricultural marketing, we prefer to think of this as physical waste and spoilage, or damage, rather than as pilferage or loading and unloading charges.⁴ For instance, a recent study for the UN Food and Agriculture Organization suggests that 13.5% of grain production in sub-Saharan Africa is lost in post-harvest processing, handling, and distribution, on average; this compares to about 4.5 percent in North America (Gustavsson et al. 2011).⁵

3 Previous literature

The paper contributes to a recent and growing literature that has revisited the relationship between transportation costs and development patterns.

The relationship between transport costs and development is difficult to examine for several reasons. One is that general equilibrium effects may dominate partial equilibrium effects, at least in the long run. For example, a new road may induce many changes in economic activity patterns, including changes in prices, wages, movements of labor and capital, and the prevalence of different economic activities. Thus, a simple comparison of incomes or production before and after an infrastructure project may give misleading results.

⁴This matters for our modeling of the Tanzanian economy; pilferage would represent a redistribution of resources, rather than a disappearance of resources; as such, a reduction in pilferage would make some individuals better off but others worse off. By contrast, a reduction in iceberg costs is efficiency-enhancing.

⁵Additional amounts are lost in North America in packaging and at the consumer level; the report suggests that losses in Africa at the consumer level are very low, while in rich countries they can be quite high.

A second difficulty in understanding the relationship is that dynamic effects may matter more than short-run effects. Adjustments to transportation improvements may have long lags. A new road will not necessarily induce changes in economic activity overnight; more precisely, the short-run responses will not be the same as the longer-run responses.

Finally, causal identification is extremely difficult. The placement of roads, railroads, and infrastructure projects is intrinsically non-random. Policy makers seldom build “roads to nowhere”. This makes cross-sectional comparisons (of areas with different levels of transport infrastructure) nearly useless in evaluating the impact of infrastructure investments, as noted by Jacoby (2000) and Jacoby and Minten (2009). Even difference-in-difference approaches will be problematic, since infrastructure projects are likely to favor areas that are seen as dynamic. This makes it difficult to know whether infrastructure improvements lead to economic growth or whether they follow it.

Several empirical approaches seek to get around these difficulties. Some studies have tried to take advantage of randomized roll-outs of road improvements, using the differences in timing of infrastructure projects as a way to identify the causal relationships (e.g., Gonzalez-Navarro and Quintana-Domeque 2011 or Casaburi et al. 2013). Others rely on instrumental variable identification strategies. Banerjee et al. (2012) show that locations that fall on a straight line between two historical cities in China (and excluding the endpoint cities) are more likely to be on a major road or railroad than locations that are (literally) offline. Based on that first-stage result, they use the straight-line property as an instrument for transport connectivity, controlling for other potentially confounding variables. A different instrumental variable approach is followed by Storeygard (2012), who uses world oil price changes to instrument for changes in transport costs over time; he links this to a data set based on the observation of light from space to estimate the effect of changes in transport costs on changes in economic activity for nearly 300 cities in sub-Saharan Africa. One particularly interesting analysis of long-run effects is provided by Donaldson (2016) who identifies the dates when each segment of the Indian rail network was developed. This allows him to find support for the proposition that railroad construction led to decreases in transport costs, increases in the flows of goods and increases in income levels in locations where railroads were constructed. A similar exercise forms the core of Jedwab and Moradi (2011), who focus on railroads in Ghana. A number of other recent papers show how the presence of roads and transport infrastructure can alter the sectoral composition of output or the spatial patterns of economic activity; see, for example, Baum-Snow et al. (2014), Duranton et al. (2014), Faber (2014), Redding and Turner (2015), and Asher and Novosad (2016).

In addition to these empirical papers, a number of recent studies look at the impacts of transportation improvements in the context of general equilibrium models. Gollin and Rogerson (2010, 2014) examine the transport cost environment in Uganda. They find that in an economy with high internal transportation costs for food, the price of food in urban areas will be quite high. As a result, in equilibrium, large fractions of the population will remain in remote areas producing food for their own consumption. Caselli, Gollin, and Gottlieb (2014) extend this result to an open economy, noting that internal frictions may prevent a country from importing all of its food even when productivity levels are well below world levels.

This paper asks to what extent the same results would hold in a relatively open economy like that of Tanzania, where food can be readily imported to Dar es Salaam. Although it is customary to think of a country like Tanzania as an open economy, we note that transportation costs imply that portions of the country can be closely connected to world markets while other portions of the country may be effectively closed. Although we do not explore this feature of the economy in great detail, we note that the model allows for internal frictions to lead to substantial differences in prices and consumption patterns. In this sense, our model is similar to Dorosh and Thurlow (2011, 2014), who also use CGE models of African economies with spatial variation across regions. One important difference with our approach, however, is that regions are not identified with specific geographic regions or provinces; instead, our regions are defined functionally and conceptually. We consider a single commercial urban area, but then we aggregate the secondary cities and well-connected rural areas across the entire country to create a distinct “region” that does not have a specific location on the map.

By using a general equilibrium model in which explicitly modeled transportation costs affect the movement of goods within and between locations, we can conduct quantitative experiments in which we can examine the effects on the entire economy of changes in transport costs. One of the advantages offered by our approach is that we can fully identify and account for causation. In this sense, we therefore offer an alternative complementary methodological approach to the existing attempts to estimate the impact of transportation infrastructure.

4 Model

Our model embeds the basic insights from Gollin and Rogerson (2014) within the framework developed by Adam and Bevan (2006). Thus both production and consumption are spatially distributed across three stylized geographic locations. One is a rural region, which produces only staple food, which is non-tradable internationally, and an exportable cash crop. A second region is the commercial capital, Dar es Salaam, which is assumed to do no agricultural production, but which serves as a production center for manufacturing and services, and is also the entrepot for all international trade.⁶ Between these two regions lies a third region, which we think of as representing all the secondary cities and urban peripheries of Tanzania: we refer to this secondary city region collectively as *Mwanza* (invoking the name of one of the major towns in Tanzania). We do not view any of these regions as literal representations of any cartographic spaces; our Dar es Salaam effectively includes the mining and tourism sectors, which are physically located at some distance from Dar. Likewise, our secondary cities do not correspond to any contiguous set of locations in Tanzania. Hence our Mwanza is not a point and 'within-Mwanza' trade is conducted across space. We do, however, assume that while trade within the secondary city region is not costless transport connections are better between the towns that make up our model Mwanza than between each and the rural economy. The essential analytical point is that goods and services move across this entire geography: imports move between the (single) port and the location at which they are consumed, exports move from the farm / factory gate to the port, while domestically produced goods and services may be consumed in locations other than where they are produced. Because movement of goods is costly, transport costs will play a central role in determining the equilibrium allocation of resources.

Transport costs consist of a number of elements allowing us to distinguish, for example, between interventions that reduce the degree of monopoly in the transport and distribution sector – which will have distributional as well as efficiency effects – from those that reduce the rate of “melt” by improving the quality and lower the cost of the road transport. The general equilibrium effects of changes in these different elements are non-similar. Aside from their impact on transport costs themselves, changes in the monopoly rents, which accrue to the capitalist household located in Dar, will entail domestic transfers of income. By the same token, changes in fuel costs will have first-order impacts on the balance of payments. The

⁶This is, of course, an abstraction from the actual Tanzanian economy, which trades significant quantities of goods overland with neighboring African countries. The essential issue, however, is that much of this is in effect cross-border transit traffic from Dar es Salaam.

“melt” associated with transportation is modeled as an iceberg cost, so that when goods are moved, a specified proportion of the initial quantity is lost *en route* from origin to destination: as such the melt is a pure loss to the economy. All three components of the transport cost margin are amenable, in principle, to change through public investments in infrastructure. In addition, the fuel cost component will respond to changes in the world price of fuel while the pure rent component may be amenable to regulatory reform. Transport costs depend both on distance and on the nature of the goods themselves so that, for example, perishable goods such as food are more vulnerable to physical deterioration whilst being transported than are manufactured goods. To reflect this, we overlay the spatial model with a highly nuanced structure of endogenous transport costs.

A listing of the model equations is provided in the Appendix. In what follows we expand on the non-standard features of the model.

Production and trade

The economy consists of a total of 11 private activities and commodities spanning four consumption goods (staple food, processed food, manufactures and services), and two pure export goods (cash crops and mining). Different varieties of each good, excluding mining, are produced in different locations which in turn differ in their endowments of a fixed factor (agricultural land) and in the production technologies available (see Table 1). In addition, we treat the natural resource sector as based in Dar.⁷ All sectors purchase intermediate goods from other locations, with different transportation and transaction costs depending on the origin and type of the intermediates. The secondary cities are engaged in all activities except for mining and the production of government services. Sectors operating in “Mwanza” can sell final goods to Dar es Salaam and to rural areas as well as supplying their local market, and they may purchase intermediates from these locations, with corresponding transportation and transaction costs. The rural location can only produce food and cash crops. These can be consumed directly by the rural household, or they can be sold onward to other markets, at the appropriate costs.

The production of staple food and cash crop production requires land and labor only; all urban production – processed food, other manufacturing and services – requires capital and labor. Fuel is a direct import; it has no domestic substitutes but contributes to transport costs along all nodes in the economy. Each sector corresponds to a distinct production technology, characterized as Cobb-Douglas in land and labour (in the rural sectors) or capital

⁷In practice, this sector will represent the mining and tourism sectors, which are pure export sectors.

and labour (in the urban sectors). Land is fixed in supply while private capital stocks are fixed in each period, but evolve over time through depreciation and gross investment. The markets in skilled and unskilled labor are competitive, so that in equilibrium labor of each skill type is fully employed and paid its marginal product. The initial skill mix is sector specific. Production in each sector exhibits constant returns to private factors while the overall productivity of private factors is a function of non-congestible public infrastructure capital, the impact of which may vary across sectors by choice of the parameter α_{gi} , as shown in Equations (8) and (9) in Appendix 1. The government sector generates revenue from a variety of taxes and tariffs. Some of this revenue is used to finance public consumption, some is returned to households in the form of transfers, and the remainder is used for public investments.

Households and preferences

The model tracks seven representative households; their consumption will serve as our principal measure of welfare. The first six are defined in terms of location (rural, Mwanza and Dar) and labour type (skilled and unskilled). Each household has preferences defined over the set of consumption goods available in its location. The gross income of each household consists of skill-and-sector specific labor income, plus land rents in the case of the rural and Mwanza households.⁸ The final household is a capitalist household whose gross income consists of the net pre-tax profits from all domestically owned capital in the economy.⁹ Households consist of large numbers of individual members. The composition of these households is somewhat fluid: individuals can move between households depending on where they sell their (skill-specific) labor. Hence the Rural, Mwanza and Dar households will change size as labor migrates between locations. By contrast, the capitalist household is fixed in size. In principle, there could be costs associated with individual movements between locations/households, but for convenience, we assume here that labor movement is frictionless. All income is pooled within the household: land is jointly owned, and land rents in each location are allocated uniformly across all members of the household regardless of their skill level or other characteristics – including their length of association with the household.¹⁰

⁸Rents are allocated between households in the same location on a equal per capita basis.

⁹As discussed below, the foreign private sector owns a share of the capital in the model economy.

¹⁰In that sense, one could envision the households as having a flavor of worker hostels that operate in each location. The hostel opens its doors to all the workers of a particular type, including new arrivals. These new arrivals adopt the common (non-homothetic) household-specific preferences of the host household. All

Consumption of the representative member of each household and skill type is defined over a vector of composite goods consisting of staple food, processed food, manufactured goods and services, each of which could be produced in different locations. Each composite good is itself an Armington aggregate of domestically produced and imported varieties of the good (Equation 14) and as such the local price of the composite will reflect the transport costs embedded in both. To reflect the spatial dimension of the model, we assume that the composite is assembled at the factory gate so that the relative price of the composite good will be a function of the transport cost associated with bringing the import to the production location. The composite good enters both final and intermediate demand vectors; in both cases demand will be a function of the cost of transporting the good to the demand location, either the household (for final consumption), to the port of Dar es Salaam (for exports), or the domestic factory gate (intermediate consumption and investment).

We adopt a savings-driven neoclassical closure in which total private investment is constrained by total savings net of exogenous public investment, but where domestic household and government savings are augmented by FDI flows. The foreign demand for domestic capital is determined by the excess of the domestic real interest rate over the world rate subject to a risk premium that is increasing in foreign equity exposure.

The model has a simple recursively dynamic structure but in this paper we focus entirely across steady-states. To focus exclusively on the impact of stationary changes in the vector of transport costs on the economy, we calibrate the model to an initial static steady-state equilibrium in which net public and private investment is zero (i.e. gross investment exactly matches depreciation) and there is no growth in the labor supply. The nominal exchange rate is fixed so that the numeraire is the world price of importables.

Because each household type has a distinct set of preferences, we cannot formally compare the utility of individuals belonging to different households. The equilibrium of the model thus does not require utility equalization across locations. Even if preferences were identical, we note that the structure of our model implies that there will be *ex post* differences in the utility of households across locations, even though marginal value products are equalized. This is because the transport and transaction cost wedges here interfere with standard welfare theorems. Instead, we solve for a competitive equilibrium in which the marginal product of labour is equalized across locations for each type of worker. Implicitly, this is an equilibrium in which firms no longer have an incentive to hire away workers from other locations. If these

the residents of the hostel then receive a utility-maximizing consumption bundle that reflects their wage income and an equal share of the rental income accruing to the household.

marginal products were not equalized, firms would have an incentive to bid away labour from other locations.¹¹

Welfare

In order to assess the impacts of different policies, we would like to be able to compare the aggregate welfare attained in the model economy in different states of the world. Constructing an aggregate measure of welfare in this economy is non-trivial. Preferences differ across household types; prices differ across locations; and consumption aggregates differ across locations. Our preferred approach is to look at the real consumption wages of each household type; i.e., at the purchasing power of each household. These are consistent measures of the within-household changes in well-being. In combination with an understanding of how labour is moving across households, this detailed picture gives us a clear understanding of the changes induced in different states of the world.

One drawback of these within-household measures of real consumption, however, is that they do not account for the changes that take place through the reallocation of labour across households. For this reason, it is useful to construct some aggregate measures of utility. These are problematic because they necessarily involve interpersonal comparisons of utility. Nevertheless, we define two welfare measures that we find useful for thinking about model impacts. One welfare measure is a weighted average of the utilities realized by each labour type, across the three locations of the economy; i.e., we calculate a measure that averages the utility of all the low-skilled workers in the economy and one for all the high-skilled workers. Our other class of measure computes the weighted average of the utilities of all the workers in each location: Rural, Mwanza, and Dar. (See equations (36) and (37) in Appendix 1). Our aggregate social welfare index is the aggregate of the two. We do not view these as rigorously defined measures, but they provide a useful way of assessing the welfare impacts that arise from different scenarios.

5 Calibration and baseline parameterization

The model is calibrated to a stylized version of the 2001 Tanzania Social Accounting Matrix (SAM) produced by the International Food Policy Research Institute (IFPRI), as described

¹¹We note that in any model with costs of living differing across locations, utility equalization will tend to imply differences in wages, and vice versa. This is not a feature unique to our model; see, for instance, Herrendorf et al. (2012), who choose to equalize utility across locations but allow wages to differ.

in Thurlow and Wobst (2003).¹² Preserving the aggregate sectoral balances in the SAM, we first collapse the production side of this 43-sector SAM to seven basic commodities (food, cash crops, natural resources, processed food, manufactured goods, private services and public services) and then disaggregate all but natural resources and public services to allow for different spatial variants of each commodity to be produced. We use the *Integrated labor Force Survey (2001)* to develop a detailed geographic breakdown of employment, by skill and activity and the *Tanzania Agricultural Sample Census (2003)* to allocate land between staple and cash crop activities and between subsistence (our rural production technology) and commercial (our 'Mwanza') technologies. There are no estimates of the size of the capital stock for Tanzania, either in aggregate or across sectors/locations for both the public and private sector, so these are imputed on the basis of gross profits in the SAM and an assumed (common) rate of depreciation across sectors.

Finally, we impose an assumption of zero growth in population and zero net investment (i.e. gross investment is set equal to depreciation) and adjust elements of the inter-sectoral allocation of factors so as to generate a stationary steady state for the model which displays broadly plausible factor shares, factor returns and consumption vectors.

Transport costs

Transport costs are central to our analysis. To calibrate the model's extensive web of transport links between locations we disaggregate the data provided by the SAM using a mixture of empirical estimates and plausible assumptions (see Raballand et al (2008), Eskola (2005), Kweka (2006) and Mkenda and van Campenhout (2011)). We start with the SAM which provides direct estimates of the transport and distribution wedge between producer and consumer prices. We decompose this wedge into the various components considered in our model (pure rents, fuel costs and a pure melt). The economy-wide transport cost mark-up is equivalent to approximately 20% of household final consumption. We assume approximately 50% of this is represented by rents that accrue to the capitalist household, around 20% is a direct fuel cost, and the remaining 30% we attribute to a pure melt component. We assume that all three components are more or less proportional to distance and/or time but can vary across commodities. (For example, food might experience a higher rate of melt than manufactured goods.) Applying a set of distance-based estimates to these

¹²This SAM itself is a mechanical update which combines data from the 2000/01 Tanzania Household Budget Survey and the 2000/01 Tanzania Labour Force Survey with the 1992 input-output matrix (the most recent available). A new input-output matrix is being produced by the Tanzania National Bureau of Statistics on the basis of the 2007 Household Budget Survey but this has not yet been published.

shares we arrive at a complete matrix of transport costs across commodity composites, and household locations. These are summarized in Table 2.¹³

In the experiments presented below we assume all six households have non-homothetic preferences; each faces a subsistence level of consumption for staple food equivalent to 90% of baseline consumption. The elasticity of substitution between domestic and imported goods in the consumption composite is less than unity (0.75), as is the elasticity of transformation of output between domestic and export variants. TFP levels are held constant, and we assume the interest elasticity of supply for foreign savings (FDI) is low (0.10). The benchmark equilibrium of the model is summarized in Table 3.

6 Experiment design

We restrict our attention in this paper to two basic experiments. The first consists of an exogenous permanent increase in the rate of public infrastructure investment, in the context where public infrastructure investment has a positive rate of return. The greater abundance of public capital increases the productivity of private factors but may do so differentially across sectors and locations (see Adam and Bevan, 2006). For example, a rural feeder road-building programme might disproportionately increase factor productivity in rural agriculture whereas a trunk road or urban transport infrastructure investment might favour factors employed in urban, non-agricultural activities. The investment increase is substantial, equivalent to approximately 3 percentage points of baseline GDP, raising public investment from approximately 9% to 12% of GDP (Table 3). Given the properties of the model, this leads to a permanent increase in the public infrastructure capital of around 14 percent. There are no non-distortionary financing mechanisms in the model so how this public investment is financed is not neutral: the full distributional consequences of public investment cannot be adequately considered independently of fiscal financing decisions. We therefore examine a number of alternative financing schemes.

The first option is straight deficit financing of public investments, so that the government operates with a permanently higher deficit funded by private saving. In the context of the closure this entails a simple and direct crowding-out of private investment: whether

¹³Table 2 suppresses a huge amount of detail. For example, the transport cost per unit of consumption at any given location will reflect not just the distance between the consumer and domestic producer but also, the import content of the composite good (recognizing that imports need to be transported to the location at which they are combined with the domestic variant) and intermediate goods intensity of production (since the transport costs associated with moving intermediates between spatially differentiated producers will also feed into the final transport costs borne by consumers).

investment is crowded out dollar-for-dollar depends on the impact of public investment on the return to private capital and, hence, the scale of FDI inflows. If public capital raises the return to private capital, and the elasticity of foreign capital inflows is high enough, the crowding-out of domestic private investment is modified by foreign inflows, and vice versa if the return to capital does not rise.

The next two options provide for the additional investment expenditures to be met from additional domestic taxation. In the first of these, the additional revenue is raised from indirect taxes levied on manufactured goods and services consumed by skilled households in Dar and Mwanza. We view this as a plausible proxy for the likely incidence of a sales tax or value added tax in Tanzania, given that the consumption of rural households tends to be dominated by staple food which is tax-exempt for VAT purposes. In the second case, higher tariffs are imposed on manufactured imports, with tariff levels set *pro rata* with baseline imports.¹⁴ For completeness, the final financing arrangement assumes public investment is wholly aid-financed. Although this might at first glance appear to imply a “manna from heaven” view of our policy interventions, aid inflows have important macroeconomic consequences flowing through spending effects that alter real exchange rates and relative prices.

Our second set of experiments consists of actions that *directly* change the cost of moving goods between locations. Here we focus on public policy actions that reduce two of the three elements of our transport cost wedge, namely the pure ‘melt’ component and the rents earned by monopoly providers of transport services. Whereas it is reasonably straightforward to define the cost of a public investment surge, since we have initial data on capital intensities and costs of investment, it is much less straightforward to do the same for this second group of reforms. How much does it cost to introduce competition into the sector, for example? There are two ways we tackle this. The first is simply to ‘wave a wand’ and introduce reforms at zero cost, and the second is to assume that the reforms must be purchased at the same (permanent) fiscal cost and through the same mechanisms as considered in the public investment surge case. This allows us to directly compare outcomes between the two sets of experiments. Reality is clearly somewhere between these two extremes: reforms typically do entail some resource cost but are more likely to be temporary rather than of the permanent

¹⁴For completeness we also examine a third domestic financing option where revenue is raised through higher direct taxes on the capital and labour income of capital owners and skilled households in Dar and Mwanza. This again is a plausible proxy for the real-world incidence of any direct tax. In practice, however, the direct tax base is narrow and changes to direct taxation are rare. It turns out that the results for this case are broadly similar to those of case one and we therefore omit a detailed discussion of this case here. Detailed results are available on request from the authors.

nature considered here. This suggest that the results discussed in the next section need to be interpreted carefully.

For each scenario, we suppress the dynamic adjustment and report the out-turn at Year 10. We are particularly interested in the distribution of economic activity across space and sector and how this affect the real wages and the well-being (as measured in utility terms) of unskilled workers in each location. The measurement of welfare takes explicit account of the fact that households in different locations have different preferences and face different prices.

We now turn to the results.

7 Results

Public infrastructure investment

Tables 4(a) to 4(c) provide a summary of the public investment experiments. Panel (a) reports the change in broad macroeconomic balances; panel (b) the change in the (spatial) economic structure; and panel (c) focuses on the welfare effects of these changes alongside equilibrium changes in relative prices than underpin these welfare changes. The left hand panel corresponds to the case where public infrastructure is biased towards the production of agricultural output (public irrigation systems, for example) and the right hand panel the case where infrastructure enhances non-agricultural production. Each column corresponds to a different fiscal financing mechanism.

A first important result is that there is no natural benchmark for this group of experiments; the results are sensitive to the financing regime and, given the absence of non-distortionary taxes in the system, none are distributionally or otherwise neutral. Even the aid-financed case is non-neutral. Since public investment places demands on both tradable and non-tradable inputs (produced in different locations) there is an 'aid spending effect' where the tradable inflow finances the demand for non-tradables thereby requiring a real exchange rate appreciation. These differential macro effects can be seen in panel (a) by considering the variation in private investment and GDP. When public investment is deficit-financed, private investment is crowded out by 3.9 percentage points of GDP from its initial value of 16.2% of GDP. This, in turn, lowers real GDP by 2.8% over the 10-year horizon; the real exchange rate depreciates by around 2% to maintain internal and external balance. By contrast, when public investment is fully aid financed, private investment is crowded in (raising the investment rate by 0.7 percentage points of GDP) with the aggregate

investment surge raising GDP by 1.1% - 1.2% over the 10 year horizon. Between these extremes lie the two domestic tax-financed cases. In both cases, higher taxes tend to crowd out private investment – more powerfully when financing relies on tariff increases. Our results suggest that if the authorities rely on indirect (consumption) taxation as the preferred mode of financing, the impact of the modest decline in private investment is outweighed by the growth-enhancing effects of public investment.

Before examining the structural change and welfare consequences of these changes, it is worth noting a few other aspects of the macroeconomics of the public investment surge, starting with the fiscal position. With the exception of the consumption tax, which is the least distortionary to overall growth, the fiscal balance typically deteriorates (although in the aid-financing case this is an artefact since aid inflows provide a fully offsetting capital inflow). The consequences for external balance also vary across the financing regime, but for a variety of reasons. When public investment is deficit-financed, the current account deteriorates as a result of a contraction in underlying export growth, which in turn requires a depreciation in the equilibrium real exchange rate. In the aid financing case there is an even larger contraction in exports but in this case it reflects the substitution of aid for trade in financing the demand for imports. Here, the real exchange rate appreciates by between 3% and 5%, depending on the productivity bias in public investment. Tariff-financing of public investment operates in a slightly different manner, principally by *improving* the trade balance, although this improvement comes about because the demand side contraction in imports exceeds the sharp contraction in exports that arises from lower growth in output. Finally, in the consumption tax case the overall effect on the external balance is broadly neutral: both exports and imports grow, partly because of the underlying growth effects and partly because, due to exemptions, the consumption tax falls on the non-tradable service sector so that tax increases shift demand (and production) in favour of tradables. It is worth noting that aggregate macroeconomic effects are more or less invariant to the direction of productivity bias in public investment.

Our fundamental interest, however, lies with the structural change and household-specific welfare effects of these interventions. We start with the deficit-financing case which neatly illustrates the complexity of the general equilibrium interactions at play. With increased public investment, output shifts *away* from Mwanza into Dar and the Rural areas of our model economy, with the shift towards the rural sector stronger if public investment is biased toward agricultural sectors. Accompanying this is a decisive movement of labour out of the rural area and a sharp fall in welfare in rural households and for unskilled labour. This

outcome reflects the interaction of two effects. First, deficit-financing of public investment results in a contraction in investment and overall absorption, but since all consumers' demand for food is non-homothetic, the demand for food falls less rapidly than for other goods; hence the increase in the rural economy's *share* in output. Second, however, when public investment is biased towards agriculture, labour productivity in agriculture increases, shifting the rural supply curve outwards. The net effect of these demand and supply shifts is that the relative price of food falls, by between 2.2% and 5.4% across different households, and labour is shed, driving down real wages for unskilled labour. Cash crops, which are also produced in the rural area but in much smaller amounts, enjoy the same favourable productivity effects from the public investment surge – but since cash crops are exportable and their demand perfectly elastic, labour demand increases in this sector. Since cash crops are more skill-intensive than staple food production, real wages for rural skilled labour increases. These same mechanisms favour households in Dar. Because these households are net consumers of food, they enjoy the benefit of falling real prices for food produced by commercial farmers in Mwanza and, especially, by smallholders in rural areas. Not only does this reduce their real cost of consumption, but in addition the inflow of labour from the rural area, combined with the real exchange rate depreciation makes the urban tradable sector more competitive. An important aspect of this result is that effects on relative food prices, labour movement and welfare are stronger when public investment is agriculture-biased: it is the interaction of inelastic demand, the unskilled intensity and the productivity boost that exposes rural households to such a sharp decline in welfare. It follows that if the productivity benefits of public investment occur in non-agricultural sectors, relative food prices fall by less and the incentives for out-migration is moderated.

Inevitably, these effects differ depending on how public investment is financed. Under the current parameterization, there are no Pareto-improving financing mechanism: all options entail at least one household or skill-type being worse off. Rural households benefit most from the public investment surge when it is financed by increasing consumption taxes or by aid and are hurt most when public investment is deficit-financed or paid for through tariff revenue. The patterns repeat for Mwanza households, although for these, aid financing is significantly more attractive. For households in Dar, composed of skilled urban workers and capitalists, welfare is maximized when public investment is deficit-financed (even though aggregate output is hurt most in this case) and they do least well under those financing scenarios that benefit Rural and Mwanza households the most. This particular pattern is broadly invariant to the sectoral bias in public investment – although, for the reasons

discussed above, rural households are absolutely better off when public investment is biased towards non-agricultural sectors and *vice versa* for Mwanza and Dar households. Likewise, gains are greatest for unskilled labour in all locations when public investment is biased towards the non-agricultural sectors (and when financed from consumption taxes) while for skilled labour in all locations, the gains are greatest when investment is biased towards agriculture.

Tariff-financing is unambiguously bad for all households, whether the investment is biased to agriculture or non-agriculture. Real GDP contracts (by 1.3% and 1.4%) and real consumption wages fall sharply for all unskilled workers. Those in Dar fare worst, relative to the benchmark; the tariff affects them as consumers more than it increases their wages, since demand from the rest of the economy is relatively elastic with respect to the tariff. The rural unskilled are also clearly worse off, as terms of trade skew strongly against them under these scenarios.

That financing through indirect taxation is more favourable to rural households and unskilled labour simply reflects the progressive pattern of tax incidence embedded in the model. Indirect taxes are non-uniform and collected only on goods that weigh heavily in the consumption basket of urban households and are relatively intensive in skilled labour, so that skilled labour and urban households bear the brunt of indirect tax-financing.

Transport sector interventions

We turn next to the consequences for the model economy of a set of interventions that directly reduce transport costs. First we consider a reduction in the 'melt', which constitutes a true cost saving to the economy. Next, we consider reforms that make the sector more competitive and hence eliminate rents accruing to the owners of the sector – in our model, the capitalist households. As noted above, we explore reductions in transport costs under two polar assumptions: the first is that reforms can be introduced at zero cost and the second that they must be purchased at the same (permanent) fiscal cost and through the same mechanisms as considered in the public investment surge case analysed earlier. Despite the fact that reality necessarily lies somewhere in between, this latter assumption has the virtue of allowing for some meaningful comparison between the two sets of experiments.

Consider first the case where reforms are achieved at a stroke of a pen with no real resource cost to the economy. In aggregate terms, a reduction in melt (Table 5, left panel) sees an expansion in private investment of around 1.6 percentage points over the baseline. This helps support an increase in aggregate output of 2.1% and contributes to an improvement

in the fiscal balance of about 0.6 percentage points of GDP and a very slight improvement in the current account position. In this case, as transport costs fall, the rural economy unambiguously contracts and the urban economy expands, both in the secondary cities and in Dar. But despite the absolute contraction in total rural output, this structural change generates an unambiguous welfare gain to the economy: all households and all labour types enjoy increased consumption and welfare. The gains, which accrue overwhelmingly to households in Mwanza and Dar households and to skilled labour, emanate from three sources. First, the lower melt supports increased export competitiveness (which is predominantly urban-located and skilled-labour intensive); second, these households face lower consumption prices for tradable goods, since a reduction in melt leads to a decline in consumption prices for all goods; and finally, households in Mwanza and Dar face lower costs for staple food transported from rural areas. Given the low elasticity of demand for food, demand effects are strongest in non-food goods and services, which tend to be relatively intensive in skilled labour. Nonetheless, rural households also gain from the absolute reduction in the price of their consumption bundle as a result of the fall in the cost of bringing their non-food consumption to the household.

The picture is rather different when the reduction in transport costs arises from the effective redistribution of rents from capitalist households to the rest of the economy. Now, the distributional effects are powerful: compared to the reduction in melt, the returns to skilled labour, which is used intensively in the production of non-food goods and services that dominate the consumption basket of the capitalists, are much diminished while the gains to unskilled labour and, concomitantly to rural households, are increased. Given the factor intensity of production and patterns of consumption, the welfare gains to Mwanza households remain positive but much lower than in the pure melt-reduction case.

When reforms are assumed to be costly (to be precise, as costly as the previous surge in public investment) the picture necessarily changes, but in a manner that is consistent with our earlier analysis of public investment. Except in the case where external aid finances the full cost of reforms, real GDP growth is always lower than in the base case of costless reform and may be negative when the financing regime bears down heavily on private investment. But it remains the case that the rural and Mwanza households (and unskilled labour) fare best in circumstances where the cost of reforms is financed by consumption taxes and, indeed, in the case of a reduction of the rate of melt, all households and labour types enjoy welfare increases. This is not the case when reforms remove rents from the system: there the Dar household experiences a decline in welfare in all cases, except when the reform is aid-financed.

Analysis and key mechanisms

In any general equilibrium analysis, the precise numerical values emerging from simulations depend not only on the quality of baseline data but also the calibration of key behavioural parameters. This model is no exception: the two big areas of uncertainty are the productivity of private capital and the cost of implementing transport cost-reducing reforms. In the interests of tractability we assume a relatively low value for the productivity of public infrastructure capital and provide for no other learning externalities in production, while, *faut de mieux*, we explore two polar cases when evaluating the resource cost of reforms. Faced with such uncertainties, the appropriate use of this approach entails focusing not on the actual numbers but rather the key general equilibrium processes they describe, particularly when these patterns are robust to variations in key parameters. The simulations presented in this paper represent a small subset of a much more extensive analysis which suggests that this is indeed the case: allowing for more powerful productivity effects, for example, does not alter the insights delivered by the model.¹⁵

Specifically the analysis underlines a number of key characteristics. The first and rather obvious point is that, holding other macroeconomic effects constant, reductions in 'pure' transport costs confer unambiguous welfare gains on the economy and accelerate the process of structural change, making the economy more tradable in the process. The exact distribution of these gains depend on the exact pattern of transport cost intensity. Second, the non-homotheticity of preferences for food plays an important role in shaping the degree of labour movement and structural transformation consequences of policy reforms. However, what really impacts distribution is the interaction of inelastic demand for essentially non-tradable food with the productivity-enhancing effects of public investment. For net sellers of food, public investment that raises labour productivity in the staple food sector drives down the market-clearing price, prompting strong out-migration of labour. It is the fall in food prices and the increase in labour supply in the urban locations that transfers the gains from agricultural-biased infrastructure investment to urban households.

Third, the method of financing any particular public investment programme, or policy reform, has first order distributional implications which may overturn the underlying gains to productivity. An increase in public capital formation targeted to agriculture can have a negative impact on the real consumption wages of the rural unskilled if it is financed

¹⁵Our value of $\alpha_g = 0.10$ is towards the low end of the range of estimates by Hulten (1996) and slightly lower than that used by Buffie *et al* (2012). Raising this value to $\alpha_g = 0.25$ or $\alpha_g = 0.40$ necessarily imparts a larger return to public investment but otherwise does not change the underlying dynamics of the model.

from a tariff (-4.8%) but a positive effect (0.15%) if financed through a consumption tax on the income of capitalists and skilled workers in Dar and Mwanza. Similarly, an investment in non-agricultural public capital will increase the welfare of rural households (2%) if financed by consumption taxes but will reduce welfare by between 1.5% and 9.3% if financed through other mechanisms. Any attempt to understand the alternative economic consequences and poverty impact of public investments in agriculture and non-agriculture or in reducing transport costs must account explicitly for the financing of these interventions: an examination that focuses only on the expenditure side is incomplete. We believe this is an under-appreciated point in the structural transformation literature. Because some sectors are more easily taxed or subsidized than others, most financing mechanisms available to governments in developing countries are highly distortionary. The distortions created through financing are likely to be non-neutral with respect to poverty and welfare, and they may have impacts that are quantitatively significant.

8 Conclusions and next steps

This analysis offers some sobering conclusions with respect to efforts to study the impacts of investments in agriculture and non-agriculture. A recurring question in policy circles is whether governments should target agriculture or other sectors if they wish to improve the well-being of the poor. We find that general equilibrium effects make this a complicated question to answer: because sectors are linked through factor markets and through a complex input-output structure, the benefits and costs of different policies do not rest in the targeted sectors. How public investments are financed also matters significantly for the aggregate consequences and the distributional consequences. This finding represents a sharp departure from previous literature that models the effects of public investments under the assumption that the government has access to non-distortionary sources of revenue. Because many developing country governments – like that of Tanzania – have relatively narrow tax bases, resource mobilization for public investment is likely to create significant distortions in the economy, operating through relative price effects and real exchange rate effects. We find, most strikingly, that the (indirect) distributional consequences of government financing choices may matter more than the (direct) consequences of targeting investment to particular sectors or locations. For instance, under some financing scenarios, interventions that aid agriculture may lead to decreases in the welfare of the rural unskilled labor force, because the financing mechanisms create distortions that effectively skew the terms of trade sufficiently

powerfully against the rural unskilled as to outweigh the direct welfare-enhancing effects of the public investment.

As with all such models, both the magnitude and, in some instances, the direction of impacts are sensitive to the calibration of parameters that are often difficult or impossible to estimate accurately. Nonetheless, although we do not claim that our model offers a sufficiently accurate representation of the Tanzanian economy to make specific policy recommendations based on the numerical results, we would argue that our analysis points to a number of key implications for future research. First, financing matters; we cannot usefully divorce discussions of the distributional consequences of public investments from discussions of financing.¹⁶ Second, sectoral targeting of government investment does not lead to straightforward impacts in general equilibrium: we find, perhaps counterintuitively, that the rural unskilled are better off under *all* financing scenarios from investments targeting non-agriculture than from investments of the same magnitude targeting agriculture. Third, the impacts of public investments on structural change are also complex: the model suggests that the labour force in Dar expands more, in all financing scenarios, when investments target agriculture than when they target other sectors.

Our model omits a number of features that merit further research. For instance, we have abstracted from the agglomeration effects of urbanization, in either Dar or the secondary cities of the model; yet many urban economists would argue that these agglomeration effects are crucial to understanding patterns of urbanization. Our research has also abstracted from frictions in factor mobility: we assume that labor of a particular skill type is fully mobile across sectors and locations. If this were not true, it might alter the story of our model considerably. We have also abstracted from growth in factors of production; yet in reality, Tanzania's economy shows increases in all three of the factors of production. The labour force continues to grow; land under cultivation has expanded; and capital flows in to the economy.

In closing, we call simply for caution in policy discussions of whether governments should target policies to particular sectors. Our ignorance about the productivity impacts of investments at the sectoral level is matched only by our difficulty in accurately modeling the general equilibrium effects that are created by sector-specific investments. These challenges are compounded by the observation that the financing of public investment may have distributional effects that exceed the first-round effects of sector-specific investments. In the end, we would call for modesty and caution in economists' efforts to prescribe the sectoral

¹⁶It is important to note that for reasonable parameterizations of the model, financing remains of first-order importance even in contexts where the implied benefit-cost ratio is high.

allocation of public investment. Given the heterogeneity of developing countries and the uncertainties around policy impacts, there is unlikely to be a single answer to the question of whether poverty is most effectively reduced through investments in agriculture or any other sector; and even within a single country, the answer to this question is unlikely ever to be simple.

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Appendix 1: Model equations

The following are the equations of the model. Except where required, sectoral indices are suppressed; a number of model identities and definitions have been excluded.

Prices

Sets: (i = sectors; h = households (*Rural*, *Mwanza*, *Dar*))

$$p_{M_i} = Rp_{M_i}^w(1 + t_{M_i})(1 + \tau_{M_i}) \quad (.1)$$

$$p_{E_i} = Rp_{E_i}^w(1 + t_{E_i})(1 + \tau_{E_i}) \quad (.2)$$

$$p_{X_i} = \frac{p_{D_i}XD_i + p_{E_i}E_i}{X_i} \quad (.3)$$

$$p_{Q_i} = \frac{p_{D_i}XD_i + p_{M_i}M_i}{Q_i} \quad (.4)$$

$$p_{VA_i} = p_{X_i} - \sum_j \tau_{Nj}\phi_j p_{Q_j} \quad (.5)$$

$$p_{C_i}^h = (1 + \tau_{D_i}^h)(1 + t_{D_i})p_{Q_i} \quad (.6)$$

$$p_{K_i} = \sum_j \phi_j^K p_{Q_j} \quad (.7)$$

Production

Sets: (*rural*= staple food and cash crops; *urban*= all other sectors; *sk* = unskilled, skilled)

$$X_{i(rural)} = A_i S_i^{\alpha S(i)} L_{U_i}^{\alpha U(i)} L_{S_i}^{(1-\alpha S(i)-\alpha U(i))} K^{\alpha g(i)} \quad (.8)$$

$$X_{i(urban)} = A_i K_i^{\alpha K(i)} L_{U_i}^{\alpha U(i)} L_{S_i}^{(1-\alpha K(i)-\alpha U(i))} K^{\alpha g(i)} \quad (.9)$$

$$L_i^{sk} = \frac{\alpha^{sk(i)} p_{VA_i} X_i}{W_i^{sk}} \quad (.10)$$

$$\sum_i L_i^{sk} = \bar{L}_{sk} \quad (.11)$$

$$X_i = A_{Ti} \left[\gamma_i E_i^{\frac{\epsilon(i)+1}{\epsilon(i)}} + (1 - \gamma_i) X D_i^{\frac{\epsilon(i)+1}{\epsilon(i)}} \right]^{\frac{\epsilon(i)}{\epsilon(i)+1}} \quad (.12)$$

$$\frac{E_i}{XD_i} = \left[\left(\frac{p_{E_i}}{p_{D_i}} \right) \left(\frac{1 - \gamma_i}{\gamma_i} \right) \right]^{\epsilon(i)} \quad (.13)$$

$$Q_i = A_{C_i} \left[\delta_i M_i^{\frac{\epsilon(i)-1}{\epsilon(i)}} + (1 - \gamma_i) X D_i^{\frac{\epsilon(i)-1}{\epsilon(i)}} \right]^{\frac{\epsilon(i)}{\epsilon(i)-1}} \quad (.14)$$

$$\frac{M_i}{XD_i} = \left[\left(\frac{p_{D_i}}{p_{M_i}} \right) \left(\frac{\delta_i}{1 - \delta_i} \right) \right]^{\epsilon(i)} \quad (.15)$$

$$N_i = \sum_j (1 + \tau_{N_j}) \phi_j X_j \quad (.16)$$

Factor Income, Disposable Income and Consumption

Per capita by skill type (where household size = $hl(h)$ and $l = imports(M), exports(E), domestic(D)$)

$$Y_{sk}^{Rur} = \frac{1}{hl(Rur_{sk})} (\phi_{Rur_{sk}} (r s_{Rur} S_{Rur}) + \sum_{sk} w_{sk} L_{Rur}^{sk}) \quad (.17)$$

$$Y_{sk}^{Mwa} = \frac{1}{hl(Mwa_{sk})} (\phi_{Mwa_{sk}} (r s_{Mwa} S_{Mwa}) + \sum_{sk} w_{sk} L_{Mwa}^{sk}) \quad (.18)$$

$$Y_{sk}^{Dar} = \frac{1}{hl(Dar_{sk})} (\sum_{sk} w_{sk} L_{Dar}^{sk}) \quad (.19)$$

$$Y^{Cap} = \frac{1}{hl(Cap)} \sum_i ((1 - \psi)(r + \delta) K_i + \sum_i \sum_l rent_{li}) \quad (.20)$$

$$YD^h = Y^h (1 - t_Y^h) + R * pkap^h \quad (.21)$$

$$H^h = s^h YD^h \quad (.22)$$

$$p_C^h C^h = p_C^h \overline{C^h} + \left(\frac{p_C^{h1-\sigma} \beta^{h\sigma}}{\sum_i p_C^{h1-\sigma} \beta^{h\sigma}} \right) [YD^h (1 - s^h) - p_C^h \overline{C^h}] \quad (.23)$$

Fiscal

$$GR = R \left[\sum t_M p_M^w \cdot M + \sum t_E p_E^w \cdot E \right] + \sum_h \sum t_D (1 + \tau_D^h) p_Q C^h + \sum_h t_Y^h Y^h - \sum_i fs \cdot R p_w^{fuel} \cdot Fuel_i \quad (.24)$$

$$H_{gov} = GR - (p_{VA} + \sum_j (1 + \tau_N) \phi_j) G + R \cdot aid \quad (.25)$$

Transport Costs

$$\tau_{M_i} = \phi_{M_i}^{fuel} (R p_w^{fuel} Fuel_{M_i}) + \phi_{M_i}^{rent} rent_{M_i} + \phi_{M_i}^{melt} melt_{M_i} \quad (.26)$$

$$\tau_{E_i} = \phi_{E_i}^{fuel} (R p_w^{fuel} Fuel_{M_i}) + \phi_{E_i}^{rent} rent_{E_i} + \phi_{E_i}^{melt} melt_{E_i} \quad (.27)$$

$$\tau_{D_i}^h = \phi_{D_i}^{h,fuel} (R p_w^{fuel} Fuel_{D_i}^h) + \phi_{D_i}^{h,rent} rent_{M_i}^h + \phi_{D_i}^{h,melt} melt_{M_i}^h \quad (.28)$$

Saving, Investment and Macroeconomic Balance

$$p_{K_i} DK_i = \theta (1 - \mu(r_i - \bar{r})) (Saving - p_{K_{pub}} DK^{pub}) \quad (.29)$$

$$I = \sum_j \phi_j^K DK_j \quad (.30)$$

$$FDI = \overline{fdi} + \beta_1 \left(\left(\frac{\bar{r}}{r^*} \right)^{\beta_2} - 1 \right) RGDP/R \quad (.31)$$

$$Saving = \sum_h H^h + H_{gov} + (FDI - \sum_i \psi(r + \delta) K_i) \quad (.32)$$

$$Q_i = \sum_h hl(h) \cdot C_i^h + N_i + I_i + G_i + \sum_l melt_{l_i} \quad (.33)$$

$$\sum p_{M_i}^w \cdot M_i + p_{fuel}^w \cdot \sum_l Fuel_{l_i} = \sum p_{E_i}^w \cdot E_i + aid + \sum_h pkap^h \quad (.34)$$

$$K_i = K_{i,-1} (1 - \delta_i) + DK_i \quad (.35)$$

Welfare Measures (by household and labour type)

$$\Omega(h) = \left(\sum_i \left[\frac{C_{i,h} - C_{i,h}^-}{hl(h)} \right]^{1-1/\sigma} \right)^{\frac{1}{1-1/\sigma}} \quad (.36)$$

$$\Omega(sk) = \left(\sum_i \left[\frac{C_{i,sk} - C_{i,sk}^-}{L_i^{sk}} \right]^{1-1/\sigma} \right)^{\frac{1}{1-1/\sigma}} \quad (.37)$$

Variables and parameters

R	Nominal exchange rate
p_M, p_M^w	Domestic (world) import price
p_E, p_E^w	Domestic (world) export price
p_D	Domestic goods price
p_Q	Composite goods price (factory gate)
p_X	Output price
p_{VA}	Value added price
p_C	Consumption price
p_K	Capital goods price
X	Domestic output
XD	Domestic sales
Q	Composite commodity
E	Exports
M	Imports
S	Land
L_U, L_S	Unskilled, Skilled labor
K	Capital
W	Nominal Wages
N	Intermediate inputs
Y	Gross factor income
YD	Disposable income
C	Consumption
s, H, H_{gov}	Savings rate, household savings, government savings
$rent$	Rents on transport
$melt$	'Melt'
$Fuel$	Direct fuel imports
$pkap$	Private capital inflows
$\tau_{M,E,D,N}$	Transport mark-up (imports, exports, domestic, intermediates)
$t_{M,E,D,Y}$	Import tariffs, export duties, indirect taxes, income taxes
fs	fuel subsidy rate
DK, I	Investment by destination, origin
FDI, ψ	Gross FDI, foreign ownership share (= foreign dividend share)
GR, G	Government revenue, government expenditure
aid	Foreign aid

Table 1: *The structure of production and trade*

Commodity	Factors of production	Production Location			Sectoral Trade	
		Rural	Mwanza	Dar	Imports by destination	Exports by origin
Staple Food	Land, Labour	X	X		Mwanza	
Cash Crops	Land, Labour	X	X		Mwanza	Rural, Mwanza
Processed Food	Cap, Labour		X	X	Mwanza, Dar	Mwanza, Dar
Manufactures	Cap, Labour		X	X	Mwanza, Dar	Mwanza, Dar
Services	Cap, Labour		X	X		
Mining / Tourism	Cap, Labour			X		Dar
Public Services	Cap, Labour			X		

Table 2: Transport cost mark-ups by production and consumption location[1],[2]

[illegible]

Table 3: Baseline Economic Structure and model calibration

Aggregate:	Percent of GDP	Share:	Location			Parameter	Baseline Value
			Rural	Mwanza	Dar		
Private Consumption	78.9%	Output	21.5%	36.3%	42.2%	Elasticity of substitution in consumption (α)	1.50
Private Investment	16.2%	Employment	70.7%	19.4%	9.9%	Armington Elasticity(ϵ)	0.75
Public Investment	8.9%	Private Consumption	36.0%	15.6%	48.4%	Elasticity of transformation in production(ϵ)	0.75
Govt. Recurrent Spending	7.5%	Value Added	32.9%	33.8%	33.3%	Productivity of public capital (αg)	0.10
Fiscal balance [1]	-2.3%					Interest (semi) elasticity of foreign investment (β_2)	0.10
Exports (fob)	19.9%					Subsistence share of food (% of initial consumption)	0.90
Imports (cif)	37.2%						
Current Account [1]	-10.8%						

Notes: Source National Bureau of Statistics National Accounts 2001 (as reported by Thurlow and Wobst, 2003).

[1] Before aid (fiscal and current account) and remittances (current account only).

Table 4: Public Investment

Experiment [1]	Agricultural Biased				Non-Agricultural Biased			
	Deficit Finance	Indirect Tax	Tariff	Aid	Deficit Finance	Indirect Tax	Tariff	Aid
<u>Panel (a)</u>								
<i>Macroeconomic aggregates (changes over baseline)</i>								
Real GDP	-2.8%	0.7%	-1.3%	1.2%	-2.8%	0.6%	-1.4%	1.1%
Real Exchange Rate [2]	2.0%	1.0%	-2.0%	-3.0%	2.0%	-1.0%	-3.0%	-5.0%
Private Investment [3]	-3.9%	-0.1%	-2.1%	0.7%	-3.9%	-0.1%	-2.1%	0.7%
Fiscal Balance [3]	-3.8%	0.2%	-1.0%	-2.8%	-3.7%	0.2%	-1.0%	-2.7%
Current Account [3]	-0.5%	-0.1%	0.0%	-2.4%	-0.4%	-0.1%	0.1%	-2.3%
<u>Panel (b)</u>								
<i>Change in share of output</i>								
Rural	0.50%	0.01%	0.20%	-0.30%	0.40%	-0.07%	0.10%	-0.39%
Mwanza	-0.84%	-0.11%	-0.68%	-0.34%	-0.81%	-0.08%	-0.65%	-0.31%
Dar	0.34%	0.10%	0.48%	0.64%	0.41%	0.15%	0.55%	0.70%
<i>Change in employment [4]</i>								
Rural	-2.30%	-0.71%	-1.80%	-1.19%	-1.24%	0.31%	-0.74%	-0.16%
Mwanza	0.17%	0.88%	-0.14%	0.70%	-1.64%	-0.87%	-1.97%	-1.10%
Dar	16.13%	3.35%	13.16%	7.12%	12.10%	-0.49%	9.15%	3.28%
<i>Change in real consumption wages [5]</i>								
Rural - Unskilled	-5.56%	0.15%	-4.77%	0.60%	-4.02%	0.81%	-3.13%	2.30%
Rural - Skilled	0.70%	1.12%	0.21%	3.65%	-0.42%	-0.08%	-0.82%	2.58%
Mwanza - Unskilled	-6.10%	-1.04%	-6.13%	0.21%	-5.04%	0.70%	-4.96%	1.42%
Mwanza - Skilled	0.92%	-2.82%	-0.37%	4.15%	0.05%	-4.34%	-1.15%	2.63%
Dar - Unskilled	-8.34%	-1.95%	-7.69%	-0.65%	-6.42%	-0.03%	-5.69%	1.43%
Dar - Skilled	-0.23%	-4.36%	-0.77%	3.94%	-1.49%	-5.55%	-1.93%	3.32%
<u>Panel (c)</u>								
<i>Social Welfare [6]</i>								
Rural	-12.7%	-1.5%	-10.9%	-1.7%	-9.3%	2.0%	-7.4%	2.0%
Mwanza	-6.6%	-2.4%	-9.9%	0.3%	-7.8%	-3.6%	-11.2%	-1.0%
Dar	2.1%	-5.8%	0.2%	4.3%	0.6%	-7.9%	-1.5%	2.4%
Skilled	4.8%	-4.8%	1.8%	6.9%	2.2%	-8.2%	-0.9%	3.9%
Unskilled	-12.6%	-1.4%	-11.0%	-1.7%	-9.3%	2.0%	-7.6%	1.9%
<i>Relative price of food: non-food [7]</i>								
Rural	94.6	98.1	95.9	100.3	96.7	100.6	98.3	103.1
Mwanza	96.1	96.2	95.5	100.0	97.7	97.7	97.1	101.7
Dar	97.8	95.2	96.9	100.1	98.8	95.9	97.9	101.3

Notes: [1] Public investment is increased by 3.12% of baseline GDP. Investment increases productivity in food and cash crop sectors only in Agriculture-biased case, all other sectors only in Non-agricultural biased case. The elasticity of sectoral output to public infrastructure is set to 0.10 (see text); [2] An increase indicates a depreciation in the real exchange rate; [3] measured in percentage points of GDP; [4] expressed as percentage of baseline population; [5] Skill-specific wage relative to household-specific consumption price index; [6] see text for definitions; [7] 100 x relative consumption prices, therefore inclusive of transport cost margins.

Table 5: *Transport Cost Reforms*

Experiment [1]	Reduction in Melt				Reduction in Rent			
	No Cost	Deficit Finance	Indirect Tax	Tariff	No Cost	Deficit Finance	Indirect Tax	Tariff
Panel (a)								
<i>Macroeconomic aggregates (changes over baseline)</i>								
Real GDP	2.1%	-1.7%	1.8%	-0.2%	0.1%	-3.6%	-0.1%	-2.2%
Real Exchange Rate [2]	5.0%	7.0%	5.0%	2.0%	2.0%	4.0%	2.0%	-1.0%
Private Investment [3]	1.6%	-2.4%	1.3%	-0.6%	0.1%	-4.0%	-0.1%	-2.3%
Fiscal Balance [3]	0.6%	-3.2%	0.6%	-0.5%	-0.4%	-4.3%	-0.2%	-1.5%
Current Account [3]	0.1%	-4.1%	0.0%	0.1%	0.0%	-4.8%	-0.1%	0.1%
Panel (b)								
<i>Change in share of output</i>								
Rural	-0.71%	-0.18%	-0.64%	-0.48%	0.06%	0.61%	0.11%	0.31%
Mwanza	0.24%	-0.67%	0.03%	-0.52%	0.36%	-0.59%	0.20%	-0.43%
Dar	0.47%	0.85%	0.61%	1.00%	-0.42%	-0.02%	-0.31%	0.12%
<i>Change in employment [4]</i>								
Rural	-0.99%	-2.61%	-1.03%	-2.12%	0.19%	-1.37%	0.24%	-0.90%
Mwanza	2.34%	1.31%	1.81%	0.97%	1.03%	-0.18%	0.56%	-0.53%
Dar	2.52%	16.12%	3.83%	13.26%	-3.39%	10.19%	-2.83%	7.44%
<i>Change in real consumption wages [5]</i>								
Rural - Unskilled	2.44%	-3.20%	2.53%	-1.84%	2.92%	-2.75%	3.39%	-1.17%
Rural - Skilled	5.15%	4.91%	4.41%	4.08%	2.17%	1.90%	1.56%	1.39%
Mwanza - Unskilled	5.02%	-1.04%	4.09%	-0.80%	4.22%	-1.82%	3.71%	-1.99%
Mwanza - Skilled	8.48%	7.03%	3.58%	6.00%	4.17%	3.54%	-1.00%	2.12%
Dar - Unskilled	4.80%	-2.89%	3.77%	-2.01%	4.51%	-3.76%	3.89%	-2.61%
Dar - Skilled	8.74%	6.34%	3.59%	6.01%	4.29%	2.00%	-2.79%	1.39%
Panel (c)								
<i>Social Welfare [6]</i>								
Rural	2.9%	-9.2%	2.0%	-7.4%	5.6%	-6.8%	5.4%	-4.9%
Mwanza	13.3%	4.1%	8.2%	0.5%	9.3%	-1.4%	4.7%	-3.7%
Dar	8.4%	8.3%	0.7%	6.5%	-1.7%	-1.2%	-10.3%	-3.1%
Skilled	12.1%	13.7%	4.9%	10.7%	4.1%	6.1%	-4.4%	3.1%
Unskilled	3.1%	-8.9%	2.3%	-7.3%	5.7%	-6.6%	5.5%	-4.9%
<i>Relative price of food: non-food [7]</i>								
Rural	98.1	94.3	98.0	95.9	100.5	96.8	100.3	98.4
Mwanza	96.5	93.8	94.1	93.3	99.9	97.0	97.1	96.5
Dar	96.6	95.3	93.3	94.4	99.4	97.9	94.8	96.9

Notes: [1] The scale of the reduction in melt and rent are calibrated to be equivalent to a 50% reduction in fuel costs on all transport links. The value of this reduction is equivalent to 3.12% of GDP, equivalent to the scale of the shock considered in Table 5; [2] An increase indicates a depreciation in the real exchange rate; [3] measured in percentage points of GDP; [4] expressed as percentage of baseline population; [5] Skill-specific wage relative to household-specific consumption price index; [6] see text for definitions; [7] 100 x relative consumption prices, therefore inclusive of transport cost margins.